



Evaluation of the European Space Agency Contribution Program of the Canadian Space Agency

For the period from April 2018 to March 2023

Prepared by the Audit and Evaluation Directorate

November 2023



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Evaluation of the European Space Agency Contribution Program of the Canadian Space Agency

Project # 22/23 – 02-01

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Acronyms used in the report

CSA	Canadian Space Agency
EFI	Electric Field Instrument
ESA	European Space Agency
ESA-CP	European Space Agency Contribution Program (ESA-CP)
FTE	Full-time equivalents
FY	Fiscal year
GBA	Gender-Based Analysis
GAC	Global Affairs Canada
GNSS	Global Navigation Satellite System
HQP	Highly qualified personnel
IIIT	Institut interdisciplinaire d'innovation technologique
ITT	Invitation to Tender
NAVISP	Navigation Innovation and Support Program
NSERC	Natural Sciences and Engineering Research Council of Canada
O&M	Operations and Maintenance
PNT	Positioning, navigation and timing
TDE	Technology Development Element
TRL	Technology Readiness Level

Executive Summary

This report presents the findings of the evaluation of the European Space Agency Contribution Program (ESA-CP) of the Canadian Space Agency (CSA). The evaluation was carried out by the CSA's Audit and Evaluation Directorate, with the support of PRA Inc. This evaluation was included in the CSA's five-year Evaluation Plan and was conducted in accordance with the Treasury Board of Canada's *Policy on Results*.

The ESA-CP was established through a cooperative agreement between Canada and the European Space Agency (ESA) that was first signed in 1979, and that has been constantly renewed since, with the most recent agreement signed in 2019. It allows Canada to participate in the development and implementation of the European space program, including the opportunity for the Canadian space sector to directly engage in missions and activities carried out by ESA.

Relevance

The ESA-CP is aligned with the needs of the Canadian space sector, as it provides opportunities for Canada's space sector to access activities and procurement opportunities that would otherwise not be available. As among the largest space agencies in the world, ESA undertakes a wide range of space missions and activities that the Canadian space sector is well positioned to engage in. Since ESA operates with the principle that any contracted work related to these missions and activities should, to the extent possible, be allocated to industries located in its member states, the ESA-CP has allowed the Canadian space sector to access an important market that, in turn, often leads to additional opportunities for international collaboration.

The ESA-CP is also aligned with the goal of the CSA to support the Canadian space sector in developing and advancing its technologies. Through work carried out as prime contractors or subcontractors, the Canadian space sector is provided with unique research and development opportunities that complement the other activities carried out by the CSA under its Space Capacity Development Program (SCDP).

Finally, the participation of Canada in ESA's governance structure provides important insights and strategic information on the emerging needs and priorities of the European space sector, which can inform the decision-making process of the CSA, in addition to nurturing a longstanding partnership between the CSA and ESA that has opened opportunities beyond the ESA-CP.

However, findings from the evaluation indicate that some factors have had an impact on the relevance of the ESA-CP. The level of Canada's investment in ESA has remained relatively stable over the past 20 years, while the costs of space missions have increased significantly. This trend has limited the ability of the Canadian space sector to engage in more advanced projects in support of ESA's missions and activities. The budget parameters have also limited Canada's ability to take full advantage of the range of optional programmes made available to ESA's member states. While Canada has invested in optional programmes that reflect the traditional strengths of the Canadian space sector, broadening the scope of these investments would create an opportunity to expand the range of Canadian industries participating in the European space market.

It is important to note that the past 20 years in the life of the ESA-CP were marked by many other changes beyond just the important funding considerations expanded upon above. ESA has consistently grown in terms not only of its budget, but also its membership, its working relationship with other entities such as the European Union and the scope of its activities. Simultaneously, the CSA matured into an agency with a full-fledged ability to deliver across the entire range of activities in space. In terms of relevance this puts the ESA-CP at an important crossroads. Canada's space program has evolved since entering into the Canada-ESA agreement and as a result, would benefit from reviewing the strategic orientations, objectives, and overall positioning of the ESA-CP.

Effectiveness

During the period covered by the evaluation, the ESA-CP has succeeded in allowing the Canadian space sector to engage in missions and activities carried out by ESA. A total of 125 contracts have been signed with the Canadian space sector covering the first four years of the evaluation period, for a total value of approximately €59 million. These contracts are associated with key strategic areas such as Earth observation, telecommunications, space exploration, navigation, and more advanced technology development. These activities have involved 44 Canadian companies, 13 universities, 3 research organizations (including the National Research Council), and 1 federal department (Environment and Climate Change Canada).

These opportunities have allowed the participating members of the Canadian space sector to further develop their technologies and build strategic partnerships that open-up opportunities beyond ESA. They have also benefited from some of ESA's basic activities, such as the Global Space Markets Challenge. For researchers and scientists, their participation has provided access to space-based data sets, including some that are not otherwise available, and facilitated collaborations on research projects, which have also involved students, postdoctoral fellows, and emerging researchers.

The CSA has benefited from the ESA-CP through its involvement in the decision-making process which provides insights into the emerging needs and priorities of the European space community, supporting CSA's own strategic planning.

Efficiency

As a mature program that dates back more than 40 years, the ESA-CP is efficiently managed. Representatives from the Canadian space sector greatly appreciate the ongoing support provided by the CSA as they engage in ESA's missions and activities. Canada's permanent delegate in Paris, along with the ESA country desk officer for Canada, and all members of the CSA who contribute to ESA's decision-making bodies ensure that Canada is part of the planning and implementation processes related to ESA's priorities, therefore maximizing the benefits to Canada associated with the missions and activities undertaken by ESA.

The internal costs incurred by the CSA to manage the ESA-CP are contained, representing between 1% and 2% of the total investment in the program. Also, Canada has historically achieved a high geo-return (close to the ideal 1.00), ensuring that it gets its fair return on the portion of optional programmes and mandatory

activities that ESA contracts out. An element of CSA expenditure that cannot be precisely measured is the proportion that is allocated for ESA overhead. Rough estimates indicate that it may represent a significant amount.

To further support the efficiency of the ESA-CP, Canada should continue to focus its participation in optional programmes, as they provide the greatest strategic value to the Canadian space sector. Also, Canada should take full advantage of the opportunities provided through the mandatory activities funded through ESA's general budget.

Finally, the efficiency of the ESA-CP could be further improved by raising the overall level of awareness among the Canadian space sector of ESA opportunities and by beginning the preparation process for the ESA Ministerial Council meetings earlier.

1. Introduction

Purpose and scope of the evaluation

This document constitutes the report for the evaluation of the Canadian Space Agency's (CSA) European Space Agency Contribution Program (ESA-CP). This evaluation was part of the CSA's five-year evaluation plan, and it assessed the program over the period covering fiscal years 2018-2019 to 2022-2023. It was conducted in accordance with the Treasury Board of Canada's *Policy on Results*.

The CSA last evaluated the ESA-CP in 2018 (CSA, 2018). That evaluation concluded that there was a strong rationale for maintaining Canada's participation in the program. It specifically highlighted that the Canadian space industry was successfully accessing foreign markets and engaging in the missions and other activities carried out by the European Space Agency (ESA), and Canadian researchers and scientists were benefiting from a range of opportunities offered in the ESA context. The ESA-CP was also found to be providing relevant information on the vision and priorities related to space activities in Europe and allowing Canada to be well positioned to engage in large-scale missions and activities that would not otherwise be available. Finally, the evaluation indicated that the program was efficiently managed and that Canada was receiving its fair share in return for its investment.

In this context, the primary purpose of the evaluation was to build on these previous findings, and assess the current relevance of the ESA-CP, its effectiveness in achieving its intended results, and the overall efficiency of the program management.

Overview of the methodology

The findings described in this report are based on a review of relevant documents and data (predominantly from the CSA and ESA), a series of 43 interviews with representatives from the CSA, ESA, the space industry, and academia, and five case studies used to illustrate the range of projects funded through the ESA-CP (see Appendix A for details). Overall, the data collection process unfolded as planned, and all key themes identified for this evaluation were addressed. However, the nature and scope of the data provided in accordance with the contribution agreement between ESA and Canada limited the extent to which the efficiency of the program could be assessed. This is further discussed on the section of the report dealing with efficiency.

2. Program Description

This section provides an overview of the ESA-CP. It focuses on the objectives and the structure of this unique program, provides an overview of the range of activities undertaken, and the resources invested.¹

The objectives of the ESA-CP

As established in its Terms and Conditions, the ESA-CP pursues the following objectives:

- Foster innovation and competitiveness by exposing Canadian space organizations to ESA's programmes and activities dedicated to developing space technologies, applications and hardware;
- Maintain or increase the capability of the domestic space sector to successfully contribute to Canadian space endeavours by providing access to ESA's space flight opportunities in order to demonstrate and qualify Canadian space technologies and hardware;
- Facilitate access to European public space markets as well as global space public and private markets, when applicable; and
- Acquire and maintain awareness of the directions of European space policies and of the European space technological, scientific, programmatic and commercial environments to feed the CSA's strategic planning process.

The mechanics of the ESA-CP

Overview

The foundation for the ESA-CP rests on the fact that, unlike other space agencies, ESA operates with 31 member, cooperating, and associate states² that participate in its missions and activities (ESA, 2023i). Through a range of decision-making bodies comprised of these member states as well as through consultations with key stakeholders such as the European Union and other space agencies, ESA establishes its priorities and uses a series of programmes to support their implementation. To ensure that member states get an equitable return on their investment in ESA, the agency operates under the driving principle that any contracted work related to its missions and activities should, to the extent possible, be allocated to industries located in its member states, on a proportional basis that reflects the level of investment made by each member state (CSA, 2018, p. 1; ESA, 2023d). This means that every dollar invested into ESA will aim to net a return to the industry and academia in participating countries.

ESA's approach creates a unique environment where ESA, which is among the largest space agencies in the world, conducts its missions and activities by providing opportunities for its members while simultaneously having one of the most protected space markets for those outside of ESA. Industries that are not located

¹ For a more detailed description of the ESA-CP and the broader context in which it operates, please see section 2 of the 2018 evaluation of the program (CSA, 2018).

² Unless otherwise stated, a reference to member states covers all member, cooperating, and associate states.

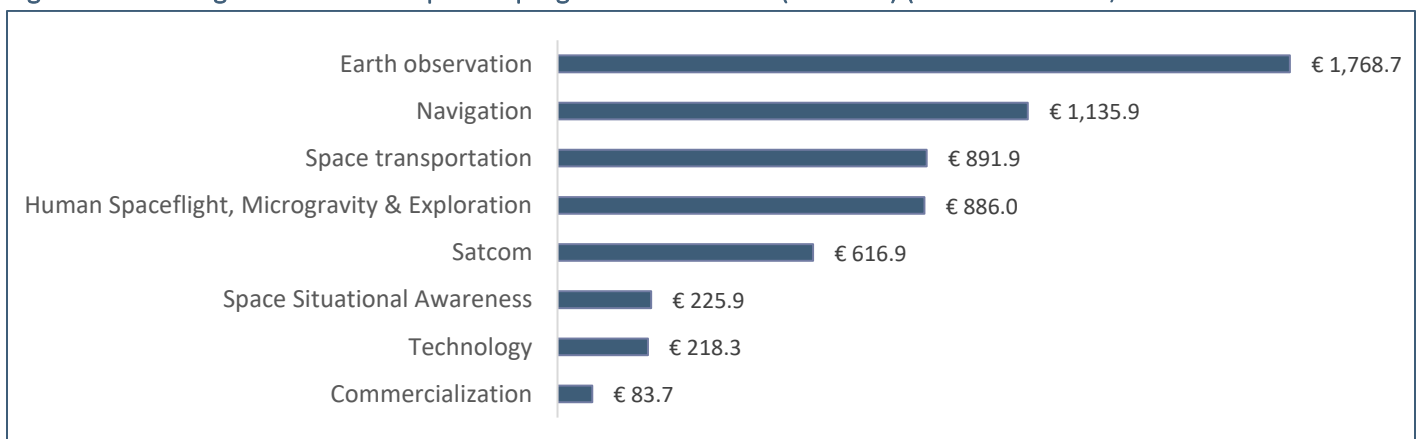
in one of ESA's member states are excluded from undertaking the majority of the agency's work to support its missions and activities.

Mandatory and optional programmes

ESA member states engage in both mandatory activities and optional programmes:

- **Mandatory activities:** Activities that fall under the General Budget and the Space Science programme of ESA are mandatory, and all member states must contribute to funding these activities based on their gross domestic product. The General Budget is used to fund studies on future projects and missions, shared technical investments, information systems and training programmes, i.e., the base elements for the overall operations of ESA as an organization. It also includes the Technology Development Element (TDE) that supports the early stages of development of promising space technologies (ESA, 2023b). In accordance with the cooperating agreement it has signed with ESA, Canada participates in the mandatory activities covered under the General Budget, but not in the TDE, and its contribution to funding mandatory activities has been adjusted to reflect that specific framework.³
- **Optional programmes:** Optional programmes are the essential means by which ESA pursues its space-related vision and priorities. As illustrated in Figure 1, optional programmes cover all of the key policy areas normally associated with space activities, such as Earth observation, space exploration, telecommunications, and navigation (including the European Global Navigation Satellite System). It is mostly through these optional programmes that the space industry of each member state can engage in specific space missions and other related projects.

Figure 1: ESA budget allocation to optional programmes for 2023 (million €) (Source: ESA website)



³ Since Canada does not participate in the Technology Development Element, which falls under the scope of mandatory activities, its contribution to the ESA General Budget represents “50% of its contribution scale calculated on the basis used for the Member States of the Agency” (Government of Canada, 2019b).

Governance structure

Through its unique status as the only non-European state, Canada's engagement in ESA is established through a number of instruments:

- Cooperative Agreement between the Government of Canada and the European Space Agency: Agreements between Canada and ESA have been consecutively signed and renewed since 1979. The parties signed the most recent agreement in February 2019, which entered into force on June 13, 2019, and will be in effect until January 1, 2030 (CSA, 2019a; Government of Canada, 2019b). This agreement is considered a treaty and it engages Canada (and not only the CSA) in cooperating with ESA. It sets the broad parameters within which Canada collaborates with ESA.
- Declarations for optional programmes: For each of its optional programmes, ESA adopts a declaration, which is a document that describes the components of the programme and the anticipated financial contribution of each participating member state.
- Arrangements for optional programmes: For each optional programme, ESA signs an arrangement with Canada. These arrangements confirm the terms of participation in the programme, and they reflect the parameters established in the associated declaration.

ESA holds Ministerial Council Meetings roughly every three years where representatives from all participating states gather to make decisions about the ongoing affairs of ESA, covering both existing missions and activities and, as applicable, new missions that respond to identified needs and priorities. During those meetings, member states may engage in new optional programmes, or increase their existing commitments. At the time of this report, the most recent Ministerial Council Meeting, held in November 2022, led to a significant 17% (€2.412 billion) increase in new funding to ESA's budget from commitments from the various member states. Among other things, these new resources are expected to enhance the capacity of ESA to engage in the NASA-led Artemis program, the European Union's IRIS2 secure connectivity constellation initiative, the Rosalind Franklin rover mission, in addition to maintaining its continued participation in the International Space Station (ESA, 2022b).

Management of programmes and activities

The CSA is responsible for managing the ESA-CP, i.e., the components that govern Canada's participation within ESA. As far as the actual implementation of ESA's programmes and activities, including the ones that Canada contributes to, these are fully managed by ESA. ESA's overhead costs are covered by the following funding sources:

- The contribution of member states to the mandatory programmes and activities;
- The portion of member states' contribution to each optional programme that is allocated to the management of the programme (this is further discussed in the section of the report addressing efficiency);

- Other funding that ESA receives, including funding from the European Union⁴, may also serve to cover these overhead costs.

It is important to note that, as part of this ongoing management of programmes and activities, ESA does contract companies from its member states. This is the case for a portion of the mandatory activities to which Canada and all other member states contribute to, though these are seen to be generally less value-added than the contracts from optional programmes and need not even be in the space sector but can comprise IT services, marketing, administration etc. This explains the fact that member states can expect a fair return for their contributions to both the mandatory programmes and activities, and the optional programmes.

Participation of the Canadian space sector

The Canadian space sector takes part in ESA activities through different mechanisms under the ESA-CP.

The participation of the Canadian space industry typically occurs through ESA's formal procurement process (ESA, 2023I). Once it has completed the planning and preparatory phases for a mission or project, ESA typically issues an Invitation to Tender (ITT), which formally triggers the tendering process. At that point, eligible companies (or other eligible entities such as universities or research centres) are invited to submit their proposals. Often, a single large company (known as the "prime contractor") leads the offer and reaches out to other eligible companies, entities, or scientific experts to build a team and a proposal that fully responds to the requirements contained in ESA's ITT. Canadian companies regularly act as subcontractors and join European prime contractors and occasionally act as prime contractors. Depending on the programme used to fund a mission or project, Canadian companies may be required to obtain a letter of support from the CSA before submitting an offer or engaging as subcontractors (CSA, 2020b).

The extent to which Canadian institutions can join missions or projects under each of ESA's optional programmes or applicable mandatory activities is determined by the overall level of funding that Canada committed to, as documented in the applicable declaration.

Academic institutions may also submit a response to an ITT, or join a team assembled by a prime contractor. In addition, as an added benefit, Canadian researchers and scientists may be invited to participate in various scientific committees that ESA establishes, which allows them to access data produced through ESA's missions (while an increasing proportion of data is open access, some data may be restricted or be available sooner to ESA member states).

⁴

In 2023, the European Union was providing 24.2% of the overall ESA budget.

ESA-CP program management structure

The role of the CSA

The ESA-CP is one component of the CSA's Space Capacity Development Program (SCDP), which covers "activities that range from pre-mission research and development to timely flight demonstrations, with the aim of positioning the Canadian space sector for global opportunities" (Government of Canada, 2023b). As such, the program is housed within the CSA's Space Science and Technology Branch, which manages the SCDP, with support from other CSA branches as needed.

As part of the program implementation, the ESA-CP program team undertakes a range of enabling activities. This team includes, among others, the Policy branch, and spans several other branches and directorates through the many delegates involved. The list of the activities undertaken by the ESA-CP includes the following components:

- It leads the negotiations related to the Cooperative Agreement and the associated declarations and arrangements;
- It engages with key Canadian stakeholders during consultations leading up to ESA Ministerial Council Meetings;
- It participates in the ongoing affairs of ESA, including the work done by Canadian delegates (approximately 30 individuals) as part of the numerous Programme Boards, Committees and advisory groups found in ESA, along with all activities related to Council Meetings at the delegate and ministerial levels;
- It manages the ongoing contributions made to ESA as part of the ESA-CP;
- It operates through a supportive role to assist stakeholders as they explore ESA opportunities or engage in missions or activities carried out by ESA.

The role of Global Affairs Canada

Since the cooperative agreement between Canada and ESA has the legal status of an international treaty, Global Affairs Canada (GAC) collaborates directly with the CSA as part of the negotiations leading up to the renewal of the agreement. It also supports the process of securing the required Orders in Council for the various arrangements that establish Canada's participation in optional programmes. The permanent Canadian delegate to ESA, who is based in Paris, also reports to GAC in addition to the CSA.

Program resources

During the five fiscal years covered by the evaluation, the CSA invested approximately \$216 million in the ESA-CP. As indicated in Table 1, annual expenditures varied between \$31 and \$51 million, which represented, on average, approximately 44% of the CSA's budget allocated to its Space Capacity

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Development Program (SCDP) (Government of Canada, 2023a).⁵ It is important to note that Table 1 shows payments from CSA to ESA for each fiscal year. The amounts that the CSA will contribute to each ESA program are committed to at the Ministerial meetings, and the contracts that ESA issues back to the Canadian space sector have long time horizons over the life of each individual program and thus, cannot be directly correlated to the figures below. The costs related to the internal management of the program within the CSA represented between 1% and 2% of the total investment in the ESA-CP. The decline in operations and maintenance (O&M) costs in fiscal years 2020-2021 and 2021-2022 is largely attributed to the fact that no travelling occurred during the COVID-19 pandemic period. Costs are expected to return to previous levels with the return of in-person meetings.

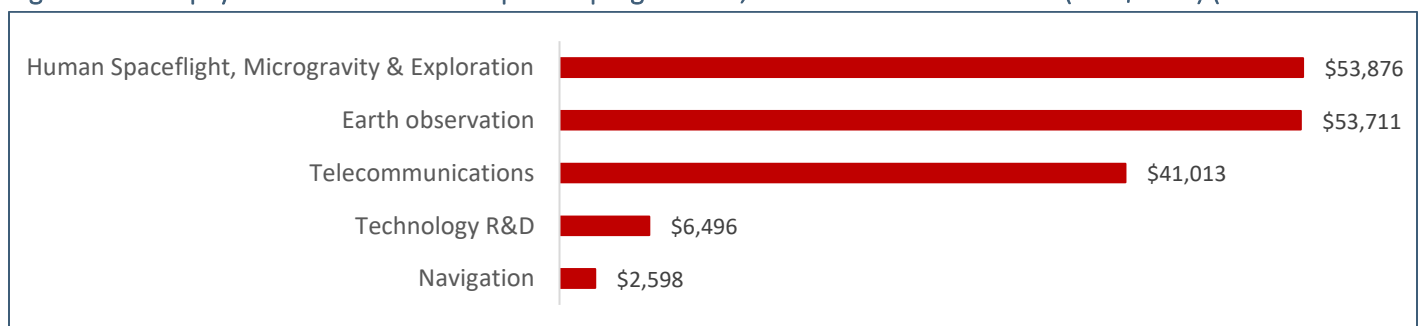
Table 1: Summary of actual resources invested in the ESA-CP (CAD\$ '000)

Activities	2018-19	2019-20	2020-21	2021-22	2022-23	Total
Contributions to ESA						
General Budget	10,099	10,273	11,642	11,631	12,050	55,696
Optional programmes	19,878	25,819	39,167	38,521	34,308	157,694
<i>Sub-total</i>	<i>29,977</i>	<i>36,092</i>	<i>50,810</i>	<i>50,152</i>	<i>46,358</i>	<i>213,390</i>
Management of ESA-CP						
Number of FTEs ¹	4	4	3	4	3	
Salaries	493	499	387	485	343	2,208
O&M	113	90	1	1	81	286
<i>Sub-total</i>	<i>606</i>	<i>589</i>	<i>387</i>	<i>487</i>	<i>424</i>	<i>2,494</i>
Total	30,583	36,681	51,197	50,639	46,782	215,884

1. The number of FTEs covers the individuals who are primarily assigned to the ESA-CP. It does not cover the time allocated by all Canadian delegates who participate in the various ESA committees.

Looking more specifically at the optional programmes in which Canada participates, Figure 2 includes the distribution of the actual payments made by the CSA to ESA over the five fiscal years covered by the evaluation.

Figure 2: CSA's payments related to ESA optional programmes, FY 2018-19 to FY 2022-23 (CAD\$ '000) (Source: CSA financial data)



⁵ The annual costs for optional programmes reflect the actual payments (as opposed to the commitments) made to ESA in accordance with the cooperation agreement. These costs are expected to vary due to the nature of the activities that Canadian industries are undertaking and the milestones they achieve.

3. Evaluation Findings

This section of the report summarizes the main findings that emerged from the evidence examined through this evaluation. It addresses the relevance, effectiveness, and efficiency of the ESA-CP.

Relevance

The strategic importance of the ESA market

Finding: The ESA-CP continues to be a key component of the Canadian space program, providing a wide range of opportunities for the Canadian space sector to create partnerships and collaboration, to advance technologies and to facilitate access to European and other follow-on international space market opportunities.

As previously noted, the public sector component of the European space economy is essentially a closed market, largely reserved for the space industry located within Europe. In this context, a key question becomes one of determining the strategic importance of providing the Canadian space industry with access to that market through Canada's privileged relationship with ESA as a cooperating state. While the ESA-CP does not form the only basis by which Canada's space sector can access a foreign public market like this, it does facilitate that access and, as a result of our formalized ESA membership, allows for continued participation of Canada's space sector in ESA projects without the need for ad-hoc arrangements on a case by case basis.

Overview of the Canadian space industry

The Canadian space industry comprises a number of defining characteristics. Revenue-wise, it is dominated by the satellite communication sector, predominantly for broadcasting purposes.⁶ Close to 80% of the \$4.9 billion in revenues recorded by the Canadian space industry in 2021 derived from satellite communication (CSA, 2023a, p. 18). This includes the manufacturing of space and ground segments, the operation of satellites, and the offering of a range of communication services, products and applications. Once we set aside satellite communication, the Canadian space industry includes a wide diversity of activities that cover all traditional areas of space, which generated around \$1 billion in revenues in 2021, as illustrated in Figure 3.

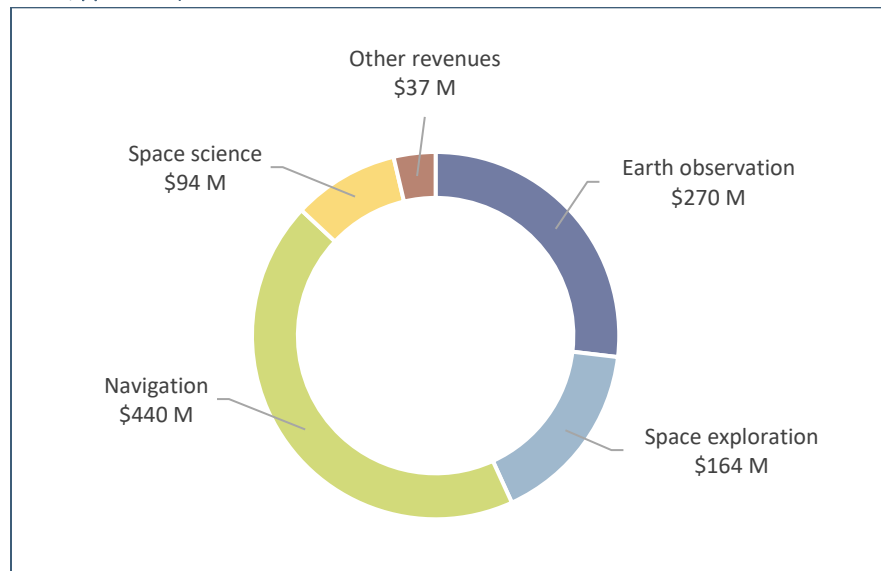
The Canadian space industry is also highly concentrated in a few major players that generate the lion's share of revenues, with a multitude of smaller organizations that make up the rest. For instance, 95% of space revenues come from 30 space organizations (26 companies and 4 universities), out of the more than 200 space organizations in Canada (CSA, 2023a, p. 31; Government of Canada, 2021). Using the 2021 economic data, this means that around \$245 million in revenues in 2021 was distributed among approximately 170 organizations, while the remaining \$4.7 billion in revenues was shared by those 30

⁶ Broadcasting typically involves the distribution (public or private) of audio or video content to the general public, and involves a range of mediums, such as radio, television and the internet.

organizations with the highest revenues. This is relevant in understanding the context within which Canadian industry interacts with ESA, these large companies are integral to Canada's space industry and may be more naturally able to leverage their size to take advantage of ESA opportunities, especially functioning as prime contractors. However, it is also worth noting that small and medium enterprises (SMEs) in Canada's space sector are in fact more export-driven than the largest players, with 61% of their revenues coming from customers abroad (CSA, 2023a, p. 31). Having access to ESA contracts is particularly important for these SMEs, which are the lynchpin of innovation in Canada's space sector.

Finally, 36% of overall revenues from the space sector in 2021 came from exports (CSA, 2023a, p. 22). While the United States does remain the largest source of export revenues (57% of all export revenues), Europe came second (22% of all export revenues) and double the level of exports to Asia, the next largest region (CSA, 2023a, p. 24).

Figure 3: Distribution of Canadian space industry revenues by sector of activity in 2021, excluding the satellite communication sector (CAD\$ millions), Source: (CSA, 2023a, pp. 20–21)



Benefits of participating in ESA

Evaluation findings point to the value attributed to Canada's participation in ESA. From the perspective of the Canadian space sector, ESA significantly opens up the range of opportunities offered to them through the following key benefit areas:

- Establishing new partnerships: Perhaps the single most important benefit that emerged from interviews with industry representatives is the ability to establish partnerships and collaborations with European companies, particularly those acting as prime contractors on ESA projects. It was emphasized that commercial opportunities in space are largely based on trust, expertise, and proven records of collaboration. Benefiting from the strong brand associated with Canada in a number of key technological areas, Canadian companies that are successful at creating and cultivating these relationships become natural partners that prime contractors may turn to when it comes to preparing

an offer to ESA, or as part of other commercial opportunities. Given that ESA has a budget that is ten times larger than what the entire Government of Canada invests in space, these partnerships are often with significant players in the global space economy. As such there is the potential to allow for cooperation on future lines of business within both the European market outside of the initial ESA contract, or through leveraging partnerships with these significant European partners into other global markets that would be absent relying on domestic partnerships alone (Euroconsult, 2022, p. 40; Euroconsult, 2022, p. 167)

- Advancing new technologies: As one of the largest space agencies in the world, ESA engages in multiple space missions and activities that broaden the range of opportunities for Canadian companies to develop and mature new technologies, services, and products. For instance, performance data confirm that projects funded with the support of the ESA-CP have succeeded in advancing the Technology Readiness Level (TRL) of Canadian technologies. Data indicate that at least 55 technologies and applications have been developed by Canadian space organizations with the support of the ESA-CP. Many technologies have also benefited from ESA opportunities for space mission access, either by already having flown or having been selected to fly on a future space mission. Despite its well-established involvement in space, Canada's investments in the sector have remained relatively stable, and are not on the same plane as the investments that the multi-nation ESA can bring to bear. Canada's participation in ESA helps maximize its investments, providing industry with opportunities in multiple areas, including those that have not systematically been the focus of CSA's missions, such as satellite communications or navigation.
- Accessing new markets: During interviews, industry representatives also emphasized that the participation in one of ESA's missions is a highly valuable achievement that opens up opportunities outside of ESA. In other words, having been part of an ESA mission is a "business card" that confers credibility, which is a central asset for expanding business opportunities. This credibility additionally comes not only from just being a part of an ESA program, but also from the fact that many of these ESA contracts allow industry to demonstrate their ability to deliver, facilitating access to new markets and follow-on business globally.

Representatives from academia also appreciate the collaborations that are made possible through ESA. Sitting on various committees, undertaking scientific research with European colleagues, or participating in specific projects funded through the ESA-CP contribute to advancing their research plans and understanding the trends that shape future priorities in space-related sciences, which helps them stay at the forefront of the research agenda.

"ESA programs have been very important, useful, and strategic for us. From a networking perspective, connecting with and collaborating with other science-focused companies in Europe that are looking to do work internationally has been a very important opportunity. We've been able to really obtain some advancements and knowledge through those partnerships that we wouldn't have been able to obtain by just being in Canada or not having those opportunities. In particular, ESA invested quite a lot of funds into Earth Observation exploitation platforms. Without that exposure to those initiatives at ESA, I am sure we wouldn't have been able to advance our capabilities to the extent that we have."

- Company Representative (Interview)

Finally, representatives from the CSA emphasized the important value of the strategic information gathered through Canada's participation in various committees and decision-making bodies of ESA. Having detailed

information on global space trends, as well as on ESA's current and future missions and activities, directly supports the planning process related to space activities undertaken by the CSA and by the federal government more generally. This longstanding collaboration between Canada and ESA also facilitates the establishment of partnerships on larger projects (outside the scope of the ESA-CP), such as the recently launched James Webb Space Telescope (CSA, 2022b). Lastly, the range of research and development opportunities offered through the ESA-CP is complementary to the other programs offered by the CSA through its Space Capacity Development Program and it is aligned with the CSA's expected departmental results of ensuring the Canada remains a leading space-faring nation, and that Canada's investments in space benefit the Canadian economy (CSA, 2022a).

Factors that impact the relevance of the ESA-CP

Finding: The relevance of the ESA-CP rests on the ability of members of the Canadian space sector to engage in actual missions and activities, which can be limited by the level of funding that Canada directs towards the various optional programmes.

While a strong rationale exists for maintaining Canada's participation in ESA, evaluation findings point to certain factors that can diminish the relevance of the ESA-CP, especially given the significant changes within both agencies over the decades.

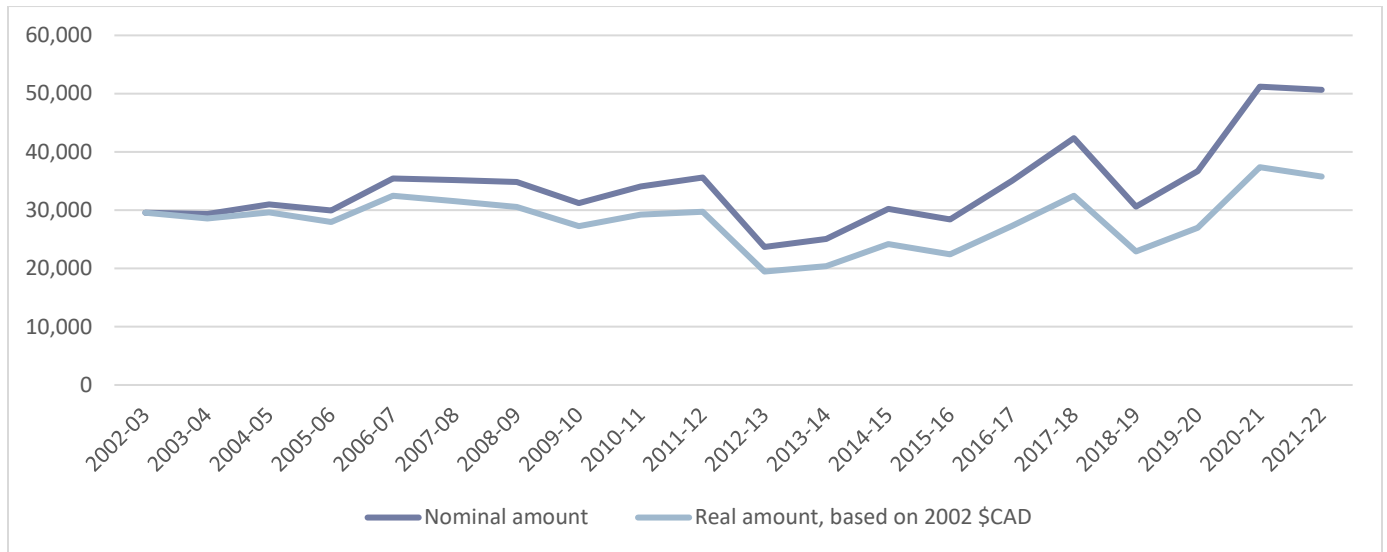
Budget framework

The rationale for any investment made by a member state into ESA's programmes rests on the assumption that its domestic space industry has the capacity to actively engage in the agency's missions and activities. As noted during interviews, some member states face challenges in achieving the targeted industrial return on their investment due to the limitations in their space industry's capacity to undertake the required tasks. This is not the case for Canada. Interviews with representatives from both ESA and the Canadian space industry indicate that the capacity of the Canadian space industry to participate in ESA missions and activities exceeds the level of investment that Canada is making in the ESA-CP. This leads to choices that must be made to enhance the capacity of the Canadian space sector as a whole. On that basis, it was repeatedly suggested during interviews with all stakeholder groups that Canada would be well-positioned to fully leverage more opportunities if available.

Establishing the appropriate level of investment in the ESA-CP falls outside of the scope of this evaluation. As such, this evaluation limits itself to documenting the impact of the current level of investment. To this end, Figure 4 illustrates the variations in annual expenditures associated with the ESA-CP for the past 20 years or so. These variations are partly due to the fact that they reflect actual payments made to ESA based on the progression of the contracts involving Canadian space organizations. In nominal dollars, it shows annual variations between \$30 million and \$40 million for most of the period (except for a drop under \$30 million between 2012-2013 and 2014-2015), with a more recent increase in 2020-2021 and 2021-2022. The nominal yearly average for the whole period is approximately \$34 million. Figure 4 also includes the variations in annual expenditures when controlling for inflation by using 2002 as the base year. It shows a

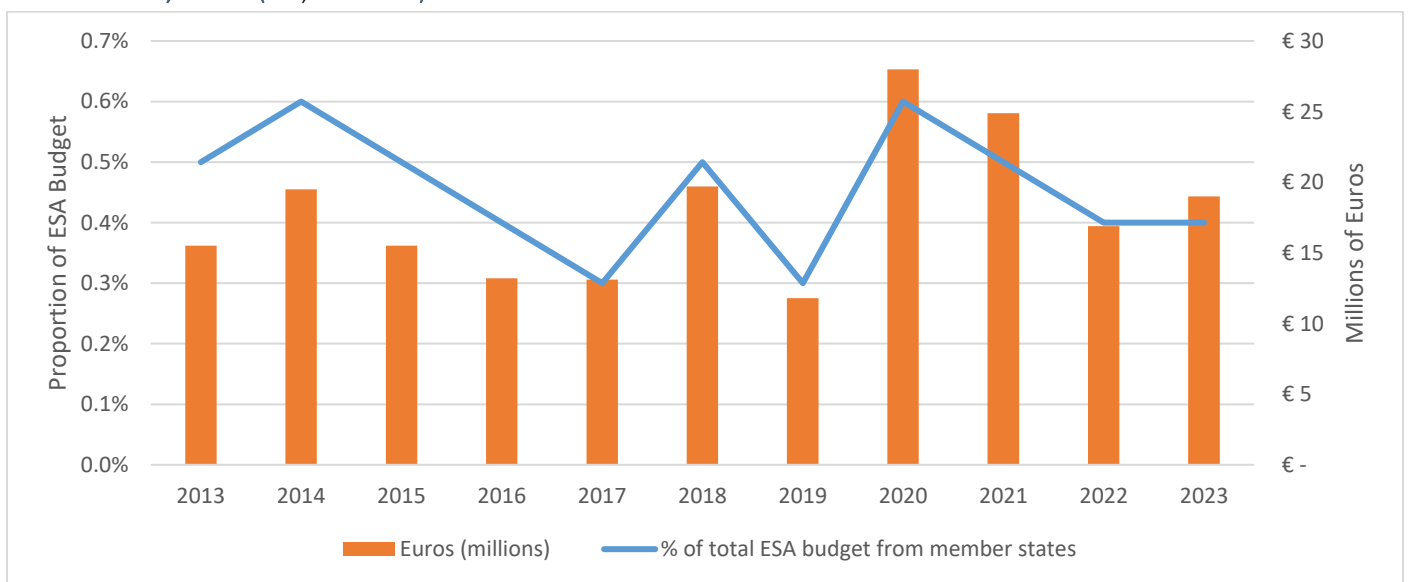
general decrease in investments for most of the period, with a yearly average (in real 2002 dollars) of approximately \$28.3 million.

Figure 4: Resources invested in the ESA-CP between FY 2002-2003 and FY 2021-2022 (CAD\$ '000), in nominal amounts and in fixed 2002 CAD\$ amounts, Source: (CSA, 2010, 2015, 2018; Official Inflation Data, Alioth Finance, 2023)



Placed in a broader context and as illustrated in Figure 5, Canada’s contribution represented less than 1% of ESA’s budget for the past ten years. One axis of the graph shows the amount of money that Canada has put into ESA, while the other axis shows the proportion of the total ESA budget this amount represents. This includes several fluctuations including some increases in 2020 and 2021, especially linked to Canada’s participation in the Mars Sample Return mission.

Figure 5: Canada’s ESA budget contribution in millions of Euros and as a percentage of total member state contributions, Source: (ESA, 2013-2023)



The data in Figure 5 confirms that Canada's contribution, despite increases in nominal value, continues to represent less than 1% of ESA's total budget coming from member states. In this context, Canada has continued to face the challenge of ensuring that the funding it directs towards the ESA-CP can lead to a diversity of opportunities (by subscribing to a range of optional programmes), while also ensuring that sufficient funding is invested in each of these programmes to allow for a meaningful participation of the Canadian space sector.

Evaluation findings indicate that achieving this balance is becoming increasingly difficult. During interviews, representatives from the space industry noted that the overall costs of space missions are steadily rising, and the limited funds available from Canada for individual projects tends to limit the ability of prime contractors to engage Canadian space organizations in more advanced technological development activities. One prime contractor noted during interviews that they increasingly opt for off-the-shelf technologies offered by Canadian companies, as the limited funds available do not allow for a more substantial participation. This is problematic, considering that the very purpose of participating in ESA is to allow Canadian companies to increase their technological capabilities (see logic model in Appendix B).

The potential issues resulting from the funding challenge are not limited to a lack of meaningful participation but may also impact the composition of Canadian industry that is likely to participate in ESA programs going forward. As previously noted, the bulk of funding made available through the ESA-CP is directed to a fairly small number of space organizations in Canada. Expanding the range of participating organizations is a goal that was expressed by all stakeholders consulted as part of this evaluation, including ESA representatives, and it is in line with the vision expressed in Canada's space strategy, which "seeks to create a vibrant and sustainable space sector anchored by a whole-of-government effort" (Government of Canada, 2019a, p. 9).

Overall, these trends point to potential risks of missing promising opportunities, of limiting the ability of Canadian space organizations to meaningfully advance their technological capabilities, and of allowing space organizations from other ESA member states to move into areas where Canada has traditionally been particularly competitive. This, in the long run, may negatively impact the relevance of the ESA-CP.

Breadth of optional programmes selected

The range of optional programmes that Canada decides to invest in is another factor that has a marked impact on the overall relevance of the ESA-CP. For reasons described earlier in this subsection, making these choices is difficult when considering the magnitude of the missions and activities undertaken by ESA, and the relatively limited financial envelope of the ESA-CP.

As illustrated in Figure 2 (page 7), Canada's investments over the evaluation period have focused on space exploration, Earth observation, telecommunications and to a lesser extent, navigation. At the most recent ESA Ministerial meeting held in November 2022, Canada added approximately \$60 million to its existing commitments (CSA, 2023b). This investment focuses on these same areas, while also adding a small investment in the Space Safety programme.

Overall, evaluation findings indicate that the current range of investments does reflect the expertise that Canada can readily offer to European partners. The solid reputation of Canada in robotics (reflected in the investments in space exploration), Earth observation and satellite communications directly aligns with the choices that Canada has made over the evaluation period (and prior to that period as well).

Those interviewed as part of the evaluation would like to see an increase in Canada's investments into existing programmes, or other ESA programs that Canada is not yet participating in, such as the Moonlight program, or the recently launched commercial program *ScaleUp* that aims to accelerate space commercialization in Europe through ESA's Business Incubation Centres (ESA, 2022c, 2023e). Commercialization support is seen as particularly well aligned with the goal of expanding the range of Canadian companies that participate in ESA's missions and activities, in addition to engaging with the broader European markets.

Ultimately, the range of optional programmes selected is expected to reflect and align with the vision that Canada has in terms of supporting existing and emerging members of the Canadian space sector. Evaluation findings indicate that having that vision more readily articulated and communicated would help to build a shared understanding among all stakeholders of the expected contribution of the ESA-CP.

Effectiveness

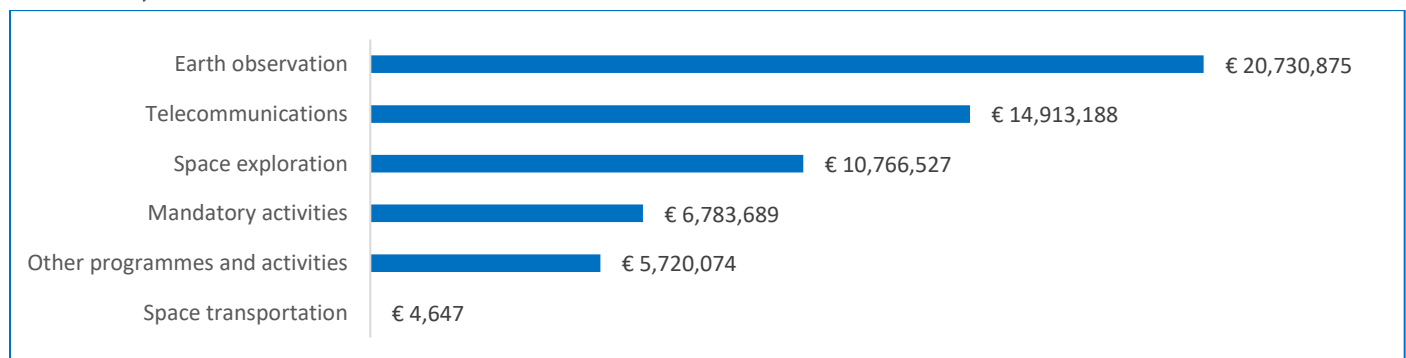
The participation of Canadian space organizations in ESA

Finding: During the period covered by the evaluation, the Canadian space sector has engaged in a wide range of missions and activities, which have allowed the expected benefits of the ESA-CP to be realized. Canada has been successful at achieving the overall targeted return coefficient over time.

Overview of the level of participation

During the first four years of the period covered by this evaluation (2018-2019 to 2021-2022), Canadian space organizations signed a total of 125 contracts associated with ESA missions and activities, for a total value of €58,919,000. As illustrated in Figure 6, these contracts predominantly covered activities related to Earth observation, telecommunications, and space exploration.

Figure 6: Value of contracts awarded to Canadian space organizations per domain for the period of FY 2018-19 to FY 2021-22, Source: ESA data

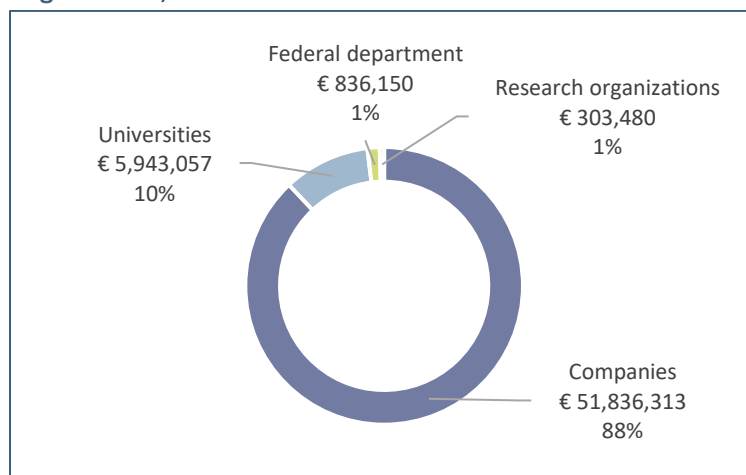


A total of 61 Canadian space organizations have been involved in these contracts (covering the first four years of the evaluation period), including 44 companies, 13 universities, 3 research organizations (non-profit organizations and the National Research Council), and 1 federal department (Environment and Climate Change Canada). Considering that there are approximately 200 Canadian space organizations in Canada (Government of Canada, 2021), it means that around 30% of them have engaged with ESA during that period.

Based on ESA's own analysis however, despite this significant range of Canadian organizations involved in working with ESA, the majority do so infrequently. This is illustrated by the relative concentration of contracts going to a small number of Canadian institutions. For instance, ESA's examination shows that the top 80% of monies disbursed to industry were managed by just 8 companies (ESA, 2021b, p. 25). This data points to a need to increase diversity in the makeup of Canadian organizations that participate in ESA managed projects, especially given the benefits that could be realized by Canadian space SMEs given their dynamism and reliance on export markets.

As illustrated in Figure 7, the vast majority of the contracts awarded were directed to Canadian companies. These contracts related to Earth observation, telecommunications and space exploration activities. While many Canadian companies acted as prime contractors on smaller ESA contracts, a number of them also worked on large contracts with foreign prime contractors like Airbus (headquartered in Leiden, Netherlands), Thales (headquartered in France), or Sener (headquartered in Spain).

Figure 7: Value of ESA mission contracts and activities by type of organization, Source: ESA data



Universities and research organizations have also focused their involvement in Earth observation activities. In the specific case of universities, their engagement has included both research activities related to various ESA missions, as well as the ESA Living Planet Fellowship, which supports emerging researchers who wish to initiate a scientific career in Earth observation (ESA, 2023h).

GBA Plus considerations

The evaluation included Gender-Based Analysis (GBA) Plus considerations. In doing so, it must first be emphasized that missions and activities that are supported through the ESA-CP are managed by ESA, using its operational and procurement rules or directives. As such, the evaluation focused primarily on documenting the gender composition of teams engaged in projects and activities supported through the ESA-CP, and understanding how ESA approaches aspects relating to equity, diversity and inclusion.

Performance data from approximately half of the projects that were funded with the support of the ESA-CP indicate that men comprised 83% of the team members involved in these projects. This reflects trends found in the space sector more generally (CSA, 2023a, p. 8). However, members of those teams who more recently joined the space sector were made up of 23% women, which may signal a trend towards greater gender parity.

Evaluation findings also indicate that ESA has undertaken efforts to more fully integrate equity, diversity, and inclusion considerations in its operations. For instance, ESA is launching a campaign to recruit a parastronaut (an astronaut who is differentially abled) and is implementing its Agenda 2025 that includes an eight-step strategy to achieve greater diversity and inclusiveness. In addition, ESA adopted the ESA Responsible Procurement Policy and Corporate Social Responsibility Code of Conduct in 2023, which incorporates gender aspects.

Reported program results

Evaluation findings indicate that the expected benefits associated with Canada's participation in ESA have continued to be realized during the period covered by the evaluation.

During interviews, representatives from the Canadian space industry emphasized that their participation in ESA has led to the development of new expertise, products, and services, has enhanced their production capabilities and has strengthened their relationships with international clients. Performance data also demonstrate that ESA-CP funding seems to directly support the engagement of highly qualified personnel (HQPs), as 81% of reported project team members were HQPs.

Findings from the case studies completed as part of this evaluation provide more detailed illustrations of the impact of the ESA-CP on the Canadian space industry:

- Biomass (Earth Observation): ESA is preparing for the launch of its Biomass mission, scheduled for 2024, which is expected to provide critical data on the state of forests, including how they are changing, and their role in the carbon cycle (ESA, 2023c). ESA has selected Airbus as the prime contractor for building this new Earth observation satellite. In turn, and with the support of the ESA-CP, Airbus has contracted the Canadian company C-Core, located in Newfoundland and Labrador, for the design, development, production, delivery and installation of a calibration transponder, which is a device that receives and transmits radio signals at a prearranged frequency range (CSA, 2019b). This opportunity has provided C-Core with the chance to showcase its capabilities in building algorithms and onboard processing systems.

- NAVISP (Navigation): ESA's Navigation Innovation and Support Program (NAVISP) supports the development of new technologies in the area of positioning, navigation and timing (PNT) that go beyond the exclusive use of satellite navigation signals and data (ESA, 2023j). This technology plays a critical role as more advanced automating processes continue to be developed. Through the ESA-CP, the Canadian company RX Networks, located in Vancouver, has developed a high-precision, cloud-based corrections service for Global Navigation Satellite System (GNSS) receivers (CSA, 2020a). This opportunity has allowed RX Networks to accelerate the development of its high precision solutions and has led to a number of partnerships with companies based in Europe and other foreign markets, including a collaboration with Qualcomm, announced in October 2022, on the integration of RX Networks' meter-level location accuracy in around 2 billion mobile phones worldwide (Rx Networks, 2022).
- GSTP (Technology): Through its General Support Technology Program (GSTP), ESA has provided funding to Umicore, a global materials technology and recycling group with headquarters located in Belgium, to enhance the efficiency of space solar cells, including a more efficient use of germanium substrates (semiconductor material). This is essential considering the fact that the demand for this semiconductor material is expected to exceed its availability, particularly with the launch of large constellations of satellites. As part of this project, Umicore reached out to the *Institut interdisciplinaire d'innovation technologique* (IIIT) of the Université de Sherbrooke to assist with the research and development activities, based on the research that the IIIT had already published. The new technologies developed as part of this project will also find applications on Earth, particularly in improving the efficiency of solar panels. To further their ongoing collaboration, the IIIT and Umicore are planning for the establishment of an industrial research chair at the Université de Sherbrooke. For the IIIT, the partnership with Umicore has helped to establish an international reputation in applied research leading to commercial opportunities.
- Global Space Markets Challenge: In collaboration with Eurisy, a European non-profit association of over 15 national space agencies and other related organizations, ESA has established the Global Space Markets Challenge, which aims to raise the visibility of promising small and medium size enterprises offering products and services in the upstream and downstream space sectors (ESA, 2023f). The first challenge occurred in 2021, where participating companies were invited to present their internationalization plan for one of their products or services. The 12 finalists (six from upstream and 6 from downstream) were invited to deliver a presentation at the 72nd International Astronautical Congress (IAC) held in Dubai. The Canadian company A.U.G. Signals finished third place in the downstream category. In addition to receiving €5,000 to advance its internationalization plan, the company was provided with an opportunity to network and be introduced to a wide community of space-based companies and capital venture companies (ESA, 2021). Representatives from A.U.G. Signals expressed a deep appreciation for this opportunity to connect with other companies in Europe, and found the whole experience very valuable for all the employees involved. They intend to participate in future rounds of this competition.

During interviews, representatives from the Canadian community of researchers and scientists also emphasized the positive impact that their participation in ESA activities has had. In addition to providing full access to a range of space-based datasets and facilitating opportunities to collaborate with researchers based in ESA's member states, the funding provided by ESA has supported the involvement of students, postdoctoral fellows, and emerging researchers. The close relationship between Canadian and European researchers and scientists also facilitates the planning of future activities related to new space missions involving ESA and the CSA. It provides access to research domains where the CSA may be less involved and multiple academics described how ESA facilitates research that may not happen without the current arrangement with ESA.

“ESA has a bigger budget, and it has a bigger scope than CSA has. But at the same time, they do tend to target certain areas which I think are of great importance for the future.

- Member of Academia (Interview)

The case study on the SWARM mission illustrates how ESA-funded research activities engage Canadian researchers and scientists. Launched in 2013, the mission was initially a constellation of three satellites that make high-precision and high-resolution measurement of the Earth's magnetic field (ESA, 2023k). These three satellites include a number of instruments, including the Electric Field Instrument (EFI) that was developed with the Canadian company Honeywell acting as prime contractor, along with Canadian researchers from the University of Calgary (acting as principal investigator), the University of Alberta, the University of Saskatchewan, and European researchers. In 2018, to enhance the capacity of the SWARM mission, ESA and Canada used ESA's Third Party Mission programme to add the Canadian satellite Echo (initially part of the CSA-funded CASSIOPE mission involving the Enhanced Polar Outflow Probe instrument) to the constellation, providing complementary data on space weather (ESA, 2018). The SWARM mission has been extended to 2025, allowing researchers to pursue their collaborations, to share their knowledge, and to engage with students and postdoctoral fellows.

The geo-return achieved by Canada

Finding: Canada is well positioned to achieve the expected return coefficient on its investment in optional programmes.

Having Canada achieve an equitable return on its investments in ESA, through contracts issued to its space sector, is a critical consideration in assessing the effectiveness of the ESA-CP. As noted earlier in this report, Canada has historically been successful at achieving the targeted return coefficient.

In the context of ESA, the return coefficient is defined as “the ratio between the share of a country in the weighted value⁷ of contracts, and its share in the contribution paid to the Agency” (ESA, 2023g). Put simply, if Canada contributes 5% of the entire budget of an optional programme, then the Canadian space sector

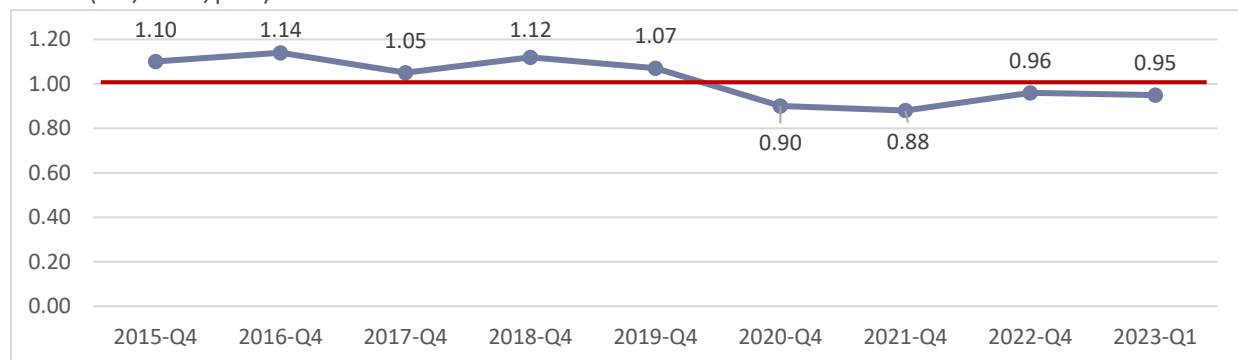
⁷ Weighted values are obtained using a technological weighting factor, where contracts relating entirely to space technologies are given a weighted ratio of 1.00 (no adjustment), whereas contracts that do not relate or only partially relate to space technologies are given weighted values that are adjusted accordingly. Contracts under ESA's optional programmes tend to have a ratio of 1.00, but contracts under mandatory activities may have a lower ratio, as they may respond to ESA's operational needs.

should receive 5% of the total amount of the optional programme that has been contracted out (therefore achieving the ideal ratio of 1.00).

Considering the scale of ESA’s missions and activities and the complexities of engaging multiple parties (such as prime contractors, subcontractors, along with researchers and scientists), the overall industrial return achieved by a member state is expected to fluctuate over time. In this context, ESA establishes statistical periods that serve for ongoing monitoring of return coefficients achieved by each ESA member state. At the time of this report, ESA was using the statistical period of January 1, 2015 to December 31, 2029. At key moments during that period, namely December 31, 2019 and December 31, 2024, ESA proceeds with a formal review of the return coefficients achieved by each member state, to identify any need for corrective measures. Since corrective measures (such as additional contracts directed to the space industry of a member state) cannot be guaranteed, it may or may not be possible to ultimately achieve the ideal ratio of 1.00. As reference points, ESA was aiming to have each member state achieve a minimum ratio of 0.91 by the end of 2019, and a minimum ratio of 0.93 by the end of 2024 (ESA, 2023a, p. 5).

As illustrated in Figure 8, Canada has tended to exceed the ideal target of 1.00 during the current statistical period, except in 2020 and 2021⁸, and is now well positioned to achieve a “fair return” from its participation in ESA. This is in line with results reported in previous evaluations of the ESA-CP (CSA, 2018, p. 24).

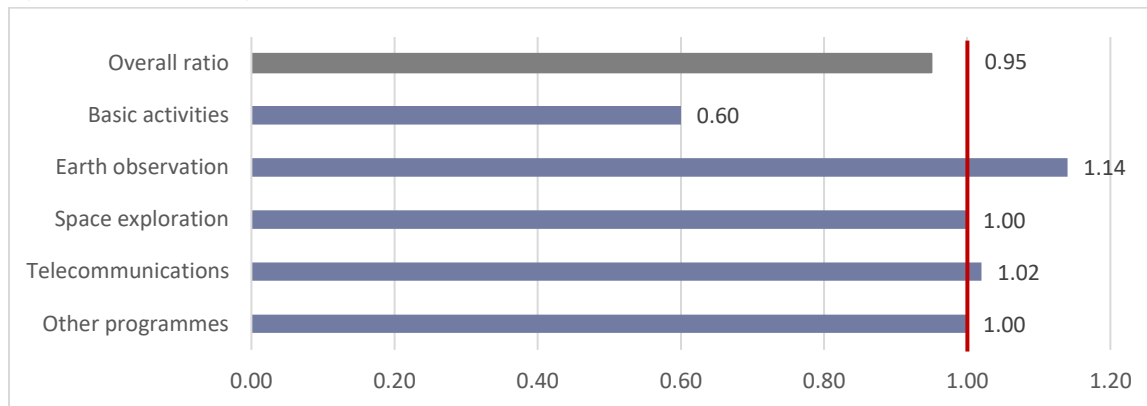
Figure 8: Overall return coefficient achieved by Canada for the period from January 2015 to March 2023,
Source: (ESA, 2023a, p. 27)



Looking more specifically at the various domains of activities in which Canada participates, Figure 9 indicates that Canada has performed well in all strategic sectors, except for the contracts related to ESA’s basic activities covered by its General Budget. This reflects an historical trend where the Canadian space sector has habitually faced challenges in providing the types of services typically covered under the General Budget of ESA, particularly since these services often require a presence onsite, at ESA’s locations, again these include maintenance services, IT etc. Over time, specific measures have been successfully implemented to address that gap (CSA, 2018, p. 25).

⁸ This period coincides with the general slowdown that the space industry has faced as a result of the COVID-19 pandemic (OECD, 2020).

Figure 9: Return coefficients achieved by Canada for the period from January 2015 to March 2023 by domain of activity, Source: (ESA, 2023a)



Efficiency

The management of the ESA-CP

Finding: Overall, the ESA-CP is a well-managed program, with ESA and the CSA collaborating closely to support the participation of the Canadian space sector. To further enhance the management of the program, the evaluation has identified a need to promote the program to a wider audience, and to engage the Canadian space sector earlier in the planning of Ministerial Council Meetings.

Ongoing management of the ESA-CP

Building upon a collaboration that dates back more than 40 years, the ESA-CP is an exceptionally mature program. Ever since the CSA has managed the ongoing relationship with ESA, trust and close collaboration has been established between the two organizations. During interviews, ESA representatives have repeatedly emphasized the efficiency and professionalism of CSA representatives who participate in the various boards, committees and working groups. Representatives from the CSA have echoed those sentiments, and greatly value the ongoing support provided by ESA.

One area raising some operational challenges is the information provided by ESA to the CSA. While ESA is generally responsive, there is some information that is typically more difficult for the CSA to obtain. This is especially the case for certain microdata with respect to specific contracts. There is an understanding that, given the size of ESA and the fact that they are the ones ultimately managing the contracts, there is a limit to how much they can instantly share with every member state. This situation nonetheless poses a challenge for internal operations in being aware of exactly when contracts are ending, or who they are going to, which are important elements for the CSA's internal reporting, especially with respect to performance measurement and financial tracking.

There have been however some notable developments with respect to ESA-CSA communication channels which has improved the ongoing administration of the ESA-CP. One specific improvement that was applauded was the introduction by ESA of a country desk officer for Canada. This staff position provides a main point of contact for ESA industry matters dedicated to Canada (ESA, 2021b). Their mandate is quite broad but includes being a primary point of contact for both member states and industry directly. This work complements the work of Canada's permanent delegate in Paris, who supports the overall management of the ESA-CP, in addition to representing Canada in various ESA forums.

Another challenge related to efficiency concerns the need for in-person meetings, especially among the various programme boards for which the CSA has representatives, which triggers significant travelling costs for Canada. This issue was mitigated during the pandemic when all meetings were online or hybrid, but ESA places a premium on having these meetings in-person. There are legitimate reasons for this, such as ensuring that all member-states benefit from the same opportunities and that there is no differentiation between those who have the resources to attend in-person and those who are remote. However, it does have a cost, especially since these meetings often happen at least four times a year for each board. This is more challenging for Canada than other member-states given our geographical location outside of the European continent. Accounting for delegates time for board meetings (which occur four times a year and are usually two days long), plus travel, in addition to the preparation for these meetings can be estimated as a total of five days of work per board meeting. This does not factor the time required for the preparation meetings for the Council nor ad-hoc meetings, work on letters of support for Canadian proposals when needed and the extensive involvement leading up to Ministerial years when investment decisions need to be made.

Overall, the efficient collaboration between ESA and the CSA benefits the participating Canadian space organizations. During interviews, representatives from both the industrial and academic sectors have expressed their appreciation for the ongoing support and availability shown by the CSA program representatives and, as applicable, the ESA representatives. Evaluation findings have not identified any major concerns related to this aspect of the program management.

Finally, there is an element of program efficiency that relates more specifically to internal CSA management of the program. As previously discussed, within the CSA, the management of the ESA-CP is located in the Space Capacity Development Program. Evaluation findings indicate that the program is well managed. As previously noted, the work that the CSA team does is greatly appreciated by not only by ESA but also internally.

"I want to commend ESA for an innovation that they did, by appointing a country desk officer for Canada. I am impressed by the amount of information that ESA is able to share/collaborate with us to prepare for our own country. This is something that they have not done in the past, but that service has been really phenomenal. It is a very large machine and it is hard for us at CSA, a small organization, to wrap our heads around all of the different processes. Having just a one-stop shop so you can ask for any information has been so helpful and so efficient. This country desk officer also has implications for industry"

- CSA Employee (Interview)

"As far as cost effectiveness, I would love it if we could participate in meetings remotely more often, out of fairness. They currently insist on having everybody on site so that people are not inadvertently left behind. Countries that could not afford to go to the meeting would be stuck on a remote call while everybody else would be making corridor conversations and making deals. So, they do it out of fairness and I understand that. But it's way more expensive for us than any other country to attend in person, because of our distance and the cost of traveling. It would be wonderful if more could be done remotely."

- CSA Employee (Interview)

There is also widespread agreement that the location of CSA management within SCDP is the logical location for the ESA-CP. There was however ongoing mention of the need to increase synergies and communication not only within the SCDP program, to ensure that the natural complementarity between ESA and Canada's domestic Space Technology Development Program is maintained, but especially with the other relevant sectors in Space Utilization and Space Exploration to ensure both their needs and the integrity of the SCDP are preserved. This perception ranges from interviewees who thought that the program could be used more strategically to meet their needs to a desire from SCDP to be more connected to the work being done in Programme Boards and by delegates.

Program awareness

One area where some concerns have been expressed during interviews conducted as part of this evaluation relates to program awareness.

Using the period from 2015 to 2022, ESA's administrative data indicates that approximately 80 Canadian space organizations have engaged with ESA. With an estimated 200 space organizations in Canada (Government of Canada, 2021), this gives an estimated participation rate of around 40 percent. While this represents a significant level of engagement, evaluation findings indicate that it remains difficult, especially for emerging organizations, to understand the logic and operations of the ESA-CP and of ESA more generally, and how they can participate in the various opportunities available.

The CSA's website has some information on the ESA-CP, but evaluation findings confirm that it is insufficient, as it is largely limited to providing a high-level description of Canada's involvement with ESA. Representatives from the Canadian space sector are seeking more practical information that can guide them as they seek to participate in opportunities facilitated by the ESA-CP.

The agency has also hosted events to promote and explain how Canadian space organizations can engage with ESA. However, evaluation findings indicate these activities are hosted on an ad hoc basis. Representatives from the Canadian space sector and from ESA are inviting the CSA to have a more sustained and comprehensive approach to raise the overall awareness level among all those organizations that could benefit from the program. As noted during interviews, this is seen as particularly important considering the complexity associated with the ESA procurement processes, which can act as a barrier to the participation for Canada space organizations, particularly emerging ones.

As documented in this report, the various processes allowing Canadian space organizations to participate in ESA are fairly technical and complex. In fact, some of the representatives from the Canadian space sector who were interviewed as part of this evaluation were not aware that Canada was providing some of the financial support that allows ESA to contractually engage them. In this context, a more involved approach to enhance the awareness of the ESA-CP and its mechanics would promote more equitable access to the program.

As noted during interviews, raising the awareness of ESA opportunities while keeping the level of engagement at its current level may raise expectations that will likely not be met. This is a relevant

consideration from an operational perspective, but it creates an environment that is less conducive to enhancing the participation of emerging space organizations.

The consultations leading up to ESA Ministerial Council Meetings

ESA Ministerial Council Meetings are critical events held on an as-needed basis (typically every three years or so) where all member states make strategic choices on how best to direct their investments in ESA's missions and activities.

There is substantial preparatory work undertaken for each Ministerial Council Meeting. Over time, and as noted in the last evaluation of the ESA-CP (CSA, 2018, p. 28), the CSA has expanded its consultation with the Canadian space sector to help inform its planning work, and findings from this evaluation confirm this trend. In particular, a survey of the Canadian space sector was undertaken to support the planning process related to the last Ministerial Council Meeting held in November 2022. This survey was also regarded as a gain in efficiency since the last evaluation.

However, evaluation findings indicate that it may be necessary for the CSA to further expand its preparatory work in support of future investment decisions. This could be done by actively engaging and collaborating with contractors, other space agencies and key stakeholders early on to discuss and plan the next series of projects and activities. As one key informant noted during their interview, the end of a Ministerial Council Meeting signals the start of the planning process for the next Meeting. It is during these early planning phases that partnerships are explored and tentatively established to pave the way for new projects. It is therefore critical to have the CSA and the members of the Canadian space sector actively engage in these discussions, with an understanding from the CSA as to the likely direction that the agency will pursue through the ESA-CP.

The overall return on investment

Finding: The ESA-CP provides Canada with an equitable return on its overall investment in ESA, as illustrated by the range of results achieved and the opportunities that would not otherwise be available to the Canadian space sector.

Assessing the extent to which the CSA and the federal government as a whole is getting its fair share on its overall investment in the ESA-CP must include a number of considerations:

- CSA management costs: As noted in the section on program resources (see page 6), the management costs incurred by the CSA directly for the management of the ESA-CP have varied between \$500,000 and \$600,000 yearly, representing 1% to 2% of the total investment in the program.
- Overhead costs for ESA optional programmes and mandatory activities: All investments made in ESA's optional programmes and mandatory activities include overhead costs charged by ESA for the actual management of these programmes and activities. In the case of optional programmes, these overhead costs may represent between 20% and 30% of the investments made by any

member state (CSA, 2015, p. 57). The remaining portion of these investments are expected to be returned to each participating member states through contracts provided to its space sector (with an ideal ratio of 1:00). As already noted, Canada has been successful at achieving the targeted overall ratio.

- The strategic relevance of the investments: While the Canadian space sector is expected to benefit from all of the investments made through the ESA-CP, those investments made in optional programmes tend to be more relevant than what is covered by the mandatory activities included in the contribution to ESA's General Budget. It is, however, important to emphasize that the amounts allocated to mandatory activities are expected to benefit the Canadian space sector, not only through contracts allocated, but also through the range of complementary activities offered by ESA, such as free initiatives for students (courses, lectures and symposiums, or the ESA academy), the presence of a Country Desk Officer for Canada, or activities such as the Global Space Markets Challenge.

At the time of the evaluation, the available data did not allow for a systemic measurement of the return on investment associated with the ESA-CP, particularly as it relates to the ratio of contracts received by the Canadian space sector to the total amount invested in ESA. As already noted, the geo-return achieved by Canada is strong, meaning that Canada is getting an overall strong return (typically the ideal 1.00) on the portion of optional programmes or mandatory activities that are contracted out. What is not possible to measure with precision is the level of resources that Canada invests in ESA that will not be contracted out. The available data from ESA offers a rough estimate at best, but what is clear is that this overhead is significant. These estimations have been used in previous evaluations of the ESA-CP to provide a sense of the overall return on investment. However, these estimates were based on data points that were not directly correlated, raising fair concerns about the actual value of the ratio provided. It should be noted that every member state involved in ESA is facing this challenge.

This limitation, while important, must be appropriately contextualized, since the benefits that Canada gains from its participation in ESA extends beyond the value of contracts coming back to the Canadian space sector. As previously noted, the active involvement of Canada in shaping and implementing the European space program had had significant benefits for the CSA, and the entire Canadian space sector, allowing for partnerships and collaborations that would not otherwise be available.

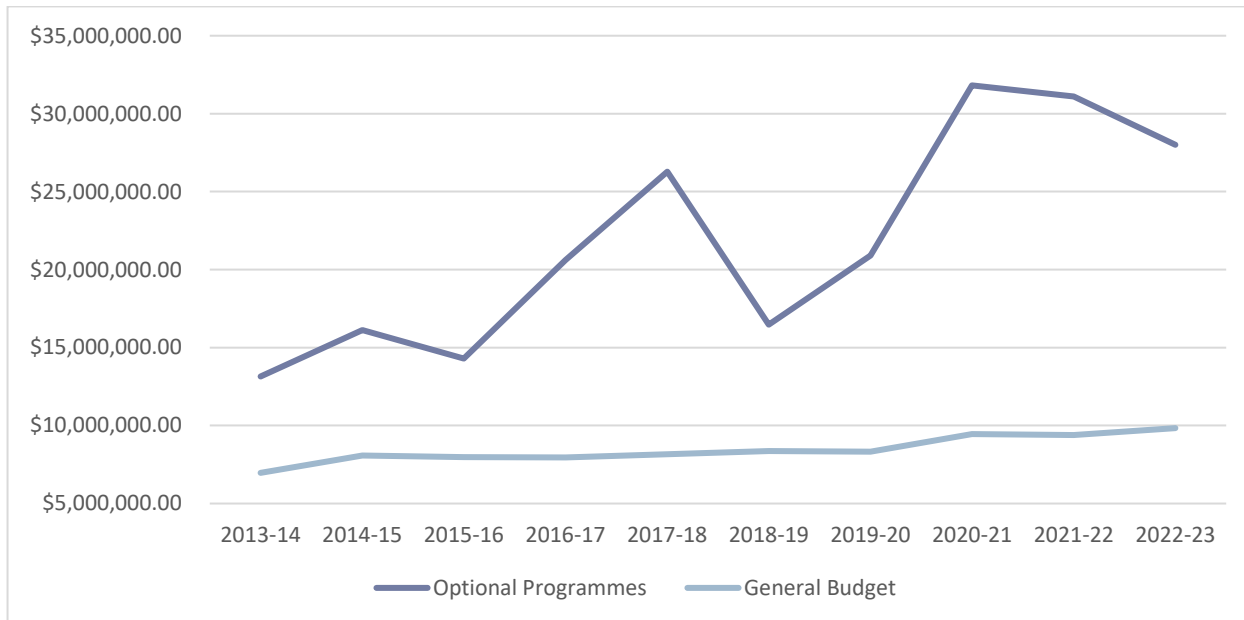
On that basis, evaluation findings point to two important considerations to maximize the efficiency of the ESA-CP. First, Canada must ensure that its investment in ESA remains largely focused on optional programmes, since they provide the greatest benefits to the Canadian space sector. Using purchasing power parity in US dollars (stripping away exchange rate and inflation fluctuations), Figure 10 shows the distribution of ESA-CP expenditures between the general budget and optional programmes over a ten-year period ending in 2022-2023. It confirms that the share of Canada's total expenditures in the ESA-CP directed toward the general budget has declined from 35% in 2013-2014 to 26% in 2022-2023 but critically the portion allocated to optional programmes has been narrowing over the past few years as some major one-off investments are wound down.

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Secondly, Canada must maximize the benefits offered through the various activities funded through ESA's general budget, particularly as it relates to students and emerging Canadian companies interested in the space sector. Evaluation findings indicate that, while progress has been made in engaging in these activities, more could be considered to fully maximize the benefits of these activities.

Figure 10: Distribution of ESA-CP expenditures between the general budget and optional programmes between 2012-2013 and 2021-2022, (Purchasing Power Parity USD\$), Source: Financial data provided by the CSA; OECD, 2023



4. Conclusion

This section concludes the evaluation of the ESA-CP by summarizing the key insights that emerged from the findings and, on that basis, it includes recommendations to the CSA.

Program relevance

With a space sector that relies on export markets and with a relatively contained national space market, Canada has historically benefited from its involvement in ESA. Canadian organizations that have participated in ESA's missions and activities value the opportunities provided to mature new technologies, develop new products and services, and establish new partnerships with European partners. Participation in ESA has also provided credibility that can, in turn, open up opportunities in other international markets. The program also meets the needs of Canadian researchers and scientists by providing a range of collaborations and partnerships related to space science. Finally, the participation of Canada in ESA provides key insights on the emerging needs and objectives of ESA, which directly supports the strategic planning of the CSA.

The evaluation identified some factors that could impact the relevance of the ESA-CP. First, Canada's space program has evolved since entering into the Canada-ESA agreement and as a result, would benefit from reviewing the strategic orientations, objectives, and overall positioning of the ESA-CP vis-a-vis the CSA's future direction. Second, while some increases in the funding allocated to the ESA-CP have occurred during the period covered by this evaluation, the overall budget of the program has remained largely stable over the past 20 years, while the costs of space missions and activities have significantly increased. In the event that funds are too limited at the individual project level, the opportunity to engage in more advanced technology development would thereby be reduced, which would force some prime contractors to simply purchase off-the-shelf products from Canadian companies.

Budgetary parameters also shape the range of optional programmes to which Canada may subscribe. Historically, Canada has focused its investments in Earth observation, space exploration, and telecommunication, which do reflect areas of strength of the Canadian space sector. As new programmes are being implemented by ESA, particularly in support of commercialization, budget limitations may limit the capacity of Canadian space organizations to benefit from them.

Program effectiveness

During the period covered by the evaluation, the Canadian space sector has continued to be actively engaged in a range of ESA's missions and activities. A total of 125 contracts, for a total value of close to €60 million have been signed during the first four years of the period covered by the evaluation. In total, 44 Canadian companies, 13 universities, 3 research organizations and 1 federal department have engaged with ESA.

Members of the Canadian space sector have confirmed that the expected benefits of the ESA-CP have been realized, as new technologies have been advanced, access to new markets have been facilitated, and a wide range of successful collaborations and partnerships have been established.

The Canadian space sector has maintained its ability to successfully respond to opportunities provided by ESA, as illustrated by the strong return coefficient on optional programmes that Canada continues to achieve.

Program efficiency

The ESA-CP is a mature program, which rests on a solid collaboration between ESA and the CSA. Representatives from the Canadian space sector greatly value the ongoing support that representatives from both the CSA and ESA are providing.

To further support efficient and fair access to the ESA-CP, evaluation findings indicate that it would be beneficial to undertake activities that could enhance the awareness and understanding of the ESA program and markets, and the options available through the ESA-CP to engage in it. The CSA has already implemented such activities, and these would benefit from being pursued in a more sustained fashion.

The CSA would also benefit from engaging earlier with the Canadian space sector in planning and coordination for ESA Ministerial Council Meetings. Potential partnerships and collaboration are being explored by the various member states and their respective space sectors. Canada needs to engage early on to ensure that meaningful opportunities may be considered in a timely manner.

While available data limits the ability to measure the precise return on investment, evaluation findings indicate that Canada is getting a fair return on its overall investment in the ESA-CP, which provides opportunities that would not otherwise be available for the Canadian space sector.

Recommendations

Based on these conclusions, the evaluation includes the following recommendations:

Recommendation 1: The CSA should review the strategic orientations of the ESA-CP.

Recommendation 2: The CSA, in collaboration with ESA, should expand its activities aiming to promote and raise awareness of the opportunities offered through the ESA-CP to current and potential members of the Canadian space sector.

Recommendation 3: The CSA should engage the Canadian space sector earlier and more actively, through direct consultations and discussions for the planning and the coordination of Canada's participation in ESA's Ministerial Council Meetings, to maximize collaboration opportunities with European partners.

Management Response and Action Plan

RECOMMENDATIONS	RESPONSIBILITY BRANCH	MANAGEMENT RESPONSE	ACTION PLAN	DEADLINE
RECOMMENDATION 1	Director General, Science and Technology in collaboration with the Director General of Space Program Policy	Management accepts the recommendation.	The ESA-CP team will prepare and implement a plan for the review of the program's strategic orientations and generate recommendations in advance of the selection of ESA optional programmes for the 2025 ESA Ministerial Council meeting.	31 Dec 2024
The CSA should review the strategic orientations of the ESA-CP.				
RECOMMENDATION 2	Director General, Space Science & Technology and Director, Technology Development Management	Management accepts the recommendation.	The ESA-CP team will prepare a marketing strategy to increase promotion and awareness of the program both within the Canadian space sector and to potential beneficiaries in other domains.	31 May 2024
The CSA, in collaboration with ESA, should expand its activities aiming to promote and raise awareness of the opportunities offered through the ESA-CP to current and potential members of the Canadian space sector.				

<p>RECOMMENDATION 3</p>	<p>Director General, Space Science & Technology and Director, Technology Development Management</p>	<p>Management accepts the recommendation.</p>	<p>The ESA-CP team will integrate opportunities to engage the Canadian space sector and provide information in advance of the 2025 Ministerial Council meeting in the marketing strategy proposed for Recommendation 2.</p>	<p>31 May 2024</p>
<p>The CSA should engage the Canadian space sector more actively, through direct consultations and discussions for the planning and the coordination of Canada’s participation in ESA’s Ministerial Council Meetings, to maximize collaboration opportunities with European partners.</p>				

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APPENDICES

Appendix A – Methodology

Overall approach

Building on the previous evaluations conducted on the ESA-CP (CSA, 2010, 2015, 2018), this evaluation explored the relevance, effectiveness and efficiency of the program. This included an analysis of the extent to which the expected results of the program (as illustrated in the logic model included in appendix B) have been realized. In doing so, the evaluation considered the broader context in which both the CSA and ESA are evolving, including transformations in the space sector, the emerging needs in terms of mission priorities, and the alignment of the program with other activities undertaken by the CSA.

As was the case with previous evaluations of the ESA-CP, the goal was to assess the program itself, and not ESA as a whole. Any recommendations that emerge from this evaluation had to be directed towards the CSA, and not ESA.

The following paragraphs describe each of the methods used to address the evaluation issues.

Document, performance and financial data review

A review was conducted of the relevant administrative, performance, and financial data provided. The document review portion of this task included both publicly available information and information provided by the CSA on the ESA-CP, as well as documents provided by other stakeholders interviewed for the evaluation.

Other information sources, such as ESA's performance data provided to the CSA, were used to provide additional insights on the ESA-CP.

Key Informant Interviews and case studies

Key informant interviews contributed to the in-depth understanding of ESA-CP activities, including results achieved and challenges faced by key stakeholders. These interviews also corroborated, explained, or further elaborated on findings from other data sources. A total of 52 individuals were consulted through 43 interviews (including both individual and group interviews). The following table includes the distribution of interviews per categories of key informants.

Distribution of interviews conducted as part of the ESA-CP evaluation

Key informant groups	# of interviews	# of individuals
CSA representatives	15	20
Industry representatives	15	17
ESA representatives	4	6

Key informant groups	# of interviews	# of individuals
Academia	9	9
Total	43	52

As applicable, interviews included questions that related specifically to the case studies completed as part of this evaluation. The criteria used to select the case studies included the type of ESA activity or optional programme through which they were funded, the Canadian partners involved in the activity or mission, the period during which the activity or mission was implemented, with the goal of covering a variety of experiences and outcomes.

Limitations

The evaluation did not encounter any significant challenges that would have constrained the ability to adequately address the evaluation issues. There were nonetheless some limitations that must be taken into account, which are described in this subsection, along with the strategies to address them.

Distribution of roles and responsibilities

A unique characteristic of the ESA-CP is the fact that ESA is, in practical terms, largely responsible for delivering the activities in which Canada participates. As a result, it also determines the range, the format, and the frequency of reporting activities, which do not always align with the standard approach used by the CSA. For instance, the fiscal year of ESA is aligned with the calendar year, instead of the April 1st to March 31st cycle used within the federal government.

To the extent possible, the data was reconciled, or the difference is directly noted. Overall, this limitation has not had a significant impact on the extent to which performance information from ESA could be used to assess the ESA-CP.

Reporting requirements

Whether they act as prime contractor or subcontractors, members of the Canadian space sector engage directly with ESA or with a prime contractor as applicable. As such, the individual projects are not managed by the CSA, and there is limited project-specific information that is gathered by the CSA, depending on the nature of the project (optional programmes or mandatory activities).

Consequently, the project-specific information, and their impact, were largely documented through the interviews conducted as part of this evaluation or, as applicable, through the survey of principal investigators conducted by the CSA on a cyclical basis.

Scope of knowledge

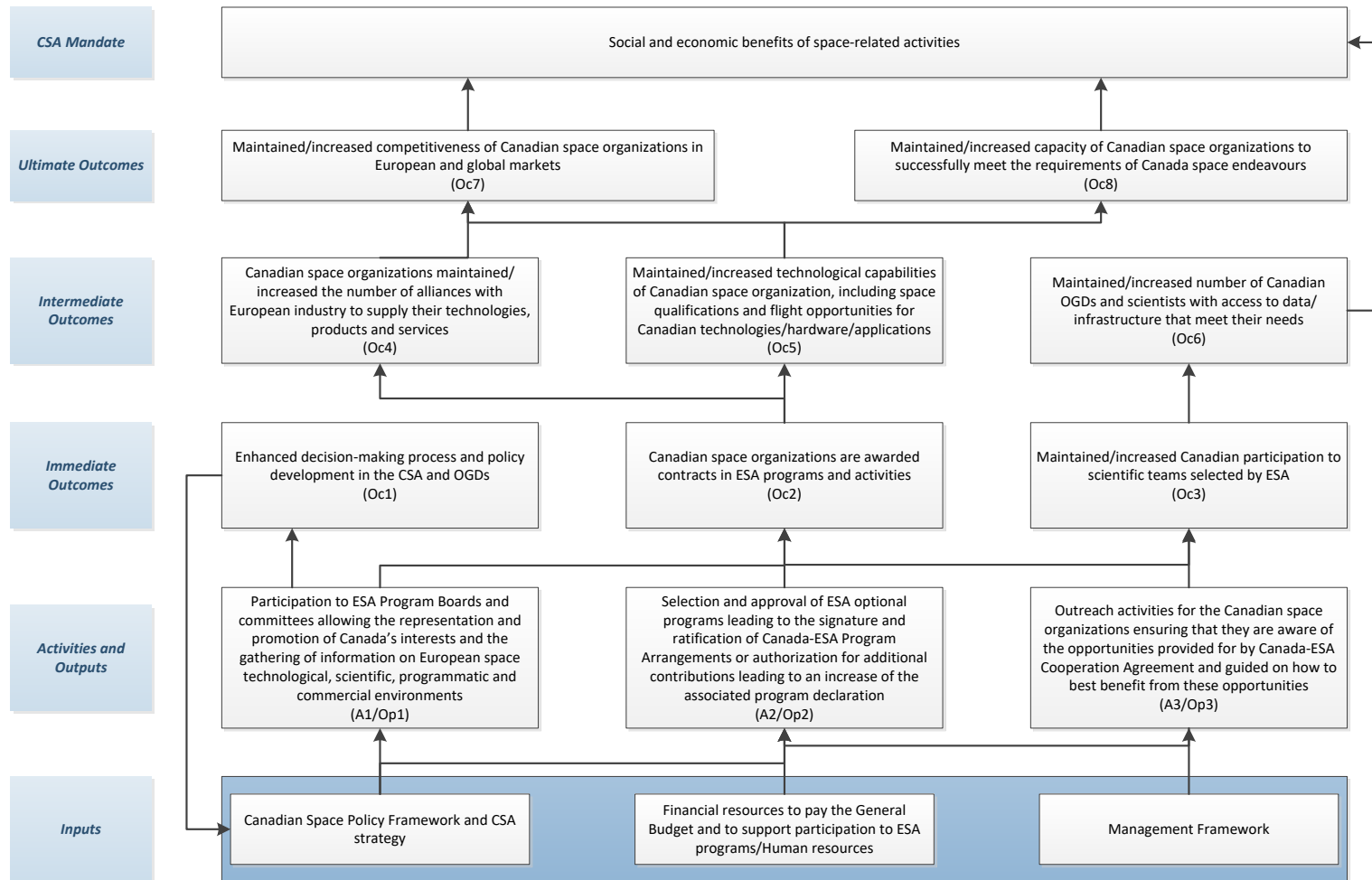
Because of the magnitude of ESA's missions and programming, key informants tended to have a targeted and more contained experience based on the specific projects in which they have been involved. Along the

same lines, ESA representatives collaborate with the space sectors of all its member states, and can therefore offer some insights on the Canadian engagement, but not a comprehensive perspective. Only CSA representatives could offer a more global view of the ESA-CP, but not systematically of project-specific activities.

As this was expected at the time that the evaluation was launched, interviews were structured to ensure that each key informant group would be addressing relevant questions that were specific to the nature of their engagement with ESA or with the ESA-CP, and the other lines of evidence were used to build the overall experience described in this report.

Appendix B – ESA-CP’s logic model

ESA Program Logic Model



Appendix C – Case studies

Case study – Swarm

Description of SWARM	
Project overview	<p>Swarm is ESA’s first constellation mission for the Earth Observation (EO) envelope. The overall objective of the Swarm mission is to provide the most accurate survey of the geomagnetic field and its temporal evolution to gain new insights into the Earth system by improving our understanding of the Earth’s interior and climate. The mission consists of four satellites. Three are identical satellites (Alpha, Bravo, Charlie) that conduct science operations from Low Earth Orbit, making high-precision and high-resolution measurements of the strength of the magnetic field and the magnetic field vector with high spatial and temporal resolution. The fourth satellite (Echo) delivers information on space weather to enhance Swarm data collection.</p> <p>Each satellite is equipped with instrument packages. The Electric Field Instrument (EFI) represents one of the significant Canadian contributions to this mission. The purpose of the EFI is to measure the electron density and temperature in the ionosphere and the ion drift velocity and temperature. The EFI is crucial for the Swarm mission because it measures the electric field along the orbit, which is essential for studying the Earth’s magnetic field and space weather. COM DEV International (now Honeywell Aerospace) was contracted to build the EFI, which consists of two instruments, namely the Langmuir Probe (LP) and the Suprathermal Ion Imager (SII):</p> <ul style="list-style-type: none"> • The LP measures electron density and temperature in the ionosphere, and is crucial for studying the Earth’s magnetic field and space weather, as it provides valuable information on the electromagnetic characteristics of plasma. • The SII measures the ion drift velocity and temperature, providing valuable information on the ion energy and direction-of-arrival, which is also essential for studying the Earth’s magnetic field and space weather. <p>The Echo satellite also represents one of the Canadian contributions to this mission. This satellite came out of the CSA-funded CASSIOPE Enhanced Polar Outflow Probe (e-POP) mission. ESA noted numerous similarities between the e-POP mission and Swarm, and that MDA (the industry lead on this project) had proven capacity in terms of platform design, high capacities like data transfer and altitude control, and working in a complimentary orbit to Swarm. As such, ESA contracted MDA to operate the satellite and deliver scientific data until the end of 2021. ESA provided funding under their Third Party Mission (TPM) Program, which helps to fund national missions after national involvement and funding has been stopped.</p>

Description of SWARM	
	Other industry partners include Magellan Aerospace (Winnipeg, MB), as well as other companies from the U.S. and Japan. By working together, the Swarm mission and e-POP provide data that improve the accuracy of the magnetic field product and the magnetometers' utility for some applications.
Project timelines	<p>The first Swarm proposal was made in 1998, and the mission was selected by ESA for feasibility studies in 2002. The initial mission proposal considered a Swarm constellation of 4 spacecraft. Following two feasibility studies, the Swarm mission was selected as the 5th mission in ESA's Earth Explorer Program in May 2004. Phase A was completed in Nov. 2005, resulting in a constellation of 3 spacecraft. Phase B was completed in summer 2007, and construction of the Swarm constellation commenced in November 2007.</p> <p>The constellation was ready for launch in 2012 but technical problems with the rocket meant that the launch only took place in November 2013. The fourth satellite (Echo) was added to the Swarm constellation in 2013. After a three-month commissioning phase, the constellation entered its four-year nominal mission which ended in February 2018. In November 2017, the ESA Earth Explorer Program Board granted a four-year extension to 2021, and in March 2023, another extension was approved through to 2025.</p>
Recipient information	<p>Tools/equipment/instruments</p> <p>The original three Swarm satellites are equipped with a set of six instruments:</p> <ul style="list-style-type: none"> • <i>Vector Field Magnetometer (VFM)</i>: measures magnetic field vector with high precision and resolution. • <i>Absolute Scalar Magnetometer (ASM)</i>: measures magnetic field strength. • <i>Electric Field Instrument (EFI)</i>: measures the electric field in the atmosphere. • <i>Accelerometer (ACC)</i>: measures non-gravitational forces acting on the satellite. • <i>Star Tracker (STR)</i>: provides information on the satellite's attitude. • <i>Laser Range Reflector (LRR)</i>: used for precise orbit determination. <p>The Echo satellite is equipped with a suite of 8 instruments, including imaging plasma and neutral particle sensors, magnetometers, dual-frequency Global Positioning System (GPS) receivers, charge coupled-device (CCD) cameras, a radio wave receiver and a beacon transmitter.</p>

Description of SWARM	
	<p>People involved</p> <p>There are numerous instruments onboard the constellation, each with a variety of stakeholders involved. The Electric Field Instrument (EFI) is the first space science instrument provided by Canada but funded by ESA. The EFI was developed by a consortium led by COM DEV (now Honeywell) that signed a direct contract with ESA in 2006/2007. Dr. David Knudsen from the University of Calgary has been the lead scientist for the EFI since 2004 and is also the principal investigator for the ePOP Suprathermal Electron Imager. Dr. Knudsen and his team led the operations scheduling and the data processing, and contributed to the organization of an international scientific community to exploit those. Support by the CSA was a strong factor in deciding to award the contract to Canadian scientists and industry. Working under the primary contractor, other Canadian contributions to SWARM over the years include work by the University of Alberta and University of Saskatchewan.</p>
Value of contribution	The initial ESA contract was valued at \$16 million CAD. Additionally, ESA has contributed at least \$5 million more to the project since the contract. The CSA has earmarked over \$2M to support scientific research activities exploiting the EFI data.
Results	<p>To date, Swarm has proven very successful. From an engineering perspective, the instruments designed for the mission have worked well; have provided ongoing, high-level monitoring of both the earth's magnetic field and any associated changes; and have exceeded their lifespan.</p> <p>From a scientific standpoint, Swarm has produced high-quality, easily useable data that has advanced scientific knowledge about geomatics and the space environment. The mission has also provided what ESA calls the "best-ever" survey of the geomagnetic field and its temporal evolution, and has provided new insights into the variability of ionospheric plasma. In addition to providing scientists with a better understanding of how space weather affects Earth, the mission has led to a more comprehensive appreciation of space climate. From an academic standpoint, involvement in this mission have led to numerous scientific outputs, publications, collaborations, post-doctoral fellowships and science studies.</p> <p>Overall, the Swarm mission has been a success due to its groundbreaking research, innovative technology, and potential to revolutionize science. The mission has been extended to 2025, indicating that it has achieved its objectives and is still producing valuable data.</p> <p>Three primary factors have contributed to the success of the mission:</p>

Description of SWARM	
	<ul style="list-style-type: none"> • Since the satellites operate within a constellation, the Earth can be observed at the same time but under different conditions of solar illumination (e.g., sun-side, or in the darkness); • As two of the satellites fly very close together and take very similar measurements, researchers are better able to see small-scale differences between given phenomena; • The quality of the technology used on the satellites far surpasses other existing technologies currently in operation that have similar scientific objectives.
Other outcomes	<p>COM DEV (now Honeywell) benefitted significantly from this mission. The flight heritage provided by this mission led to numerous follow-on contracts. For example, they received a contract with JAXA for a Cloud Profiling Radar (CPR) instrument, and are involved in the EW ALTIUS project to support University of Saskatchewan's participation in the areas of Ozone data processing and the retrieval. The company is also in discussions with NASA to develop an instrument similar to the Thermal Ion Imager developed for Swarm. The sustained work generated by the Swarm mission has allowed COM DEV (now Honeywell) to retain highly qualified scientists and thus develop a deeper technical base within the company than would have otherwise been possible.</p> <p>Dr. Knudsen has become a global spokesperson on ionosphere science, and Canada is recognized internationally as a leader in this field.</p>
Source: Administrative files provided by the CSA, key informant interviews, and web sources.	

Case study – Global Space Markets Challenge

Description of Global Space Markets Challenge	
Project overview	<p>In collaboration with Eurisy, a European non-profit association of over 15 national space agencies and other related organizations, ESA established the Global Space Markets Challenge, which aims to raise the visibility and reach of promising small and medium size enterprises (SMEs) offering products and services in the upstream and downstream space sectors (ESA, 2023f). The competition was created following a survey that identified capacity to access export market as a major barrier to the growth of SMEs in the space domain.</p> <p>As part of the first competition held in 2021, companies were invited by ESA to submit proposals for internationalization/export plans. Proposals were evaluated for the following criteria:</p> <ul style="list-style-type: none"> • Technical merit and credibility of product/service. • Understanding of target markets and potential internationalisation challenges. • Feasibility of implementation plan. • Adequacy and credibility of cost estimations, schedule and planning. • Team (skills, resources, and experience). <p>12 finalists (six upstream and six downstream) were invited to present their proposals to delegates of the Agency’s Industrial Policy Evolution Working Group (IPE-WG) at the International Astronautical Congress (IAC). Six top-placing companies were selected (three upstream and three downstream), and winners were ranked by the ESA Director General. Awards included:</p> <ul style="list-style-type: none"> • Funding to support internationalization plans; • Access to a mentoring program, whereby ESA and the winner work together to address the specific needs of each winner to their internationalisation plans; • Opportunity and funding to attend and present at a prestigious 3rd party event; • Upstream winners were offered a company booth at ESA Industry Space Days to present their company, products and services.

Description of Global Space Markets Challenge	
	<ul style="list-style-type: none"> Downstream winners were offered a Virtual Reality Package, whereby the company could present their brand, products and services as part of a Eurisy video, to be presented online and at international events and fairs.
Project timelines	As part of the 2021 themed competition focusing on export markets, participating SMEs were invited to present their internationalization plan for one of their products or services. The finalists were invited to deliver a presentation at the 72 nd International Astronautical Congress (IAC) held in Dubai. The Canadian company A.U.G. Signals finished third place in the downstream category, and received €5,000 to advance its internationalization plan.
Recipient information	<p><i>People involved</i></p> <p>The competition was launched by ESA in collaboration with Eurisy. It is sponsored and supported by several major European space-focused venture capital funds, including Seraphim Capital and Primo Space (ESA).</p> <p>The Canadian company A.U.G. Signals finished third place in the downstream category of the 2021 competition for their work in crop disease risk assessment and crop monitoring.</p>
Value of contribution	The competition is supported through ESA's general budget.
Results	<p>Results from this competition include:</p> <ul style="list-style-type: none"> The chance to attend and present at the IAC gives companies visibility on an international stage, and the opportunity to connect with worldwide potential partners, customers and investors. This networking can lead to new business opportunities and access to international private markets. Attending the IAC gives companies exposure to world leaders in the industry and their activities and technologies, and insight into what ESA considers to be key technologies. The mentorship programme gives companies the opportunity to leverage ESA's knowledge, global reach, and experience. For example, at the IAC held in Dubai, ESA provided valuable training for marketing space technologies to attendees.

Description of Global Space Markets Challenge	
Other outcomes	<p>Overall, participation in the Global Space Market Challenge supports the growth of the Canadian space industry by providing visibility and support to SMEs, thereby demonstrating Canada's capabilities and expertise in the sector and strengthening Canada's position in the global space market.</p> <p>A.U.G. Signals was provided with an opportunity to network and be introduced to a wide community of space-based companies and capital venture companies (ESA, 2021). Representatives from A.U.G. Signals expressed a deep appreciation for this opportunity to connect with other companies in Europe and found the whole experience very valuable for all the employees involved. They intend to participate in future rounds of this competition.</p>
Source: Administrative files provided by the CSA, key informant interviews, and web sources.	

Case study – NAVISP

Description of NAVISP	
Project overview	<p>ESA's Navigation Innovation and Support Programme (NAVISP) supports the development of new technologies in the area of positioning, navigation and timing (PNT) that go beyond the exclusive use of satellite navigation signals and data (ESA, 2023j). This technology plays a critical role as more advanced automating processes continue to be developed. NAVISP contracts are awarded to organizations that propose innovative concepts, techniques, technologies, and systems related to the PNT sector.</p> <p>The NAVISP programme is structured according to three Elements :</p> <p>Element 1 – Innovation: Aims to develop innovative concepts, techniques, technologies, and systems related to the PNT sector along the entire value chain.</p> <p>Element 2 – Competitiveness: Aims to maintain and improve the capabilities and competitiveness of the participating States' industry in the global market for satellite navigation and PNT technologies and services.</p> <p>Element 3 – Support to Member States: supports national PNT strategies by providing support for the development and promotion of products, applications and services based on global navigation satellite system (GNSS) and, more broadly, PNT systems to foster national and international cooperation.</p>
Recipient information	<p><i>Tools/equipment/instruments</i></p> <p>Various new technologies and systems related to the PNT sector to complement, replace and upgrade current technologies.</p> <p><i>People involved</i></p> <p>With the support of the ESA-CP, the Canadian company RX Networks, an organization specializing in location-based services (LBS) technology, created the High Accuracy Assistance Service (HAAS) technology. The objective of the project is to develop a high-precision, cloud-based corrections service for Global Navigation Satellite System (GNSS) receivers.</p>
Value of contribution	RX Network's HAAS project under NAVISP is estimated at approximately 546,000 euros (\$824,620 CAD).
Project timelines	The project received initial funding in 2018, and additional funding in 2021.

Description of NAVISP	
Results	<p>Results from the project include:</p> <ul style="list-style-type: none"> Enhanced accuracy and reliability of GNSS positioning for various applications, which can lead to improved location accuracy and performance, benefiting users who rely on GNSS for navigation, tracking, and other location-based services. The enabling of applications and services, and the extension of uses, within navigation; for example, turn-by-turn navigation for vehicles, high-value asset tracking, or high accuracy receivers used in agriculture for autonomous tractors and surveys.
Other outcomes	<p>This opportunity has allowed RX Networks, a small SME, to accelerate the development of its high precision solutions, and has led to a number of partnerships with companies based in Europe and other foreign markets, including the collaboration with Qualcomm, announced in October 2022, on the integration of RX Networks' meter-level location accuracy in mobile phones (Rx Networks, 2022).</p>
<p>Source: Administrative files provided by the CSA, key informant interviews, and web sources.</p>	

<https://insidegnss.com/rx-networks-offers-meter-level-location-accuracy-for-mobile-phones-in-collaboration-with-qualcomm-in-china-and-across-the-globe/>

Case study – GTSP ELLA

Description of GTSP ELLA	
Project overview	<p>The General Support Technology Programme (GSTP) is an ESA programme that aims to develop and demonstrate innovative technologies for space applications. The program funds the development of new technologies that can be used in future space missions, as well as the improvement of existing technologies to make them more efficient and cost-effective.</p> <p>Through the GTSP, ESA has provided funding to Umicore, a global materials technology and recycling group with headquarters located in Belgium, for the Epitaxial Layer and Lift-Off Approach (ELLA) project. This projects seeks to enhance the efficiency of space solar cells, including a more efficient use of germanium substrates (semiconductor material), which is expensive and highly-pure, and which current satellite manufacturing processes yield high losses of material. With the support of the ESA-CP, the Université de Sherbrooke has been involved in the development of a weak layer based on porous germanium.</p>
Project timelines	<p>The GSTP was initiated on May 13, 1993, and has supported numerous programs and technologies since. In 2018, the programme introduced de-risk and building blocks frameworks with the objective of maturing future space technologies, and supporting capability building and sustainability across all participating member states. This allowed for the implementation of the ELLA project, which is still in progress.</p>
Recipient information	<p><i>Tools/equipment/instruments</i></p> <p>The key objective of the ELLA project is to develop a germanium substrate that contains a weak layer designed to both allow epitaxial growth as well as lifting-off the eventual epitaxial structures from the mother substrate.</p> <p><i>People involved</i></p> <p>Umicore was contracted to direct the tool design for ELLA. Umicore worked with IMEC, a research and development organization based in Belgium, on Phase 1 of the project. As part of Phase 2 of the project, Umicore reached out to the <i>Institut interdisciplinaire d'innovation technologique</i> (IIIT) of the Université de Sherbrooke to assist with the research and development activities, based on the research that the IIIT had already published. To further their ongoing collaboration, the IIIT and Umicore are planning for the establishment of an industrial research chair at the Université de Sherbrooke.</p>

Description of GTSP ELLA	
Value of contribution	Through the ESA-CP, the Université de Sherbrooke received \$200,000 (CAD) for its involvement in the project.
Results	<p>Expected results of the ELLA technologies include:</p> <ul style="list-style-type: none"> • Allowing solar cell manufacturers to use only as much germanium as is strictly necessary for a functioning solar cell, which would have a significant impact on important satellite metrics, including W/kg, W/m³ and \$/W. • Applications on Earth, including improving the efficiency of solar panels, and providing high efficiency solar cells for power generation on electric cars, unmanned aerial vehicles (UAV), and other consumer applications. • Moving away from wasteful options, and having a significant impact on costs and sustainability.
Other outcomes	<p>For the IIIT at the Université de Sherbrooke, the partnership with Umicore has helped to establish an international reputation in applied research leading to commercial opportunities.</p> <p>The ELLA project is expected to impact the existing space solar cell market, as well as generate opportunities for new markets to materialize.</p> <p>Canada's involvement in the GSTP leads to an increased ability to demonstrate and qualify technologies, facilitates access to European space contracts and international public and private space contracts, and keep abreast of European space technologies and policy direction.</p>
Source: Administrative files provided by the CSA, key informant interviews, and web sources.	

Case study – EO Biomass

Description of EO Biomass	
Project overview	<p>The purpose of the mission is to provide critical data on the state of forests, including how they are changing, their dynamics, and their role in the carbon cycle (ESA, 2023c). The mission will gather data using a P-band synthetic aperture radar (SAR), optimized to map and monitor forest biomass. The SAR antenna is based on a large deployable structure that will allow the satellite to measure the height of trees and determine the amount of biomass and carbon stored in the world's forests with unprecedented accuracy. With accurate, frequent and global information on these forest properties, it will be possible to address a range of critical issues with far-reaching scientific and societal consequences.</p> <p>The Biomass mission is part of ESA's Living Planet Programme, which consists of Earth observation missions. This will be the first-ever P-band SAR to be launched, and the first-ever P-band SAR transponder.</p>
Project timelines	<p>In May 2013, Biomass was selected as ESA's 7th Earth Explorer mission. In May 2016, ESA signed a contract with Airbus Defence and Space UK to build the Biomass satellite. In 2017, it was established that the Biomass mission will explore Earth's surface for the first time at the P-band wavelength. The Biomass launch was initially set for 2020, but is now expected to take place around April 2024.</p>
Recipient information	<p><i>Tools/equipment/instruments</i></p> <p>The main scientific instrument aboard the Biomass satellite is a P-band SAR operating at 435 MHz. It is equipped with full polarimetric and interferometric capabilities, meaning it can capture information about the polarization and phase of the radar signal, allowing for more detailed analysis of the target area.</p> <p><i>People involved</i></p> <p>Airbus Defence and Space UK is the prime contractor for the Biomass mission, responsible for designing, developing and building the satellite, as well as integrating the SAR into the satellite.</p> <p>Canada has contributed to the Biomass mission in several ways. With the support of the ESA-CP, Airbus contracted C-Core for the design, development, production, delivery and installation of a calibration transponder, which is a device that receives and transmits radio signals at a prearranged frequency range. MDA was also contracted by Airbus to provide the communication antennas for the satellite. Canadian scientists are</p>

Description of EO Biomass	
	also involved in the research of the mission, including researchers from the University of British Columbia who are developing algorithms to analyze satellite data.
Value of contribution	The Biomass mission is valued at over 420 million euros, or over \$600 million (CAD). The contract signed by Airbus is valued at 229 million euros, or \$333 million (CAD).
Results	<p>The Biomass mission has many expected results, including:</p> <ul style="list-style-type: none"> • Providing accurate maps of forest biomass, which will provide a better understanding of the distribution of forest biomass and improved calculations of carbon stock and fluxes associated with the terrestrial biosphere. • Improving knowledge of carbon stored in forests and the planet's carbon cycle, which will support management of forest resources, provide valuable scientific data, and contribute to international agreements and programs to reduce emissions from deforestation and forest degradation.
Other outcomes	<p>This project has provided C-Core with an opportunity to showcase its capabilities in building algorithms and onboard processing systems.</p> <p>Canadian involvement in the Biomass mission has also provided an exceptional opportunity to forward collaborative research and development on space weather prediction and the prediction of radiation effects on navigation in the Arctic.</p>
Source: Administrative files provided by the CSA, key informant interviews, and web sources.	

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