Canadian Space Agency

2019–20

Departmental Plan

Supplementary Information Tables

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Canadian Space Agency

2019–20 Departmental Sustainable Development Strategy

1. Context for the Departmental Sustainable Development Strategy

Although the Canadian Space Agency is not bound by the *Federal Sustainable Development Act* and is not required to develop a full departmental sustainable development strategy, the Canadian Space Agency adheres to the principles of the Federal Sustainable Development Strategy (FSDS) by implementing the *Policy on Green Procurement*.

The *Policy on Green Procurement* supports the Government of Canada's effort to promote environmental stewardship. In keeping with the objectives of the policy, the Canadian Space Agency supports sustainable development by integrating environmental performance considerations into the procurement decision-making process through the actions described in the "FSDS goal: low-carbon government" table in section 2.

2. Commitments for the Canadian Space Agency

FSDS goal: low-carbon government

FSDS target	FSDS contributing action	Corresponding departmental action(s)	Support for UN Sustainable Development Goal target	Starting point(s), target(s) and performance indicator(s) for departmental actions	Link to the department's Program Inventory
Reduce greenhouse gas (GHG) emissions from federal government buildings and fleets by 40% below 2005 levels by 2030, with an aspiration to achieve it by 2025.	Support the transition to a low-carbon economy through green procurement.	1- Implement a directive to respond to the policy for green procurement 2- Draw a portrait of goods and services purchased by the Agency 3- Identify and evaluate the potential of responsible modes of supply 4- Establish environmental/social criteria in supplies	Goal 8: Decent work and economic growth Goal 12: Responsible consumption and production	Starting point (baseline): To be determined Action to take: —Calculate the quantity and gain knowledge on the kinds of goods and services purchased by the CSA Target: To be determined Performance indicator: To be determined	Internal services

3. Integrating sustainable development

The department is planning to further integrate sustainable development into its internal policy and operational processes by:

1. In the Greening Government Strategy context:
    - In order to meet the Greening Government Strategy objectives, the Canadian Space Agency will implement a multi-year action plan that will integrate sustainable development into its activities, operations and processes, as well as into its internal policies.
2. For the purchase of a new hybrid or electric vehicle:
    - In order to find the most cost-effective and environmentally optimal choice, a cost-benefit study will be carried out taking into account the CSA's vehicle usage data, operational needs and the Greening Government Strategy objectives. The main goal is to reduce the CSA's greenhouse gas emissions.
3. A communication plan is currently being drafted to support the Greening Government Strategy implementation. Communications activities will start in the 2019–20 fiscal year.

The Canadian Space Agency will continue to ensure that its decision-making process includes consideration of FSDS goals and targets through its Strategic Environmental Assessment (SEA) process. A SEA for policy, plan or program proposals includes an analysis of the impacts of the given proposal on the environment, including on FSDS goals and targets.

Details on transfer payment programs of $5 million or more

Name of transfer payment program	Contributions under the Canada/European Space Agency (ESA) Cooperation Agreement.
Start date	The renewed Agreement was signed in February 2019. The ratification of the Agreement and the approval of the revised Terms and Conditions will occur in 2019–20.
End date	January 1, 2030 (end date of the Agreement).
Type of transfer payment	Contribution
Type of appropriation	Annually through Estimates.
Fiscal year for terms and conditions	The revised Terms and Conditions for the contributions, under the 2019–29 Cooperation Agreement, will be submitted for approval in 2019–20.
Link to department's Program Inventory	Space Capacity Development
Description	Enhance Canadian industry's technological base and provide access to European markets for value-added products and services in the fields of Earth observation (EO), telecommunications, navigation, space exploration and generic technological activities; foster the participation of Canadian academia and make possible the demonstration of Canadian space technologies in European microgravity and space exploration missions and programs. This is achieved through a financial contribution by the CSA to ESA optional programs.

Expected results	Result: Opportunities to advance science and technology. Performance Indicator: Canadian industrial return coefficient (Ratio between the actual value of contracts awarded by ESA to Canadian organizations and the ideal value of contracts awarded by ESA to Canadian organizations). Result: Space science and technology readiness is advanced. Performance Indicator: Number of scientific activities and technologies that have advanced their readiness
Fiscal year of last completed evaluation	2018–19
Decision following the results of last evaluation	The CSA is preparing for the ESA Ministerial Council 2019: findings of the 2018 Program evaluation will be taken into considerations during that process.
Fiscal year of planned completion of next evaluation	2021–22
General targeted recipient groups	Canadian space sector firms, universities and not-for-profit research organizations.
Initiatives to engage applicants and recipients	The CSA will continue to actively consult the Canadian space sector (industry and academia) and Government of Canada organizations as part of the program selection process. More specifically, this will be done for the preparation of Canada’s participation to ESA’s 2019 Ministerial Council.

Planning Information (dollars)

Type of transfer payment	2018–19 Forecast spending	2019–20 Planned spending	2020–21 Planned spending	2021–22 Planned spending
Total contributions	28,574,435	32,123,000	32,185,000	31,833,000
Total program	**28,574,435**	**32,123,000**	**32,185,000**	**31,833,000**

Name of transfer payment program	Class Grant and Contribution Program to Support Research, Awareness and Learning in Space Science and Technology
Start date	October 1, 2009
End date	N/A — Ongoing program
Type of transfer payment	Grant and Contribution
Type of appropriation	Annually through Estimates
Fiscal year for terms and conditions	2009–10
Link to department's Program Inventory	Space Utilization Space Exploration Space Capacity Development Internal Services (Communications Services, Management and Oversight Services)
Description	This program supports knowledge development and innovation in the CSA's priority areas while increasing the awareness and participation of Canadians in space-related disciplines and activities. The program has two components: a) Research and b) Awareness and Learning. The Research Component aims to support the development of science and technology; foster the continual development of a critical mass of researchers and highly qualified people in Canada; and support information gathering and space-related studies and research pertaining to Canadian Space Agency priorities. The Awareness and Learning Component aims to provide learning opportunities to Canadian students in various space-related disciplines; to support the operations of organizations dedicated to space research and education; and to increase awareness of

	Canadian space science and technology among Canadian students and their participation in related activities. This Transfer Payment Program is composed of grants and non-repayable contributions.
Expected results	**Research Component** Result #1: Increased knowledge from research projects in priority space S&T areas. Performance Indicator: Number of new and ongoing space science and technology initiatives (Announcement of Opportunity) and projects. Performance Indicator: Number of completed space science and technology initiatives (Announcement of Opportunity) and projects. Performance Indicator: Number of highly qualified personnel involved in space science and technology initiatives and projects. Result #2: Maintained and/or increased space focus in universities, post-secondary institutions, and not-for-profit and for-profit organizations. Performance Indicator: Number of universities, post-secondary institutions and not-for-profit and for-profit organizations involved in financed projects. Result #3: Partnerships established and/or sustained. Performance Indicator: Number and type of new partnerships created and sustained. Performance Indicator: Number of research partnerships (national and international). Result #4: Partners' contributions leveraged. Performance Indicator: Number of agreements leveraged funding.

	Performance Indicator: Proportion of leveraged funds vs. grant/contribution funds. Result #5: Access to international collaboration for Canadian organizations. Performance Indicator: Number of agreements leveraged by international funding. **Awareness and Learning Component** Result #6: Increased knowledge and skills in space-related disciplines among target audience Performance Indicator: Number and type of learning events attended Result #7: Target audience reached through learning activities and materials related to science and technology Performance Indicator: Number of persons reached by audience segments
Fiscal year of last completed evaluation	2016–17
Decision following the results of last evaluation	• Continuation
Fiscal year of planned completion of next evaluation	2020–21

General targeted recipient groups	▸ Industry-related (for example, for-profit businesses) ▸ International organizations (for example, non-profit international organizations) ▸ Persons (for example, students) ▸ Non-profit organizations (for example, universities, research institutions)
Initiatives to engage applicants and recipients	Since January 2012, an initiative to engage recipients has been undertaken through an automated annual follow-up of projects. The CSA has extended this initiative via its web page in order to establish a dialogue with potential applicants and recipients. Consultations, presentations to, and discussions with, the academic and industrial communities as well with other potential recipient groups, are ongoing and will continue.

Planning Information (dollars)

Type of transfer payment	2018–19 Forecast spending	2019–20 Planned spending	2020–21 Planned spending	2021–22 Planned spending
Total grants	10,518,216	10,003,000	8,525,000	9,386,000
Total contributions	15,904,117	16,570,000	16,839,000	16,848,000
Total program	**26,422,333**	**26,573,000**	**25,364,000**	**26,234,000**

Gender-based analysis plus

Governance structures	Since 2017, Gender-Based Analysis plus (GBA+) is integrated in the requirements of the Investment Governance and Monitoring Framework and is part of the roles and responsibilities of the executive sponsor. A policy has been implemented to state the roles and responsibilities of CSA personnel and stipulates that all initiatives that are new or which need re-approval will be subject to a GBA+. More specifically, the policy requires that: • All CSA initiatives (e.g. policies, programs, projects, grants and contributions, budget proposals) that are new or which need re-approval will be subject to GBA+ to ensure they do not have detrimental impacts on certain diverse groups of women and men and that they seek to achieve better results for all Canadians. • Documented evidence of the elaboration of GBA+ is required to support approval of initiatives for Treasury Board (TB) Submissions and Memorandum to Cabinet (MC). • The documented evidence of the elaboration of GBA+ will be collected in order to monitor the implementation and continuous improvement of the GBA+ processes at CSA, and for reporting to Status of Women Canada (SWC) on a regular basis. The President is responsible for ensuring that the Government of Canada's commitment to implementing GBA+ is fulfilled at the CSA as per the aforementioned policy requirements. The Executive Committee Members are responsible for: • Ensuring that gender and other identity factor considerations are identified and that inequalities are corrected within the context of their respective program's activities, from policy and program development to service delivery, including in MC and TB Submissions.

	• Supporting and encouraging GBA+ training opportunities for their employees. • Appointing one of their members as the GBA+ Champion that will be the functional authority for GBA+ at the CSA. • Appointing a GBA+ Point of contact for each branch of the CSA. The executives and managers are responsible for: • Applying GBA+, and for integrating the results thereof, to the decision-making process within their sector. • Supporting their employees who are engaged in applying GBA+ to the initiatives under their responsibilities, from concept to implementation to operations as applicable, and for supporting related adjustments that might be required in this regard. • Providing training opportunities in GBA+ for their employees.
Human resources	One Champion, member of the Executive Committee spending a portion of her time on GBA+ 13 CSA representatives called “GBA+ point of contact” spending a portion of their time on GBA+
Planned initiatives	Tools and guides were developed and kept up to date in order to implement the GBA+ framework and monitor and report on its effectiveness: • Guide to implementing GBA+ at the CSA; • A GBA+ questionnaire, applicable at different phases of the life of a CSA initiative, from initiation to development, implementation and monitoring to examine the impacts of an initiative on diverse groups of women and men, taking into account gender and other identity factors;

	• Case studies based on various work environments (developed by other departments or internally); • An evolving database of aggregated and disaggregated data about gender and other intersecting identity factors pertinent to CSA initiatives will be established and maintained by the sectors and monitored by the GBA+ Responsibility Centre; this database will progress with each CSA initiative which is subject to a GBA+, and will also benefit from exchanges of related information with other departments and agencies; • Internal and external information (a dedicated section on GBA+ on the CSA Intranet; informative capsules on GBA+ on corporate screens; link to Status of Women Canada GBA+ GCpedia Website; link to Gender-Based Analysis/Action Plan; link to GBA+ Community of Practice). A GBA+ component has been included in the two program evaluations planned in 2019–20, i.e. the Evaluation of Human Space Exploration Program and the Evaluation of the Space Capacity Development Program.

Status report on transformational and major Crown projects

Project name	RADARSAT Constellation Mission (RCM)
Description	The RADARSAT Constellation Mission (RCM) is the next generation of Canadian Earth observation (EO) radar satellites. RADARSAT-1 was launched in 1995 and continued its operation until March 2013. RADARSAT-2, developed by the private sector in partnership with the Government of Canada (GoC), was launched in 2007 for a seven-year mission, but given its current performance, it is expected to remain operational for several more years. Canada has established itself as a leading global supplier of C-band satellite radar data for EO. The successor mission to RADARSAT-2, the RCM will contribute to maintaining the leadership position of Canadian industry in space radar technology and value-added product markets. The RCM is comprised of three identical satellites equipped with two payloads: a powerful Synthetic Aperture Radar (SAR) and an Automatic Identification System (AIS). The launch of the RCM is planned for 2019. The three-satellite configuration will provide on average daily coverage of Canada's maritime approaches and frequent coverage of Canada's land, as well as the capability to observe a specific point over 90% of the world's surface. It will also provide a four-day exact revisit, allowing coherent change detection using an InSAR mode (as opposed to 24 days with previous RADARSAT missions). The creation of a three-satellite constellation increases the frequency of available information, as well as the reliability of the system, making it better suited to respond to the needs of a large variety of users that develop services and information products. The scope of the RCM Major Crown Project includes the requirement definition, design, development, manufacturing, integration, testing and launch of the satellites as well as the design, development, manufacturing and installation of the associated ground segment. One

	year of operation of the three-satellite constellation is also included as well as an application development program. The RCM will provide reliable data in all weather and illumination conditions in support of federal departments' operations and mandates in areas such as maritime surveillance, disaster management, environmental monitoring and natural resource management. The constellation will have the ability to cover the North Pole region up to four times a day. In support of the maritime surveillance requirements of federal departments, the RCM is the principal data source envisaged for wide-area surveillance of Canada's remote areas and marine approaches. The daily coverage of marine areas will also support fisheries monitoring, ice and icebergs monitoring, pollution monitoring, and integrated ocean and coastal zone management. The RCM's maritime surveillance capabilities also support Canadian sovereignty and security. Only satellite data can offer regular cost-effective information to task ships and aircrafts with intercepting suspicious vessels. The RCM's maritime surveillance capabilities also support Canadian sovereignty and security. The RCM satellites will be able to capture ship-originated Automatic Identification System (AIS) signals from space. The combination of space-based radar images and AIS signals will provide a powerful surveillance capacity over Canada's maritime approaches and elsewhere in the world. In support of disaster management, both in Canada and around the world, the RCM will provide critical and timely data to support disaster mitigation, warning, and response and recovery activities, while helping Canada meet its obligations with respect to international disaster relief. The types of disasters for which RCM data will be used for monitoring and relief purposes include floods, oil spills, volcanic eruptions, earthquakes and hurricanes. RCM data will also contribute to the production of more accurate weather forecasts and warnings pertaining to marine conditions, winds, severe storms and floods. In support of environmental monitoring, the RCM will provide data for wide-area change detection in order to provide support for activities

	such as water management, wetlands mapping, coastal change monitoring and changes in the permafrost in northern Canada. In support of natural resource management, RCM data will be a critical source of information to monitor the changing state of Canada's agricultural areas, forests and wildlife habitats. RCM data will also be used in the mining and energy sectors for resource exploration operations to ensure that critical infrastructure is monitored properly for safety and integrity. In addition, the RCM will sustain the development of Canadian high-technology design and manufacturing capabilities and the integration of satellite data into information products and services. Canada's space and geomatics industries will benefit from better positioning in international markets and privileged access to data deemed essential by many international users.
Project outcomes	This Major Crown Project (MCP) contributes to the Space Utilization program, which includes the provision of space-based solutions and the progression of their utilization. It also serves to install and run ground infrastructure that operates satellites, receives, processes and distributes the data This Program utilizes space-based solutions to assist Government of Canada (GoC) organizations in delivering growing, diversified and cost-effective programs and services within the purview of their respective mandates, each related to key national priorities such as sovereignty, defence, safety and security, resource management, environmental monitoring and the North. It also provides academia with data required to perform its own research. The contribution of the MCP to the program objectives is measured through the Performance Information Profile results and indicators.
Industrial benefits	The RCM is expected to generate significant industrial benefits in the space and Earth Observation sectors, such as employment, innovation, economic growth, competitiveness and improved productivity. Investments in the RCM also support the growth of small and medium-sized companies as well as Canadian capabilities in terms of infrastructure and services.

	The prime contract includes a requirement for 70% Canadian content, excluding launch services and subsystems for which there are no suppliers available in Canada. As of March 31, 2018, this corresponds to a Canadian content requirement of $498.8 million. For the same period, the CSA provided the Canadian industry with funding of more than $593.8 million to carry out work resulting directly from the design of the RCM MCP, thus surpassing the requirement. The prime contract also requires that 3.5% of the 70% Canadian content be subcontracted in the Atlantic Canada region. For the same period, the actual Atlantic Canada content was $24.7 million, considerably higher than the requirement of $17.5 million. The prime contract includes reporting obligations and performance measurements as well as financial penalties for not meeting the minimum Atlantic Canada content requirement.
Sponsoring department	Canadian Space Agency (CSA)
Contracting authority	Public Services and Procurement Canada (PSPC)
Participating departments	Agriculture and Agri-Food Canada Canadian Coast Guard Environment and Climate Change Canada Fisheries and Oceans Canada Global Affairs Canada Indigenous and Northern Affairs Canada Innovation, Science and Economic Development Canada National Defence and the Canadian Armed Forces Natural Resources Canada Parks Canada Public Safety Canada

	Royal Canadian Mounted Police Statistics Canada Transport Canada
Prime contractor	MDA Systems Ltd. (a division of MacDonald, Dettwiler and Associates), Richmond, British Columbia
Major subcontractors	Tier 1 Major Subcontractors: - MDA Montreal, Ste-Anne-de-Bellevue, Quebec - Magellan Aerospace, Winnipeg, Manitoba - MDA, Halifax, Nova Scotia - SpaceX, Hawthorne, California, USA - Airbus Defence and Space, United Kingdom - Honeywell Aerospace, United Kingdom Tier 2 and Tier 3 Canadian Subcontractors: - Stelia Aerospace North America, Lunenburg, Nova Scotia - IMP Group, Halifax, Nova Scotia - DRS, Ottawa, Ontario - Mecachrome, Mirabel, Quebec - Maya, Montreal, Quebec
Project phase	Phase D—Implementation

Major milestones	Phase A: Requirement Definition (March 2008) Phase B: Preliminary Design (March 2010) Phase C: Detailed Design Review (November 2012) Phase D: Launch satellite #1, #2, and #3 (2019) Phase E1: Operations (part of MCP) (2020) Phase E2: Operations (not part of MCP) (2026)
Progress report and explanation of variances	On December 13, 2004, the Domestic Affairs Committee of Cabinet granted approval-in-principle to a 10-year program to implement a RADARSAT Constellation Mission (RCM) aimed at addressing the operational needs of users from the public and private sectors in relation to Canadian sovereignty and marine surveillance, environmental monitoring and change detection, and disaster management. The RCM would be government owned and operated. On June 6, 2005, Treasury Board granted Preliminary Project Approval (PPA) for the RCM and expenditure authority for the Project Initial Planning and Identification (i.e. Phase A). During Phase A, feasibility studies were completed, user requirements were defined, and risk mitigation activities and options analysis for the bus and payload were carried out. The initial scope of work for Phase A was completed in December 2006. Phase A was then extended to allow additional technical risk reduction activities to continue during the period prior to the Phase B contract award. This was completed in March 2008. In March 2007, Treasury Board approved a revised Preliminary Project Submission to proceed to Phases B and C. Following a competitive Request for Proposal (RFP) process, Public Services and Procurement Canada (PSPC) obtained authority to enter into negotiations with MDA, the prime contractor, and awarded the contract for Phase B in November 2008. The Preliminary Design (i.e. Phase B) was completed in March 2010. The contract for Phase B was subsequently amended to include the detailed design (i.e. Phase C). A second revised PPA was approved by Treasury Board in December 2010. The purpose of this revised PPA was to provide additional

	expenditure authority to include the procurement of long-lead items during Phase C and also to include a technology demonstration for Automatic Identification System (AIS) payloads, funded by the Department of National Defence. The final review of the overall mission-level system detailed design, the Mission Critical Design Review (CDR), was conducted in November 2012. A selected set of activities, such as completing the design qualification activities and the procurement of long-lead items, were pursued under Phase C and were completed in March 2015. These selected activities were scheduled to be completed in March 2014 but were delayed due to technical difficulties encountered during the building of the qualification models. The delay has no impact on the project. Treasury Board granted Effective Project Approval for the RCM in December 2012, which provides expenditure and contracting authorities to complete the project and carry out the first year of RCM operations (Phases D and E1). The contract was awarded on January 9, 2013. Since the contract award, planning activities have been completed and major milestones achieved to initiate the implementation phase of the satellites and associated ground systems. In 2013, a Deputy Ministers' Governance Committee on Space (DMGCS) was established to provide oversight, coordination and accountability on the RCM MCP. The DMGCS reports to the Minister of Innovation, Science and Economic Development and provides strategic direction while making timely decisions to address issues and risks that could affect the success of the MCP. In 2016–17. Assembly, integration and testing of the last of the three synthetic aperture radar (SAR) and automatic identification system (AIS) payloads were completed, and the payloads were delivered. Challenges in completing the flight software were addressed. Assembly and integration of the first satellite were completed, and its testing was well underway. Significant progress continued to be achieved in the manufacturing of the RCM satellites throughout 2017–18. The third satellite bus was

	delivered, and the assembly, integration and testing of all three satellites is now well underway. The remaining five ground segment subsystems were completed. Upgrades to CSA headquarters in Saint-Hubert to accommodate the RCM ground segment subsystems were also completed in 2017–18, and mission control centre is ready to receive the ground segment subsystems when they are delivered in the latter part of 2017–18. The entire remaining infrastructure to be supplied by the Government of Canada is also expected to be completed and fully integrated and tested with the ground segment subsystems by the end of 2017–18. In 2018–19, the assembly, integration and testing of the three satellites were completed; the satellites were transported to a location near the launch site in California for storage until the start of the launch campaign; the training of the operations personnel was completed; and in the latter part of 2018–19, the full-up rehearsals will be completed in preparation for the launch of the three satellites, currently planned for the spring of 2019. The launch date was first delayed from the fall of 2018 to the winter of 2019 due to delays in the launch service provider's launch schedule and subsequently to the spring of 2019 due to a mishap with the recovery of the Falcon 9 launch vehicle first stage that was assigned to the launch of the RCM. The launch into orbit of the three spacecraft is scheduled to take place in the early part of 2019–20. Once on orbit, the three satellites will be fully tested and commissioned, nominally three to six months following the launch. Following the commissioning, the system will begin routine operations and provide SAR data to users. The RCM Major Crown Project also includes the first year of operations, until the summer/fall of 2020. The project will be completed and closed following this initial period of routine operations.

Project name	James Webb Space Telescope
Description	The James Webb Space Telescope is a joint international mission involving National Aeronautics and Space Administration (NASA), the European Space Agency (ESA) and the Canadian Space Agency (CSA). The mission concept is for a large field-aperture telescope to be located 1.5 million km from Earth. Like Hubble, the James Webb Space Telescope will be used by the astronomy community to observe targets ranging from objects within our solar system to the most remote galaxies which can be seen during their formation in the early universe. The science mission is centred on the quest to understand our origins: • Observing the very first generation of stars to illuminate the dark universe when it was less than one billion years old; • Understanding the physical processes that have controlled the evolution of galaxies over cosmic time and, in particular, identifying the processes that led to the assembly of galaxies within the first four billion years after the Big Bang; • Understanding the physical processes that control the formation and early evolution of stars in our own and other nearby galaxies; and • Studying the formation and early evolution of proto-planetary disks, and characterizing the atmospheres of isolated planetary mass objects. The James Webb Space Telescope is scheduled for launch in 2021. James Webb instruments will be designed to work primarily in the infrared range of the electromagnetic spectrum, with some capability in the visible range. The James Webb Space Telescope will have a large mirror, 6.5 metres in diameter and a sun shield that will be the size of a tennis court once deployed in outer space. Canada is providing the Fine Guidance Sensor (FGS) and the Near-Infra-Red Imager and Slitless Spectrometer (NIRISS). The FGS is

	integral to the attitude control system of the James Webb Space Telescope, and consists of two fully redundant cameras that will report precise pointing information. Canadian expertise in this area was established previously with the successful fine error sensors for the former Far Ultraviolet Spectroscopic Explorer (FUSE) mission. Packaged with the FGS but functionally independent, the NIRISS covers the 0.7 to 5 micrometer spectral range. NIRISS provides a specialized capability for surveys of objects such as primeval galaxies, for the study of transiting planetary systems and for high-contrast imaging applications such as the detection of extrasolar planets. With COM DEV Canada as the prime contractor, the James Webb Space Telescope-FGS Major Crown Project consists of the design, development, testing and integration into the spacecraft, launching and commissioning of the FGS and NIRISS. By participating in this leading-edge international space exploration mission, the CSA is actively promoting Canadian scientific expertise and innovative, advanced space technologies. The National Research Council's Herzberg Astronomy and Astrophysics (NRC Herzberg) is a key Government of Canada (GoC) partner for activities related to the development of science instruments and distribution of telescope data. In return for its overall investment in the James Webb Space Telescope, Canada will obtain a minimum of 5% of the time on this unique space telescope. Already, the news of Canada's involvement in this international space exploration mission is inspiring youth, educators and amateur astronomers, and rallying members of Canada's world-renowned astrophysics community.
Project outcomes	This Major Crown Project (MCP) contributes to Space Exploration program which provides valuable Canadian science, signature technologies and qualified astronauts to international space exploration endeavours. It fosters the generation of knowledge as well as technological spin-offs that contribute to a higher quality of life for Canadians. This Program appeals to the science and technology communities. It is targeted mostly towards Canadian academia and

	international space exploration partnerships. Canadian industry also benefits from the work generated within this Program. The contribution of the MCP to the program objectives is measured through the Performance Information Profile results and indicators.
Industrial benefits	Most of the direct industrial benefits from the construction of the Webb-FGS and NIRISS system will accrue to Ontario.
Sponsoring department	Canadian Space Agency (CSA)
Contracting authority	Public Services and Procurement Canada (PSPC)
Participating departments	NRC Herzberg Astronomy and Astrophysics Innovation, Science and Economic Development (ISED)
Prime contractor	—Honeywell Aerospace, Ottawa, Ontario
Major subcontractors	—Teledyne, USA —Corning Netoptix, USA —IMP Aerospace Avionics, Canada —ABB Bomem, Canada —MDA, Canada —INO, Canada —BMV, Canada —CDA Intercorp, USA —ESTL, Europe —Bach Research Corporation, USA —Materion, USA —Camcor, Canada

Project phase	Pase D—Implementation
Major milestones	Phase A: Requirement Definition (2004) Phase B: Preliminary Design (May 2005) Phase C: Detailed Design (September 2008) Phase D: Manufacturing/Assembly, Integration/Testing, Pre-launch preparations, Launch/System Commissioning (2021) Phase E: Operations (part of MCP) (2024)
Progress report and explanation of variances	In March 2004, Treasury Board granted Preliminary Project Approval for Phases B, C and D. In December 2006, before the completion of Phase C, detailed design of the FGS, the CSA requested increased expenditure authority to complete the project. In February 2007, the Treasury Board granted Effective Project Approval (EPA) and the project became a Major Crown Project (MCP). In March 2007, the first Critical Design Review (CDR) for the guidance function of the FGS revealed technical issues. During the preparation of the system-level CDR, new issues became apparent. The technical issues needed to be addressed. In December 2007, Treasury Board granted a revised EPA after project costs had raised significantly due to technical issues by the end of Phase C, the detailed design phase. In 2010, NASA discovered that the infrared detectors, extremely sensitive cameras capable of “seeing” light produced by heat, were showing signs of performance degradation due to a design fault. Following investigation, NASA concluded that all detectors, including the four procured by Canada, needed to be replaced. In effect, two years after their acceptance by the project, the detectors started to show the same degradation. NASA initiated an improvement project

	with Teledyne Scientific & Imaging LLC to address the design issue causing the degradation. In 2011–12, work continued on hardware and software development. The Proto Flight Model (PFM) successfully completed a very stringent environmental test campaign during which the instrument was subjected to cryogenic temperatures over a period of 80 continuous days. Teledyne Scientific & Imaging LLC completed the detector design improvements and, pursuant to testing successfully addressed the degradation issues. NASA then initiated the procurement process for new detectors for the James Webb Space Telescope Mission; the acquisition of the detectors for the FGS/NIRISS was under the responsibility of the CSA. The FGS Engineering Test Unit (ETU) was integrated into the NASA Goddard Space Flight Center (GSFC) test set-up and underwent system-level testing with the other science instrument engineering units. The integration test onto the Integrated Science Instrument Module (ISIM) of the James Webb Space Telescope was successfully conducted. A technical issue surfaced with a component, the Tunable Filter Instrument (TFI), which triggered the need for a change in the design approach and led to the design and development of the Near-Infrared Imager and Slitless Spectrograph (NIRISS). This new instrument relied on existing components of the old TFI but used a different approach to cover the light spectrum required for the science mission. On July 30, 2012, the PFM FGS/NIRISS was delivered to NASA GSFC. On November 15, 2012, the PFM FGS/NIRISS was officially accepted by NASA following the successful completion of post-delivery functional tests. The FGS/NIRISS was the first instrument officially accepted by NASA as part of the James Webb Space Telescope project. As to the procurement of the four new detectors for FGS/NIRISS, the CSA and NASA agreed on cost sharing: NASA would manage the procurement with Teledyne Scientific & Imaging LLC until the detectors

	are completed at which point they would be procured off-the-shelf by the CSA (through PWGSC). In August 2013, NASA initiated a cryogenic test campaign with the Integrated Science Instrument Module (ISIM). The test was completed in November 2013, and the FGS/NIRISS performed as expected. The second cryogenic test campaign was conducted in 2014–15 as the integration and test activities at NASA with ISIM continued. As well, in 2014, the FGS/NIRISS detectors were replaced after the completion of the second cryogenic test campaign. In January 2016, NASA completed the third and final cryogenic test campaign of ISIM at NASA's GSFC. During this test campaign, the FGS/NIRISS performed as expected, thus successfully closing the final performance verification of Canada's contribution to the James Webb Space Telescope. In March 2016, NASA entered the next level of spacecraft integration and testing with the joining of ISIM and the Optical Telescope Element to form the OTIS (Optical Telescope element and Integrated Science instrument module). Starting in late 2016, OTIS underwent a series of rigorous environmental testing, comprised of ambient functional, vibration and acoustic testing, at NASA's Goddard Space Flight Center in Maryland. These tests were successfully concluded in March 2017, and OTIS was then shipped to NASA's Johnson Space Center (JSC) for its last cryogenic test before launch. In July 2017, OTIS was moved inside JSC's Thermal Vacuum Chamber A and began a nearly 100-day cryogenic test designed to ensure that the telescope functions as expected in a cold, vacuum environment similar to space. The test was successfully completed in the fall of 2017, with the FGS/NIRISS performing as expected. In the winter of 2018, OTIS has been delivered to Northrop Grumman (NASA's prime contractor for the Webb) for integration with the Spacecraft and the Sunshield and the last environmental tests prior to launch.

	Schedule The launch date for the James Webb Space Telescope is currently planned for 2021. In 2007, when the project obtained Treasury Board approval for the revised EPA, the anticipated mission launch date was May 2013. Following a replanning exercise conducted by NASA, the launch date was slipped to October 2018, extending the project life by 5.5 years. There was an associated cost increase in the mission's integration and test phase, due to NASA having originally underestimated the work needed for this phase. Ultimately this remaining scope of work and the extension of the mission schedule resulted in cost increases that could not be absorbed by the 2007 project authorities. As well, PWGSC needed contractual authorities for acquiring the new detectors under a sole-source contract with a US supplier. As a result, the CSA prepared a new submission to Treasury Board addressing the issues above. The submission was approved in February 2014. Treasury Board granted a revised EPA of $169.9 million (excluding taxes). Then, on September 28, 2017, NASA announced that the launch will be delayed to the spring of 2019. This schedule change was the result of an analysis which took into account the remaining tasks that needed to be completed; the lessons learned from unique environmental testing of the telescope and science instruments at NASA's Goddard Space Flight Center in Greenbelt, Maryland; and the current performance rates of integrating the spacecraft element. On March 27, 2018, after an independent review of the remaining integration and test tasks, NASA announced a revised launch window targeted to approximately May 2020 and established an Independent Review Board mandated to provide an assessment to the US Congress. Following the Independent Review Board report released in June 2018, NASA delayed the launch date to March 30, 2021.

	The work remaining to be completed for this project is as follows: Although the flight instrument was delivered in 2012, the project is still in the implementation phase where the CSA and its prime contractor must provide direct support for the integration of the FGS/NIRISS with the spacecraft element, for the launch activities and for the spacecraft commissioning activities until late 2021. Specifically, in fall of 2019, OTIS will be integrated with the spacecraft element, which is the combined sunshield and spacecraft bus. Together, the pieces form the complete James Webb Space Telescope observatory. Once fully integrated, the entire observatory will undergo more tests during what is called “observatory-level testing”. This testing is the last exposure to a simulated launch environment before flight and deployment testing on the whole observatory. These tests are planned to be completed in 2020, leading to launch in the spring of 2021. Official mission operations will commence after the completion of the telescope’s commissioning, six months after its launch. The James Webb Space Telescope operations centre will be located in the Space Telescope Institute in Baltimore, Maryland, in the United States. Canadian scientists will be on location to directly support the operations of the FGS and NIRISS throughout the mission’s operations. The operations will also be supported by engineering staff in order to be able to address technical issues if and when they occur to ensure the functionality of Canada’s instruments.