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**Committee on the Peaceful
Uses of Outer Space**
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International cooperation in the peaceful uses of outer space

Submission by Canada


2014 marked the 25th anniversary of the creation of the Canadian Space Agency (CSA), the government organization responsible for coordination of the country's space activities. Some highlights from Canada's year in space include the announcement of Canada's Space Policy Framework in February 2014 followed by significant steps to strengthen the governance of the national space programme; contributions to a number of international space-related activities, missions and conferences; continued development of the RADARSAT Constellation Mission (RCM); and ongoing support to the operations in the International Space Station (ISS).

National space policy and governance

Canada's Space Policy Framework provides a guide for Canada's strategic activities and future in space. The policy framework is based on five main principles: (1) Canada First: sovereignty, security and prosperity will be at the heart of Canada's activities in space; (2) Using space to strengthen our economy by supporting Canada's space industry to bring to market cutting-edge technologies that promote jobs and growth; (3) Working together globally and partnering with other countries on major space projects; (4) Promoting Canadian innovation by investing in proven Canadian strengths and expertise; and (5) Inspiring and encouraging a future generation of Canadians to pursue careers in space and related disciplines.

Canada's Space Policy Framework has clarified the direction the Government of Canada wishes to adopt with regards to space and criteria for decisions that will account for the multiple government organizations using space technology to fulfil their mandates, as well as the non-governmental actors engaging in space activities across the country. In 2014, the CSA also initiated a number of economic studies to

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acquire a deeper understanding of the Canadian space sector and its impact on the economy, and to identify trends and opportunities for the future.

The International Space Station (ISS)

Canada pursued its partnership in the ISS where its contribution of the Mobile Servicing System (Canadarm2, Dextre and the Mobile Base System) continues to perform a variety of operations ranging from resupply, maintenance and service tasks critical to the operations of the ISS. For example, Canadarm2 was used to capture Japanese and American space vehicles and berth them to the ISS and a team of dedicated mission controllers and support staff ensured the reliable operations of Canada's robotic system.

Canada worked with the ISS partners in the elaboration of a new International Docking System Standard (IDSS) to enable on-orbit crew rescue operations and joint collaborative space exploration endeavours using different spacecraft.

Human health and medical science remain Canadian priorities for the utilization of the ISS.

In 2014, Canada worked with international partners to prepare experiments to be conducted on-board ISS. Canada and France (Centre National d'Études Spatiales — CNES) are currently collaborating with the European Space Agency (ESA) on ISS experiments studying cardiovascular changes. Canada is also participating in the International Life Sciences Research Announcement coordinated by the International Space Life Science Working Group to solicit new research for the ISS.

In pursuing partnerships to study the effects of aging on astronauts, Canada seeks out opportunities to translate the results of space research into benefits for humanity through the Space Health and Aging Research (SHARE) initiative. At the national level, the CSA is working with the Canadian Institutes of Health Research — Institute of Aging to develop and offer related research opportunities to Canadian industry and academia. Canada is also coordinating global efforts to promote sharing of knowledge and expertise in this domain through a series of webinars with international counterparts and with the support of the Gerontological Society of America.

In early 2014, Canada participated in the Human Space Technology Initiative (HSTI) along with other partners of the ISS and a representative of the World Health Organization (WHO) to discuss how space technology could support health priorities.

In September 2014, Canada participated in the 24th United Nations/International Astronautical Federation Workshop on "Space Technology for Socio-Economic Benefits" with focus on global health and maritime applications. The event was hosted in Toronto, Canada. At the workshop, participants agreed that space could contribute to global health, particularly in: telemedicine (medical practice and mentoring), tele-health (health services), health sciences (applied medical research), tele-epidemiology (investigation, prevention and control of infectious and chronic diseases) and disaster management (global health security).

This year, Canada also undertook five new studies to assess innovative Canadian health technologies that could one day be used on the ISS. These technologies are also expected to advance applications for earth-based medical and life science

research. In particular, the studies look at: (1) Astroskin — a bio-monitoring smart shirt that could be worn by astronauts; (2) the Canadian High-Energy Neutron Spectrometry System II (CHENSS II) — advanced radiation detection technology; (3) the ISS Microflow Lab Concept — a miniaturized flow cytometer to prepare and process biological samples; (4) the ISS Wrist Magnetic Resonance Imager (MRI) — a non-invasive MRI instrument specifically for the wrist; and (5) the Osteo-X Cell Culture System — a cell culture system for the ISS.

Human space flight

In anticipation of future space flight assignment opportunities, Canadian astronauts Jeremy Hansen and David Saint-Jacques continued their pre-assignment training. This includes ISS Systems, Flight, Russian Language and Medical, as well as simulated missions and extravehicular activities. In 2014, both astronauts successfully completed the Robotics Operator training course at the CSA, as well as the subsequent Robotics Specialist Skills training at Johnson Space Centre (JSC).

They also participated in expeditionary-type training activities that serve to expand their knowledge as well as survival and leadership skills. From September 8 to 14, Jeremy Hansen was the Exploration Lead for the NEEMO 19 (NASA Extreme Environment Mission Operations) underwater analogue mission which included international crew members. This kind of mission is designed to test new equipment and techniques, and to develop new tools that would be applicable for future space exploration endeavours. From August 18 to September 3, David Saint-Jacques participated in a Field-Geology training expedition at a meteor-crater impact structure in northern Quebec, led by the Centre for Planetary Science and Exploration (CPSX) at Western University. The objective of this training is to learn methods and techniques for conducting geological fieldwork that could be applied to future missions to the Moon or to an asteroid.

Both CSA astronauts continued to be actively involved in raising awareness about Canada's activities in space, and inspiring and motivating youth to pursue careers in science, technology, engineering and math. The influence of Canadian astronauts, especially since Chris Hadfield's flight, frequently extends beyond Canadian borders.

Planetary exploration

In July 2014, Canada announced its contribution to the US-led Origins-Spectral Interpretation-Resource Identification-Security-Regolith Explorer (OSIRIS-REx). The mission will study the asteroid "Bennu" and Canada is providing the OSIRIS-REx Laser Altimeter (OLA) — a sophisticated laser-based mapping system that will be manufactured, assembled and tested by Canadian companies MacDonald, Dettwiler and Associates Ltd. (MDA) and Optech. The Laser Altimeter will be used to create unprecedented 3D maps of the asteroid to help the mission team select a site from which to collect a sample.

August 2014 marked two years since NASA's Mars Science Laboratory safely arrived on Mars. Aboard the Curiosity rover, Canada's Alpha Particle X-Ray Spectrometer (APXS) continues to support scientists in determining the chemical composition of Martian rocks and soil. Canada will continue to support the APXS operations and science team during the MSL mission extension.

From April 2013 to September 2014, the CSA chaired the International Space Exploration Coordination Group (ISECG). Pursuant to the release of the updated Global Exploration Roadmap (August 2013) and a document on the Benefits Stemming from Space Exploration (September 2013), ISECG supported several conferences and community engagement events, including the International Space Exploration Forum (ISEF) and IAA Space Exploration Conference (January 2014), the NASA Community Workshop on the Global Exploration Roadmap (April 2014), the International Space University, Montreal (July 2014), and Symposium on International Space Exploration 2014, Tokyo (July 2014).

Canada also continued its work developing advanced robotics technologies and terrestrial prototypes of landers and rovers in anticipation of its potential role in future international space exploration missions.

Space-based astronomy

In February 2014, the Government of Canada confirmed its continued support to the James Webb Telescope project, a partnership between NASA, ESA and the CSA. The partners are working towards a 2018 launch date. Canada is providing the Fine Guidance Sensor (FGS), a critical element of the mission used for extremely precise pointing of the telescope, and the Near-Infrared Imager and Slitless Spectrograph (NIRISS), a science instrument with unique capabilities for finding the most distant objects, and discovering and characterizing planets in other solar systems.

Canada also continued its work with the Japanese Space Agency, JAXA, on the ASTRO-H Astronomy satellite to be launched in 2015. The Canadian company Neptec Design Group is building the Canadian ASTRO-H Metrology System (CAMS), an innovative measuring system that will help better calibrate the observatory's main telescope and significantly enhance the images it captures.

After more than ten years of studying the Universe, the CSA transferred the ownership and control of operations of the Canadian Microvariability and Oscillation of Stars (MOST) to Microsat Systems Canada Inc. (MSCI), a private company. In collaboration with the University of British Columbia, the new owners of MOST continue gathering photometry data on stars to observe oscillations, search for exo-planets and perform Asteroseismology studies.

Space weather

Canada's proximity to the magnetic North Pole makes it vulnerable to space weather while also making its landmass among the best places in the world to study the effects of space weather. Space weather science is still in its infancy, much as meteorology was 100 years ago, and requires ground and space-based observations from all over the world to develop models that will ultimately contribute to detection and mitigation of risks. Canada is interested in promoting increased international collaboration and advancement with regards to space weather.

The Geospace Observatory (GO) Canada initiative takes advantage of this front row seat to observe geospace (the magnetosphere, ionosphere, and thermosphere system) using ground-based instruments deployed all over Canada. The instruments are operated by scientists from the universities of Alberta, Calgary, New Brunswick, Saskatchewan, and Athabasca University. The data acquired by these instrument arrays is openly available to scientists worldwide and is used, along with data

acquired by space-based instruments, by Canadian scientists supported through the GO Canada initiative to understand the physics behind space weather and to begin developing applications that will reduce its impact on the lives of Canadians.

The Canadian satellite CASSIOPE (CAScade, Smallsat and IOnospheric Polar Explorer) was successfully launched in September 2013. The suite of eight scientific instruments of the Enhanced Polar Outflow Probe (ePOP) mission aboard CASSIOPE observes the Earth's ionosphere to study space weather effects and how atomic oxygen escapes Earth's gravity at polar regions during solar storms. The ePOP mission is driven by the University of Calgary in close collaboration with other Canadian universities, the Japanese Space Agency (JAXA) and the United States Naval Research Laboratory. Throughout 2014, the ePOP team measured particle densities in the ionosphere, observed the aurora in the infrared, measured the magnetic field, and carried-out a number of radio propagation investigations in partnership with more than 20 countries.

Canada is a partner in ESA's Swarm mission which was launched successfully in November 2013. The mission is designed to precisely measure the magnetic fields generated by the Earth's core, mantle, crust, oceans, ionosphere and magnetosphere. Canada contributed the Electric Field Instruments (EFI) for the three satellites. The instruments were designed and built by COM DEV based on previous work done by the University of Calgary. Supported by the CSA, the University of Calgary continues to monitor the functioning of the EFIs and is using measurements from the instruments to learn more about the ionosphere and how space weather influences the Earth's space environment.

Canada also continues to collaborate with NASA on the THEMIS (Time History of Events and Macroscale Interactions during Substorms) mission. The constellation of three satellites in highly elliptical orbits crosses regions in space that are magnetically coupled to sensors located in Canada, the United States of America and Denmark. This trajectory of the satellites aims to observe events in space such as magnetic reconnections while their effects are measured from the ground. The THEMIS mission has been extended until December 2016 and the CSA will continue to fund the participation of Canadian scientists from the University of Alberta and the University of Calgary to make magnetic and optical observations of the aurora borealis, and analyse the data in relation to the in situ measurements from THEMIS spacecrafts. This work will increase our understanding of space weather and help increase resilience to this potentially catastrophic phenomenon.

Finally, during the 2014 session of the Science and Technology Subcommittee of the Committee on the Peaceful Uses of Outer Space, Canada proposed the creation of a new expert focus group on space weather that will report and propose recommendations to member States under the Space Weather agenda item of the Scientific and Technical Subcommittee. Canada is preparing to lead discussions/negotiations among experts to establish the mandate and programme of work for this group at the 2015 Scientific and Technical Subcommittee.

Space situational awareness

Canada's Near-Earth Object Surveillance Satellite (NEOSSat), launched in February 2013, is the world's first space telescope dedicated to detecting and tracking asteroids and satellites. Some early technical issues were resolved in 2014

and the satellite is now stable, responsive and capable of imaging specified targets, including space. Additional improvements are continuing in order to achieve the level of performance necessary for faint asteroid detection.

The Canadian Armed Forces (CAF) space situational awareness satellite, Sapphire, completed its operational testing in early 2014. Since then, Sapphire has been monitoring space objects orbiting between 6,000 and 40,000 kilometres above the Earth's surface on a 24-hour basis. Data from this satellite is contributed to the United States Space Surveillance Network and incorporated into an international catalogue that is used to help prevent collisions in space. This helps ensure the long-term sustainability of outer space activities.

In October 2014, the Canadian Department of National Defence signed a Memorandum of Understanding to conduct space operations with the defence departments of Australia, the United States and the United Kingdom of Great Britain and Northern Ireland. The Combined Space Operations Initiative formalizes an already existing partnership, enables the sharing of space-related information and resources aimed at identifying and understanding space objects, ensuring uninterrupted satellite operations, and avoiding satellite collisions.

Missions such as ePOP, Swarm, THEMIS and GO Canada, described in the space weather section, also contribute to Canada's Space Situational Awareness efforts. These missions constitute a world class capacity to observe and quantify the effects of space weather on our communication and navigation systems, on our ground infrastructure such as power lines, railroads and pipelines, and on all the technologies that rely on them.

Earth observation

The CSA continued to support a large number of R&D activities using RADARSAT-2 data at both national and international levels through various initiatives under the Science and Operational Applications Research (SOAR) program. More than 200 projects are currently ongoing with Canadian and foreign principal investigators who explore the unique capabilities offered by the RADARSAT-2 satellite and their potential contributions to various applications.

The SOAR framework has also been used to enhance collaboration with international partners: 49 projects were initiated under a bilateral agreement with ESA providing Canadian and ESA Members States researchers' access to RADARSAT-2 and ESA mission data. Similarly, Canadian (CSA) and Italian (ASI) Space Agencies have joined resources to stimulate scientific utilization of data acquired by RADARSAT-2 and the COSMO-SkyMed Constellation, with 50 projects seeking basic and applied research, development of algorithms, methods and applications. RADARSAT-2 data was also provided to scientists affiliated with the Geohazard Supersites and Natural Laboratories GEO initiative linked with CEOS activities to develop, demonstrate and promote the use of synthetic aperture radar (SAR) remote sensing in the field of Geohazard and other applications.

Through a collaborative arrangement between the CSA and the German Space Administration (DLR) established in 2013, both agencies have committed to further cooperation in the area of Earth observation and encouraging industry to develop applications to capitalize on C-band (RADARSAT) and X-band (TerraSAR-X, TanDEM-X) SAR sensors and their capabilities. In 2014, an Announcement of

Opportunity (AO) was issued under the CSA's Earth Observation Applications Development Program (EOADP) that encourages Canadian Industry to develop related applications in collaboration with German EO Industries. DLR simultaneously launched a similar initiative to support its stakeholders.

Canada, through the CSA, continued contributing to the Committee on Earth Observation Satellites (CEOS), a Participating Organization in GEO. In addition to contributing its expertise, Canada supports two key leadership positions in CEOS: the incoming Executive Officer and the Vice-Chair of the Working Group on Disasters.

Canada also provides unique datasets from RADARSAT to support GEO flagship programs in agriculture, forest and also disaster and polar-related initiatives.

Since its inception in 2000, the International Charter "Space and Major Disaster" has been joined by twelve other space agencies, bringing the total membership to 15. It has been activated for 442 disasters in 116 countries (as of 15 December 2014). From January to December 2014, the Charter was activated 40 times for disasters in 28, countries, in addition to the countries of South West Africa in response to the Ebola outbreak. With the exception of only a few, Canada provided RADARSAT reference and post-disaster imagery for all these activations.

Planning for the future, Canada's RADARSAT Constellation Mission (RCM) is currently in its development phase with a target for launch in 2018. RCM represent an evolution of the RADARSAT Program and aims to ensure C-Band Synthetic Aperture Radar (SAR) data continuity to national and international users and to provide new applications enabled by the constellation approach.

The RCM has been designed primarily to respond to the requirements of the various Canadian government users (including Environment Canada, Natural Resources Canada and the Canadian Forces). The main areas of interest are Canada's landmass and the surrounding Arctic, Pacific and Atlantic maritime areas. The greatly enhanced temporal revisit combined with accurate orbital control will enable advanced change detection applications in between satellites on a four-day cycle that will allow the generation of very accurate coherent change maps. RCM will also improve ongoing applications such as ice and iceberg monitoring, marine winds, oil pollution monitoring and response, and ship detection.

In 2014, the CSA committed to cooperate with NASA and CNES in the Surface Water and Ocean Topography Mission (SWOT). Planned for launch no earlier than 2020, SWOT is an international mission intended to enable the study of the Earth's surface water and sea surface topography.

Finally, the CSA and the Public Health Agency of Canada have a longstanding collaboration in the promotion and development of Canadian capacity to use space technology to address health and security issues, including the spread of infectious disease through tele-epidemiology. In 2014, Canada pursued bilateral and multilateral initiatives with other countries and through the Committee on the Peaceful Uses of Outer Space promoted further cooperation and advancement in this area. During the 2014 session of the Scientific and Technical Subcommittee, Canada proposed the creation of a new expert focus group on Space and Global Health to build on work accomplished through Action Team 6 and Action Team 6 Follow-Up Initiative. The group will report and propose recommendations to member States

under the Space and Sustainable Development agenda item of the next Scientific and Technical Subcommittee. Canada is preparing to lead discussions/negotiations among experts to establish the mandate and programme of work for this group.

Collaborative agreements

Canada has collaborative agreements to further develop bilateral and multilateral cooperation in space activities with other countries. In 2014, Canada established or renewed a number of collaborative arrangements, including:

Canada and the United States signed the Tomatosphere™ Joint Project Agreement (2014-2016), which will further joint collaboration on the award-winning educational project. Tomatosphere™ uses the excitement of space exploration to teach scientific experimentation and inquiry, and educate youth about space, agriculture and nutrition.

A Memorandum of Understanding (MOU) was signed between Canada (CSA and Natural Resources Canada) and Norway (Norwegian Space Centre) on cooperation in satellite remote sensing. This Memorandum builds upon cooperation established through an original MOU in 2002 and will remain in effect for a period of five years.

The CSA and the Brazilian Space Agency signed a “Program of Cooperation” to promote training of human resources in space-related areas of interest to Canada and Brazil as well as the exchange of experts for projects.

Israel and Canada signed an addendum to their 2005 MOU to enhance cooperation between the two countries and further promote industry to industry collaboration in matter related to space.

The CSA and CNES (France) signed a Letter of Intent (LOI) to promote cooperation in areas of common interest related to the exploration and utilization of outer space for peaceful purposes. Potential areas for cooperation include earth observation, research and development in the health domain and search and rescue.

The CSA also renewed its contribution to the activities of the Organization for Economic Cooperation and Development (OECD) Forum on Space Activities until 31 March 2019. The forum looks closely at space sector statistics and sets in motion the development and calibration of socioeconomic methods to produce reliable, accredited and comparable data on the contributions of space-based assets to the economy. CSA sits on the Global Forum’s steering group with other major international partners and is represented in working groups.

Capacity-building

From August 19 to September 26, 2014, the CSA and CNES held the Strato Science 2014 research campaign from the stratospheric balloon launching facility in Canada. During the campaign, 15 European and 7 Canadian experiments were successfully completed. This initiative enhances future Canadian space capacity by supporting scientists and engineers with a new platform to test technologies, perform science experiments and train undergraduate and graduate students in the field of space science and technology. The campaign falls under a France-Canada collaboration agreement signed on 30 September 2012.

Through expertise provided by the McGill Institute of Air and Space Law (IASL), Canada contributed to the completion of the Education Curriculum on Space Law, a recent accomplishment of the Legal Subcommittee of the Committee on the Peaceful Uses of Outer Space. In 2014, the IASL offered to conduct courses and training sessions at United Nations Regional Centres to help with the implementation of the curriculum. IASL will provide these at no cost to the Office of Outer Space Affairs.

As indicated above, the CSA renewed its contribution to the activities of the Organization for Economic Cooperation and Development (OECD) Forum on Space Activities. This is a voluntary contribution programme established in 2006 at the demand of several countries (including Canada, the United States, France, Italy, Norway, and the United Kingdom) to address the need to demonstrate the socioeconomic impacts of space sector activities and the return on investment made by governments. A founding member of this international forum, Canada is in many ways leading the pack in terms of data collection through an annual national industrial survey and new methodologies to assess domestic performance (i.e. the GDP impact and R&D intensity of the sector).

The Forum is mandated to identify the space sector statistically and investigate its impact on the economy and society at large. Members are working in close collaboration to identify internationally comparable methodology to benchmark the sector through publications such as *The Handbook on Measuring the Space Economy*, as well as build a library of impacts, case studies and reference points, such as in *The Space Economy at a Glance*. Member countries benefit from having their countries' space sector activities featured in such publications. Overall, the OECD Global Forum on Space Economics helps member countries leverage funding and expertise to promote the "case for space" and provide a strong evidence base for decision makers.