



# **THE CANADIAN SPACE AGENCY**

**2011-2012 Estimates**

**Report on Plans and Priorities**

## **SECTION 2:**

**Analysis of Program Activities by Strategic Outcome**

***- Detailed Information -***

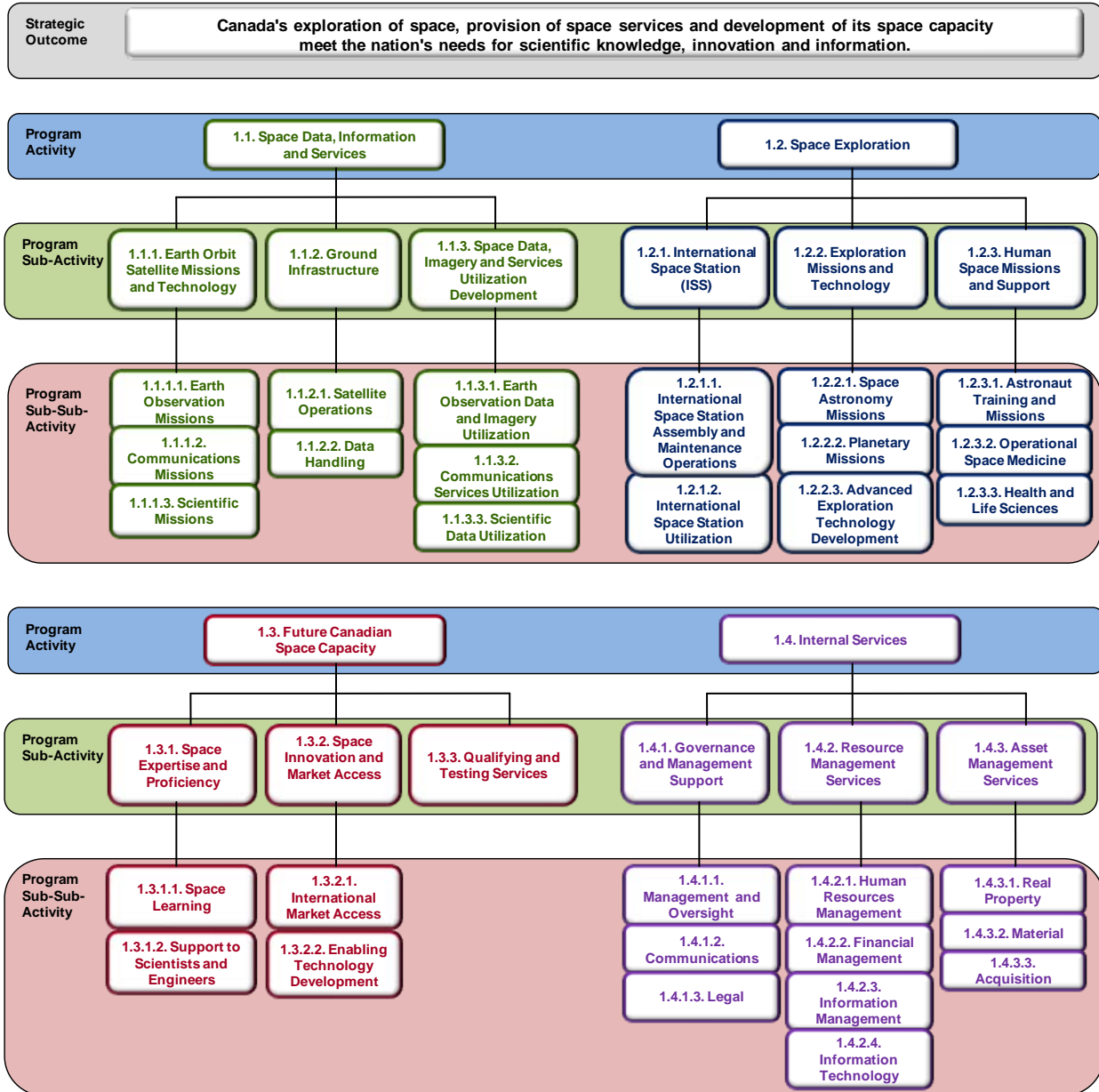


## TABLE OF CONTENTS

<b>SECTION 2: ANALYSIS OF PROGRAM ACTIVITIES BY STRATEGIC OUTCOME .....</b>	<b>2</b>
1.1. Space Data, Information and Services .....	4
1.2. Space Exploration .....	20
1.3. Future Canadian Space Capacity .....	34
1.4. Internal Services .....	46
<b>SECTION 3: SUPPLEMENTARY INFORMATION.....</b>	<b>53</b>
3.1 Financial Highlights .....	53
3.1.1 <i>Financial Statements</i> .....	53
3.1.2 <i>Supplementary Information Tables</i> .....	53
3.2 CSA ContributionS to Government of Canada Outcomes .....	54
3.3 Index of CSA Space Missions .....	57

# SECTION 2: ANALYSIS OF PROGRAM ACTIVITIES BY STRATEGIC OUTCOME

## Canadian Space Agency's 2011-2012 Program Activity Architecture (PAA)



**STRATEGIC OUTCOME:** Canada's exploration of space, provision of space services and development of its space capacity meet the nation's needs for scientific knowledge, innovation and information.

## **PERFORMANCE INDICATORS**

### **1. Depth and width increase of needed scientific knowledge**

The depth and width of knowledge, generated in part through the CSA's support, is primarily based on the analysis of the following factors:

- production of knowledge is measured by the number of publications and can be broken down by field of knowledge and referred to invested funds;
- dissemination of knowledge is measured by the number of cited publications which can also be broken down by field of knowledge and by type and extent of the audience reached; and,
- relevance of knowledge is measured, among others, by the number of publications listed under areas of knowledge previously targeted by the CSA.

The CSA already conducts in-house measurement of certain inputs such as the number of publications produced. To hone its approach, the CSA is considering the establishment of a bibliometric system which will list the number of publications, citations and type of audiences related to the areas of knowledge falling under the priorities endorsed by Other Government Departments (OGDs).

### **2. Space generated innovation index**

Innovation, generated in part through the CSA's support, is primarily based on the analysis of the following factors in the specific context of space:

- idea generation which results in the creation of new knowledge, technologies, processes or their subsequent improvements;
- idea development that can take the form of prototypes, scientific instruments and experiments; and,
- commercialization and utilization measured by the number of applications developed and used or data requested and provided.

Canadian Government and private organizations collect and publish a large amount of aggregated information on innovation. The CSA must be able to report adequately on the impact of its programs on Canadian innovation. The Agency intends to draw from the performance measurement methods developed by the Organization of Economic Cooperation and Development (OECD), which opens on the partnership created since 2006 between the CSA and other members of the OECD Space Forum.

### **3. Acknowledgement/success stories by OGDs of impact on mandate delivery**

OGDs' recognition of the impact on quality of programs and services delivery attributable to data utilization, information, research results, or space services lies in monitoring of Web information and public documents and relies on the capability of OGDs to systematically acknowledge the benefits obtained from applications developed with the support of the CSA. Longitudinal information will be collected jointly with OGDs to analyse the impact of the support provided by the CSA on the delivery of their programs.

## 1.1. Space Data, Information and Services

**Description:** This Program Activity includes the provision of space-based solutions (data, information and services) and the expansion of their utilization. It also serves to install and run ground infrastructure that processes the data and operates satellites. This Program Activity utilizes space-based solutions to assist Other Government Departments (OGDs) in delivering growing, diversified or cost-effective programs and services within their mandate, which is 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.

<b>SPACE DATA, INFORMATION AND SERVICES</b>			
<b>PROGRAM ACTIVITY PERFORMANCE MEASUREMENT</b>			
<b>Expected Result #1</b>	<b>Performance Indicators</b>		
User Other Government Departments (OGDs) offer more diversified or cost-effective programs and services due to their utilization of space-based solutions.	1. Number of OGDs' programs serviced by space data/services that are outlined in their reports to parliament (RPP, DPR) – New success stories of improved efficient/effective departmental mandate delivery due to space-based solutions.  2. Degree of appreciation expressed by OGDs through formal and informal structures.		
<b>Planning and Reporting Continuity:</b>			
RPP 2010-2011 and DPR 2009-2010: <a href="http://www.asc-csa.gc.ca/asc/eng/resources/publications/default.asp#parliament">http://www.asc-csa.gc.ca/asc/eng/resources/publications/default.asp#parliament</a>			
<b>RESOURCES</b>	<b>2011-2012</b>	<b>2012-2013</b>	<b>2013-2014</b>
<b>FINANCIAL</b> (\$ in millions)	136.6	159.6	108.0
<b>HUMAN</b> (FTEs)	103.7	103.7	103.7

**Space Data, Information and Services programs are grouped into three Sub-Activities:**

- **Earth Orbit Satellite Missions and Technology;**
- **Ground Infrastructure; and,**
- **Space Data, Imagery and Services Utilization Development.**

**Program Sub-Activity: 1.1.1. Earth Orbit Satellite Missions and Technology**

**Description:** This Program Sub-Activity (SA) encompasses the development and use of complete Canadian satellite systems or of sub-systems, payloads, instruments or other components provided to domestic and foreign satellites. The SA also includes the development of advanced technologies that could shape or determine the nature of potential new Earth orbit satellite missions. This SA is necessary because Other Government Departments (OGDs) use satellite-generated data, information and services to deliver their mandate; and so do academia to perform their research.

This SA is delivered in collaboration with OGDs, along with the participation of Canadian industry, academia and foreign space agencies. This collaborative effort is formalized under contracts, grants, contributions and partnership agreements with national, public/private and international organizations.

EARTH ORBIT SATELLITE MISSIONS AND TECHNOLOGY PROGRAM SUB-ACTIVITY PERFORMANCE MEASUREMENT			
Expected Result #1		Performance Indicators	
OGDs are using satellite-generated space-based solutions.		1. Number of consultations with OGDs regarding their needs.  2. Number of partnerships/agreements signed or modified.	
RESOURCES	2011-2012	2012-2013	2013-2014
FINANCIAL (\$ in millions)	103.7	133.3	77.8
HUMAN (FTEs)	78.9	78.9	78.9

**This Sub-Activity is further divided into three Sub-Sub-Activities.**

**Program Sub-Sub-Activity: 1.1.1.1. Earth Observation Missions**

**Description:** This Program Sub-Sub-Activity (SSA) encompasses the definition, design, technology development, implementation and operational use of Earth orbit satellites dedicated to producing data, information or imagery of Earth and its atmosphere, ranging from its sub-surface to its upper atmospheric layers, including space surveillance for asteroids, Earth orbiting objects and space debris. This SSA serves continuous operations and is necessary to produce pertinent Earth Observation data and imagery that assist with the mandate delivery of Other Government Departments (OGDs) that deal especially with key national priorities, such as environment, climate change, weather, natural resources, sovereignty, defence, safety and security. It also provides academia with data required for its research.

The SSA is delivered in collaboration with OGDs, along with the participation of Canadian industry, academia and foreign space agencies. This collaborative effort is formalized under contracts, grants, contributions and partnership agreements with national, public/private and international organizations.

Expected Result #1		Performance Indicators		
Earth Observation missions provide OGDs and academia with pertinent data and information that address key national priorities.		1. Earth Observation roadmaps are developed, maintained current and endorsed by OGDs. (Target: Consultations to be reported retroactively)  2. Number of Earth Observation missions/instruments in concept, development and operations. (Target: 1 concept, 1 development, 4 operations)  3. Number of OGDs requesting data and images from Earth Observation missions. (Target: 9 for R1/R2, 4 for ESA-ENVISAT and ESA-Sentinel 1, 2, 3)		
RESOURCES	2011-2012	2012-2013	2013-2014	
FINANCIAL (\$ in millions)	93.0	128.4	63.4	
HUMAN (FTEs)	58.5	58.5	58.5	

***Program Sub-Sub-Activity: 1.1.1.2. Communications Missions***

**Description:** This Program Sub-Sub-Activity (SSA) encompasses the definition, design, technology development, implementation and operational use of Earth orbit satellites dedicated to delivering continuous communications, including Navigation, Positioning and Timing (NPT) services. This SSA serves continuous operations and is necessary to provide pertinent communications and NPT services that assist Other Government Departments (OGDs) in the delivery of their mandate, particularly those locating and monitoring vehicle or ship signals, those dealing with remote communities or those managing other key national priorities, such as sovereignty, defence, safety and security.

This SSA is delivered in collaboration with OGDs, along with the participation of Canadian industry, academia and foreign space agencies. This collaborative effort is formalized under contracts, grants, contributions and partnership agreements with national, public/private and international organizations.



Expected Result #1		Performance Indicators		
Satellites provide communications including Navigation, Positioning and Timing (NPT) services that respond to the expressed needs of OGDs.		1. Satellite Communication roadmaps are developed, maintained current and endorsed by OGDs. (Target: Preliminary roadmap)  2. Number of Satellite Communication missions/instruments in concept, development and operations. (Target: 5)  3. Number of client-OGDs requesting data from Satellite Communications missions. (Target: 3)		
RESOURCES	2011-2012	2012-2013	2013-2014	
FINANCIAL (\$ in millions)	6.7	1.8	4.9	
HUMAN (FTEs)	11.0	11.0	11.0	

***Program Sub-Sub-Activity: 1.1.1.3. Scientific Missions***

**Description:** This Program Sub-Sub-Activity (SSA) encompasses the definition, design, technology development, implementation and use of Earth orbit satellites dedicated to producing scientific data and information for research performed by Other Government Departments (OGDs) or academia. Examples of this research are those pertaining to climate processes and space weather (solar winds and their interaction with the Earth's magnetic field). This SSA is necessary to produce pertinent scientific data and information that allow OGDs to mitigate damage or avoid the disabling of critical ground and space infrastructure, such as pipelines, electricity networks and satellites that can sustain damage from the effects of solar winds. In addition, with their enhanced understanding of climate processes and the improved models made possible through this SSA, OGDs are better able to provide weather and climate forecasting. Academia also uses the data and information produced through this SSA to perform its own research.

This SSA is delivered in collaboration with OGDs, along with the participation of Canadian industry, academia and foreign space agencies. This collaborative effort is formalized under contracts, grants, contributions and partnership agreements with national, public/private and international organizations.

<b>Expected Result #1</b>		<b>Performance Indicators</b>		
Solar and Earth System scientific space missions reflect OGDs and academia priorities.		1. Solar and Earth System roadmaps are developed, maintained current and endorsed by OGDs and academia. (Target: Preliminary Solar-Terrestrial and Earth System Science roadmaps)  2. Number of Solar and Earth System missions/instruments in concept, development and operations. (Target: 5 concept, 3 development, 6 operations)  3. Number of Canadian and international partners participating in CSA Solar and Earth System science missions. (Target: 55 Canadian, 110 international in Solar and 50 Canadian, 110 international in Earth System)		
<b>RESOURCES</b>	<b>2011-2012</b>	<b>2012-2013</b>	<b>2013-2014</b>	
<b>FINANCIAL</b> (\$ in millions)	3.9	3.2	9.5	
<b>HUMAN</b> (FTEs)	9.4	9.4	9.4	

**Program Sub-Activity: 1.1.2. Ground Infrastructure**

**Description:** This Program Sub-Activity (SA) includes the development of an integrated and coordinated national system of ground infrastructure to receive data from domestic or foreign satellites. In addition, the ground infrastructure houses and uses the equipment required for satellite operations. This SA is necessary to operate satellites as well as to process and make available space-based data received by the Canadian Space Agency to assist Other Government Departments (OGDs) in delivering their mandate. Finally, this SA capitalizes on Canada's geographical advantage by capturing space data from the increasing number of satellites flying over the Arctic and by installing ground stations in this strategic location.

This SA is delivered with the participation of industry, OGDs and foreign space agencies. This collaborative effort is formalized under contracts, grants, contributions and partnership agreements with national, public/private and international organizations.

<b>GROUND INFRASTRUCTURE</b>	
<b>PROGRAM SUB-ACTIVITY PERFORMANCE MEASUREMENT</b>	
<b>Expected Result #1</b>	<b>Performance Indicator</b>
Expressed Canadian and foreign data needs are fulfilled by ground infrastructure.	1. Percentage of response to data requests fulfilled by ground infrastructure operations.

Expected Result #2		Performance Indicators		
A reliable national ground infrastructure.		1. Percentage of reliability. 2. Quality of the internal expertise specializing in advice and technology-watch to ensure the successful development of a satellite ground infrastructure.		
RESOURCES	2011-2012	2012-2013	2013-2014	
FINANCIAL (\$ in millions)	16.4	10.7	12.3	
HUMAN (FTEs)	24.8	24.8	24.8	

**This Sub-Activity is further divided into two Sub-Sub-Activities.**

***Program Sub-Sub-Activity: 1.1.2.1. Satellite Operations***

**Description:** This Program Sub-Sub-Activity (SSA) encompasses the Telemetry, Tracking and Command (TT&C) of Canadian satellites or of foreign satellites when such services are required from Canadian stations. This SSA is necessary to render orbiting satellites functional.

The operations of Canadian Space Agency (CSA) satellites are mostly conducted with CSA equipment located in its ground facilities. In some instances, formal arrangements can be concluded between CSA, Canadian industry, Other Government Departments (OGDs) or international partners to operate one party's satellites using another party's equipment. Those arrangements can also provide for the location of one party's equipment in another party's facilities.

Expected Result #1		Performance Indicators		
CSA's satellites are functioning as per operational requirements.		1. Number of satellite anomalies successfully handled during flight operation maintaining satellite health. (Target: To be reported retroactively) 2. Number of Canadian satellites operated by CSA as per operational requirements. (Target: 2)		
Expected Result #2		Performance Indicator		
Foreign Satellite Missions are supported.		1. Number of ground station support contracts provided to foreign satellite missions. (Target: At least 1)		
RESOURCES	2011-2012	2012-2013	2013-2014	
FINANCIAL (\$ in millions)	9.9	7.6	10.0	
HUMAN (FTEs)	24.8	24.8	24.8	

***Program Sub-Sub-Activity: 1.1.2.2. Data Handling***

**Description:** This Program Sub-Sub-Activity (SSA) includes a coordinated national approach to determine optimal station locations and space data handling. This SSA is necessary for the planning and tasking of data acquisition, as well as the capture, calibration, cataloguing, archiving and availability of space data received from domestic or foreign satellites to assist Other Government Departments (OGDs) in delivering their mandate.

Data handling operations are mostly conducted with Canadian Space Agency (CSA) equipment, located in its ground facilities. In some instances, formal arrangements can be concluded between CSA, OGDs or international partners to use another party's equipment located within its facilities. This SSA is delivered with the participation of Canadian industry, foreign space agencies and OGDs. This collaborative effort is formalized under contracts, grants, contributions and partnership agreements with national, public/private and international organizations.

<b>Expected Result #1</b>		<b>Performance Indicators</b>		
Satellite data provided as per data requirements.		1. Volume of data from various missions delivered to OGDs and other customers. (Target: 200 SCISAT GBytes, 5,000 R-1 minutes, 10,000 R-2 minutes)  2. Volume of data archived. (Target: 200 SCISAT GBytes, 5,000 R-1 minutes, 10,000 R-2 minutes)  3. Number of different satellites from which data is received. (Target: 3)		
<b>RESOURCES</b>		<b>2011-2012</b>	<b>2012-2013</b>	<b>2013-2014</b>
<b>FINANCIAL</b> (\$ in millions)		6.5	3.1	2.3
<b>HUMAN</b> (FTEs)		0.0*	0.0*	0.0*

\*Note: Operations are not carried out by CSA personnel.

**Program Sub-Activity: 1.1.3. Space Data, Imagery and Services Utilization Development**

**Description:** This Program Sub-Activity (SA) develops utilization of space-based data, imagery and information, and of communications services available on space assets for the benefit of the user community, primarily Other Government Departments (OGDs) and academia. This SA is necessary to foster the development of a Canadian value-added industry that turns space data and information into readily useable products, as well as to increase the ability of Other Government Departments (OGDs) to use space-based solutions (data, information and services) for the delivery of their mandate and to increase the ability of academia to perform their research.

This SA engages the participation of the Canadian space industry and academia and is formalized under contracts, grants, contributions and partnership agreements with national, public/private and international organizations.

<b>SPACE DATA, IMAGERY AND SERVICES UTILIZATION DEVELOPMENT</b>			
<b>PROGRAM SUB-ACTIVITY PERFORMANCE MEASUREMENT</b>			
<b>Expected Result #1</b>		<b>Performance Indicator</b>	
The ability of OGDs to use space-based solutions is enhanced.		1. OGDs' spending on Earth Observation related activities (data, resources).	
<b>Expected Result #2</b>		<b>Performance Indicator</b>	
A Canadian industry that turns space data and information into useable products is emerging.		1. Number of applications/services developed that are moving forward operational implementation.	
<b>Expected Result #3</b>		<b>Performance Indicator</b>	
Ability of Canadian scientific community to use space-based data.		1. Number of peer-reviewed papers related to data utilization produced in academia and R&D community in Canada.	
<b>RESOURCES</b>	<b>2011-2012</b>	<b>2012-2013</b>	<b>2013-2014</b>
<b>FINANCIAL</b> (\$ in millions)	16.6	15.6	17.8
<b>HUMAN</b> (FTEs)	0.0*	0.0*	0.0*

\*Note: Operations are not carried out by CSA personnel.

**This Sub-Activity is further divided into three Sub-Sub-Activities.**

***Program Sub-Sub-Activity: 1.1.3.1. Earth Observation Data and Imagery Utilization***

**Description:** This Program Sub-Sub-Activity (SSA) develops the utilization of Earth observation imagery and atmospheric data acquired from Canadian and foreign space assets, ranging from its sub-surface to its upper atmospheric layers. This also applies to weather and climate imagery. This SSA is necessary to broaden the applicability of currently available Earth Observation space products and services (optimization) or to create new ones (innovation) for the user community (Other Government Departments (OGDs) and academia).

This SSA engages the participation of the Canadian space industry and academia and is formalized under contracts, grants, contributions and partnership agreements with national, public/private and international organizations.

Expected Result #1		Performance Indicators		
Broadened Canadian use of already existing Earth Observation data and imagery in Canada.		1. Number of Earth Observation application development activities supported. (Target: 20 EOADP, 28 GRIP)		
		2. Number of users. (Target: 60 EOADP, 90 GRIP)		
Expected Result #2		Performance Indicator		
Optimized data consumption.		1. Volume of data consumed. (Target: 42,000 acquisitions)		
RESOURCES	2011-2012	2012-2013	2013-2014	
<b>FINANCIAL</b> (\$ in millions)	14.1	13.3	15.8	
<b>HUMAN</b> (FTEs)	0.0*	0.0*	0.0*	

\*Note: Operations are not carried out by CSA personnel.

***Program Sub-Sub-Activity: 1.1.3.2. Communications Services Utilization***

**Description:** This Program Sub-Sub-Activity (SSA) develops the utilization of space communications, including Navigation, Positioning and Timing (NPT) services available through Canadian and foreign satellites. This SSA is necessary to broaden the applicability of currently available communications services (optimization) or to create new ones (innovation) for Other Government Departments (OGDs).

This SSA engages the participation of the Canadian space industry and is formalized under contracts, grants, contributions and partnership agreements with national, public/private and international organizations.

Expected Result #1		Performance Indicators		
Broadened communication satellite-based applications/services.		1. Number of communication application development activities supported. (Target: To be reported retroactively)  2. Volume of data available to OGDs. (Target: 150 data acquisitions)  3. Number of users of communication satellite-based applications/services. (Target: 1)		
RESOURCES	2011-2012	2012-2013	2013-2014	
FINANCIAL (\$ in millions)	2.3	2.2	1.9	
HUMAN (FTEs)	0.0*	0.0*	0.0*	

\*Note: Operations are not carried out by CSA personnel.

**Program Sub-Sub-Activity: 1.1.3.3. Scientific Data Utilization**

**Description:** This Program Sub-Sub-Activity (SSA) develops the utilization and validates the quality of Canadian and foreign space-based scientific data and derived information that address science questions, such as those related to our understanding of the Earth's climate system and magnetic field (magnetosphere). This SSA involves the collaboration of Canadian scientists from Other Government Departments (OGDs) and academia. This SSA is necessary to broaden the applicability of currently available space scientific data (optimization) or to create new ones (innovation) for OGD and academia, especially in weather forecasts, climate change and space weather.

This SSA engages the participation of the Canadian space industry, academia and OGDs scientists, and is formalized under contracts, grants, contributions and partnership agreements with national, public/private and international organizations.

Expected Result #1	Performance Indicators
Broadened use of Solar and Earth System scientific data in Canada.	1. Number of Solar and Earth System scientific operations and research activities supported. (Target: 26 grants, 32 contracts, 7 Memorandum of Understanding and 6 international agreements)  2. Number of Solar and Earth System scientific instruments that are validated and used. (Target: 10 Solar, 6 Atmospheric, 2 Earth System)

<b>Expected Result #2</b>		<b>Performance Indicator</b>		
New uses are developed from Solar and Earth System scientific data.		1. Number of Solar and Earth System scientific uses. (Target: 6)		
<b>RESOURCES</b>	<b>2011-2012</b>	<b>2012-2013</b>	<b>2013-2014</b>	
<b>FINANCIAL</b> (\$ in millions)	0.2	0.1	0.1	
<b>HUMAN</b> (FTEs)	0.0*	0.0*	0.0*	

\*Note: Operations are not carried out by CSA personnel.

## **Highlights of Expected Accomplishments for Space Data, Information and Services**

### **EARTH OBSERVATION**

- The RADARSAT Constellation Mission (RCM), carried on with the detailed design phase initiated in March 2010. A Memorandum to Cabinet (MC) seeking access to the \$397 million of additional funding announced in Budget 2010 was submitted in June 2010. A joint Revised Preliminary Project Approval (PPA) was then been prepared by CSA and PWGSC, and was approved by Treasury Board (TB) on December 9<sup>th</sup> 2010. The RCM Major Crown Project indicative cost estimates were revised from \$625M to \$873M. The purpose of this Revised PPA was also to request Revised Expenditure Authority for RCM to include the procurement of long-lead items during Phase C and also the inclusion of a technology demonstration program for the Department of National Defence (DND) funded Automatic Identification System (AIS) payload. As a result of the addition of the long-lead items, the phase C is now planned to end in July 2012, although the Critical Design Review (CDR) of the mission will occur in January 2012. The launch of the first satellite is planned to occur in fiscal year 2014-2015 followed by the other two satellites in fiscal year 2015-2016. This project will enhance Canada's ability to use radar imagery for operational maritime surveillance, disaster management and ecosystem monitoring and will support the strategic objectives of Canada on security and sovereignty, particularly in the Arctic.
- RADARSAT-2 operations got off to a good start in its first years. There are currently 13 departments taking advantage of its many capabilities some of which are investing resources in the development of applications to support their mandates. The consumption of scenes is expected to grow as new applications become operational. The CSA will continue to manage the \$445 million worth of prepaid data allocation to ensure that maximum benefits are realized, following the RADARSAT-2 Data Utilization Management Plan that is updated every year. The CSA will continue to negotiate agreements with other government departments to develop data acquisition plans and reporting. In the meantime, the CSA will continue to provide data to the national and international Earth Observation community that includes Canadian Provinces and Territories, in a wide selection of applications ranging from fundamental to applied research and development activities.



- RADARSAT-1 operations continue to supply radar imagery data to the existing client base with a high performance for satellite reliability, data delivery, and image quality. Moreover, through the operations of the Government of Canada order desk, RADARSAT-2 data is supplied to meet the needs expressed by CSA and other government departments. With two satellites in operation, data continuity and user's satisfaction, when conflicting needs arise, are better assured. A contingency plan is in place to secure the use of ESA ENVISAT satellite in a situation where Canadian satellites would be unable to meet user operational requirements. This contingency plan provides an equivalent back-up capability to ESA using RADARSAT-1 and 2 data.
- The CSA continues to ensure Canada's commitment, as an official member of the International Charter *Space and Major Disasters*, to use Earth Observation (EO) satellites in response to disasters. The CSA continues to regularly provide RADARSAT-1 and 2 data and strategic EO-derived information products upon Charter activation, and to provide the various Charter operational and administrative services, including participation at the Charter Board and Executive Secretariat.
- The CSA will continue satellite data application development and utilization, to support the growth of EO capabilities within other government departments and agencies and the service industry. In particular, twelve new contracts were awarded following a call for proposals to industry for innovative application development using RADARSAT-2 for the benefit of the Canadian Government. A new call for proposals should also result in new contracts to industry during fiscal year 2011-2012.
- The CSA will continue to support the implementation of international EO activities such as the Forest Carbon Tracking and the Caribbean Flood Project in collaboration with other space agencies. Web supersite initiatives are also in preparation such as GeoHazard to respond to the scientific and operational geospatial information needs for the prediction and monitoring of geological hazards (earthquakes, tsunamis, volcanoes and land instability) and JECAM (Joint Experiment for Crop Assessment and Monitoring) for the space-based monitoring of agriculture.
- CSA will keep developing an integrated and sustainable vision for the Space Data, Information and Services Program Activity through consultations with the Government of Canada departments and ongoing participation in international coordination bodies such as the Committee on Earth Observation Satellites (CEOS).

## SATELLITE COMMUNICATIONS

- A Mission Definition Study for the Polar Communications and Weather (PCW) Mission initiated in November 2008 and conducted in collaboration with the Department of National Defence (DND) and Environment Canada is expected to be completed by March 2011. The Concept of the Polar Communications and Weather Mission is to put a constellation of satellites in highly elliptical orbit over the North Pole which will provide broadband communication services and monitor weather in the Arctic area. This mission is responding to the needs expressed by other government departments and Northern communities. If approved, the mission will provide unique high temporal and spatial resolution data for meteorological, environment, and climate monitoring over the northern circumpolar region. Nordic countries, the European Union, the United States, the European Space Agency and the World Meteorological Organization have expressed strong interest in joining the PCW mission.
- The CSA will continue to work towards the full utilization of the Government of Canada capacity credit for broadband telecommunications services in the North. Additional demonstrations of Ka-band technology will improve the use of the Anik F2 by Northern communities for trials of innovative government services. With the ground segment upgrades at the Vancouver and Winnipeg teleports completed, the next phase is the large scale deployment of the terminals for the operational phase. The planning for the remaining 4 years of the utilization phase is nearing completion. A Call for Applicants to potential end-users in the Northern communities will be issued in the spring of 2011.
- CSA and the Department of National Defence (DND) are partnering to manage M3MSat, a second micro-satellite project (the first one being NEOSSat) whose primary payload will consist of an Automatic Identification System (AIS) supported on a micro-satellite bus. The satellite will also provide a test bed and demonstration platform for a low data rate communication system as well as for an electrical discharge monitor. This project will demonstrate and further develop a multi-mission micro-satellite bus capability, will establish micro-satellites as operationally cost effective, will allow optimization of the AIS payload in maritime traffic identification, will significantly support Canadian industry business development strategies in a global market context, and will be a complement to CSA's RADARSAT Constellation and DND's Polar Epsilon missions. Detailed design is being finalized and the manufacturing has been initiated. The launch is planned for July 2012 and the mission demonstration should end in 2014.
- As part of the CASSIOPE mission the CSA integrated the Cascade telecommunications payload and the Enhanced Polar Outflow Probe (ePOP) instrument on a small satellite bus. This small spacecraft is scheduled to be launched by the end of 2011. Cascade is the precursor of a communication satellite constellation that will help position Canadian industry on the international market, both as a supplier of advanced components and as a service provider of high-volume, high-data-rate telecommunications world-wide. The ePOP instrument will probe the

upper atmosphere and ionosphere region where solar variability exerts influence on global change in various time scales. The scientific data collected by ePOP will help scientists understand particle exchange and energy coupling processes between the Earth's atmosphere and space environment.

- With the successful completion of risk mitigation activities on key technologies, the CSA will undertake phase 0 activities for a V-Band Next Generation Satellite Communications Payload, which aims at developing and demonstrating advanced, world-leading broadband services to Canadians living in remote areas.
- Through Canada's collaboration with the European Space Agency (ESA), our industry can access forward-looking studies on new telecommunications services, develop new technologies, equipment and applications in multi-media, inter-satellite and mobile communications, and demonstrate satellite-based communications services such as interactive communications services for remote communities and for disaster management. For example, in satellite navigation, the CSA will continue its collaboration with ESA on the development of the Galileo ground infrastructure to support the monitoring of the quality of the localisation signal generated by the four experimental In-Orbit-Validation satellites planned to be launched in 2011-2012.
- The CSA will continue a coordinated effort with other government departments such as Natural Resources Canada (NRCan), the Department of Foreign Affairs and International Trade and the Department of National Defence to improve the governance structure of global navigation satellite system activities within the federal government.
- The CSA will continue to assess the telecommunications requirements of federal government users and evaluate how future telecommunications satellite systems can respond to identified needs.

#### **EARTH SYSTEM AND SPACE ENVIRONMENT SCIENCE**

- The CSA will continue to develop promising mission concepts for space-borne observations of atmospheric gases and aerosols related to climate and air quality. These mission concepts will be for Canadian instruments on foreign as well as Canadian spacecrafts. They will involve Canadian government and university scientists.
- The CSA will continue to support Canadian scientists in validation of greenhouse gas measurements made with foreign spacecraft (e.g. Japanese GOSAT) and in the development of capabilities to assimilate and utilize greenhouse gas observations.
- Many Canadian companies are anticipating their participation in EarthCARE mission through ESA and JAXA (Japan Aerospace Exploration Agency). Canada is expected to provide components for the cloud radar RF Front-end and microbolometer detector in the Broad-Band Radiometer. Canada is also actively pursuing the opportunities of participating in Earth Explorer 7 and 8 candidate missions.

- The CSA continues to support and operate SCISAT, a Canadian mission launched in August 2003. The mission is providing a large amount of high quality data on more than 30 chemical species in the atmosphere for climate, weather and pollution studies. The mission is in the 8<sup>th</sup> year of operation and the satellite operation performance is being maintained, fully meeting the academic users' requirements.
- The CSA continues to support MOPITT and OSIRIS, two major Canadian science instruments that are currently orbiting Earth and collecting new environmental data. MOPITT, on the NASA Terra satellite, measures pollutants in the troposphere, providing a wealth of data on global pollutants while OSIRIS, on the Swedish Odin satellite, measures ozone in the stratosphere and mesosphere and provides important data to assess and predict the health of the ozone layer.
- The CSA will continue collaborating with the Meteorological Service of Canada and with the National Research Council of Canada in the development of new data products from CloudSat and EarthCARE, and in establishing requirements for future cloud and precipitation radars such as the SnowSat mission.
- Through the participation in European Space Agency Programs, the CSA will support Canadian scientists to access Earth Explorer mission data and Canadian companies to participate in the development of advanced space-borne instruments and user-oriented applications such as:
  - The calibration and validation activities of the Earth Explorer Soil Moisture and Ocean Salinity (SMOS) and CryoSAT-2 missions.
  - The development of applications in the field of aquaculture, forestry and subsidence, global wetland and Polar monitoring.
  - The development of the Electric Field Instrument, designed to monitor the ionosphere for the SWARM mission.
  - The development of algorithms and models, designed to monitor information on snow, glaciers and surface water for the CoreH2O mission.
  - The participation of Canadian scientists in the areas of next generation precipitation observation from space high latitude precipitation measurements.
  - The development of a microbometer detector in the Broadband Radiometer for the EarthCARE Mission and access to the data by scientists involved climate modelling and meteorology.

## **GROUND INFRASTRUCTURE**

- The CSA supports the Canadian GeoSpace Monitoring (CGSM) Program, a network of ground facilities and instruments across Northern Canada. It supports national and international scientific activities related to understanding near-Earth space weather. The CGSM serves also to collect and distribute high quality science data used by other government departments and in support of Solar-Terrestrial science satellite missions including ePOP, PCW, THEMIS and SWARM.
- Canada will pursue discussions for an agreement with the European Commission to ensure continued participation of Canadian companies in supplying space and ground segment subsystems for the missions Sentinel-1, 2 and 3 of the European Global Monitoring for Environment and Security (GMES) space component program. It is expected that Canadian northern ground stations will play a role in receiving the Sentinel data. Sentinel missions will provide useful data to an array of Canadian users including Canadian Government departments such as the Canada Centre for Remote Sensing (CCRS) as well as the Natural Resources Canada (NRCan) for Sentinel-2 and-3 data for land cover and forestry application, and the Department of Fisheries and Oceans (DFO) for Sentinel-3 data for ocean colour application.
- In satellite navigation, the CSA will continue its collaboration with ESA on the development of the Galileo ground infrastructure to support the monitoring of the quality of the localisation signal generated by the four experimental In-Orbit-Validation satellites planned to be launched in 2011-2012.

## 1.2. Space Exploration

**Description:** This Program Activity provides valuable Canadian science, signature technologies and qualified astronauts to international space exploration endeavours. This Program Activity contributes to the Government of Canada's Science and Technology Strategy. It could also generate spin-offs that contribute to a higher quality of life for Canadians and could foster nation-building. This Program Activity appeals to the science and technology communities and generates excitement within the population in general. It is targeted mostly towards Canadian academia and international space exploration partnerships. Canadian industry also benefits from the work generated within this Program Activity.

<b>SPACE EXPLORATION</b>			
<b>PROGRAM ACTIVITY PERFORMANCE MEASUREMENT</b>			
<b>Expected Result #1</b>		<b>Performance Indicator</b>	
Expansion of scientific knowledge acquired through space exploration endeavours.		1. Number of peer-reviewed scientific publications, reports and conference proceedings using space exploration information and produced by researchers (sciences and technologies) in Canada.	
<b>Expected Result #2</b>		<b>Performance Indicator</b>	
Multiple use and applications of knowledge and know-how acquired through space exploration endeavours.		1. Number of terrestrial applications and of space re-utilization of knowledge and know-how acquired through space exploration endeavours.	
<b>Planning and Reporting Continuity:</b>			
RPP 2010-2011 and DPR 2009-2010: <a href="http://www.asc-csa.gc.ca/asc/eng/resources/publications/default.asp#parliament">http://www.asc-csa.gc.ca/asc/eng/resources/publications/default.asp#parliament</a>			
<b>RESOURCES</b>	<b>2011-2012</b>	<b>2012-2013</b>	<b>2013-2014</b>
<b>FINANCIAL</b> (\$ in millions)	152.4	98.5	88.8
<b>HUMAN</b> (FTEs)	189.1	189.1	189.1

**Space Exploration programs are grouped into three Sub-Activities:**

- **International Space Station;**
- **Exploration Missions and Technology; and,**
- **Human Space Missions and Support.**

**Program Sub-Activity: 1.2.1. International Space Station (ISS)**

**Description:** This Program Sub-Activity (SA) uses the International Space Station (ISS) – a unique Earth orbiting laboratory – to learn, to live and work in space while conducting scientific, medical and engineering studies. It includes the assembly and maintenance of the ISS through the use of the Canadian Mobile Servicing System (MSS) and the design, development and operations of payloads and technological demonstrations aboard the ISS. This SA is necessary to generate specific understanding and technological advances to prepare for the challenges of space exploration and for terrestrial benefits. This SA provides Canadian industry and academia privileged access to the ISS.

This SA is performed in collaboration with Other Government Departments (OGDs) and foreign space agencies. This collaborative effort is captured under contracts, contributions, grants and/or international partnership agreements.

<b>INTERNATIONAL SPACE STATION (ISS)</b>			
<b>PROGRAM SUB-ACTIVITY PERFORMANCE MEASUREMENT</b>			
<b>Expected Result #1</b>		<b>Performance Indicator</b>	
Development of operational and technological know-how related to long-duration space missions (with potential Earth application) acquired through participation in the International Space Station (ISS) operations and laboratory missions.		1. Number and percentage (and description) of Canadian missions/solutions/instruments flown on ISS that met their mission requirements.	
<b>Expected Result #2</b>		<b>Performance Indicator</b>	
Canada, a well-positioned partner, influences the ISS program direction.		1. CSA active participation in ISS program boards and panels.	
<b>RESOURCES</b>	<b>2011-2012</b>	<b>2012-2013</b>	<b>2013-2014</b>
<b>FINANCIAL</b> (\$ in millions)	44.3	43.4	47.9
<b>HUMAN</b> (FTEs)	92.65	92.05	93.15

**This Sub-Activity is further divided into two Sub-Sub-Activities.**

***Program Sub-Sub-Activity: 1.2.1.1. International Space Station Assembly and Maintenance Operations***

**Description:** This Program Sub-Sub-Activity (SSA) includes the provision and operation of the Canadian Mobile Servicing System (MSS), composed of three Canadian robots – Canadarm2, Dextre and the Mobile Base System. MSS operations and maintenance services are conducted by Canadian or foreign astronauts on board the International Space Station (ISS) and by ground controllers and engineers located in established facilities at the Canadian Space Agency (CSA) and the National Aeronautics and Space Administration (NASA) – Johnson Space Center. This SSA also includes the provision of specialized MSS training, systems engineering and software services, flight procedures development as well as the facility infrastructure necessary to operate the MSS through its life cycle. This SSA is necessary to fulfill Canada's ongoing commitment to the international partnership to assemble and maintain the ISS, a legally binding obligation under the Canadian *Civil International Space Station Agreement Implementation Act*.

Expected Result #1	Performance Indicator		
The Canadian contribution (Mobile Servicing System) meets the planned operational requirements identified in the ISS Increment Definition Requirements Document (IDRD) in accordance with the Intergovernmental Agreement (IGA) and the NASA/CSA Memorandum of Understanding (MOU).	1. The Mobile Services System (MSS) fulfills its operational requirements. (Target: Scheduled MSS operations conducted in accordance with ISSP requirements)		
RESOURCES	2011-2012	2012-2013	2013-2014
FINANCIAL (\$ in millions)	40.1	39.3	39.9
HUMAN (FTEs)	82.1	81.5	82.6

***Program Sub-Sub-Activity: 1.2.1.2. International Space Station Utilization***

**Description:** This Program Sub-Sub-Activity (SSA) encompasses the implementation of scientific, operational, medical and technological studies in specific areas, such as life sciences, radiation, material or fluid sciences, to be conducted aboard the International Space Station (ISS) by Other Government Departments (OGDs), academia or the private sector. This ISS offers them the advantages of an orbiting platform with human presence and prolonged microgravity exposure. This SSA is necessary for testing novel technologies and conducting scientific studies in the unique environment of the ISS, leading to a better understanding of long-duration space missions and to potential terrestrial benefits.



This SSA is performed in collaboration with Other Government Departments (OGDs) and foreign space agencies. This collaborative effort is captured under contracts, contributions, grants and/or international partnership agreements.

Expected Result #1		Performance Indicators		
Optimal utilization of the International Space Station (ISS).		1. Ratio of programmatic objectives achieved through ISS utilization. (Target: 2 fields out of 5)  2. Number of Canadian stakeholders involved in activities on the ISS. (Target: To be reported retroactively)  3. Proportion of ISS resources used. (Target: 100%)		
RESOURCES	2011-2012	2012-2013	2013-2014	
FINANCIAL (\$ in millions)	4.2	4.1	7.9	
HUMAN (FTEs)	10.6	10.6	10.6	

**Program Sub-Activity: 1.2.2. Exploration Missions and Technology**

**Description:** This Program Sub-Activity (SA) encompasses the development and use of astronomy and planetary missions as well as the development of advanced exploration technologies. This SA is necessary as it contributes valued Canadian signature technologies to international space exploration endeavours and generates a better understanding of the universe, the solar system and our home planet. It could also lead to technology transfers for terrestrial benefits. This SA provides Canadian industry and academia with unique opportunities through their participation in international space exploration initiatives.

This SA is performed in collaboration with foreign space agencies, Other Government Departments (OGDs) and through CSA participation in international groups, such as the International Space Exploration Coordination Group. This collaborative effort takes shape under contracts, grants, contributions and/or international partnership agreements.

EXPLORATION MISSIONS AND TECHNOLOGY PROGRAM SUB-ACTIVITY PERFORMANCE MEASUREMENT	
Expected Result #1	Performance Indicator
Technological know-how acquired through Space Exploration endeavours.	1. Proportion of CSA's missions/solutions/instruments that met their mission performance requirements at acceptance review and/or at commissioning.

Expected Result #2		Performance Indicator	
Canada maintains a strategic positioning which supports its capacity to influence space exploration missions and decision making process in key international space exploration forums.		1. Key roles played by the CSA or by CSA's sponsored highly qualified personnel (HQP) on the international scene.	
Expected Result #3		Performance Indicator	
CSA's participation in space exploration missions provides access to scientific data about the Solar system and the universe.		1. Use of CSA's sponsored space astronomy and planetary missions' data by Canadian scientific community.	
RESOURCES	2011-2012	2012-2013	2013-2014
FINANCIAL (\$ in millions)	102.3	49.7	34.9
HUMAN (FTEs)	71.58	72.15	71.05

**This Sub-Activity is further divided into three Sub-Sub-Activities.**

***Program Sub-Sub-Activity: 1.2.2.1. Space Astronomy Missions***

**Description:** This Program Sub-Sub-Activity (SSA) encompasses the definition, design, technology development, implementation and use of complete Canadian space telescope systems and the provision of Canadian instruments, sensors and sub-systems to international space telescope or probe missions. This SSA is necessary to generate scientific data about the universe through the observation of the solar system and deep space.

This SSA is performed in collaboration with foreign space agencies, Other Government Departments (OGDs) and through consultation with the Canadian Astronomical Society. This collaborative effort takes shape under contracts, grants, contributions and/or international partnership agreements.

Expected Result #1		Performance Indicator	
Canadian know-how and expertise allow Canada to lead or participate in international space astronomy missions.		1. Number of technological and scientific solutions being developed by the CSA in the context of astronomy missions. (Target: 2)	
RESOURCES	2011-2012	2012-2013	2013-2014
FINANCIAL (\$ in millions)	18.7	9.8	5.6
HUMAN (FTEs)	13.2	14.8	14.7

***Program Sub-Sub-Activity: 1.2.2.2. Planetary Missions***

**Description:** This Program Sub-Sub-Activity (SSA) encompasses the definition, design, technology development, implementation and use of Canadian exploration signature technologies and scientific instruments made available to international exploration missions. The SSA is necessary to reach remote bodies (planets, asteroids, etc.) and to conduct detailed observations and science.

This SSA is performed in collaboration with the International Space Exploration Coordination Group, Other Government Departments (OGDs) and foreign space agencies. This collaborative effort takes shape under contracts, grants, contributions and/or international partnership agreements.

Expected Result #1		Performance Indicator		
Canadian know-how and expertise allow Canada to participate in planetary exploration missions.		1. Number of technological and scientific solutions being developed by the CSA in the context of planetary missions. (Target: 4)		
RESOURCES	2011-2012	2012-2013	2013-2014	
FINANCIAL (\$ in millions)	11.0	23.8	18.2	
HUMAN (FTEs)	10.9	9.5	9.5	

***Program Sub-Sub-Activity: 1.2.2.3. Advanced Exploration Technology Development***

**Description:** This Program Sub-Sub-Activity (SSA) includes the development of advanced Canadian signature technologies to be used in potential astronomy and planetary missions that could be destined for the Moon, Mars, asteroids or other celestial bodies. This SSA is necessary to shape or determine the nature of Canada’s contribution to potential international exploration and astronomy missions and could lead to spin-offs. In addition, the SSA includes terrestrial deployments in analogue sites that offer geological similarities with Martian or Lunar surfaces, where this technology and its operational aspects are being tested and where exploration-related science is conducted for proof of concepts.

This SSA is performed in collaboration with foreign space agencies and Other Government Departments (OGDs) and through the Canadian Space Agency participation in international groups, such as the International Space Exploration Coordination Group. This collaborative effort takes shape under contracts and/or international partnership agreements.

Expected Result #1		Performance Indicator		
Maturing science, technology and operational solutions for planning and strategic positioning purposes.		1. Number of science, technology and operational solutions that are under development in conformity with the orientations and conclusions of the Canadian Space Exploration strategic plan. (Target: 47)		
RESOURCES		2011-2012	2012-2013	2013-2014
FINANCIAL (\$ in millions)		72.6	16.1	11.1
HUMAN (FTEs)		47.5	47.9	46.9

### Program Sub-Activity: 1.2.3. Human Space Missions and Support

**Description:** This Program Sub-Activity (SA) encompasses all activities required to recruit, develop, train and maintain a healthy and highly-qualified Canadian astronaut corps capable of participating in space exploration missions. It also includes all activities directed at mitigating health risks associated with those missions, such as the development of advanced technologies to be used in support of human space missions. This SA is necessary to generate specialized knowledge in fields that sustain human space flights, such as life sciences and space medicine. Furthermore, by exploring technological solutions to the various challenges of human space flight, this SA could contribute to alternate healthcare delivery mechanisms for terrestrial applications.

This SA is performed with Other Government Departments (OGDs) and foreign space agencies. This collaborative effort is formalized under contracts, grants, contributions or international partnership agreements.

HUMAN SPACE MISSIONS AND SUPPORT				
PROGRAM SUB-ACTIVITY PERFORMANCE MEASUREMENT				
Expected Result #1		Performance Indicator		
Human space flight generates “unique” health and life sciences knowledge, and technological know-how to sustain life and mitigate health risk during long-duration space flight.		1. Number of activities that lead to health risk mitigation strategies, technologies and/or countermeasures.		
RESOURCES		2011-2012	2012-2013	2013-2014
FINANCIAL (\$ in millions)		5.9	5.4	6.1
HUMAN (FTEs)		24.9	24.9	24.9

**This Sub-Activity is further divided into three Sub-Sub-Activities.**

***Program Sub-Sub-Activity: 1.2.3.1. Astronaut Training and Missions***

**Description:** This Program Sub-Sub-Activity (SSA) encompasses activities associated with all phases of an astronaut career from recruitment to retirement, including space missions. This SSA includes the management of National Astronaut Recruitment Campaigns; the implementation of individualized astronaut career management plan; the implementation of basic, advanced and mission-specific training; collateral duties assignment; space mission negotiations and assignment; as well as all the logistical, administrative and operational support activities in the pre-flight, in-flight and post-flight periods. This SSA is necessary to live and work in a space environment and in order to further our understanding of human behaviour and health in space, and to conduct experiments and collect space-based scientific data useful to the science community.

This SSA is performed with Other Government Departments (OGDs) and foreign space agencies. This collaborative effort is formalized under contracts or international partnership agreements.

Expected Result #1		Performance Indicator		
Canadian astronaut corps is ready to assume any responsibilities on an expedition to the International Space Station (ISS).		1. Number of astronaut activities undertaken in preparation for eventual ISS mission assignments. (Target: 3)		
RESOURCES	2011-2012	2012-2013	2013-2014	
FINANCIAL (\$ in millions)	4.0	3.7	3.7	
HUMAN (FTEs)	16.6	16.6	16.6	

***Program Sub-Sub-Activity: 1.2.3.2. Operational Space Medicine***

**Description:** This Program Sub-Sub-Activity (SSA) delivers operational and clinical healthcare activities during all phases of basic, advanced and mission-specific training as well as during the pre-flight, in-flight and post-flight periods. It also promotes and ensures the physical, mental, social well-being and safety of Canadian astronauts. This SSA is necessary to ascertain the overall health of Canadian astronauts and to monitor long-term health status.

This SSA is performed with Other Government Departments (OGDs) and foreign space agencies. This collaborative effort is formalized under contracts, grants, contributions or international partnership agreements.

Expected Result #1		Performance Indicator		
Astronauts' health is optimized to meet mission requirements.		1. Number of active astronauts medically certified for ISS assignment and duties. (Target: 2/3)		
Expected Result #2		Performance Indicator		
Astronauts' long-term health is monitored following their active careers.		1. Ratio of eligible astronauts participating in their long-term health monitoring. (Target: 4/7)		
RESOURCES	2011-2012	2012-2013	2013-2014	
FINANCIAL (\$ in millions)	1.3	1.1	1.3	
HUMAN (FTEs)	2.9	2.9	2.9	

***Program Sub-Sub-Activity: 1.2.3.3. Health and Life Sciences***

**Description:** This Program Sub-Sub-Activity (SSA) encompasses space medicine and life sciences activities that explore health care delivery and life sustainability solutions on future long-duration exploration missions. These benefits are targeted at the space exploration community, mainly academia and partnering agencies. This SSA develops collaborative projects with academia and industry. It uses analog sites that offer relevant similarities with the harsh environment of space, and where exploration-related medical and life science studies are conducted. This SSA is necessary to identify, understand, mitigate or eliminate health risks associated with human space flights, and to understand and address the needs of humans during those missions. The solutions could also be offered as alternative healthcare delivery mechanisms for terrestrial benefits through the transfer of space technology.

This SSA is performed with Other Government Departments (OGDs) and foreign space agencies. This collaborative effort is formalized under contracts, grants, contributions or international partnership agreements.

Expected Result #1		Performance Indicators		
Performance of space life sciences studies with potential benefits for Canadians and to enable human exploration of space.		1. Number of studies aiming at the development of countermeasures and enhanced human performance and life support. (Target: 3)		
		2. Number of partnerships addressing potential terrestrial healthcare solutions. (Target: 2)		
RESOURCES	2011-2012	2012-2013	2013-2014	
FINANCIAL (\$ in millions)	0.6	0.5	1.1	
HUMAN (FTEs)	5.4	5.4	5.4	

## Highlights of Expected Accomplishments for Space Exploration

### ISS OPERATIONS AND UTILIZATION

- The CSA will continue to fulfill its obligations towards the Mobile Servicing System (MSS). This involves maintaining and providing technical support for the MSS hardware and software, continuing the repair and overhaul of failed hardware, providing MSS related training and qualification for astronauts, cosmonauts and ground support personnel, planning and supporting MSS operations, and conducting operations in conjunction with the NASA Houston flight control room from the Remote Multi-Purpose Support Room in St-Hubert, Québec.
- The CSA will continue to maintain MSS operational preparedness to carry out ISS assembly and maintenance operations. This will entail the development and certification of new flight products and procedures to support MSS operations. The CSA will also continue the upgrade of its ground control operations. The development of expanded ground control capabilities for future Dextre operations will enable more efficient on-orbit utilization of this new element and thereby significantly reduce astronaut time requirements.
- The CSA, along with its ISS International Partners, will continue the assessment of how to extend the operating life of the Mobile Servicing System to 2029. Initially, the MSS was designed to operate for a 15 year period. This milestone will be reached in 2015.
- The CSA will release MSS-7.1 software versions, which will provide further capabilities to reduce the amount of analysis required during mission preparation and also provide more autonomy to the operators of the MSS.
- The CSA will continue its collaboration with NASA for on-orbit technology demonstration experiments using Dextre on the International Space Station, including the on-orbit Robotic Re-fueling Mission.
- The CSA will continue to work with the European Space Agency to support the activities of research that plan to utilize the CSA-developed Microgravity Vibration Isolation System (MVIS), which is part of the Fluid Science Laboratory on the ISS.
- The CSA will continue to support experiments and educational activities on the ISS such as:
  - The APEX-Cambium wood experiment seeks evidence that gravity has a direct effect on the cells that contribute to the formation of reaction wood in willows. Current activities focus on the completion of scientific requirements for full gravity control plants, and the subsequent microscopic and chemical analysis of the plants flown in ISS. Such knowledge is critical to both the paper and lumber industries.

- In collaboration with Natural Resources Canada, the APEX-CSA2 experiment used white spruce, an economically important species for the forest industry, to determine the effects of gravity on gene expression. The remaining activities consist of laboratory analysis and interpretation of the plant material flown in space and on Earth. Both Cambium and APEX-CSA2 resulted from a close collaboration with the Kennedy Space Centre of NASA.
- Three experiments, namely called Bodies in the Space Environment (BISE), Vascular and Hypersole, will attempt to better understand the effects of long-duration microgravity on human adaptability and health. The Hypersole experiment, led by scientists at the University of Guelph (Ontario), uses shuttle crew members to study the changes in the foot sole skin sensitivity that occur during spaceflight, to better understand balance control. This experiment is expected to be completed with the final shuttle flight in 2011. This knowledge is key to supporting future human space exploration as well as having Earth benefits.
- The Cardiovascular and Cerebral control on ISS (CCISS) experiment completed its ISS requirements, and the science team at the University of Waterloo (Ontario) is carrying out its analysis of the data. This study aims to uncover the root causes for the susceptibility to fainting observed when astronauts return to Earth. This experiment's results, as well as those of BISE, Vascular and Hypersole, will be used to develop new strategies for addressing the adverse effects of spaceflight on humans, thus leading to decreased risk in future exploration studies. They all also hold relevancy and application to disease conditions and disease risks on Earth.
- BCAT-C1 (Binary Colloid Alloy Test) is a continuation of the successful BCAT-5 (NASA-CSA collaboration) experiment, which gathers unique data on the physical characteristics of colloids which are important constituents of many commercial products. Hitherto unseen crystalline structures were observed during BCAT-5 and further novel discoveries are expected in this follow-on experiment.
- Through the International Space Life Sciences Working Group (ISLSWG), the CSA works with the European Space Agency (ESA), the Japan Aerospace and Exploration Agency, NASA, the German Space Agency (DLR), the French Space Agency (CNES) and the Italian Space Agency (ASI) to coordinate space life sciences and multinational world-class scientific research on the ISS. Proposals that were selected during the 2009 International Life Sciences Research Announcement will be developed for execution on the ISS in the 2012-2014 timeframe.



## EXPLORATION MISSION AND TECHNOLOGY

- In 2011-2012, the CSA will continue to work with its industrial contractor team to deliver the projects under the *Stimulus* initiative on space robotics announced as part of Canada's Economic Plan. The *Stimulus* initiative is developing terrestrial prototypes of the next generation Canadarm and prototypes of different rovers and their associated technologies for Moon and Mars exploration. Using the Exploration Core funding, the CSA will also issue contracts for the development of science instruments and to support analogue mission deployments.
- The TriDAR vision system will be used on a third flight in 2011 for docking the space shuttle to the ISS. This project is a joint venture with NASA. The technology is relevant to space applications that could include rendezvous and docking, rover navigation and terrain mapping, as well as a number of terrestrial spin-offs.
- The CSA will continue to participate actively to the International Space Exploration Coordination Group (ISECG). This group was created in 2007 to promote coordination of Moon and Mars exploration between 14 space agencies around the world. In 2011, the ISECG will present the Global Exploration Roadmap for robotics and human exploration of the Moon, Mars and asteroids to the Heads of various space exploration programs including the CSA.
- Through partnership with the European Space Agency (ESA), the CSA will position the Canadian industry and scientists in future scientific and technological developments relating to the European Aurora planetary exploration program, the Lunar Lander mission and to the physical and life sciences ELIPS-2 and ELIPS-3 programs. The CSA is also contributing to the International Berthing and Docking Mechanism activity since this represents a key Canadian technology niche.
- The CSA will collaborate with the European Space Agency on the operations and analysis of bed-rest studies through the ELIPS Program. Bed-rest is an excellent simulation of spaceflight with regards to physiological effects, and provides both improved understanding of the response of the human body to deliverance from gravity, and the ability to test new spaceflight countermeasures on the ground.
- Canada is participating in the James Webb Space Telescope (JWST), a major facility-class space observatory that will be launched in 2014. The JWST is a successor to the highly successful Hubble Space Telescope. Canada is responsible for the design and construction of the Fine Guidance Sensor (FGS), a critical element of the mission, which ensures the very precise pointing of the telescope and the provision to the international astronomical community of simultaneous images. The manufacturing and testing of the FGS will continue in 2011 in order to be delivered to NASA during the year. By virtue of CSA's contribution, Canadian astronomers will have guaranteed access to 5% of the observing time of the James Webb Space Telescope.

- The CSA will continue to support the integration of the Flight Detector Subsystem for the Ultra Violet Imaging Telescope (UVIT) on board the ASTROSAT satellite of the Indian Space Research Organization (ISRO). The subsystem was delivered to ISRO in February 2010. ASTROSAT is scheduled for launch by 2011. The CSA's participation will guarantee 5% of the observing time for Canadian scientists and access to ASTROSAT's astronomic data.
- The CSA will continue to support the assembly and test launch operations of the Alpha Particle X-ray Spectrometer (APXS) for the Mars Science Laboratory to be launch in 2011. The Canadian contribution will help scientists to determine the chemical composition of various soil, dust and rock samples on Mars.
- The CSA will complete the feasibility study and will begin the design of an instrument called MATMOS (Mars Atmospheric Trace Molecule Occultation Spectrometer) for the detection, profiling, and mapping of trace gases in the MARS atmosphere. This Canadian instrument will be part of the 2016 joint ESA/NASA Exomars Trace Gas Orbiter mission, aimed at reaching a better understanding of the Martian atmosphere and its evolution over time.
- The CSA will continue feasibility studies for a potential participation in the NASA New Frontiers program. The CSA could provide an instrument to three candidate missions: Moonrise, a lunar sample return mission, OSIRIS-Rex, an asteroid sample return mission, and SAGE, a planetary explorer to study the surface and atmosphere of Venus. NASA will likely make the selection of the best mission by mid-2011.
- The CSA will complete the feasibility study and, if successful, will begin the design of a metrology system for participation in JAXA's lead ASTRO-H mission, an X-ray space astronomy telescope, scheduled for launch in 2014. This mission also includes participation from Europe and NASA. The CSA's participation will enable Canadian scientists to apply for observation time on the telescope.
- With the successful launch of ESA's Herschel and Plank space telescope, in May 2009 to study how galaxies were formed in the early universe and how stars have been created throughout the history of time, CSA will continue to support the Canadian science teams involved in the operations and utilization of instruments on board this space observatory.
- The CSA will continue to support the Canadian science team with the operations and utilization of MOST, a micro-satellite, carrying a space telescope to study Micro-variability & Oscillations of Stars. Since its launch in 2003, MOST has vastly exceeded expectations by observing approximately 2000 targets during 7 years of operations.

## **HUMAN SPACE MISSIONS AND SUPPORT**

- Canadian astronaut Chris Hadfield has been assigned to the second Canadian long-duration mission to the ISS. Mr Hadfield will live and work on the ISS for 6 months from November 2012 to May 2013 and will become the first Canadian to command the vehicle and its crew.
- The CSA will maintain its human space flight expertise to meet the requirements of the CSA's exploration program. Two Canadian astronaut candidates will continue basic training at NASA's Johnson Space Center in preparation for long-duration space flight assignments to the International Space Station. The Canadian astronaut corps will adapt to the new reality of fewer flight opportunities as a result of the Shuttle retirement and will continue to utilize the expertise and skill set of flown astronauts to advance and position the Canadian Human Space flight program.
- The CSA will plan and start setting the framework for the medical support for the second Canadian long-duration mission scheduled for 2012-2013. For this purpose the lessons learned from the 2009 long-duration mission will be analyzed and taken into account. The CSA will also continue the monitoring and coordination of medical support with international partners and actively support the ISS Medical committees.
- The CSA will continue to explore how the Advanced Astronaut Medical Support (ADAMS) project can contribute to human exploration. More specifically, the CSA will explore solutions to the delivery of healthcare on future long duration exploration-class missions and how these solutions can help improve healthcare delivery on Earth through the transfer of space technologies. CSA will develop collaborative projects with academia and industry and will continue to use analog environments for requirements definition and proof of concept. As part of the ADAMS project, the CSA will continue to investigate the development of a tool called PRET (Performance Readiness Evaluation Tool) through its participation in the MARS 500 Russian Isolation Study to assess the neurocognitive functions and readiness to perform complex tasks, an internationally approved medical requirement of the ISS that is yet to be fully met.

### 1.3. Future Canadian Space Capacity

**Description:** This Program Activity attracts, sustains and enhances the nation’s critical mass of Canadian space specialists, fosters Canadian space innovation and know-how, and preserves the nation’s space-related facilities capability. In doing so, it encourages private-public collaboration that requires a concerted approach to future space missions. This Program Activity secures the nation's strategic and ongoing presence in space in the future and to preserve Canada’s capability to deliver internationally renowned space assets for future generations. It is targeted at Canadian academia, industry and youth, as well as users of Canadian space solutions (Other Government Departments (OGDs) and international partners).

<b>FUTURE CANADIAN SPACE CAPACITY</b>			
<b>PROGRAM ACTIVITY PERFORMANCE MEASUREMENT</b>			
<b>Expected Result #1</b>	<b>Performance Indicators</b>		
Canada has a space community (academia, industry and government) able to contribute to the sustained and strategic Canadian use of space.	1. Vitality index of the Canadian space community (academic, industrial and government communities in terms of HQP, S&T investments and development facilities, university space-related programs and research facilities).  2. Degree of match between workforce supplied and space community (industry and government) workforce requirements.		
<b>Planning and Reporting Continuity:</b>			
RPP 2010-2011 and DPR 2009-2010: <a href="http://www.asc-csa.gc.ca/asc/eng/resources/publications/default.asp#parliament">http://www.asc-csa.gc.ca/asc/eng/resources/publications/default.asp#parliament</a>			
<b>RESOURCES</b>	<b>2011-2012</b>	<b>2012-2013</b>	<b>2013-2014</b>
<b>FINANCIAL</b> (\$ in millions)	86.1	65.2	72.3
<b>HUMAN</b> (FTEs)	121.5	121.5	121.5

**Programs under Future Canadian Space Capacity are grouped into three Sub-Activities:**

- **Space Expertise and Proficiency;**
- **Space Innovation and Market Access; and,**
- **Qualifying and Testing Services.**

**Program Sub-Activity: 1.3.1. Space Expertise and Proficiency**

**Description:** This Program Sub-Activity (SA) includes the development and enhancement of Canada’s space capacity through people. To do so, it supports research in private or public organizations and includes learning activities targeted at Canadian youth. This is accomplished by encouraging scientists and engineers to pursue relevant space science and technology development activities with attractive initiatives and top facilities, and by promoting scientific and technical studies with Canadian students. This SA is necessary to create and sustain a pool of space expertise and proficiency that will form the next generation of space professionals and workers, continuously able to provide solutions for future Canadian space endeavours. The activities are carried out mostly by Canadian academia, under the leadership of, in collaboration with, and with the support of the CSA and/or industry.

This SA is delivered with the participation of funding agencies, Other Government Departments (OGDs), foreign space agencies, not-for-profit organizations and provincial governments. This collaborative effort is formalized under grants, contributions or national and international partnership agreements or contracts.

<b>SPACE EXPERTISE AND PROFICIENCY</b>			
<b>PROGRAM SUB-ACTIVITY PERFORMANCE MEASUREMENT</b>			
<b>Expected Result #1</b>	<b>Performance Indicators</b>		
A pool of space experts and professionals is sustained and enhanced.	1. Number of organizations that incorporate the space theme in their program planning.  2. Number of registrations in space relevant learning activities (post-secondary levels).  3. Number of scientists and engineers pursuing space research and activities.		
<b>RESOURCES</b>	<b>2011-2012</b>	<b>2012-2013</b>	<b>2013-2014</b>
<b>FINANCIAL</b> (\$ in millions)	12.2	11.4	14.7
<b>HUMAN</b> (FTEs)	30	30	30

**This Sub-Activity is further divided into two Sub-Sub-Activities.**

***Program Sub-Sub-Activity: 1.3.1.1. Space Learning***

**Description:** This Program Sub-Sub-Activity (SSA) uses space to increase interest in science and technology among Canadian students and educators and promotes the development of hands-on expertise. This SSA reaches primary, secondary, college and university students through the development of curriculum-based educational materials; through on-site and off-site presentations and training, in class or via distance learning; and through educator professional development, training conferences and workshops. This SSA is necessary to attract and develop tomorrow’s space experts and professionals.

This SSA is delivered in collaboration with Provincial and Territorial Ministries or Departments of Education, Boards of Education, and not-for-profit organizations, and is formalized through grants, contributions, and collaborative agreements and contracts.

<b>Expected Result #1</b>		<b>Performance Indicator</b>		
Educators further their professional development through the space theme.		1. Number of educators reached through professional development initiatives. (Target: 1,221 or more)		
<b>Expected Result #2</b>		<b>Performance Indicator</b>		
Students further their learning related to science and technology through space-related themes.		1. Number of students reached through space-related learning opportunities. (Target: 6,873,623 or more)		
<b>Expected Result #3</b>		<b>Performance Indicator</b>		
Space training and academic programs, initiatives, activities or other opportunities offered are used by targeted institutions.		1. Number of institutions that use space-related themes in their activities. (Target: Benchmarking)		
<b>RESOURCES</b>		<b>2011-2012</b>	<b>2012-2013</b>	<b>2013-2014</b>
<b>FINANCIAL</b> (\$ in millions)		1.4	1.9	2.5
<b>HUMAN</b> (FTEs)		5.0	5.0	5.0

**Program Sub-Sub-Activity: 1.3.1.2. Support to Scientists and Engineers**

**Description:** This Program Sub-Sub-Activity (SSA) includes supporting graduate university students and working professionals through shorter lead-time and small-scale missions that allow frequent flight opportunities and through the upgrade of world-class space research and training facilities that secure Canada’s ongoing strategic presence in space. These actions encourage private and public research establishments to devote portions of their activities to space research. This SSA is necessary to attract scientists and engineers to the space sector and encourage them to develop their space know-how.

This SSA is delivered with the participation of funding agencies, Other Government Departments (OGDs), foreign space agencies, not-for-profit organizations and provincial governments. This collaborative effort is formalized under grants, contributions, or national and international partnership agreements or contracts.

Expected Result #1		Performance Indicators		
Scientists and engineers advance their space proficiency and know-how through the opportunities offered in priority space science and technology areas.		1. Number of scientists and engineers involved through opportunities provided by the program. (Target: 300)  2. Number of opportunities offered per year to scientists and engineers. (Target: 25)  3. Number of collaborative research agreements. (Target: 5)		
RESOURCES	2011-2012	2012-2013	2013-2014	
FINANCIAL (\$ in millions)	10.7	9.5	12.2	
HUMAN (FTEs)	25.0	25.0	25.0	

**Program Sub-Activity: 1.3.2. Space Innovation and Market Access**

**Description:** This Program Sub-Activity (SA) includes the development and enhancement of Canada’s space capacity through innovation and market positioning. Through leading-edge technology and facilities, and international arrangements, the SA improves Canadian industrial competitiveness so that space users are continuously well served through constantly improving optimal and cost-effective space solutions. This SA is necessary to foster entrepreneurship that enhances Canadian industry’s international positioning on commercial and government markets.

This SA is performed with industry and is formalized under contracts or contributions. Foreign space agencies are partners in this endeavour, so that Canadian industry can access foreign markets through innovation or international arrangements.

<b>SPACE INNOVATION AND MARKET ACCESS</b>			
<b>PROGRAM SUB-ACTIVITY PERFORMANCE MEASUREMENT</b>			
<b>Expected Result #1</b>		<b>Performance Indicator</b>	
Through innovation and international arrangements, Canadian industry is well positioned on international commercial and government markets.		1. Number of Canadian companies (size) exporting space-related goods and services (value).	
<b>Expected Result #2</b>		<b>Performance Indicator</b>	
Enhanced Canadian industry competitiveness.		1. Number of Canadian companies successfully obtaining national/international work orders.	
<b>RESOURCES</b>	<b>2011-2012</b>	<b>2012-2013</b>	<b>2013-2014</b>
<b>FINANCIAL</b> (\$ in millions)	67.5	47.4	51.0
<b>HUMAN</b> (FTEs)	50.45	50.45	50.45

**This Sub-Activity is further divided into two Sub-Sub-Activities.**

***Program Sub-Sub-Activity: 1.3.2.1. International Market Access***

**Description:** This Program Sub-Sub-Activity (SSA) consists in facilitating foreign market access by the Canadian space industry through negotiating, implementing and managing special international arrangements. For example, in return for Canadian Space Agency (CSA) monetary contributions to the European Space Agency (ESA) under the long-lasting ESA-Canada Agreement, Canadian industry obtains some of the contracts awarded by ESA; thus penetrating a market that would otherwise be limited to Europeans. This SSA is necessary as it results in increased access to foreign government market share for Canadian industry.

This SSA is delivered through concluding international agreements, trade measures, or other mutually beneficial arrangements that create a favourable political or trade environment that facilitates access to global markets.



Expected Result #1		Performance Indicator		
International arrangements are implemented to open market access.		1. Canadian industrial return through ESA. (Target: Overall industrial return through ESA of 94% or higher)		
Expected Result #2		Performance Indicator		
The Canadian industry has access to flight opportunities for its technologies.		1. Number of space-qualified technologies or components developed by Canadian industry and/or having flown through Canada's participation in ESA Programs. (Target: 2)		
RESOURCES		2011-2012	2012-2013	2013-2014
FINANCIAL (\$ in millions)		48.0	29.6	29.1
HUMAN (FTEs)		4.0	4.0	4.0

***Program Sub-Sub-Activity: 1.3.2.2. Enabling Technology Development***

**Description:** This Program Sub-Sub-Activity (SSA) consists of technology development and demonstration activities that contribute to maintaining or developing a technological edge in promising fields, such as switches, batteries, launchers, antennas, solar panels, etc. This SSA is necessary as the enabling (generic) technology developed reduces costs and technological risks on multiple mission types, enhances the efficiency or performance of already established space solutions, and facilitates the commercialization of new products through innovation.

This SA is performed with industry and is formalized under contracts or contributions.

Expected Result #1		Performance Indicator		
Increased technological capability of Canadian industry.		1. Number of different technologies addressed and their progression against the technology development plan. (Target: 23)		
RESOURCES		2011-2012	2012-2013	2013-2014
FINANCIAL (\$ in millions)		19.5	17.8	22.0
HUMAN (FTEs)		46.5	46.5	46.5

**Program Sub-Activity: 1.3.3. Qualifying and Testing Services**

**Description:** This Program Sub-Activity (SA) consists of specialized activities and services for the assembly, integration, and testing of space hardware and involves space qualifying technology, sub-units, units or entire spacecraft developed by Canadian academic institutions, government organizations, and industry, as well as international partners and clients. This SA is necessary to ensure that mission-assigned technology and entire systems can safely and reliably meet the rigors of space and to demonstrate the suitability and effectiveness of new Canadian space technology for providing valuable contributions to space missions. This provides an effective base for increasing Canada's capability to participate in future space programs.

This SA is delivered by the CSA's David Florida Laboratory on a fee-for-service basis.

<b>QUALIFYING AND TESTING SERVICES</b>			
<b>PROGRAM SUB-ACTIVITY PERFORMANCE MEASUREMENT</b>			
<b>Expected Result #1</b>		<b>Performance Indicators</b>	
Test results of space hardware prove to be reliable in demonstrating suitability for launch and space environment.		1. Maintenance of DFL's certification and conformance to the ISO 9001:2008 standard.  2. Client satisfaction surveys measuring the quality of the services provided.	
<b>RESOURCES</b>	<b>2011-2012</b>	<b>2012-2013</b>	<b>2013-2014</b>
<b>FINANCIAL</b> (\$ in millions)	6.5	6.4	6.5
<b>HUMAN</b> (FTEs)	41.0	41.0	41.0

**Highlights of Expected Accomplishments for Future Canadian Space Capacity**

**AWARENESS ACTIVITIES**

- Awareness campaign marking Canada's fiftieth anniversary of the launch of Alouette-1, signalling Canada's entry into the league of space-faring nations, third after Russia and the United States. The commemoration of this launch also signifies 50 years of outstanding collaboration between Canada and the United States through the National Aeronautics and Space Administration (NASA).
- Development and implementation of a national awareness campaign generating public interest in the C-2 Mission, of Canadian astronaut Chris Hadfield who will live and work aboard the International Space Station for a period of six months. During the last two months of his six month tour Chris Hadfield will become the

first Canadian to assume the role of Commander of the International Space Station, before returning to Earth in June 2013. Throughout 2011-2012, other members of the Canadian astronaut corps will continue to participate in outreach activities and events to heighten awareness of the role and achievements of the CSA programs in support of the priorities of the Government of Canada.

- Awareness initiatives enhancing understanding of the benefits that flow from Canada's continued partnership with Europe following renewal of the Canada-European Space Agency Cooperation Agreement. After thirty years, Canada's membership in ESA continues to strengthen relations, increase collaboration and assure access for Canadian space industries, academia and scientists in European space programs.
- Awareness campaign in support of the launch and operation of Canada's NEOSat, the world's first space telescope designed to track asteroids, satellites and debris in the lower Earth orbit; and Canada's M3MSat, which will demonstrate the viability of a space-based automatic identification system monitoring maritime traffic.
- Awareness campaign on the ongoing construction of the RADARSAT Constellation of three Earth Observation spacecraft that, when launched in 2014 and 2015, will enhance support for Government priorities, securing safety, sovereignty and security, especially in the Arctic, through surveillance activities along its ocean and coastal approaches and in support of Canadian Forces at home and abroad.

#### **SPACE EXPERTISE AND PROFICIENCY**

- Signature of Memorandum of Understanding with the Ministries of Education, Culture and Workforce Development of the Northwest Territories enhancing collaboration and use of space-science-and-technology-focused curriculum, tele-learning, and educators development activities.
- Implementation of a Memorandum of Understanding with the *Association québécoise autochtone en science et en ingénierie* to expand space-focused learning opportunities for First Nations and Inuit students and educators in the province of Quebec.
- Collaboration with *Women in Aerospace Canada* will enhance learning opportunities and career development of Master's and Doctoral level students pursuing degrees in the space sector.
- Leveraging the interests and expertise of university level students trained and acting as Canadian Student Space Ambassadors, who will deliver learning workshops in primary and secondary classrooms across the country.

- Space Educator professional development workshops and an annual conference will expand educator awareness, while providing them with accurate, up-to-date and pedagogically appropriate tools helping them to effectively engage student interest and learning through space science, engineering, mathematics and technology.
- Partnered space-focused learning initiatives led by academia, private sector organizations, not-for-profit groups, and other government institutions will increase the scientific literacy of students and educators in communities across the country.
- Space-focused pedagogical materials and teaching modules will be produced to meet the needs of Provinces and Territories for use by educators and students at the primary and secondary level.
- Web-based learning products will be designed as extra-curricular activities for youth, students and families facilitating a concrete understanding of abstract concepts, and expanding understanding of space science and technology at all levels.
- Attribution of grants and contributions supporting the development of students, and educators who will benefit from learning initiatives, activities, or conference participation related to space science and technology; and, not-for-profit organizations offering national and community space-based science and technology programs targeting Canadian youth, educators and families.
- The CSA provides support to scientists and engineers through two new initiatives: the selection and creation of Research Clusters and the selection of projects to fly on sub-orbital platforms, both through competitive announcements of opportunity. The competitive process begins in 2010-2011, with funding beginning in 2011-2012.
- Through the renewal of its Class Grant and Contribution Program for Research, and Awareness and Learning in Space Science and Technology, the CSA will continue to support the development of science and technology, to foster the development of a critical mass of researchers and highly qualified people in Canada.
- CSA will implement a 2-year Engineering Development Program and recruit 8 new junior engineers (ENG-02) in various disciplines with an expected graduation date of January 2013.
- CSA will expand the technical proficiency of its workforce by maintaining a Professional Development Program and delivering specialized training in space science and technology.

## INNOVATION AND MARKET ACCESS

- Canada's participation in the European Advanced Research in Telecommunications Systems (ARTES) will continue to allow our industry to access forward-looking studies on new telecommunications services, develop new technologies, equipment and applications in multi-media, inter-satellite and mobile communications, and to demonstrate satellite-based communications services such as interactive communications services for remote communities and for disaster management.
- The CSA will continue to support the maturation of Canadian space technologies in view of their potential use in ESA missions and to support Canadian industry's participation to In-orbit technology demonstration missions such as Proba-3.
- By using the Partnership Support Program and Natural Sciences and Engineering Research Council of Canada's (NSERC) Collaboration R&D Program, the CSA and NSERC will continue to foster close collaboration between industry, universities and government in space research and technology development, and to develop a critical mass of researchers and highly qualified people in Canada in areas relevant to the priorities of the Canadian Space Agency.
- Using the results for the CSA's long-term roadmaps exercise for space technology development based on the needs of future missions, the CSA will issue R&D contracts in areas that have been selected after consultation with Government, industry and academia. The CSA will therefore continue to ask industry and research organizations to work on identified priority technologies in order to retire risk on the technologies required for future missions of Canadian interest, and contribute to the enhancement of Canadian capabilities. Examples of projected science and technology development activities in 2011-2012 are:
  - Critical technologies to reduce risks and enable implementation of the Polar Communications and Weather (PCW) and similar HEO missions;
  - New generation of imaging sensors operating the visible and near infrared region for astronomical instruments' improvements;
  - "Lab-on-a-chip" Technology for in-situ cellular or molecular analysis required for long duration space missions;
  - Digital beam forming antenna prototype for multi-satellite acquisition; and,
  - Thermo-mechanical detector for the spatial heterodyne observation of water.
- The CSA will conclude technology development for risk reduction on the QuickSat microsatellite bus. A mission will be proposed to take advantage of the flight opportunity offered by this platform, and activities to confirm its feasibility and target performance will be initiated. Activities to adjust the microsatellite bus to the selected mission will be initiated.

- The CSA will continue to participate actively in the International Space Debris Coordination Committee (IADC). This committee is an international government forum of 13 space Agencies, for the global coordination of research activities related to man-made and natural debris in space. CSA access to the latest space debris research activities will minimize potential threats to Canadian satellites and other space assets.
- The CSA will complete Phase 0/A of the Concurrent Design Facility (CDF) which is a computer-based system that facilitates fast and efficient design of space missions by gathering all engineering disciplines in the same room, thus allowing concurrent design and validation of space missions. Combining calculation, simulation and visualization tools, the CDF will provide the CSA, industry and academia the capability to perform higher quality and detailed feasibility studies in a few weeks.
- The CSA will manage its portfolio of patents and intellectual property licenses in order to support the commercialization of space technologies and the transfer of space technologies and their applications to other sectors of the economy to enhance Canada's industrial competitiveness.

#### **QUALIFYING AND TESTING SERVICES**

- The David Florida Laboratory (DFL) will continue to provide world-class and cost-effective environmental space qualification services for the assembly, integration and testing of spacecraft systems to CSA's programs, as well as national and international clients. The CSA intends to make its research facilities more accessible and available to academia and the Canadian space industry. Significant facilities and equipment updating will have to commence in 2011 in order to fulfil the requirements foreseen for 2013 and beyond. The hardware for many priority projects in 2011-2012 will be assembled and tested at DFL:
  - Space Exploration: The DFL will continue testing activity on both the James Webb Space Telescope Fine Guidance Sensor, and NEOSat. In addition, DFL will be supporting the environmental test programs for the Exploration Surface Mobility Program, again initially at the sub-system level and progressing through to the full rovers.
  - Satellite Communications: M3MSat testing has moved into fiscal year 2011-2012 with the majority of testing to be completed in the first half of the fiscal year.
  - Earth Observation: On the RADARSAT Constellation Mission (RCM), the DFL will be involved in both component and subsystem level testing on RCM prior to the initiation of the environmental test campaign on the all-up spacecraft scheduled for fiscal year 2012-2013 through to fiscal year 2014-2015.
  - Commercial Programs such as:
    - MDA / Space Systems Loral (S/C G, S/C H)
    - MDA (Express AM5 and EM6), various antennas and reflectors
    - Advantech – Probe (EMC)

- Alenia – SICRAL 2 Satellite Program (Antenna RF & PIM)
  - Belair Networks – Wireless Communications (Antenna RF)
  - Blinq Networks – Wireless Communications (Antenna RF)
  - CMC Electronics – Inmarsat Satcom (Antenna RF & PIM)
  - COMDEV – switch(es) (multipaction)
  - Dowkey – MUOS – switch(es) (multipaction)
  - CarlisleIT/ECS – cables (PIM)
  - EMS Satcom/Ottawa – Inmarsat Satcom (Antenna RF & PIM)
  - Lockheed Martin – CFP (EMC)
  - L3 Targa – DTU (EMC)
  - Optech – ALTM (EMC)
  - Rutter – antenna (Antenna RF)
  - RYMSA – Galileo antennas (PIM)
  - Sanmina – SCI – Wireless Communications (Antenna RF)
  - Tallysman – Glonass/GPS (Antenna RF)
  - TenXc Wireless – Wireless Communications (Antenna RF)
- o Other Government Departments (OGDs): Department of National Defence (Sapphire); DND and L3 Communications (CF-18 Radome Characterization Projects).

## 1.4. Internal Services

**Description:** In accordance with the Management Accountability Framework this Program Activity serves to implement the government’s commitment to modern Public Service management. Internal Services include only those activities and resources that apply across an organization in the areas of Governance and Management Support which includes Management and Oversight Services, Communications Services, and Legal Services; Resource Management which includes Human Resources Management Services, Financial Management Services, Information Management Services and Information Technology Services; and Asset Management which includes Real Property Services, Material Services, and Acquisition Services.

<b>INTERNAL SERVICES</b>			
<b>PROGRAM ACTIVITY PERFORMANCE MEASUREMENT</b>			
<b>Expected Result #1</b>		<b>Performance Indicator</b>	
Internal Services provide an added value to CSA managers in the performance of their duties.		1. CSA's rating against MAF criteria based on Round VIII assessment.	
<b>Expected Result #2</b>		<b>Performance Indicator</b>	
The highest priority risks identified in the CSA corporate risk profile are addressed and mitigated.		1. Mitigation action plans are implemented against the corporate risks identified as highest priorities.	
<b>Planning and Reporting Continuity:</b>			
RPP 2010-2011 and DPR 2009-2010: <a href="http://www.asc-csa.gc.ca/asc/eng/resources/publications/default.asp#parliament">http://www.asc-csa.gc.ca/asc/eng/resources/publications/default.asp#parliament</a>			
<b>RESOURCES</b>	<b>2011-2012</b>	<b>2012-2013</b>	<b>2013-2014</b>
<b>FINANCIAL</b> (\$ in millions)	49.4	47.8	48.5
<b>HUMAN</b> (FTEs)	295.9	296.0	296.0

**Internal Services are grouped into three Sub-Activities:**

- **Governance and Management Support;**
- **Resource Management Services; and,**
- **Asset Management Services.**



**Program Sub-Activity: 1.4.1. Governance and Management Support**

RESOURCES	2011-2012	2012-2013	2013-2014
FINANCIAL (\$ in millions)	17.5	16.3	16.5
HUMAN (FTEs)	93.82	93.95	93.95

**This Sub-Activity is further divided into three Sub-Sub-Activities. *Legal Sub-Sub-Activities* doesn't appear in this report.**

***Program Sub-Sub-Activity: 1.4.1.1. Management and Oversight***

**Description:** Management and Oversight services involve activities undertaken for determining strategic direction and governance, program planning and design; representing values and ethics; and allocating resources and taking investment decisions; as well as those activities related to analyzing exposure to risk and determining appropriate countermeasures. They ensure that the service operations and programs of the federal government comply with applicable laws, regulations, policies and/or plans.

Service groupings for Management and Oversight services include: Strategic Policy, Planning and Government Relations (incl. Federal/Provincial/Territorial/International); Executive Services; Corporate Policy, Standards, Guidelines; Investment Planning; Project Management; Risk Management; Performance and Reporting; and, Internal Audit and Evaluation.

RESOURCES	2011-2012	2012-2013	2013-2014
FINANCIAL (\$ in millions)	10.4	10.1	10.7
HUMAN (FTEs)	65.0	65.1	65.1

***Program Sub-Sub-Activity: 1.4.1.2. Communications***

**Description:** Communications services involve activities undertaken to ensure that Government of Canada communications are effectively managed, well coordinated and responsive to the diverse information needs of the public. The communications management function ensures that the public – internal or external – receives government information, and that the views and concerns of the public are taken into account in the planning, management and evaluation of policies, programs, services and initiatives.

Service groupings for Communications services include: Public Opinion Research; Corporate Identity; Consultations; Media Relations; Advertising, Fairs, Exhibits; In-Person Service, Telephone, Facsimile, Mail, Internet; Translation; and Publications.

<b>RESOURCES</b>	<b>2011-2012</b>	<b>2012-2013</b>	<b>2013-2014</b>
<b>FINANCIAL</b> (\$ in millions)	6.6	5.8	5.4
<b>HUMAN</b> (FTEs)	27.8	27.8	27.8

**Program Sub-Activity: 1.4.2. Resource Management Services**

<b>RESOURCES</b>	<b>2011-2012</b>	<b>2012-2013</b>	<b>2013-2014</b>
<b>FINANCIAL</b> (\$ in millions)	17.7	17.2	17.6
<b>HUMAN</b> (FTEs)	169.12	169.12	169.12

**This Sub-Activity is further divided into four Sub-Sub-Activities.**

***Program Sub-Sub-Activity: 1.4.2.1 Human Resources Management***

**Description:** Human Resources Management services involve activities undertaken for determining strategic direction, allocating resources among services and processes, and activities relating to analyzing exposure to risk and determining appropriate countermeasures. They ensure that the service operations and programs of the federal government comply with applicable laws, regulations, policies, and/or plans.

Service groupings for Human Resources Management services include: HR Planning, Work, Organization Design and Reporting; Job and Position Management; Employee Acquisition and Orientation; Total Compensation; Employee Performance, Learning, Development and Recognition; Permanent and Temporary Separations; and Workplace Management.

<b>RESOURCES</b>	<b>2011-2012</b>	<b>2012-2013</b>	<b>2013-2014</b>
<b>FINANCIAL</b> (\$ in millions)	3.9	3.7	3.8
<b>HUMAN</b> (FTEs)	42.4	42.4	42.4

***Program Sub-Sub-Activity: 1.4.2.2. Financial Management***

**Description:** Financial Management services involve activities undertaken to ensure the prudent use of public resources, including planning, budgeting, accounting, reporting, control and oversight, analysis, decision support and advice, and financial systems.

Service groupings for Financial Management services include: Financial Planning and Budgeting; Accounting Management; Expenditure Control; Payments Service; Collections and Receivables Service; and, Asset and Liability Management Service.

<b>RESOURCES</b>	<b>2011-2012</b>	<b>2012-2013</b>	<b>2013-2014</b>
<b>FINANCIAL</b> (\$ in millions)	5.4	5.3	5.3
<b>HUMAN</b> (FTEs)	56.0	56.0	56.0

***Program Sub-Sub-Activity: 1.4.2.3. Information Management***

**Description:** Information Management services involve activities undertaken to achieve efficient and effective information management to support program and service delivery; foster informed decision making; facilitate accountability, transparency, and collaboration; and preserve and ensure access to information and records for the benefit of present and future generations. Information management is the discipline that directs and supports effective and efficient management of information in an organization, from planning and systems development to disposal or long-term preservation.

Service groupings for Information Management services include: Information Design Services; Data Management Services; Records and Document Management Services; Library Services; Content Management Services; Archival Services; Business Intelligence and Decision Support Services; Access to Information; and Privacy Services.

<b>RESOURCES</b>	<b>2011-2012</b>	<b>2012-2013</b>	<b>2013-2014</b>
<b>FINANCIAL</b> (\$ in millions)	3.8	3.8	4.0
<b>HUMAN</b> (FTEs)	34.8	34.8	34.8

**Program Sub-Sub-Activity: 1.4.2.4. Information Technology**

**Description:** Information Technology services involve activities undertaken to achieve efficient and effective use of information technology to support government priorities and program delivery, to increase productivity, and to enhance services to the public. The management of information technology includes planning, building (or procuring), operating and measuring performance.

Service groupings for Information Technology services include: Distributed Computing; Application/Database Development and Maintenance; Production and Operations Computing; Telecommunications Network – (Data and Voice); and IT Security.

RESOURCES	2011-2012	2012-2013	2013-2014
FINANCIAL (\$ in millions)	4.6	4.3	4.4
HUMAN (FTEs)	36.0	36.0	36.0

**Program Sub-Activity: 1.4.3. Asset Management Services**

RESOURCES	2011-2012	2012-2013	2013-2014
FINANCIAL (\$ in millions)	14.3	14.3	14.4
HUMAN (FTEs)	32.94	32.94	32.94

**This Sub-Activity is further divided into three Sub-Sub-Activities. *Material Sub-Sub-Activities does not appear in this report.***

**Program Sub-Sub-Activity: 1.4.3.1. Real Property**

**Description:** Real Property services involve activities undertaken to ensure real property is managed in a sustainable and financially responsible manner, throughout its life cycle, to support the cost-effective and efficient delivery of government programs. Real property is defined as any right, interest or benefit in land, which includes mines, minerals and improvements on, above or below the surface of the land.

Service groupings for Real Property Services include: Acquisition; Operations and Management; and Disposal.

<b>RESOURCES</b>	<b>2011-2012</b>	<b>2012-2013</b>	<b>2013-2014</b>
<b>FINANCIAL</b> (\$ in millions)	13.5	13.5	13.5
<b>HUMAN</b> (FTEs)	21.5	21.5	21.5

***Program Sub-Sub-Activity: 1.4.3.3. Acquisition***

**Description:** Acquisition services involve activities undertaken to acquire a good or service to fulfill a properly completed request (including a complete and accurate definition of requirements and certification that funds are available) until entering into or amending a contract.

Service groupings for Acquisition services include: Goods Acquisitions; Services Acquisitions; Construction Acquisitions; and Other Acquisitions (acquisitions that fall outside the definitions of goods or services).

<b>RESOURCES</b>	<b>2011-2012</b>	<b>2012-2013</b>	<b>2013-2014</b>
<b>FINANCIAL</b> (\$ in millions)	0.8	0.8	0.9
<b>HUMAN</b> (FTEs)	11.4	11.4	11.4

**Highlights of Expected Accomplishments for Internal Services**

In order for the CSA to have its management practices meet the standards set by the Government wide policies, the following actions will be undertaken in 2011-2012:

- The review of the CSA’s external and internal governance structure in order to increase credibility of the CSA with central government agencies and foster fruitful collaborations with government partners.
- The final development and implementation of the Investment Plan in accordance with TBS policies on investment planning, acquired assets and management of projects.
- The update of the CSA Corporate Risk profile in accordance with the new Framework for the Management of Risk in time for the planning of fiscal year 2012-2013.
- The development of the CSA’s performance measurement capacity to implement the PAA Performance Management Framework in time for the 2011-2012 Departmental Performance Report.
- The implementation of a five-year Evaluation Plan applicable to the CSA’s 2011-2012 Program Activity Architecture.

Based on lessons learned from the Management Accountability Framework assessments, and Internal Audit recommendations, the following actions will be undertaken in 2011-2012:

- The development of an integrated planning approach in order to align human, financial and technical resources with the CSA's strategies, priorities and operations for fiscal year 2012-2013.
- The implementation of an Integrated Corporate Human Resources Plan in line with the Program Activity Architecture in order to attract and retain a qualified workforce to deliver its mandate.
- The review of existing policies pertaining to the management of intellectual property in order to guarantee their access and promote the transfer of technologies.
- The management of information assets created by or for the CSA in order to guarantee access for decision making, protection for security access and to conform to Canadian regulations, and to assure conservation for historical purposes.
- The assessment of management requirements to allow public access to space data produced by satellites and scientific experiments.

## SECTION 3: SUPPLEMENTARY INFORMATION

### 3.1 FINANCIAL HIGHLIGHTS

#### 3.1.1 Financial Statements

The Future-Oriented Financial Statements (FOFS) presented in this RPP are intended to serve as a general overview of the CSA's financial operations. The FOFS are prepared on an accrual basis to strengthen accountability and improve transparency and financial management.

Information on CSA's Financial Statements is at the following address:

<http://www.asc-csa.gc.ca/eng/publications/default.asp#parliament>

#### 3.1.2 Supplementary Information Tables

All electronic supplementary information tables found in the 2011-2012 Report on Plans and Priorities can be found on the Treasury Board of Canada Secretariat's Website at: <http://www.tbs-sct.gc.ca/est-pre/estime.asp>

- Annexe 1: Details on Transfer Payment Programs (TPPs)
- Annexe 2: Upcoming Internal Audits and Evaluations over the next Three Fiscal Years
- Annexe 3: Sources of Respendable and Non-Respendable Revenue
- Annexe 4: Status Report on Transformational and Major Crown Projects
- Annexe 5: Summary of Capital Spending by Program Activity
- Annexe 6: User Fees

## **3.2 CSA CONTRIBUTIONS TO GOVERNMENT OF CANADA OUTCOMES**

CSA contributes to two of the Government of Canada outcomes

### **1 - WELL-MANAGED AND EFFICIENT GOVERNMENT OPERATIONS**

Mainly two of the CSA's Program Activities contribute to this outcome.

#### **PROGRAM ACTIVITY SPACE DATA, INFORMATION AND SERVICES**

The contributions of this Program Activity are an expanded use of space data, applications and information by Government departments and Agencies to better deliver their policy, programs and operational responsibilities. This calls for a strong partnership between the Canadian Space Agency and Other Government Departments (ODGs).

Together with the OGDs, the CSA ensures that the country strategically select, build and operate the space assets and ground infrastructure that Canada needs to address national priorities, perform world-class science in and from space in priority areas and in order to provide high-quality space data, applications and services. Canada will contribute to international space missions when it is a cost-effective way to obtain the data needed to meet its priorities. The Canadian space community is called upon to innovate technically, scientifically, financially, as well as through a broader range of business practices.

#### BENEFITS FOR CANADIANS

Space assets generate multiple benefits for Canadians. More concretely, here are a few examples of the positive impacts generated from synergistic collaboration between the CSA and Other Governmental Departments (ODGs).

The Department of National Defence is rapidly increasing its capacity to use space assets to deliver its mandate with the construction and operation of satellite data reception stations in Canada. The key objectives are to use space capabilities to contribute to the security and defence of Canadians, both at home and abroad.

Environment Canada is the largest user of satellite data within the Government of Canada. Space data is critical to its core mandate, including weather and air quality forecasting, environmental and ice monitoring, enforcement of environmental laws and regulations, climate change studies and the science needed to improve weather and environmental forecasts for Canadians.

Natural Resources Canada (NRCan) is a key user and provider of space data within the Government of Canada as it is mandated under the Department of Natural Resources Act to '*promote the development and use of remote sensing technology*'. In doing so NRCan receives, uses, archives and disseminates satellite data in order to deliver its core mandate of mapping the Canadian landmass, managing natural resources, assessing natural hazards and maintaining the Canadian spatial reference system.

The Department of Fisheries and Oceans uses space data and information to support safe navigation, maritime surveillance, and ocean science and observations. It relies on accurate and timely satellite imagery of ice allowing the Canadian Coast Guard to direct icebreaking activities in a more efficient and effective way.



## **PROGRAM ACTIVITY INTERNAL SERVICES**

The contribution of this Program Activity is a better management of programs and services in accordance with the Management Accountability Framework.

### BENEFITS FOR CANADIANS

Canadians will benefit from well-managed and efficient government operations while maintaining rigorous stewardship over financial resources, assets, and human resources, as well as of a transparent, accountable, and responsive federal government.

## **2- AN INNOVATIVE AND KNOWLEDGE-BASED ECONOMY**

Mainly two of the CSA's Program Activities contribute to this outcome.

### **PROGRAM ACTIVITY SPACE EXPLORATION**

The contributions of this Program Activity are advances in knowledge, exploration, technologies and expertise and an increased use of this knowledge and know-how both in space and on Earth.

The CSA ensures that the country remains a key partner in international initiatives to explore our solar system and perform science in space. Canada strives to make optimal use of its access rights to the International Space Station. International partnerships, a hallmark of the Canadian approach to space exploration, will be core to the pursuit of this vision. The achievement of the endeavours is strongly dependant on international consensus and on decisions by international partners in general and the United States and Europe in particular.

### BENEFITS FOR CANADIANS

The International Space Station is an excellent example of mutually beneficial collaboration among space faring countries. Through our contribution of specialized technologies, Canadian astronauts and scientists have a privileged access to a unique microgravity laboratory to conduct scientific and engineering studies. These priority research areas have great potential to bring about new knowledge that will improve how we live, prosper, and evolve on our planet.

Space exploration, science and technology endeavours, provide opportunities for Canada to take part in the exploration of Mars. Increasing our understanding of Mars would almost certainly increase our understanding of the Earth, particularly about our atmosphere and magnetic field.

In parallel to the scientific advancements stemming from planetary exploration, the development of exploration vehicles and their associated robotic technologies challenges the use, for example, of solar-powered electric propulsion, which, in turn, could lead the way toward spin-off commercialization of green technologies.

Space astronomy provides an additional platform for Canadian astronomers and space industry to build on existing strengths and achieve global levels of excellence. The James Web Space Telescope is a perfect example with Canada's contribution of two very advanced instruments namely the Fine Guiding System (FGS) and the Tunable Filter Imager (TFI).

#### **PROGRAM ACTIVITY FUTURE CANADIAN SPACE CAPACITY**

The contributions of this Program Activity are the maintenance of the critical mass of academic, industrial and business expertise needed to address future national needs and priorities in space, as well as an increased pace of discovery, and innovation.

The CSA leverages the innovation capability of industry by enhancing synergy through partnerships. The means to encourage leveraging are the creation of clusters of excellence, the promotion of closer links between universities and industry in priority areas to facilitate knowledge and technology transfer, and the development of industrial policies that foster the emergence and continued growth of innovative small and medium-size enterprises. Canada also relies on its collaboration with the European Space Agency to enhance its technology base and improve access to European markets. These achievements call for greater coordination between the Agency and the Granting Councils to foster collaboration between Canadian Universities working in partnership with space industry and Government to grow and develop our future space expertise and capacity.

#### **BENEFITS FOR CANADIANS**

Canada's future space capacity resides within academia, the space industry and OGDs and agencies. By investing in programs that stimulate innovation within the space community, and encouraging the competitiveness of our high-tech companies, the CSA contributes to the creation and sustainability of Canada's knowledge-based economy. However, it is important to note that the results of these investments in terms of benefits require a certain amount of time before being felt.

For example, the CSA's program "Space Expertise and Proficiency" encourages the education and training of tomorrow's highly educated and highly skilled labour. The CSA's program "Space Innovation and Market Access" encourages dynamic trade relationships with other nations and therefore increases the ability our Canadian companies over the medium and long run to compete in the global marketplace. There are significant benefits for Canada in terms of revenues and Canadians in terms of quality of life in a steadily expanding space industry currently comprised of 200 organizations and more than 7,500 highly skilled engineers, scientists and researchers.

The CSA will also work at maintaining and developing the capacity and expertise of its scientific and technical staff by providing opportunities to contribute to leading-edge priority activities in collaboration with academia, industry and OGDs.

### **3.3 INDEX OF CSA SPACE MISSIONS**

#### **ADAMS**

Advanced Astronaut Medical Support (ADAMS) project can contribute to human exploration. Specifically, CSA has continued to explore solutions to the delivery of healthcare on future long duration exploration-class missions and how these solutions can help improve healthcare delivery on Earth through the transfer of space technology.

#### **Anik F2**

The Anik F2, Telesat Canada's innovative, high-speed Ka-Band, multimedia telecommunications satellite is one of the largest, most powerful communications satellites ever built. It is designed to support and enhance North American voice, data, and broadcast services. Through its support of Anik F2, the Government of Canada has secured a Government Capacity Credit access worth \$50 million over 11 years to support the connectivity for remote and underserved northern rural communities.

#### **APEX- CAMBIUM**

CAMBIUM is part of the Advanced Plant Experiments (APEX) on orbit. The objective of the CAMBIUM experiment is to determine the role of gravity in the formation of "tension wood" forming after tilting or looping of the stem. The experiment has implications for fundamental plant responses to gravity and to the understanding and potential control of tension wood formation, which is important to the forestry industry.

#### **APEX-CSA 2**

APEX-CSA2 follows APEX-Cambium, a University of New Brunswick study led by Professor Rod Savidge that sent willows to the Space Station in November 2009. Canadian white spruce seedlings will be sent to the International Space Station (ISS) to help researchers understand how trees make wood. Known as APEX-CSA2 (short for Advanced Plant Experiments on Orbit), the experiment is led by Natural Resources Canada's Canadian Wood Fibre Centre in Quebec City, with the close collaboration of the Canadian Space Agency (CSA) and NASA. 24 white spruce (*Picea glauca*) seedlings will be launched to the ISS aboard the Space Shuttle Discovery on April 5, 2010. After 30 days of growing in space, the tips of the seedlings' and their roots will be clipped and placed in cold storage. They will return to Earth on Space Shuttle mission STS-132 in May 2010.

### **AQUATIC ORGS in $\mu$ G**

The objective of this multi-institutional, team-based and multidisciplinary project is to establish the first permanent facility in Canada for studies of the effects of altered gravity on fish. This will be realized through the construction of aquaria and 2- and 3-dimensional clinostats (equipment that will move the aquaria in such a way as to constantly change the direction of gravity as experienced by the fish) to simulate reduced-gravity conditions, and the 3-dimensional clinostat will be adapted to allow study of increased gravitational forces. This equipment will then be used to study the effects of gravity on fish embryonic development, and the effects of gravity on the function of adult fish, as a general model of development for aquatic animals with backbones.

### **ASTRO-H**

Scheduled for launch in 2014, Astro-H is a Japan Aerospace Exploration Agency (JAXA) X-ray Space Observatory spacecraft. The satellite will be equipped with hard X-ray imager, soft X-ray imager, a spectrometer and a gamma-ray detector, to explore structure and evolution of the Universe. With a total length of 14 m, the spacecraft will deploy an extensible boom holding the hard X-ray imager. Canada is considering providing a metrology system that will measure precisely the vibration of the boom in order to improve the performance of the imager.

### **Astronauts: Expedition 20/21**

In 2008, Canadian astronaut Dr. Thirsk was assigned to the crew of Expedition 20/21 21 also known as C1 Mission, the first Canadian mission using the Russian Soyuz spacecraft for travel to and from the ISS. This Expedition represents a milestone for the Canadian Space Program since it was the first time a Canadian took part in a long duration mission. Robert Thirsk had the privilege to expand the boundaries of space exploration by living and working on board the International Space Station for six months. The launch took place on May 27, 2009 aboard a Soyuz rocket from the Cosmodrome in Baikonur, Kazakhstan. During this long duration mission Dr. Thirsk assumed responsibilities for the maintenance and repair of the ISS, while conducting experiments on behalf of Canadian and international researchers.

### **Astronauts: STS-115**

Mission STS-115 took place from September 9 to 21, 2006. During these 12 days in space, Canadian astronaut Steve MacLean and his crewmates successfully resumed the assembly of the International Space Station. They delivered and installed on the Station new truss segments and solar arrays, doubling the power capacity of the orbiting laboratory. During this mission, Steve MacLean became the first Canadian to operate Canadarm2 in space and the second Canadian to perform a spacewalk.

### **Astronauts: STS-118**

Launched on August 8, 2007, the top priority of mission STS-118 is to deliver and assemble the S5 truss segment to the ISS. The 11 + 3 day mission marks the 22<sup>nd</sup> shuttle trip to the ISS, and the 20<sup>th</sup> flight of space shuttle Endeavour. Canada's contribution is once again crucial. During the mission, astronaut Dave Williams, a veteran of shuttle mission STS-90, will set a Canadian record by spending over 19 hours outside the space station during three scheduled spacewalks. In addition, Canadian-made robotics and sensor technologies will help ensure the success of the mission and the safety of the shuttle and crew.

### **Astronauts: STS-121**

Mission STS-121 took place from July 4 to 17, 2006. During these 13 days in space, the crew of Space Shuttle Discovery continued to test new equipment and procedures that increase the safety of space shuttles. Canada played a critical role in this mission by providing an extension to the Canadarm tipped with a Laser Camera System that allows the inspection of every inch of the spacecraft for possible signs of damage. This flight to the International Space Station also delivered critical supplies and cargo to the complex for repair and future expansion of the outpost. Canadian Space Agency's Chief Astronaut Julie Payette was the lead Station Capsule Communicator acting as the orbiting astronauts' sole voicelink with Mission Control.

### **Astronauts: STS-127**

The second spaceflight of astronaut Julie Payette with the main goal of this ambitious mission: delivering the final permanent components of the Japan Aerospace Exploration Agency's (JAXA) contribution to the International Space Station. Astronauts completed assembly of Kibo – the multi-part Japanese Experiment Module (JEM) by attaching an outdoor terrace or porch filled with Japanese experiment packages designed to be exposed to the vacuum of space. Also on the docket for the Shuttle crew was a tricky replacement of six batteries at one of the farthest ends of the station's truss.

### **Astronauts: TMA-6/10S**

The Italian Mission took place from April 15 to 25, 2005 on board Soyuz. During the mission the Canadian astronaut Robert Thirsk was a communications coordinator based at the European Control Centre. The European Space Agency (ESA) invited him to train as a backup astronaut to Roberto Vittori for the upcoming Italian Soyuz Mission, also known as Eneide - Italian for The Aeneid, the epic poem by Virgil about the voyages of Aeneas and the founding of Rome. So, for example, if Roberto Vittori encountered a problem with an experiment in orbit, he contacted Robert Thirsk who worked with the ground crews to solve the problem and fulfill the mission objectives.

### **BCAT-5 / BCAT-C1**

The Binary Colloid Alloy Test 5 (BCAT C-5) is a Canadian experiment concept that will study the effect of phase separation on crystal growth in the ISS microgravity environment using samples consisting of colloidal suspensions with added polymer. On Earth, gravity causes the colloids to settle making such a study particularly difficult. Improved understanding of crystal growth will lead to more refined manufacturing processes and commercial products. During the Expedition 20/21 (C1 Mission), Canadian astronaut Dr. Robert (Bob) Thirsk has performed colloid experiments aboard the ISS where visual information will be transmitted to scientists on the ground for data analysis.

### **BISE**

The Bodies in Space Environment (BISE) experiment measures the relative contributions of internal and external cues to self-orientation before, during and after microgravity exposure. The project aims to better understand the importance of different types of cues in the neurological process that tell astronauts which way is "up" in a microgravity environment. Illusions and other phenomena could interfere with routine operational processes as well as emergency procedures on platforms such as the International Space Station.

### **BLAST**

In June 2005, a team of researchers from Canada, the U.S., the U.K. and Mexico has launched the Balloon-borne Large Aperture Sub-millimetre Telescope (BLAST) to probe the heavens to identify starburst galaxies and enabling researchers to study the formation and evolution of stars, galaxies and star clusters.

### **BRITE**

BRight Target Explorer (BRITE) is a nano-satellite developed by Space Flight Lab of University of Toronto's Institute for Aerospace Studies. The nano-satellite will carry a small telescope to observe very precisely the brightness variation of many bright stars from space. The uninterrupted observations over a long duration, with similar science objectives as MOST, will help to understand the structure and evolution of massive stars that create the heavy elements in our galaxy. The mission includes a constellation of 6 nano-satellites, 2 provided by Canada, 2 by Austria and 2 by Poland. CSA plans to fund this project through a contribution agreement in 2010. Launch is planned for 2012.

### **CADC/HUBBLE**

The Canadian Astronomy Data Center (CADC) is a data archiving and access facility to support science done by Canadian astronomers and to contribute to international astronomy research. CADC archives astronomical images and data from major ground based observatories, from CSA missions as well as from the Hubble Space Telescope.

### CanALSS

The Canadian Advanced Life Support System (CanALSS) is a CSA mission concept to supply the Higher Plant Chamber as one component of an international bioregenerative life support system by the year 2050. CanALSS is based on Canadian technologies currently being developed and will allow Canada to expand on this capability where it is recognized as a world leader.

### CANSOC

CANSOC (Canadian Satellite Operation Centre) is a multi-mission control centre with ground stations for telemetry, tracking and commanding and data reception, and it is composed of data ordering and planning, flight control, data archiving and cataloguing, data processing and quality control, and communications networks systems, and it is responsible for end-to-end operations and management of satellite missions.

### CASS

The Chemical and Aerosol Sounding Satellite (CASS) mission is a partnership concept study composed of a NASA instrument and a CSA instrument on a small satellite that will provide solar occultation measurements that address issues of stratospheric ozone recovery and impacts of climate change.

### CASSIOPE

The **Cascade** Demonstrator, Smallsat Bus and Ionospheric Polar Explorer (CASSIOPE) is a small hybrid satellite that includes the telecommunications instrument Cascade, which will provide the very first digital broadband courier service for commercial use, and the scientific payload **enhanced Polar Outflow Probe** (ePOP), which will be used to study the ionosphere.

### CCAP

The Cell Culture and Analysis Payload (CCAP) is to be a wide-use automated cell and tissue culture facility that will be capable of obtaining sufficient science data such that it will not be necessary to return the biological specimens to ground for post-processing. CCAP is intended for installation and application on the International Space Station.

### CCISS

The experiment Cardiovascular and Cerebrovascular Control on return from ISS (CCISS) will study cardiovascular and cerebrovascular adaptations to microgravity to improve astronaut function and capacities upon return into planetary gravity.

### CGSM

The Canadian GeoSpace Monitoring (CGSM) system is a Canadian network of ground-based instruments to monitor and study geomagnetic activity near Earth, as well as space weather. It includes high-frequency radars, sky imagers, computer models and data portals located across the country. Canada is especially vulnerable to the effects of space weather and solar storms and CGSM provides data, knowledge and information to protect critical and expensive space and ground communication and navigation assets from space weather.

### **CHENSS**

The Canadian High Energy Neutron Spectrometry System (CHENSS) will increase scientific understanding of the high-energy neutron spectrum in space. This will help understand and plan mitigations for radiation risk to astronauts during long term space missions.

### **CIMEX**

The Convection and Interfacial Mass Exchange (CIMEX) experiment will investigate fundamental and applied aspects of mass transfer through fluid interfaces (mainly evaporating liquids). Improved understanding of this process can be achieved through microgravity experiments because of the lack of convection. The results can be applied to heat-exchange pipe design and design of evaporators.

### **CloudSat**

CloudSat is making the first comprehensive three-dimensional study of clouds. It gathers data on their structure, frequency and volume, and helps improve our understanding of how they influence the weather and climate. It uses a radar hyperfrequency device to probe the cloud cover.

### **CoreH2O Mission**

The CoreH2O mission will use space SAR detailed observation at X and Ku-bands to monitor snow, ice and water parameters in regions where they play a major role in the global energy cycles as well as in biospheric processes.

### **DynAMO**

The Dynamic Atmosphere Mars Observer (DynAMO) is CSA concept of an instrument proposed as a key element in the 2016 Mars Science Orbiter program for characterization of the Martian Atmosphere. DynAMO would be capable of measuring winds globally on Mars.

### **EBEX**

NASA's E and B EXperiment (EBEX) is a mission using a high-altitude balloon-borne instrument to study the sky in the far infra-red (FIR) and measure the polarization of the cosmic microwave background which is the signature of the Big Bang. Canada will provide a state-of-the-art digital electronic readout system for use with large arrays of FIR bolometers.

### **ELERAD**

The ELERAD study will assess radiation damage on long duration flights. A genetically engineered strain of *C. elegans* worms is currently on board the ISS to test if it can be used as a biological dosimeter. Upon return, the worms will be analyzed to assess the genetic alterations caused by radiation in Low Earth Orbit. The experiment will be carried out in a scientific/educational mission sponsored by NASA and the Malaysian Space Agency.



### **eOSTEO**

The goal of the eOSTEO mission is to better understand the fundamental causes of bone loss in microgravity using an automated cell culture system. The eOSTEO is made of three Canadian experiments to study how bone cells in microgravity react to signals that increase and decrease bone formation; whether microgravity compromises bone cell architecture; and whether a hormone that promotes bone creation can, in weightless conditions, prevent the death of cells that build bone. Applications of the research are expected for development of better treatments for osteoporosis on Earth and during long duration space missions.

### **ESA - ADM/Aeolus**

The Atmospheric Dynamics Mission (ADM) is an European Space Agency (ESA) Explorer Core mission, which will probe the lowermost 30 km of the atmosphere from 400 km above the Earth's surface using a high power Doppler wind lidar. The measured data will improve the accuracy of numerical weather forecasting and advance our understanding of atmospheric dynamics and processes relevant to climate variability and modeling.

### **ESA – Alphasat**

The primary objective of ESA under the Alphasat Program is to facilitate an early first flight, and in-orbit validation of the Alphasat platform, currently under development with European industry. The Alphasat mission will extend the capabilities of geostationary satellite infrastructure, both in terms of performances and capacity, resulting in an enhancement in the current services and additional capacity for new services.

### **ESA - Cross Scale**

Cross-Scale is an ESA mission concept to study multi-scale coupling in space plasmas. Its objectives are the quantification of fundamental plasma processes (shocks, reconnection, and turbulence) that operate universally in astrophysical and laboratory plasmas but are only accessible to direct sampling of particles and fields in near-Earth space. Possible Canadian participation would be through instrument contribution.

### **ESA - Cryosat**

Cryosat will measure changes in the sea-ice thickness and variations in snow depth to better understand the influence that climate change is having on the Earth's polar ice masses. It is one of six missions being developed under ESA Earth Explorer Opportunity mission.

### **ESA/JAXA - EarthCARE**

The ESA Earth Clouds, Aerosols and Radiation Explorer (EarthCARE) mission is being implemented in cooperation with JAXA (Japan Aerospace Exploration Agency). The payload consists of instruments for measuring clouds (Cloud Profiling Radar and multispectral imager) and aerosol properties (atmospheric lidar), and a broadband radiometer to measure top-of-the-atmosphere radiances and fluxes.

### **ESA - ENVISAT**

ENVISAT, is the European Space Agency's (ESA) most ambitious Earth Observation (EO) satellite, which was launched successfully in 2002. It carries a suite of 10 instruments including an Advanced Synthetic Aperture Radar (SAR), scatterometer, altimeter, and passive optical instruments for atmospheric chemistry, ocean and sea surface temperature observations. There are 28 Canadian scientific teams currently participating in exploiting the data, and its mission duration has been extended to 2013.

### **ESA - ERS-2**

ESA Earth Observation satellite was launched in 1995 and is carrying similar set of instruments as the ENVISAT satellite. It is still operating and providing useful data to many scientific teams. Canada participated in development of the satellite for ERS-1 and ERS-2. This participation also played an important role in the building of Canada's RADARSAT-1.

### **ESA - EXOMARS**

Exomars is a European-led space exploration mission, currently under development by the European Space Agency (ESA) that will send a robotic rover to the surface of Mars. The mission began as part of ESA's Aurora program. Exomars will combine technology development with investigations of major scientific interest. It is a robotic mission which will provide Europe with new technologies for the exploration of Mars, specifically the Entry, Descent and Landing System (EDLS), the surface Rover and its Drill and Sample Preparation and Distribution System (SPDS).

### **ESA - Galileo**

Galileo is a joint program of the European Space Agency and the European Union that will create a system of 32 satellites to improve and complement satellite navigation and positioning systems such as the US-led GPS and Russia's Glonass. Canada was the first non-European country to join the program in 1999. Specifically, Galileo targets the design and development of four satellites to prove the In-Orbit Validation (IOV) concept of the Galileo GNSS Constellation.

### **ESA - GOCE**

The ESA Gravity field and steady-state Ocean Circulation Explorer (GOCE) mission is dedicated to measuring the Earth's gravity field and modeling the geoid with unprecedented accuracy and spatial resolution. This mission will advance our knowledge of ocean circulation, which plays critical role in energy exchanges, sea level change and Earth interior processes. GOCE will also make significant advances in the field of geodesy and surveying.

### **ESA - Herschel-HIFI/Spire**

The Herschel Space Observatory will help scientists determine how early galaxies formed and evolved. The observatory has three instruments and Canada is contributing to two of them: the Heterodyne Instrument for the Far Infrared (HIFI) and the Spectral and Photometric Imaging Receiver (SPIRE).

### **ESA - MICAST**

The MICAST (Microstructure in CASTings) European Space Agency project is a ground-based and microgravity experiments. Canadian members of the MICAST team will be carrying out specific ground-based solidification of aluminum experiments under combined magnetic fields (with strong static and weak rotating magnetic fields) using the existing state-of-the-art experimental facility at the University of Victoria Crystal Growth Laboratory.

### **ESA - NEQUISOL**

The Non-equilibrium Solidification, Modeling for Microstructure Engineering of Industrial Alloys (NEQUISOL) study aims to use microgravity experiments to improve models of solidification of "under cooled" alloys, in order to better predict conditions required for the production of superior materials.

### **ESA - Planck**

Planck is a European Space Agency medium-sized mission that will be launched with the Herschel Space Observatory. It is a survey instrument that will map the entire sky. Canada is involved mainly in the development of Quick Look Analysis software and Real Time Analysis software for scientific checkout of the data at early stages.

### **ESA - Sentinel-1**

The Sentinel-1 mission is being built under ESA Global Monitoring for Environment and Security (GMES) program. Its payload consists of a C-band Synthetic Aperture Radar (SAR) (Similar to RADARSAT-2) to provide operational data continuity beyond existing C-band SAR.

### **ESA - Sentinel-2**

The Sentinel-2 mission is developed within ESA Global Monitoring for Environment and Security (GMES) space component program. Its payload consists of a multispectral optical imaging mission as follow-on to Landsat and SPOT missions for monitoring of land cover application. The mission consists of two satellite constellation.

### **ESA - Sentinel-3**

The Sentinel-3 mission is developed within ESA Global Monitoring for Environment and Security (GMES) space component program. Its payload consists of an instrument suite providing data from visible to thermal at medium (200 m) to modest spatial resolution (1 km) for ocean color, sea surface temperature and global land mapping (data continuation of MODIS and MERIS), an interferometric SAR altimeter for ocean observation. The mission consists of two satellite constellation.

### **ESA - Sentinel-5 Precursor**

The Sentinel-5 Precursor mission is developed within ESA Global Monitoring for Environment and Security (GMES) space component program. It is designed as a gap filler mission to ensure the continuity of data of Sentinel-5 which will be launched in 2019 as part of Post-EPS mission of EUMETSAT. The mission is to monitor atmospheric composition covering spectral range from UV, VIS NIR and SWIR. The UN-VIS-NIR spectrometer is based on the TROPOMI developed by the Netherland.

### **ESA - SMOS**

The ESA Soil Moisture and Ocean Salinity (SMOS) mission objective is to measure soil moisture and ocean salinity using a novel technique of aperture synthesized radiometry in L-band. The measures will be used for weather/climate prediction.

### **ESA - SODI DSC**

This mission is dedicated to the study of the movement of molecules in liquids due to temperature gradients (thermodiffusion). Thermodiffusion is a process common to various industrial processes including petroleum extraction from deep reservoirs such as Hibernia off the East coast of Canada. This European-led long-duration mission on board the International Space Station will allow Canadian and international scientists to further understand the role of gravity in molecular movement important for Canadian industry. The predecessor of the DSC experiment, known as IVIDIL, was assembled and commissioned by CSA's astronaut Bob Thirsk in 2009. Both missions involve Canadian co-investigator Professor Ziad Saghir from Ryerson University in Toronto, Canada.

### **ESA - SODI IVIDIL**

The Influence of Vibration on Diffusion in Liquids (IVIDIL) experiment will help understand and acknowledge the effects of vehicle vibration on microgravity experiments on double diffusion. Double molecular and thermal diffusion often occurs in hydrocarbon reservoirs, making assessment of reservoir composition difficult. Microgravity experiments can improve such assessments.

### **ESA - SWARM**

The ESA SWARM mission is a constellation of three satellites that will provide high-precision and high-resolution measurements of the strength and direction of the Earth magnetic field. Canada is providing an Electric Field Instrument (EFI).

### **EVARM**

EVARM, Extra Vehicular Activity Radiation Monitor, measures the radiation exposure astronauts receive while working outside the Space Station or Shuttle. Astronauts on a spacewalk, or EVA, will wear small electronic badges in their space suits to record the amount of radiation they are exposed to on their spacewalk.

### **EVIS**

The Extraction Vehicle for In Situ Resource Utilization (EVIS) is a CSA concept study to create a concept definition and high level requirements for the systems, technologies and materials required for an extraction vehicle. In particular, this concept study will address the operating and design concepts for a mobility platform focused on In Situ Resource Utilization and associated accessories and instrumentation.

### **FIRI**

FIRI is a Far Infra-Red Interferometer capable of achieving high resolution imaging and spectroscopy dedicated to the study of the early stages of the galaxies, stars and planets formation. It was proposed as part of the ESA Cosmic Vision program but was not retained in the down-selection. However groups of international researchers are continuing to develop mission concepts.

### **FPEF**

The Fluid Physics Experiment Facility (FPEF) is installed on the ISS. Its objective is to collect important experimental data on the role of a liquid bridge in material solidification, an important system used in semiconductor manufacturing. The role of gravity complicates industry's understanding of this system on Earth, and different inserts will allow researchers to study various liquids and liquid bridge dimensions.

### **FPNS**

The Feature-based Planetary Navigation System (FPNS) is a CSA concept study of a camera and Lidar-based navigation system that uses surface features to provide absolute navigation capability to planetary orbiters and landers. These are functionally similar to GPS and GNSS on Earth but without the cost and complexity of a GPS constellation. The FPNS aims to integrate Canadian Lidar Technology, space-qualified cameras and advanced algorithms into a self-contained navigation subsystem that will meet the requirements of a large number of future planetary missions.

### **FUSE**

NASA's Far Ultraviolet Spectroscopic Explorer (FUSE) mission was terminated in October 2007 after nine successful years of operations. Canadian scientists have obtained the data in exchange of the CSA contributing the Fine Error Sensors to the telescope.

### **GPR**

The Ground Penetrating Radar (GPR) is a CSA concept study to examine the scientific, technical and programmatic aspects of using radar to explore the lunar subsurface. While current lunar missions are focusing on global-scale mapping and understanding of geological processes, future efforts will require detailed site-scale characterization of local geology and resource potential. The GPR would yield a greater understanding of the structure and composition of the shallow subsurface at targeted sites of interest.

### **Halo**

The CSA Hyperspectral And Luminescence Observer concept study will examine the combination of an orbital hyperspectral imager and rover-borne luminescence instrument for Mars in the context of the Mars Sample Return mission. Data analysis techniques will be developed to solve the data volume problem associated with this type of instrumentation for the particular case of the robust identification and mapping of predefined, targeted, water-related mineral deposits on the surface of Mars, supported directly by ground/rock truth data from in-situ luminescence measurements.

### **HAWAII**

As part of the Hawaii 2010 analog deployment on Mauna Kea, astronaut Chris Hadfield took part in ARTSE (Augmented Reality Tools for Space Exploration). The goal of this mission was to understand how a science backroom can help an astronaut accomplish geological tasks over a series of lunar surface traverses, and to explore the potential of an augmented shared reality (ASR) system to enable this activity. This was accomplished by tracking communications between a group of geologists 'on Earth' at the ExDOC mission control facility at CSA, and Hadfield on site carrying out geological tasks relevant to in-situ resource utilization. Hadfield had some geological training, but also needed the expertise of the remote team to complete his tasks successfully.

### **H-Reflex**

It is Canada's first International Space Station (ISS) science experiment. It studies the effect of space travel on our nervous system.

### **Hypersole**

The proposed study aims to use monofilament (vonFrey Hairs) and vibration testing to determine changes in skin sensitivity post space flight. The results will formally document changes in skin sensitivity post-space flight and will contribute to our knowledge of current theories on skin contribution to postural control on Earth which could have an impact on crew safety upon return to gravity and/or public health.

### **ICAPS**

The Interactions of Cosmic and Atmospheric Particles (ICAPS) experiment will study the interactions of cosmic and atmospheric particle systems under microgravity conditions. ICAPS has applications to particle physics, atmospheric sciences, and planetary science.

### **ICE-First**

The project ICE-First focuses on genetic repair mechanisms using *C. elegans*, a small worm widely used for genetics research. Half of *C. elegans*' genes have human counterparts. This worm can also mate, reproduce and develop normally during space flight, making it an ideal subject to study the effects of space travel on living organisms. The project will measure the amount of radiation, its effects on genes, and to eventually develop a biological radiation dosimeter for measuring how much damage radiation causes to living cells on long flights.

## **ILN**

The CSA Canadian International Lunar Network (ILN) mission concept study is to examine the scientific and technical feasibility of creating a stand-alone Canadian ILN node. Along with the base ILN science objectives, the project will identify the scientific questions that Canadian scientists will explore on the mission. The project will then define a conceptual mission capable of delivering the international and Canadian scientific payloads to the lunar surface and show how the resultant technologies are reusable for future space missions and for terrestrial applications.

## **Insect Habitat**

The CSA Insect Habitat (IH) instrument provides the systems required to support a wide range of fundamental gravitational biology research on the ISS. It is a facility intended to house insect specimens for long duration exposure to a microgravity environment.

## **ISRU**

The Drilling Systems in Support of In-Situ Resource Utilization (ISRU) is a CSA concept study of a sample acquisition system based upon drilling and coring technology. ISRU would characterize the form and concentration of the resources available, understand the environment the resource is found in, and adequately validate that the processes required for extracting and processing the resource will operate in the environment for the desired mission duration.

## **ISS**

The International Space Station (ISS) is the most ambitious engineering project ever undertaken by humanity. Canada is contributing the Mobile Servicing System (MSS), a space robotics system astronauts use to assemble and maintain the ISS. The MSS consists of three main elements: the Space Station Remote Manipulator System (SSRMS), known as Canadarm2, the Mobile Base System (MBS), and the Special Purpose Dexterous Manipulator (SPDM), known as Dextre.

## **IXO**

The International X-ray Observatory (IXO) is aimed as the next generation large X-ray observatory. It is a concept proposed by ESA, JAXA and NASA and recently mentioned in the US Decadal survey as one of the top mission priority. Launch is planned in the 2020's.

## **JC2Sat**

JC2Sat is a Canada-Japan collaborative research and engineering project to develop a pair of nano-satellites. The objective of the mission is to demonstrate innovative technologies as well as formation flying techniques using very small spacecraft.

### **JDEM**

The Joint Dark Energy Mission (JDEM) is a joint mission between NASA and the U.S. Department of Energy (DOE) proposes to investigate the Dark Energy. The recently released US Decadal survey of Astronomy and Astrophysics recommends that a dark energy mission be the top priority in space astronomy over the next decade. The report refers to a mission named WFIRST (Wide Field Infrared Survey Telescope) which is based on one of the designs proposed for JDEM. It is a similar concept of the ESA Euclid mission, retained in the Cosmic Vision program. Neither missions are officially approved, but concept development continues and may result in further collaboration mission. CSA has supported a mission concept study (2010) to identify potential contribution to such a mission. Launch would be in the late 2010's.

### **JWST**

The James Webb Space Telescope (JWST) is a joint mission involving NASA, ESA, and the CSA. This major facility-class space observatory will be a successor to the Hubble Space Telescope. The JWST will be used to observe targets that range from objects within our Solar System to the most remote galaxies, which are seen during their formation in the early universe. The CSA is contributing with the development of two instruments; a Tunable Filter Imager (TFI) and a Fine Guidance Sensor (FGS).

### **LEMUR**

The Lunar Exploration Manned Utility Rover (LEMUR) is a CSA exploration concept that could lead to a critical and central Canadian contribution to the lunar surface mobility architecture. LEMUR is a small, agile, unpressurized surface mobility system. When driven manually, it accommodates two suited astronauts. In addition, LEMUR accommodates small payloads (such as luggage and small scientific instruments) with expansion capabilities for larger payloads (such as cargo and full suites of scientific instruments).

### **LiteArm**

The Lightweight, Scalable Manipulator Family for Exploration (LiteArm) is a CSA concept study focused on potential Canadian manipulator participation in future surface exploration missions. This study would provide an overview of present and planned surface exploration missions which could require manipulator systems, and Canada's potential role in them. Additionally, this study would provide architectures for an optimal number of manipulator classes that satisfy the range of capabilities required to meet the objectives of these surface missions and their associated costs and development schedules.



### **LORE**

The CSA Lunar Origins and Resource Explorer concept study will examine the scientific and technical feasibility of investigating the lunar polar environment, determining surface and near-surface solar wind-implanted ions, ilmenite abundances, surface and subsurface ice distribution, dust physical and compositional properties, mineralogy, and dust levitation using Ultra-violet (UV), Visible (VIS) and Mid-InfraRed (MIR) reflectance spectroscopy and a Complementary Metal-Oxide Semiconductor (CMOS) micro-imager for target morphology and grain size.

### **LSC**

The Lunar Surface Communications (LSC) is a CSA study of requirements, architecture and a design concept for a Moon surface communication system that enables wireless surface operational support. The proposed lunar network comprises a combination of orbiter relay, direct to Earth links and surface radio communications. This study would focus on defining a Moon surface communication architecture and design concepts that would enable future surface communication.

### **Luna - Resource**

Two concepts are being developed for further consideration in future mission to the moon.

### **Lunar Rover**

The CSA Lunar Rover Concept Study is an operational concept for a rover and associated subsystems that would fit into the published NASA Lunar Exploration Architecture. The proposed concept is a general-purpose, configurable rover that satisfies mission requirements ranging from short one and two-day sortie missions to longer multi-day outpost missions.

### **M3MSat**

CSA and the Department of National Defence are partnering to manage the Maritime Monitoring and Messaging Microsatellite (M3MSat) which payload will be an Automatic Identification System (AIS) supported on a micro-satellite bus. This project will demonstrate a multi-mission micro-satellite bus capability and will allow optimization of the AIS payload in maritime traffic identification.

### **Marangoni**

The JAXA's Marangoni experiment will be carried out on the ISS. The Canadian scientific contribution is an advanced three-dimensional numerical model that will be developed and used with the g-jitter data from the ISS to predict vibration-induced surface oscillations of a liquid bridge undergoing oscillatory Marangoni convection that can affect adversely the synthesis of new materials such as semi-conductor crystals.

### **Matroshka-R**

The Matroshka-R experiment investigates how much radiation different organs in the human body receive in space over prolonged periods of time. The data gained from Matroshka-R will be vital to estimate health risks to astronauts aboard the ISS and on longer space missions since the total radiation risk depends largely on the dose received by the internal organs. It will also increase understanding of the distribution of different types of radiation within the ISS and within the human body. This experiment is followed by the RaDI-N experiment.

### **MCAP**

The Mission for Climate and Atmospheric Pollution (MCAP) is a CSA concept study composed of four nadir-viewing instruments on a small satellite for the acquisition of a global precise dataset of atmospheric composition measurements (trace gases and aerosols) that are important for climate process and air quality studies.

### **MEMS LIDAR**

The CSA Micro-Electro-Mechanical Systems and Light Detection And Ranging (MEMS LIDAR) concept study will focus on the Canadian contribution of a 3D active vision sensing capability based on the needs for rover operations on the JAXA SELENE-2 Lunar mission.

### **MEOS**

The Miniature Earth Observing Satellite (MEOS) mission is a CSA concept study composed of several miniaturized limb and nadir-viewing instruments on a micro satellite focusing on the measurement of greenhouse gases, aerosols and clouds. It will permit the study of terrestrial vegetation absorption and emission of tropospheric gases.

### **MEOSAR**

Middle Earth Orbit Search-and-Rescue (MEOSAR) will use navigation satellites such as GPS and Galileo to relay in near real-time signals from activated distress beacons located in ships, plane or on a single individual needing help for search and rescue missions. Its payload will support the COSPAS-SarSat Search-and-Rescue satellite system.

### **M-FTSIS**

The Mars Fourier Transform Spectrometer Interferometer Subsystem (M-FTSIS) is a CSA concept of an occultation Fourier Transform Spectrometer for measuring the atmosphere of Mars based on Canada's experience with the Atmospheric Chemistry Experiment Fourier Transform Spectrometer on Canada's SCISAT satellite. A solar occultation spectrometer has the potential to significantly increase knowledge of the atmosphere of Mars and provides a unique Canadian opportunity to perform international cutting-edge research in space exploration.

### **MIM/ATEN**

The Microgravity Vibration Isolation Mount (MIM) is an ISS hardware that isolates experiments from on board vibrations, providing a more "pure" microgravity. ATEN is used with the MIM Base Unit. It is a furnace designed to meet a wide range of scientific requirements on the ISS.

### **MLM**

The Manned Lunar Mission (MLM) is a CSA concept study that will provide a budgetary Rough Order of Magnitude (ROM) cost for a core mobility system concept as the foundation of Canada's contribution to the international exploration architecture. It will establish a Canadian Lunar Mobility Architecture to aid definition of architectures by international partners and provide CSA with the prerequisites to kick-start rover technology developments.

### **MOPITT**

One of five instruments on NASA's Terra satellite, MOPITT (Measurements of Pollution in the Troposphere) contributes to our understanding of the sources and pathways of atmospheric pollutants.

### **MOPITT-2**

Concept studies to develop the next generation of instruments for the measurements of pollution in the troposphere. This is one of the instruments being proposed as part of the Mission for Climate and Air Pollution (MCAP), one of the CSA mission concepts being completed in 2009.

### **MORSE**

This initiative aims at developing and demonstrating the usefulness of EO data for monitoring coastlines and coastal processes in the Arctic focusing on the information needs of Arctic coastal users in government, industry and in scientific organizations. It supports, enhances and stimulates coordination among Arctic coastal communities having common Earth observation-related information needs and activities across sectors and across disciplines.

### **MOST**

The Microvariability and Oscillations of Stars (MOST) microsatellite is Canada's first space telescope launched in 2003. It measures tiny fluctuations in light intensity from stars, enabling scientists to probe star interiors seismically and to set a lower limit on the age of the universe. MOST is also sensitive to the light variations caused by planets around other stars, giving us unique information about these distant worlds.

### **MSL - APXS**

The Alpha-Particle-X-Ray-Spectrometer (APXS) is an instrument for the Mars Science Laboratory. The Canadian contribution will help scientists to determine the chemical composition of various soil, dust and rock samples on the planet.

### **MSO - FTIR**

The CSA study will focus on increasing the level of readiness of the science and the technology associated with the solar occultation Fourier Transform InfraRed (FTIR) spectrometer of the Mars Science Orbiter (MSO). The long-term goal is to propose the successful Canadian technology to that NASA mission.

### **MSO - SAR**

The Synthetic Aperture Radar (SAR) Payload for Mars Science Orbiter (MSO) is a CSA study to advance the payload concept of a dual-band SAR instrument and radiometer for the exploration of Mars. This study targets the MSO opportunity in 2013 as a possible Canadian-built SAR instrument mission.

### **MSR - NET**

The CSA concept study Vision system for Mars Sample Return (MSR) will focus on vision system technology needs for the automated rendezvous and capture operations of the MSR mission while simultaneously introducing key technology components for next generation 3D vision sensors.

### **MSS - STS-114**

The Return to Flight Space Shuttle mission took the American flagship spacecraft back into orbit; it's been over two years since the Columbia accident. A mission like no other, STS-114 is a unique test flight that serves as a foundation for every Shuttle mission to follow. The mission tested new designs incorporated into the Shuttle's external fuel tank and processes that eliminate the likelihood that future Space Shuttle flights could suffer damage similar to Columbia. New cameras and techniques photographed the tank during launch and after it is jettisoned from the Shuttle to allow engineers to evaluate the performance of those new designs. The mission also tested a variety of new techniques to ensure that the health of the heat shield can be confirmed in space. New ground and flight camera and sensor systems observe the Shuttle environment during launch and in orbit. New techniques will be used for in-flight inspection. New methods under development for repair of the Shuttle's heat-shielding Thermal Protection System were tested. Also, Discovery delivered a pressurized cargo container full of supplies to the Space Station and a key spare part that was installed during one of the mission's three spacewalks.

### **MSS - STS-119**

Move over, Morning Star. Once Canadarm2 installs the fourth and final set of solar array wings to the International Space Station, the Station will surpass Venus as the brightest object in the night sky, second only to the Moon. The Space Shuttle Discovery is set to deliver the power-generating solar panels and Starboard 6 (S6) truss segment to the ISS on the 125th mission in the Shuttle program, known as STS-119/15A (which launched on March 15, 2009). This final piece of the Station's backbone brings the ISS to its full length of 102 metres (roughly the size of a Canadian football field), and increases the quantity of electricity available for science experiments by 50%. This additional power also means that the Station is ready to house a crew of 6 astronauts instead of the current 3. Canadian Space Agency's astronaut Dr. Robert Thirsk will be a member of Expedition 20/21 – the first 6-person Station crew set to launch in late May 2009.

### **MSS - STS-123 1J/A (DEXTRE)**

In mid-March 2008, Space Shuttle Endeavour flew its 25th assembly mission to the International Space Station to deliver the Canadian-designed two-armed robot called "Dextre" the Special Purpose Dexterous Manipulator (SPDM), supply the first component of the Japan Aerospace Exploration Agency (JAXA) Japanese Experiment Module (JEM), and make an astronaut rotation. An essential, versatile tool for servicing the Station, Dextre can remove and replace small components on the Station's exterior that require precise handling. It is equipped with specialized grippers, built-in socket wrenches, four robotic tools, video equipment, lights, and umbilical connectors to provide power and data connectivity, and a stowage platform. Dextre is a sophisticated two-armed robot, part of Canada's contribution to the International Space Station. Canadarm2, a moveable work platform called the mobile base, and Dextre form the Mobile Servicing System. These three robotic elements can work together or independently.

### **MSS - STS-124**

CSA supported the STS-124 mission whose main objective was to install the Japanese Experimental Module (Kibo) to the ISS. The STS-124 mission was the second of three flights where Canadarm2 was used to assemble an element of the final Kibo laboratory. Afterwards, Kibo's logistics module, which had been installed in a temporary location during STS-123, was relocated by Canadarm2 and attached to the Japanese Experiment Module (JEM). STS-124 was the 26th shuttle mission to the International Space Station.

### **MSS - STS-126**

On November 10, 2008, Canadarm2 extracted the Multi-Purpose Logistics Module (MPLM) from the Space Shuttle Discovery and berthed it to the ISS to support the transfer of supplies and other logistics payloads to the ISS. Canadarm2 then reinstalled the MPLM into Discovery's payload bay prior to its return to Earth.

### **MSS - STS-128**

On August 31, 2009, Canadarm2 extracted the Multi-Purpose Logistics Module (MPLM) from the Space Shuttle Discovery and berthed it to the ISS to support the transfer of supplies and other logistics payloads to the ISS. Canadarm2 then reinstalled the MPLM into Discovery's payload bay prior to its return to Earth.

### **MSS - STS-129**

CSA supported the STS-129 mission whose main objective was to install Express Logistics Carriers ELC 1 and ELC 2: moved from payload bay to respective locations on P3 and S3 truss segments, Transfer S-Band Antenna and Support Assembly (SASA) to Z1 location, Transfer and install spare High Pressure Gas Tank (HPGT) (O2) from ELC2 to ISS Airlock using the Space Station Remote Manipulator System (SSRMS) and Relocate Pressurized Mating Adapter (PMA) 3 to Node 1 Nadir using SSRMS.

### **MSS - STS-131**

On April 08, 2010, Canadarm2 extracted the Multi-Purpose Logistics Module (MPLM) from the Space Shuttle Discovery and berthed it to the ISS to support the transfer of supplies and other logistics payloads to the ISS. The Space Station Remote Manipulator System (SSRMS) was also used to transfer an Ammonia Tank Assembly (ATA) to the ISS. Canadarm2 then reinstalled the MPLM into Discovery's payload bay prior to its return to Earth.

### **MVIS**

Canada has developed key technology that will help isolate experiments from the harmful effects of these vibrations. The compact Canadian-built Microgravity Vibration Isolation Subsystem (MVIS) is a control system that is integrated into the European Space Agency's Fluid Science Lab protecting it from the daily shakes and trembles on board the ISS. It uses a magnetic field to suspend a container for experiments.

### **MWD**

The Measure While Drilling (MWD) is a CSA concept study that would examine the potential for combining information from sensors attached to the drill with intelligent algorithms as a tool for identifying prospective lunar resources. This technology would involve monitoring specific characteristics of the drilling process, analyzing and interpreting this data and implementing algorithms to efficiently extract knowledge from these large data sets. The sensors would monitor drilling parameters such as drill rotational speed, dynamic thrust forces, rate of penetration and real-time power consumption of the drill.

### **NEOSSat**

The Near Earth Orbit/Object Surveillance Satellite (NEOSSat) is a joint CSA-DND mission. It is a combination of the Near Earth Space Surveillance (NESS) and the High Earth Orbit Surveillance (HEOS) projects. It will be used to observe the inner portion of the solar system to discover, track and study asteroids and comets, and will also be used to track satellites in high-Earth orbit to update the orbit parameters of known satellites flying over the Canadian territory.

### **NEW FRONTIERS**

New Frontiers is a NASA program to explore the solar system with frequent, medium class spacecraft missions that will conduct high-quality, focused scientific investigations designed to enhance our understanding of the solar system. The program objective is to launch high-science-return planetary science investigations on an average of once every 36 months. Added to the NASA budget for the first time in 2003, New Frontiers will build on the innovative approaches used in NASA's Discovery and Explorer Programs, but will provide a mechanism for identifying and selecting missions that cannot be accomplished within the cost and time constraints of Discovery.

## **NEXT GEN**

**Advanced Broadband:** First experimental payload on board a commercial satellite in GEO to provide ultra-high speed connectivity.

**NGS:** The Northern Ground Stations (NGS) Project will provide ground stations infrastructure in the Canadian Arctic to support CSA Missions and other fulfill other Government Departments. It consist of 3 to 4 ground stations in Northern Canada, a data archiving facility and a network hub for interconnecting the the stations, the archiving facility and control center in St-Hubert.

## **NIRST (Aquarius/SAC-D)**

The New Infra Red Sensor Technology (NIRST) is a CONAE (Comision Nacional de Actividades Espaciales) instrument to which CSA contributed detectors that use advanced Canadian microbolometer technology. NIRST is carried on the Aquarius/SAC-D satellite, a partnership mission being developed by NASA and CONAE. The NIRST instrument will acquire thermal imagery that will be especially useful for measuring the radiative power of biomass fires, an indication of emission type and quantity. NASA's Aquarius instrument will measure global sea surface salinity (SSS). The observations it makes will fill the gaps between conventional in situ sampling to give a global view of salinity variability. Aquarius will help us understand the physical processes that link the water cycle, the climate, and the ocean.

## **OCLE-DOCLE**

Oort Cloud Dynamic Occultation Experiment (OCLE-DOCLE) is a payload concept study done for CSA in 2009. The study considered a micro-satellite platform for 30 cm telescope to observe transient events – occultation of Oort cloud and Kuiper belt objects (small bodies at edge of the solar system), in order measure their distribution and better understand the model of our solar system.

## **ORBITALS**

The Outer Radiation Belt Injection, Transport, Acceleration, and Loss Satellite (ORBITALS) is a Canadian space physics mission that aims at studying the harsh space weather phenomena in the outer radiation belts. That part of space is intensely radioactive and experiences occasional severe storms that can damage expensive and critical space assets. Understanding and predicting the radiation phenomena in this part of near-Earth space is also essential to support long-duration human space flights and robotic missions.

## **OSIRIS**

ODIN Swedish satellite carries the Optical Spectrograph and Infra-Red Imaging System (OSIRIS). It measures the concentration of various gases in the stratosphere, thereby allowing our scientists to make a significant contribution to the global understanding of stratospheric ozone depletion processes.

### **PCW**

The Polar Communications and Weather (PCW) mission is to position a constellation of satellites in highly elliptical orbit over the North Pole to provide robust 24/7 two-way communications capability to all of the Canadian North for high data rate (HDR) data and information products, potentially also low-data rate (LDR) communications capability, and also near-real time (NRT) meteorological information products in the Arctic region. The CSA will complete the assessment of the requirements of the Canadian government users for a polar satellite system as part of a joint study with DND and Environment Canada.

### **PHEMOS**

Polar Highly Elliptical / Molniya Orbit Science (PHEMOS) aims at developing a secondary Science payload that could potentially be accommodated on the «Polar Communication and Weather» (PCW) Mission. The PCW platform and its highly elliptical orbit provide significant potential to advance science payload concepts that address certain topics in Atmospheric Remote Sensing, Geospace Imaging and In-situ Space Environment Science. The PHEMOS Atmospheric Remote Sensing concept studies will assess the feasibility of measuring gases and aerosols that are important for climate warming and for air quality.

### **PHOENIX**

The Phoenix Mars Lander is the first mission to explore a polar region of Mars at ground level. Phoenix landed near Mars's northern polar cap on May 25, 2008, and then spent 90 days probing Mars's soil and atmosphere to determine if the environment could be hospitable to life. Canada's contribution to Phoenix is a meteorological station that recorded daily weather using temperature, wind and pressure sensors, as well as a light detection and ranging instrument.

### **PMDIS**

The Perceptual Motor Deficit in Space (PMDIS) experiment will demonstrate the cause of the hand-eye coordination dysfunction seen early in space missions and indicate countermeasures to reduce or eliminate the problem. PMDIS is the first experiment to use the ISS allocation rights.

### **PRET**

This exploration mission is planned to take place from September 2010 to November 2011. CSA has developed a prototype of a Performance Readiness Evaluation Tool (PRET) to provide neurocognitive assessment capability using a 3D virtual reality simulator with embedded neurocognitive tests. This activity is the result of the medical evaluation requirement for long-duration missions to the International Space Station which stipulates that astronauts must undergo neurocognitive assessment before, during and after the flight to detect any indications of a reduced performance state. The prototype is planned to be tested in the Russian Isolation Study, Mars-500.



## **PROBA**

The Project On board Autonomy (PROBA) was launched in 2001, as a technology demonstration mission and it is now operating as an Earth Observation mission. PROBA performs autonomous guidance, navigation, control, on board scheduling and payload resources management. Its payload includes a compact multi-spectral imager and high-resolution camera. PROBA also aims to use and demonstrate automatic functions, both on board and in the mission ground segment.

## **QUICKSAT**

QuickSat is a microsatellite platform that was designed and built by CSA engineers and by students, in collaboration with industry. The platform has reached the stage where it is available to accommodate a payload and to transit into a CSA mission.

## **RADARSAT-1**

RADARSAT-1, Canada's first Earth Observation satellite is the only fully operational civilian remote sensing satellite that carries Synthetic Aperture Radar (SAR). This technology, contrary to optical sensor satellites, has the capacity to image day and night, in all weather conditions, regardless of cloud cover, smoke, haze and darkness. Launched in November 1995, RADARSAT-1 was meant to operate for five years. RADARSAT-1 has continued to supply SAR data to clients in its extended mission.

## **RADARSAT-2**

RADARSAT-2 was launched on December 14, 2007. RADARSAT-2 is a Canadian satellite from the next generation with its Synthetic Aperture Radar (SAR) technology and the most advanced satellite of its kind in the world. It incorporates new capabilities that ensure Canada's continued leadership in the global marketplace for radar image data by leveraging the knowledge and experience gained through the RADARSAT-1 mission.

## **RADARSAT Constellation Mission (RCM)**

The RADARSAT Constellation Mission also known as RCM is the evolution of the RADARSAT missions with the objective of ensuring data continuity, improved operational use and improved system reliability over the next decade. The three-satellite configuration will provide complete coverage of Canada's land and oceans offering an average daily revisit at 50m resolution, as well as a significant coverage of international areas for Canadian and international users. It will also offer average daily access to 95% of the world.

## **RADI-N**

Radi-N is the next generation bilateral Russia-CSA radiation study, based on and following Matroshka-R project. The CSA continued to collect radiation exposure data through a collaborative project with International Partners on ISS using Canadian made radiation dosimeters. Specifically, CSA implemented project RADI-N during ISS Expedition 20/21 (Mission C1). During this expedition, astronaut Robert Thirsk conducted 4 sessions during which he collected neutron radiation data on the ISS using Canadian made Bubble Detectors. This data is currently being analyzed and will continue until May 2011. Another set of sessions is planned for C2 Mission in 2012-2013.

### **RAO**

The Robotics and Automation for Orion (RAO) is a CSA concept study of Canadian participation in future NASA Constellation Program missions centered on the Orion Crew Exploration Vehicle (CEV). The study would include a comprehensive overview of planned exploration missions which require in-space automation and robotics. This study would propose a highly configurable robotic system concept that can be tailored to suit the launch constraints imposed by the various missions.

### **RAPIER**

The Robotic Assistant & Precursor Investigation and Exploration Rover (RAPIER) is a CSA concept of a small rover with a “plug-and-play” reconfigurable chassis and built-in provisions for communication, power and variable autonomy tele-operation guidance and navigation. It is capable of operating as an investigative scout, astronaut assistant and mobile infrastructure platform in support of returning astronauts to the Moon. This concept could lead to a critical and central Canadian contribution to the lunar surface mobility architecture.

### **RAVENS**

Recurrent Auroral Visualization of Extended Northern Storms (RAVENS) is a concept study submitted to the CSA from a proposed Canadian-led space science mission which would use UV cameras on two polar-orbiting satellites to study space weather over Canada.

### **REMOTE HEALTHCARE**

The CSA concept study entitled "Training Development and Maintenance of a Competence Program for Remote Healthcare Providers" focuses on optimal ways of providing autonomous medical support for exploration space missions. Some of the top medical challenges for Moon exploration space missions and beyond that have been identified include clinical training and maintenance of skills for crew medical providers. The study explores the concept of Medical Autonomy as part of a possible infrastructure contribution that could be made by Canada to a global partnership for exploration missions.

### **ROSM**

The CSA Robotic Orion/Orbital Service Module (ROSM) study will perform an evaluation of concepts for a robotic service module for NASA-Orion and ESA Exploration Missions and other commercial missions. It will define fielding concepts for manned and unmanned missions, interface definition and resource requirements, technology development requirements, roadmap for the development and fielding, and development of preliminary system design requirements.

### **SBIS**

The Surface-Base Infrared Sensor (SBIS) is a CSA concept of an optical payload based on a Fourier Transform spectrometer operating in the infrared that will be used to map and classify minerals on the surface of the Moon. The payload will operate on the surface from a rover or other platform, and will measure spectra of the radiance reflected and emitted by the surface.

### **SCCO**

The Soret Coefficient in Crude Oil (SCCO) experiment will determine the diffusion coefficient of crude oil under microgravity conditions in order to improve extraction processes.

### **SCISAT**

The Space Science Satellite (SCISAT) is Canada's first scientific satellite in 30 years. SCISAT focuses on polar ozone budget and dynamics but also contributes to measurements and modeling of mid latitude ozone and upper troposphere chemistry as well as Chlorinated Fluorocarbons' (CFC) greenhouse gases. SCISAT has continued to produce large volumes of very-high quality space data for climate, weather and pollution studies. The Canadian Space Agency will continue to operate SCISAT-1 and provide science data to the Canadian and international scientific community.

### **SCOPE**

SCOPE is a JAXA mission concept involving five spacecraft flying in a tetrahedral formation with an apogee of 30 Earth radii in the magnetosphere. The mission proposes to untangle the fundamental physics underlining energy storage and release processes behind space weather. Possible Canadian participation would be contribution of instrumented spacecraft.

### **Si Si-Ge Alloys**

The Silicon in Silicon-Germanium Alloys (Si Si-Ge Alloys) study is dedicated to understanding the role of gravity in the solidification of semiconductor materials. Understanding the gravitationally-induced microscopic movements of liquid molecules in the semiconductor fabrication process is important for both scientific and industrial communities, as well as for the Canadian economy. This Canadian study prepares the Canadian scientific community for mission opportunities on board the International Space Station. The Principal Investigator of the study is Prof. Daniel Labrie from Dalhousie University in Halifax, NS.

### **SMAP**

The NASA's Soil Moisture Active and Passive (SMAP) mission will measure soil moisture and surface freeze/thaw with the accuracy, resolution, and coverage that are required to further our understanding of the Earth's water, energy, and carbon cycles.

### **SNOWSAT**

SnowSat is a CSA mission concept study composed of a cloud/precipitation radar instrument on a small satellite (or as a contribution to a partner platform) to measure clouds, snowfall and light precipitation. The advanced instrument concept builds on the experience of CloudSat and EarthCARE.

### **SOAR**

The Solar Occultation for Atmospheric Research (SOAR) mission is a CSA concept study composed of two instruments on a small satellite that will study the changes occurring in our atmosphere, specifically those related to climate change and air quality. The satellite will use an advanced Fourier Transform Spectrometer in solar occultation to provide vertical profiles of atmospheric composition, both trace gases and aerosols.

### **SPICA**

SPICA is a JAXA and ESA lead mission to discover the origins of galaxies, stars and planets. SPICA offers an improvement in sensitivity over Herschel Space Observatory by two orders of magnitude and observations over the full MIR/FIR range with sophisticated imaging, spectroscopic and coronagraphic instruments. Canada contributes a concept study for instrument design of the different detector technologies.

### **SPIDER**

Spider is a mission concept using high-altitude balloon-borne instrument to study the sky in the far infra-red and measure the polarization of the cosmic microwave background which is the signature of the Big Bang.

### **STEP**

The Stratosphere-Troposphere Exchange Processes (STEP) mission is a CSA concept study composed of three limb-viewing instruments on a small satellite focusing on the retrieval of relevant information about the photochemistry, dynamics and radiative properties associated with the upper troposphere and lower stratosphere.

### **SWIFT (Chinook)**

SWIFT, Stratosphere Wind Interferometer For Transport studies, is a Canadian instrument that will increase our understanding of our atmosphere and will lead to advances in weather and climate prediction models that are key tools to provide answers on the health of the ozone layer and climate change.

### **THEMIS**

The THEMIS mission stands for "Time History of Events and Macroscale Interactions during Substorms". The CSA is funding the participation of Canadian scientists in the NASA THEMIS mission comprised of a system of 5 satellites for the study of northern lights phenomena. THEMIS will help to pinpoint where in the magnetosphere the energy of the solar wind transforms explosively into auroras.

### **TICFIRE**

The Thin Ice Clouds in Far IR Experiment (TICFIRE) mission is a CSA concept study composed of one nadir-viewing instrument on a micro satellite that aims to fill a global observational gap in the far IR for the detection and the measurements of radiation anomalies induced by thin ice clouds and light precipitation from cold regimes in polar regions and in the upper troposphere.

### **TRAC**

The Test of Reaction and Adaptation Capability (TRAC) is to determine if the degradation of human manual skills during spaceflight occurs because the process of adaptation to spaceflight consumes a substantial portion of available computational resources in the brain, leaving fewer resources to carry out skilled manual actions. TRAC is carried out on the International Space Station (ISS).

### **TRACTEUR**

The Terrainable Reconfigurable Autonomy-Capable Tool-using Exploration and Utility Rover (TRACTEUR) is a CSA concept of a large, modular “work-horse” rover that could lead to a critical and central Canadian contribution to the Global Exploration Strategy (GES). The concept is primarily targeted at manned exploration of the Moon but has a technology development path that could lead through a robotic precursor mission.

### **TriDAR DTO**

The TriDAR is a vision system built to support rendezvous and docking operations. It permits to track spacecraft from a distance of 1 km down to 0 meter. The TriDAR flew on the STS-128 and STS-131 flights as a Detailed Test Objective (DTO) under a collaboration between NASA and CSA. The TriDAR was used to provide images of the International Space Station (ISS) and to track it while the Space Shuttle was approaching the ISS. Similar operations were performed during undocking.

### **UVAMC**

UVAMC means Ultra Violet Auroral Monitoring Camera. It is a technology in phase 0 that the University of Calgary is developing to photograph the aurora borealis from space. Some candidate missions are KuaFu (China) and PCW. Current studies aim to determine the sensitivity required to obtain scientific validated images.

### **UVIT-ASTROSAT**

The ASTROSAT satellite is a Multi-wavelength Space Borne Observatory for carrying out astronomical research. The Ultra-Violet Imaging Telescope (UVIT) aims to image selected parts of the sky in three distinct spectral regions (Far UV, Near UV and Visible) using two nearly identical telescopes. The CSA has agreed to provide to the Indian Space Research Organization (ISRO) the Flight Detector Subsystem. Our participation in the mission ensures that Canadian astronomers have observation time on ASTROSAT, providing new opportunities for astronomical research and discoveries.

### **Vascular**

The Cardiovascular health consequences of long-duration space flight (Vascular) project will investigate vascular inflammation occurring during space flight and support the development of countermeasures to improve astronaut health upon return to gravity.

### **V-Band Experimental Payload**

Following the successful deployment of broadband, multimedia services using Ka- Band technology on the Canadian Anik F2 satellite operated by Telesat, the objective of this mission will be to demonstrate new telecommunications services using extremely high frequencies, thereby allowing new niche expertise for Canadian industry and improved, faster two-way internet service in all regions of Canada.

### **VSE**

The Vision Systems for Exploration (VSE) is a CSA concept study to examine the potential technology to fulfill requirements for autonomous rendezvous and docking mission, and for planetary surface operations such as inspection and navigation. The study would identify technology roadmaps for both near-term and long-term applications as early as 2 years, and as far as 12 years from now.

### **WaMI**

Advanced study for an instrument to observe upper atmosphere dynamics through Waves Michelson Interferometer (WaMI).

### **WISE**

The Women International Space Simulation for Exploration (WISE) study is to assess the roles of nutrition and combined physical exercise in countering the adverse effects of extended gravitational unloading through bed-rest. Bed-rest studies have been used for decades to reproduce on Earth the impact of weightlessness or weight unloading that is experienced by astronauts in orbit or during space flight. Results will prove valuable in planning long-duration human missions in space. This research will also have clinical significance on Earth, advancing knowledge and pointing to improved methods of assisting recovery by bedridden patients.