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# **CANADIAN SPACE AGENCY**

## **Departmental Performance Report For the period ending March 31, 2011**

**Analysis of Program Activities by Strategic Outcome**

***- Detailed Performance Information -***



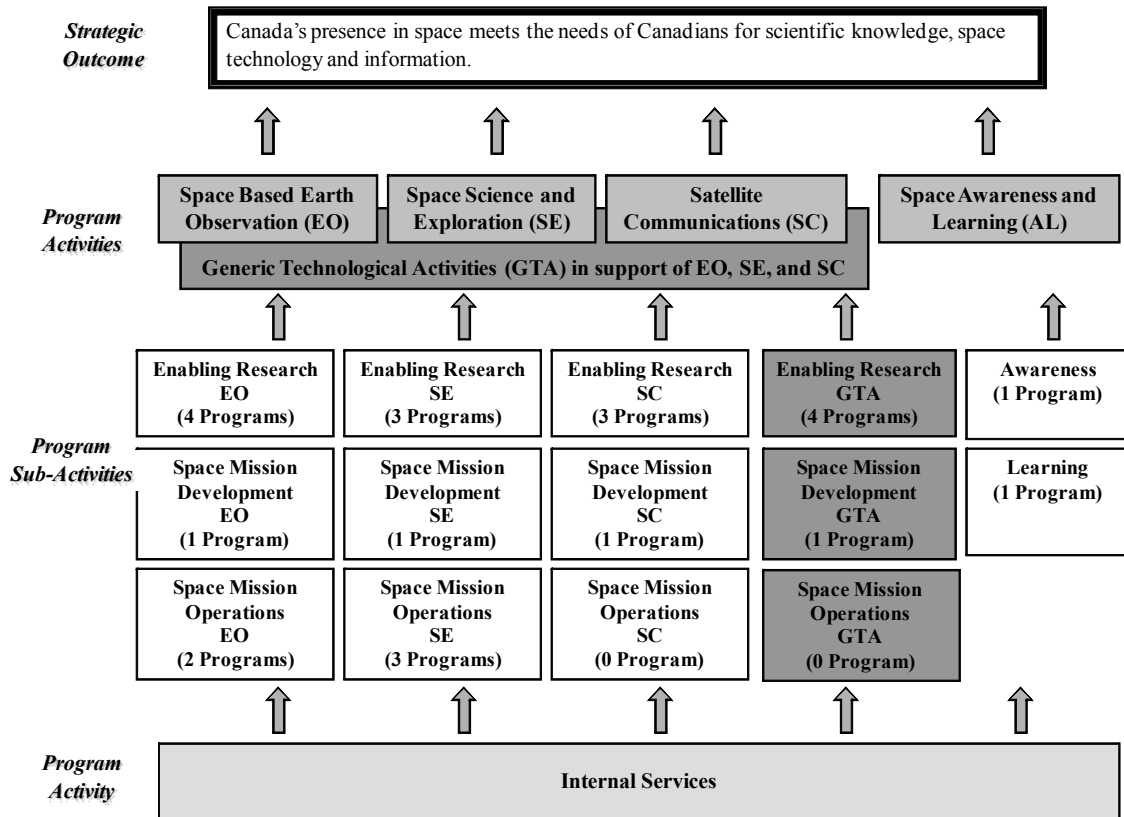
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## INTRODUCTION

Since 2005-2006, the Canadian Space Agency's (CSA) achievements are reported according to the Program Activity Architecture (PAA). The information is presented by Program Activities, Program Sub-Activities and then by Program Sub-Sub-Activities. However, this is the last Departmental Performance Report based on this PAA because a new PAA became effective on April 1<sup>st</sup>, 2011.

As a result of nearly two years of consultation with senior executives of other government departments, academia and industry stakeholders, and heads of space agencies, the CSA revised its strategic direction and realigned its Program Activity Architecture and adjusted its Performance Measurement Framework presented in the Report on Plans and Priorities 2011-2012. To learn more about the new Program Activity Architecture, go to: <http://www.asc-csa.gc.ca/eng/publications/rpp-2011.asp#s1.2>



## SECTION 2: ANALYSIS OF PROGRAM ACTIVITIES BY STRATEGIC OUTCOME





### 2.1 HOW TO READ THE DETAILED ANALYSIS

**Program Activity:** For this level, the information is reported against final results and performance indicators. During the Performance Measurement Framework (PMF) exercise, the results and indicators were reviewed thoroughly and were presented for the first time in the 2008-2009 Report on Plans and Priorities (RPP). The first final results full analysis took place in 2010 at the end of the five-year cycle that started with the approval of the Canadian Space Strategy in February 2005 and the implementation of the Program Activity Architecture (PAA) in 2005-2006. It is the second time that a progress report from the year 2005-2006 is provided.

**Program Sub-Activity:** For this level, intermediate results and performance indicators were only developed in 2007-2008 and were listed for the first time in the 2008-2009 RPP. For each Program Sub-Activity, the section *Highlights of Main Accomplishments* shows example of achievements selected from the array of projects and activities carried out by the CSA and its industry, academic and government partners, in response to what was forecasted in the corresponding RPP.

**Program Sub-Sub-Activity:** For this level, the information is reported yearly against immediate results and performance indicators. In this year's report, a 3-year trend performance analysis is provided for each sub-sub-activity.

**Performance Analysis:** Every year, a performance analysis is completed for each level of the PAA. This analysis provides contextual, complementary or methodological, as well as financial and human resources information. A 3-Year Trend Analysis at the sub-sub-activity level is provided as illustrated by the following star system. In addition, trend analysis is annually performed by slipping one year – adding the new-year value and knocking the fourth year value. This allows displaying the trend stability.

	<b>SUPERIOR ACHIEVEMENT:</b> Uncommon achievement over targeted superior limit.
	<b>SATISFACTORY ACHIEVEMENT:</b> Expected or maintained achievement within lower and superior targeted limits.
	<b>OPPORTUNITY FOR IMPROVEMENT:</b> Achievement below targeted lower limit.
	<b>COMPARISON TO PREVIOUS YEAR:</b> The current trend is compared to the one recorded the previous year. Icons can show an improving, stable or declining trend.

## 2.2 SPACE BASED EARTH OBSERVATION

<b>SPACE BASED EARTH OBSERVATION 2010-2011 PROGRAM ACTIVITY PERFORMANCE MEASUREMENT</b>	
<b><u>BENEFITS FOR CANADIANS</u></b>	
<p>Earth Observation (EO) enables monitoring of the environment with unparalleled coverage and scope, enhancing our forecasting capabilities and our understanding of environmental systems.</p> <p>EO data are used for sustainable management and development of natural resources, land use, fisheries and agriculture and providing support for disaster management.</p> <p>EO missions are critical to security and sovereignty, offering cost-effective, wide-area surveillance of land and maritime environments that are difficult to access such as the Northwest Passage.</p> <p>Among Canada's government users benefiting from EO data are Environment Canada, Fisheries and Oceans Canada, the Canadian Ice Service, Natural Resources Canada, the Department of National Defence, and the Provinces and Territories.</p>	
<b><u>EXPECTED RESULT</u></b>	
<p>The benefits of activities involved in Earth Observation from space serve Canadian users in the fields of environment, resource and land-use management, and, security and sovereignty.</p>	
<b><u>MAIN ACCOMPLISHMENTS IN 2010-2011</u></b>	
<p>RADARSAT-2 is fully operational since April 2008. The Canadian Government has a \$445 million credit over the life of the satellite. There continues to be an increase in the use of data by a number Canadian government departments which used data valued at over \$37 million in 2010-2011 compared to \$34 million in 2009-2010.</p> <p>The CSA continued the planning and development of the first of three satellites for the RADARSAT Constellation, the follow-on mission to RADARSAT-2, to be launched in 2014 and 2015. A Preliminary Design, initiated in November 2008, was completed in March 2010 and the detailed design phase started in March 2010.</p> <p>The CSA ensured Canada's commitment, as an official member of the International Charter <i>Space and Major Disasters</i>. CSA continued to contribute critical EO images in support of relief, aid and humanitarian efforts undertaken in response to disasters in countries around the world. This year alone CSA has supported 46 Charter activations providing data world-wide for covering different disaster types such as floods, earthquakes, volcanoes, oil spills, landslides, and hurricanes.</p>	
<b>Indicators</b>	<b>Performance Summary</b>
1. Proportion of active missions relative to the total number of missions supported by Canada in the EO priority areas.	37%; 11 active missions out of 36 supported missions.
2. Number of applications developed as a result of CSA's participation in space missions and/or support to projects/activities in EO considered "operational" from program standards.	A total of 22 applications became operational in 2010-2011.

3. Number of uses of EO data as a result of CSA's participation in space missions and/or support to projects/activities in EO.	A total of 32 new uses were reported.
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<p><u>Indicator 1 – Performance Analysis</u></p> <p>At the time of the Departmental Performance Reporting, the Canadian Space Agency presents a list of space missions to which it actually contributes or plans to contribute. The fact that a mission appears on the list does not mean that it will be completed. Any mission must necessarily follow many critical steps depicted in a simple manner as such:</p> <ul style="list-style-type: none"> <li>▪ Mission under review: A mission that is subject to concept of feasibility studies. At the end of this step, a decision is made whether to continue, to cancel or to postpone the participation to the mission.</li> <li>▪ Mission in development: The participation implies that activities produce assets which are not yet operational. The final milestones prior to operation are the launch and the full commissioning of the mission.</li> <li>▪ Mission in operation: The mission is operational, delivering results until being fully completed. By virtue of being in operation, a mission will spark scientific, technological and operational activities in order to reach its objectives.</li> </ul> <p>EO missions at the operation stage (11): * = 0  EO missions at the development stage (10): * = 0  EO missions under review (15): * = 1</p> <p>(Year) = Actual or projected launch date or date of completion when known.  * = New missions in 2010-2011.</p> <p>Descriptions of missions can be found in <a href="#">Section 2.8</a> – List of Space Missions.</p> <p><b>Earth Observation (EO) missions at the operation stage:</b></p> <table border="1" data-bbox="264 1276 1382 1829"> <thead> <tr> <th data-bbox="264 1276 727 1318"><b>Mission</b></th> <th data-bbox="727 1276 997 1318"><b>Status</b></th> <th data-bbox="997 1276 1382 1318"><b>Field</b></th> </tr> </thead> <tbody> <tr> <td data-bbox="264 1318 727 1388">CloudSat (2006)</td> <td data-bbox="727 1318 997 1388">In operation, objectives met</td> <td data-bbox="997 1318 1382 1388">Environment</td> </tr> <tr> <td data-bbox="264 1388 727 1474">ESA-ENVISAT (2002)</td> <td data-bbox="727 1388 997 1474">In operation, objectives met</td> <td data-bbox="997 1388 1382 1474">Environment, Resource and Land Management</td> </tr> <tr> <td data-bbox="264 1474 727 1560">ESA-ERS-2 (2005)</td> <td data-bbox="727 1474 997 1560">In operation, objectives met</td> <td data-bbox="997 1474 1382 1560">Environment, Resource and Land Management</td> </tr> <tr> <td data-bbox="264 1560 727 1602">ESA-GOCE (2009)</td> <td data-bbox="727 1560 997 1602">In operation</td> <td data-bbox="997 1560 1382 1602">Environment</td> </tr> <tr> <td data-bbox="264 1602 727 1644">ESA-SMOS (2009)</td> <td data-bbox="727 1602 997 1644">In operation</td> <td data-bbox="997 1602 1382 1644">Environment</td> </tr> <tr> <td data-bbox="264 1644 727 1686">ESA-Cryosat-2 (2010)</td> <td data-bbox="727 1644 997 1686">In operation</td> <td data-bbox="997 1644 1382 1686">Environment</td> </tr> <tr> <td data-bbox="264 1686 727 1755">MOPITT (1999)</td> <td data-bbox="727 1686 997 1755">In operation, objectives met</td> <td data-bbox="997 1686 1382 1755">Environment</td> </tr> <tr> <td data-bbox="264 1755 727 1829">OSIRIS (2001)</td> <td data-bbox="727 1755 997 1829">In operation, objectives met</td> <td data-bbox="997 1755 1382 1829">Environment</td> </tr> </tbody> </table>	<b>Mission</b>	<b>Status</b>	<b>Field</b>	CloudSat (2006)	In operation, objectives met	Environment	ESA-ENVISAT (2002)	In operation, objectives met	Environment, Resource and Land Management	ESA-ERS-2 (2005)	In operation, objectives met	Environment, Resource and Land Management	ESA-GOCE (2009)	In operation	Environment	ESA-SMOS (2009)	In operation	Environment	ESA-Cryosat-2 (2010)	In operation	Environment	MOPITT (1999)	In operation, objectives met	Environment	OSIRIS (2001)	In operation, objectives met	Environment
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OSIRIS (2001)	In operation, objectives met	Environment																									

RADARSAT-1 (1995)	In operation, objectives met	Environment, Resource and Land Management, Security and Foreign Policy
RADARSAT-2 (2008)	In operation	Environment, Resource and Land Management
SCISAT (2003)	In operation, objectives met	Environment

(Year) = Actual or projected launch date or date of completion when known.

\* = New missions in 2010-2011.

**Earth Observation (EO) missions at the development stage:**

<b>Mission</b>	<b>Status</b>	<b>Field</b>
RADARSAT Constellation (2015)	In development	Environment, Resource and Land Management, Security and Foreign Policy
ESA/JAXA-EarthCARE (2016)	In development	Environment
ESA-ADM/Aeolus (2013)	In development	Environment
ESA-Sentinel-1 (2011)	In development	Environment, Resource and Land Management, Security and Foreign Policy
ESA-Sentinel-2 (2016)	In development	Environment, Resource and Land Management, Security and Foreign Policy
ESA-Sentinel-3	In development	Environment, Resource and Land Management, Security and Foreign Policy
ESA-Sentinel-5 Precursor	In development	Environment
ESA-Swarm (2012)	In development	Environment
NIRST (AQUARIUS / SAC-D) (2011)	In development	Environment
PROBA-2 (2011)	In development	Environment, Technology demonstration

(Year) = Actual or projected launch date or date of completion when known.

\* = New missions in 2010-2011.

**Earth Observation (EO) missions under review:**

<b>Mission</b>	<b>Status</b>	<b>Field</b>
CANSOC	Under review	Infrastructure, Data reception
CASS	Under review	Environment
MCAP	Under review	Environment
MEOS	Under review	Environment
MOPITT 2	Under review	Environment

PCW/PolarSat (weather component) (2016)	Under review	Meteorology, Climatic Change, Environment, Resource and Land Management, Security and Foreign Policy
PHEMOS (atmospheric component)	Under review	Environment
SMAP	Under review	Environment
Snowsat	Under review	Environment
SOAR	Under review	Environment
STEP	Under review	Environment
SWIFT	Under review	Environment
* SWOT	Under review	Climate Change, Water cycle, Environment
TICFIRE	Under review	Environment
WaMI	Under review	Environment

(Year) = Actual or projected launch date or date of completion when known.  
\* = New missions in 2010-2011.

Indicator 2 – Performance Analysis

A total of 22 applications became operational in 2010-2011 compared to 15 last year; 7 from the Earth Observation Application Development Program (EOADP) and 15 from Government Related Initiatives Program (GRIP) divided into monitoring applications (e.g. *Environmental Monitoring, Ecological Integrity, Ice Movement Mapping; Water Quality Monitoring*), detecting applications (e.g. *Oil Slick and Ship Detection; Forest Monitoring; Energy and Biomass Monitoring*), and measuring applications (e.g. *Soil Moisture and Geological and Water Monitoring, Winds and Waves Extraction*). An interesting trend has been observed; while only 23% (6/26) of the operational applications came from the GRIP in 2008-2009, this percentage rose to 68% (15/22) in 2010-2011.

Source: Internal documents.

Indicator 3 – Performance Analysis

Eleven of the 32 uses (35%) reported had national purposes. Last year, a similar, 47% of uses for national purposes was reported though more uses, 74, were reported. Here are a few examples:

Natural Disaster

On November 5, 2010, Hurricane Tomas hit Haiti, sweeping the country with strong winds and torrential rain. The hurricane caused widespread flooding in low-lying areas and damaged infrastructure and housing along the country’s western coast. Since a large number of people were still living in tents following the January 2010 earthquake Hurricane Tomas had a major socio-economic impact. RADARSAT-2 data from before and after the event were used to produce change detection maps. Flood-related products were developed and sent to Haiti in order to assist local emergency response activities in the wake of Hurricane Tomas. (Volume 47, Topic 10)

Far North/Arctic

ENVISAT observed a rare event in the Arctic in August 2010: a giant iceberg breaking off the Petermann Glacier in northwestern Greenland. The Petermann Glacier is one of the largest glaciers connecting the Greenland inland ice sheet with the Arctic Ocean. Upon reaching the sea, a number of these large outlet glaciers extend into the water with a floating “ice tongue.” The CSA created an animation by combining three ENVISAT acquisitions (July 31, August 4 and August 7, 2010) taken over the same area. The breaking of the glacier tongue and the movement of the iceberg can be clearly seen in this sequence. (Volume 45, Topic 4)

Water/Fisheries

In order to be able to observe the cleanup efforts following the giant oil spill in the Gulf of Mexico on April 22, 2010 after a drilling rig exploded and sank off the coasts of Louisiana and Mississippi, the US Geological Survey, on behalf of the US Coast Guard, requested satellite maps of the area captured by the ENVISAT Earth Observation satellite. With the help of Canadian technology, this optical image of the oil spill was captured by the Medium Resolution Imaging Spectrometer (MERIS) on April 25, 2010. (Volume 43, Topic 2)

Forest/Mining/Agriculture

Since the glacial retreat at the end of the last ice age, fire has helped form the ecosystems that we know today and maintain their diversity and balance. From a socio-economic perspective, however, fire can have negative effects on public health and safety, property and natural resources. Earth observation satellites can provide key data used in forest fire disaster response efforts, for example when smoke from forest fires in May 2010 reached the St Lawrence Valley and New England. In the case of relief operations such as this, it is important to be able to deliver data in near real-time so that damage can be monitored and the future impact can be assessed. (Volume 44, Topic 2)

Source: CSA's EO Express publication: <http://www.asc-csa.gc.ca/eng/newsletters>

<b>2010-2011 – Financial Resources (\$ in millions)</b>		
<b>Planned Spending</b>	<b>Total Authorities</b>	<b>Actual Spending</b>
88.7	93.2	96.4
<b>2010-2011 – Human Resources (FTEs)</b>		
<b>Planned</b>	<b>Actual</b>	<b>Difference</b>
62.9	61.8	1.1

**The programs under this Program Activity are divided into three Sub-Activities: Enabling Research, Space Mission Development and Space Mission Operations.**

<b>Program Sub-Activity: Enabling Research – Earth Observation</b>
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**Objective:** Provide leadership, coordination or support to Earth Observation (EO) applied research and experimental development in line with the CSA priorities and stakeholders expectations in order to increase the knowledge base and devise new applications through space missions, and to allow the transfer of intellectual property and proven technologies to Canadian industry, academia, and government organizations.

<b>Expected Result #1</b>	
New project/mission concepts that progress to subsequent development phases related to Agency's priorities.	
<b>Indicators</b>	<b>Performance</b>
1. Ratio of the number of new concepts presented to the number of new concepts retained for subsequent phase.	There was no new concept presented nor retained in 2010-2011.
2. Quality of the concepts retained based on the average evaluation rating obtained according to the Priority Ranking Framework.	Unavailable this year. Will be addressed under forthcoming investment governance structure.
<b>Expected Result #2</b>	
The CSA's in-house personnel are highly qualified, with recognized expertise, and are supported by a high-technology infrastructure that is suited to all Enabling Research projects/missions.	
<b>Indicator</b>	<b>Performance</b>
1. Number of consulting requests received by CSA personnel from external sources such as the private sector, academia and other space agencies.	For all program activities combined, the CSA personnel responded to a 121 consulting requests from external sources in 2010-2011.

<b>Performance Analysis</b>
<p><b>Expected Result #1</b>  <u>Indicators 1-2</u>            Analysis not applicable.</p> <p><b>Expected Result #2</b>  <u>Indicator 1</u>            The number "121 requests", 45 more than last year, represents an estimation based on an average number of days allocated per request from OGD, universities and industry for rare expertise held by CSA personnel. Examples of such requests are participation in research grant submissions or academic case studies, provision of technical advice to industry and academia on space related projects, and technical evaluation of proposals or documents received by OGDs.            Source: Internal documents.</p>


<b>2010-2011 – Financial Resources (\$ in millions)</b>	
<b>Planned Spending</b>	<b>Actual Spending</b>
26.4	23.4
<b>2010-2011 – Human Resources (FTEs)</b>	
<b>Planned</b>	<b>Actual</b>
14.1	13.4

**ENABLING RESEARCH – EARTH OBSERVATION**

Four Earth Observation Enabling Research Programs with a combination of accomplishments demonstrate how the following expected results were measured and attained at the program sub-sub-activity level.

**1- EO Mission Concepts – Objective:** Assume the leadership and support in the enabling research and development of new mission concepts leading to the realization of CSA or international EO space missions.

<b>EXPECTED RESULT #1</b>	
Industry, government and/or academia conduct mission and payload concept and feasibility studies to establish the technical and/or scientific feasibility and relevance of missions or payloads in order to enable CSA decisions on future EO space missions.	
<b>Indicator</b>	<b>Performance</b>
1. Number of concept/feasibility (mission and payload) and phase 0/A studies initiated, pursued or completed. (Target: 8)	<b>Target met:</b> 8 concepts.

<b>PERFORMANCE ANALYSIS:</b>	
<p><u>3-Year Trend</u></p> <p>The 3-year trend is measured for the third time based on five consecutive data. Trend analysis maintains the satisfactory rating for targeted achievements were met on the three occurrences evaluated. Benchmark cannot be extrapolated at this time since available values did not reach appropriate stability.</p> <p><u>Indicator 1</u></p> <p>4 concept/feasibility studies completed: SNOWSAT-1, CASS-2 and SMAP-1. 4 ongoing concept/feasibility studies: CASS-CATS, PHEMOS-Atm-FTS, PHEMOS-Atm-Spec and SWIFT/DASH.</p> <p>Source: Internal documents</p>	 <b>Satisfactory</b>

<b>2010-2011 – Financial Resources (\$ in millions)</b>	
<b>Planned Spending</b>	<b>Actual Spending</b>
1.1	2.0
<b>2010-2011 – Human Resources (FTEs)</b>	
<b>Planned</b>	<b>Actual</b>
2.1	2.6

**2- European Space Agency (ESA) Programs in EO – Objective:** Through key international partnerships, enhance the Canadian industry's technological base and provide access to European market for value-added products and services in the field of EO.

<b>EXPECTED RESULT #1</b>	
Successful development and demonstration of advanced technologies, systems, components, or studies provided for in the contracts awarded by ESA to Canadian firms under EO optional programs. (ENVISAT, EOEP, EarthWatch GMES Service Element, GMES Space Component)	
<b>Indicator</b>	<b>Performance</b>
1. Canadian industrial return in ESA optional programs in EO. (Target: 84% or higher)	<b>Target exceeded: 113%</b>

**PERFORMANCE ANALYSIS:**3-Year Trend

The 3-year trend is measured for the fourth time based on six consecutive data. Trend analysis maintains the superior rating for targeted achievements were consistently exceeded. Benchmark is well established among ESA community.

Indicator 1

The return coefficient corresponds to the ratio between the actual number of weighted contracts given to a country and the ideal number of contracts to be given to that country according to existing rules. Canadian industrial return coefficients are by Program Activity. The EO optional programs are: ENVISAT (the largest ever Earth observation satellite built by ESA), EOEP (Earth Observation Envelope Program), Earth Watch GMES (Global Monitoring for Environment and Security) Service Element and GMES Space Component.


Source: "Geographical distribution of contracts" [ESA/IPC(2010)13], published on March 28 2011, and covering the period between January 1, 2000 to December 31, 2010.

The ESA reports are always published with a minimum 3 months delay therefore, the data currently available is as of December 2010.

<b>2010-2011 – Financial Resources (\$ in millions)</b>	
<b>Planned Spending</b>	<b>Actual Spending</b>
9.3	6.9
<b>2010-2011 – Human Resources (FTEs)</b>	
<b>Planned</b>	<b>Actual</b>
0.0	0.0

**3- Science Programs in EO – Objective:** Coordinate the Canadian Earth Observation (EO) scientific community in order to pursue world-class research space missions to advance our knowledge in the fields of atmospheric environment and climate change phenomena studies.

<b>EXPECTED RESULT #1</b>	
Identified opportunities for Canadian scientists to advance understanding and scientific knowledge of atmospheric environment through the use of space-based observations.	
<b>Indicators</b>	<b>Performance</b>
1. Number of scientific publications, reports and conference proceedings acknowledging CSA funding. (Target: 50)	<b>Target exceeded:</b> 83 as of April 29, 2011.
2. Number of Highly Qualified Personnel (HQP) involved in the program. (Target: 120)	<b>Target exceeded:</b> 130 as of April 29, 2011.
3. Number of research partnerships (nationally and internationally). (Target: 18)	<b>Target exceeded:</b> 23 as of April 29, 2011.

<b>PERFORMANCE ANALYSIS:</b>	
<p><u>3-Year Trend</u></p> <p>The 3-year trend is measured for the fourth time based on six consecutive data. Trend analysis continues to be superior because all targeted achievements were exceeded. Benchmark values could only be confirmed for two indicators, the others have yet to reach an appropriate stability.</p> <p><u>Indicator 1</u></p> <p>38 Peer Reviewed Publications acknowledging CSA funding.  0 Non-Peer Reviewed Publications acknowledging CSA funding.  0 Books acknowledging CSA funding.  43 Peer Reviewed Publications Enabled CSA funding.  2 Non-Peer Reviewed Publications Enabled by CSA funding.  0 Books Enabled by CSA funding.</p> <p>Target exceeded due to better management of survey; facilitated principal investigator (PI) responses with a user friendly survey and an easier data management/reporting procedure using ORIS (Organized Research Information System).</p> <p>Source: CSA annual survey of external principal investigators/scientists.</p>	 <p>Superior</p>

Indicator 2

- 5 Canada Research Chair
- 22 Tenure Faculty
- 9 Non-Tenured Faculty
- 13 Research Associates
- 16 Post Doctoral Fellows
- 2 Research Assistants
- 35 Graduate Students
- 4 Undergraduate Students
- 4 Engineers/Technicians
- 20 Other personnel

Target exceeded due to better management of survey; facilitated principal investigator (PI) responses with a user friendly survey and an easier data management/reporting procedure using ORIS (Organized Research Information System).

Source: CSA annual survey of external principal investigators/scientists.

Indicator 3

- 13 partnerships for Atmospheric Sciences
- 10 partnerships for Grants
- 56 additional partnerships for Internal Collaborative Arrangements partnerships (MOU, MOA, etc.)


Target exceeded due to better management of survey; facilitated principal investigator (PI) responses with a user friendly survey and an easier data management/reporting procedure using ORIS (Organized Research Information System).

Source: CSA annual survey of external principal investigators/scientists.

<b>2010-2011 – Financial Resources (\$ in millions)</b>	
<b>Planned Spending</b>	<b>Actual Spending</b>
1.1	1.9
<b>2010-2011 – Human Resources (FTEs)</b>	
<b>Planned</b>	<b>Actual</b>
4.4	0.5

**4- EO Application Development Programs – Objective:** Enhance Canada's ground receiving and data processing systems, develop and demonstrate EO data value-added applications for commercial use and for Canadian government operations.

<b>EXPECTED RESULT #1</b>	
Development of EO applications responding to user needs in government, industry, academia and not-for-profit organizations in the fields of environment, resource and land use management, and, security and foreign policy.	
<b>Indicators</b>	<b>Performance</b>
1. Number of new applications using EO data. (Target: 24 that is 10 for EOADP and 14 for GRIP)	<b>Target exceeded:</b> 35 (12 applications for EOADP and 23 for GRIP)
2. Number of new users of EO applications. (Target: 48 that is 20 for EOADP and 28 for GRIP)	<b>Target exceeded:</b> 64 (24 for EOADP and 40 for GRIP)

<b>PERFORMANCE ANALYSIS:</b>	
<p><u>3-Year Trend</u></p> <p>Indicator #2 was introduced in 2008-2009 RPP and is measured for the third time. Trend analysis is based on three measurements for the first indicator and six for the second one and since both achievements exceeded increased targets, the rating continues to be superior. Benchmark values could only be confirmed for indicator #2 even though it was slightly increased, the other indicator has yet to reach an appropriate stability.</p> <p><u>Indicators 1 and 2</u></p> <p>1) New applications cover the following areas: Sea Ice and fresh water mapping and monitoring, Port Security and Marine Surveillance, Infrastructure Monitoring, Environment Monitoring, Military and Agricultural Change Detection, Forestry (paludification, biomass and ecosystem), Marine Ecosystem Monitoring, Crop mapping and monitoring, Topographic mapping (Canada North), Arctic Ecosystems Monitoring (ocean and coastal process, permafrost, wetlands, river ice) and Software Development.</p> <p>2) Twelve Canadian suppliers of value-added services use RADARSAT-2 imagery for applications that meet the needs of end users such as: DND, EC, Parks Canada, NRCan-CFS, DFO, National Research Council Canada. For GRIP, each project involves one or more new users, whether within a department, in collaboration with one or more other departments or with industry or universities.</p> <p>Source: Internal documents.</p>	 <p>Superior</p>

<b>2010-2011 – Financial Resources (\$ in millions)</b>	
<b>Planned Spending</b>	<b>Actual Spending</b>
14.8	12.6
<b>2010-2011 – Human Resources (FTEs)</b>	
<b>Planned</b>	<b>Actual</b>
7.7	10.3

### **Highlights of Main Accomplishments – Enabling Research (EO)**

- Interest in RADARSAT-2 data is still growing after 3 years in operation. 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 continued to grow as new applications became operational. The CSA continued to carefully manage and optimize the \$445 million worth of prepaid data allocation to ensure that maximum benefits are realized, in accordance with the RADARSAT-2 Data Utilization Management Plan which is updated every year. The CSA continues to negotiate agreements with other government departments to develop data acquisition plans and reporting. Out of the 13 departments currently acquiring images from RADARSAT-2, 7 agreements were signed and approved. In the mean time, the CSA continues to provide data to the national and international Earth Observation community to support a wide selection of applications ranging from fundamental to applied research and development activities.
- Through the Earth Observation Application Development Program (EOADP) and the Earth Observation Government Related Initiatives Program (EO-GRIP), the CSA continued 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 proposal to industry for innovative application development using RADARSAT-2 for the benefit of the Canadian Government. As for the Canadian government departments, 15 projects were completed and 32 projects are currently on-going to enhance their ability of using RADARSAT-2 data and create benefits for Canadians.
- A Mission Definition Study for the Polar Communications and Weather (PCW) mission, initiated in November 2008 and conducted in collaboration with Department of National Defence (DND) and Environment Canada, was completed in March 2011. This mission is responding to the needs expressed by other government departments and Northern communities, and 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 expressed strong interest in joining the PCW mission.

- Through Canada's participation in European Space Agency (ESA) Earth Observation Envelope Program, the CSA supported Canadian scientists to access ESA 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), CryoSAT-2, and CoReH2O missions;
  - The development of applications in the field of aquaculture, forestry and subsidence, global wetland; Arctic tourism, and Polar monitoring and services;
  - A Doppler cloud radar forward model was developed, and retrieval modeling and performance assessment are on-going;
  - Delivery of two Flight Models of the Electric Field Instrument, designed to monitor ionosphere for the Swarm mission; and,
  - The development of algorithms and models, designed to monitor information on snow, glaciers and surface water for the CoreH2O mission.
  
- The CSA continued development of several promising mission concepts for space-borne observations of atmospheric gases and aerosols related to climate and air quality. These mission concepts were for Canadian instruments on foreign spacecraft as well as Canadian spacecraft. They involved Canadian government and university scientists.
  
- The CSA continued to support the implementation of international EO activities such as the Forest Carbon Tracking and the Caribbean Flood Project, and the Joint Experiment for Crop Assessment and Monitoring (JECAM) in collaboration with other space agencies. Supersite initiatives were 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). The CSA's participation in these activities contributed to the development of observation system under the GEO Societal Benefit Areas.
  
- The CSA supported Canadian scientists in the validation of greenhouse gas measurements made with foreign satellites (e.g. Japanese GOSAT) and in the development of capabilities to assimilate and utilize greenhouse gas observations.

**Program Sub-Activity: Space Mission Development – Earth Observation**

**Objective:** Provide coordination or support to the development of Earth Observation space missions in line with CSA priorities and stakeholders' expectations through the definition, critical design, manufacturing, integration, testing and delivery phases leading to launch and early operations of space systems.

<b>Expected Result #1</b>	
Space mission proposals that efficiently, effectively and economically progress to subsequent operations phases in accordance with objectives, requirements, initial or revised specifications.	
<b>Indicator</b>	<b>Performance</b>
1. Number of projects requiring more than one EPA (Effective Project Approval) or an amendment to initial EPA over the total number of projects.	There were no new EPA submitted to TB in 2010-2011 nor were there any amendments made to previous EPAs for the Earth Observation Program Activity.
<b>Expected Result #2</b>	
The CSA's in-house personnel are highly qualified, with recognized expertise, and are supported by a high-technology infrastructure that is suited to all Space Mission Development projects.	
<b>Indicator</b>	<b>Performance</b>
1. Rate of expertise matrix support to all of CSA's program activities.	A 97% rate of planned expertise matrix – all program activities combined.

<b>Performance Analysis</b>
<p><b>Expected Result #1</b></p> <p><u>Indicator 1</u></p> <p>Analysis not applicable.</p> <p><b>Expected Result #2</b></p> <p><u>Indicator 1</u></p> <p>This 97% rate of planned expertise matrix support represents a significant increase compared to last year's 51%. This increase is due to the new internal structure which created an additional type of matrix called "vertical matrix exchange". This new type along the previously type "horizontal matrix exchange", accounted the time allocation of 235 specialized personnel for a total amount 121 projects/activities identified needing matrix support. This indicator has lost its relevancy in the context of the reorganization and therefore will no longer be measured.</p> <p>Source: Internal reporting documents (E-Ram).</p>

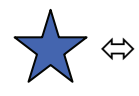
<b>2010-2011 – Financial Resources (\$ in millions)</b>	
<b>Planned Spending</b>	<b>Actual Spending</b>
48.2	60.4
<b>2010-2011 – Human Resources (FTEs)</b>	
<b>Planned</b>	<b>Actual</b>
27.2	26.6

### **SPACE MISSION DEVELOPMENT – EARTH OBSERVATION**

One EO Space Mission Development Program, with a combination of accomplishments, demonstrates how the expected result outlined below was measured and attained at the program sub-sub-activity level.

**1- EO Projects – Objective:** Ensure the development, delivery and commission of space-qualified systems for EO missions in the fields of advanced imaging technologies, atmospheric environment and climate change phenomena studies through effective project, quality and engineering management.

<b>EXPECTED RESULT #1</b>	
EO projects' deliverables meet mission objectives at critical steps.	
<b>Indicator</b>	<b>Performance</b>
1. Number of missions/projects associated with science support. (Target: 1)	<b>Target met: 1</b>
<b>EXPECTED RESULT #2</b>	
EO projects' deliverables are met.	
<b>Indicators</b>	<b>Performance</b>
1. Project milestones are met as defined in the detailed work plan. (Target: 75% of milestones achieved versus planned)	<b>Postponed (to another fiscal year):</b> Of the eight Bus unit CDRs (Critical Designed Review) planned in 2010-2011, for RADARSAT Constellation (RCM), one was held and was not successful (the PCU CDR).
2. Project cost is maintained within authorized levels. (Target: 100%)	<b>Target met:</b> RCM budget is still within authorized funding level.
3. Risks are identified and mitigation plans prepared for each project. (Target: 100%)	<b>Target met:</b> 100 % risks are identified and mitigation plans prepared for each project.

<b>PERFORMANCE ANALYSIS:</b>	
<p><u>3-Year Trend</u></p> <p>The 3-year trend is measured for the second time for all indicators. Trend analysis maintains the satisfactory rating for targeted achievements have almost all been met. Benchmark values could only be confirmed for two indicators, the others have yet to reach an appropriate stability.</p> <p><b>Expected Result #1</b></p> <p><u>Indicator 1</u></p> <p>Ongoing missions: SMAP project SMAP is the only EO project associated with science support in phases B-C-D. Source: Internal documents.</p> <p><b>Expected Result #2</b></p> <p><u>Indicator 1</u></p> <p>The RADARSAT Constellation detailed design (phase C) contract was awarded to MDA in a series of authorizations to proceed (ATPs) while an important issue on the intellectual property was being sorted out. The resulting inefficiencies combined with an off-set appropriation sequence led to a schedule re-baselining that pushed the many CDRs scheduled towards the end of fiscal year 2010-2011 outside the latter, and through fiscal year 2011-2012. Source: Internal documents.</p> <p><u>Indicator 2</u></p> <p>No comment. Source: Internal documents.</p> <p><u>Indicator 3</u></p> <p>No comment. Source: Internal documents.</p>	 <b>Satisfactory</b>

<b>2010-2011 – Financial Resources (\$ in millions)</b>	
<b>Planned Spending</b>	<b>Actual Spending</b>
48.2	60.4
<b>2010-2011 – Human Resources (FTEs)</b>	
<b>Planned</b>	<b>Actual</b>
27.2	26.6

## **Highlights of Main Accomplishments – Space Mission Development (EO)**

- The Preliminary Design for RADARSAT Constellation, initiated in November 2008, was completed in March 2010. Work on the detail design phase began in March 2010. The launch of the first satellite is planned for mid-2015 followed by the other two satellites in 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.
- Through the Canada-ESA Cooperation Agreement, many Canadian companies are supplying space and ground segment subsystems for the missions Sentinel-1, 2 and 3 of the ESA Global Monitoring for Environment and Security (GMES) Space Component. Sentinel missions are designed to provide input data to an array of users including Canadian Government departments. In particular, cooperation in the areas of ground station and data sharing between ESA Sentinel-1 and the RADARSAT Constellation missions is being carried out. For Sentinel-1, Canada is supplying a SAR processor, and for Sentinel-3, Canadian companies are involved in building an antenna for the Synthetic Aperture Radar Altimeter and providing support to the Attitude Orbit Control Subsystem.
- Many Canadian companies are participating in the EarthCARE mission through ESA and JAXA (Japanese Space Agency). Canada is providing the cloud radar RF Front-end and High-power amplifier to JAXA and the microbolometer detector to ESA for the Broad-Band Radiometer instrument. Canadian scientists are participating in Earth Explorer 7 candidate missions as members of mission advisory groups.

**Program Sub-Activity: Space Mission Operations – Earth Observation**

**Objective:** Provide coordination or support to the operations of Earth Observation space missions in line with the CSA priorities and stakeholders' expectations through the development and conduct of on-orbit operations, system maintenance and logistic support, as well as data handling and delivery.

<b>Expected Result #1</b>	
The CSA's in-house personnel are highly qualified, with recognized expertise, and are supported by a high-technology infrastructure that is suited to all Space Mission Operations activities.	
<b>Indicators</b>	<b>Performance</b>
1. Annual rate of investment in maintenance and improvement of the infrastructure required for missions in operation phases.	No longer being measured.
2. Quality of the internal expertise specializing in advice and technology-watch to ensure the successful flow of missions reaching operation phases.	No longer being measured.

<b>2010-2011 – Financial Resources (\$ in millions)</b>	
<b>Planned Spending</b>	<b>Actual Spending</b>
14.1	12.7
<b>2010-2011 – Human Resources (FTEs)</b>	
<b>Planned</b>	<b>Actual</b>
21.6	21.8

Note: Planned Spending exclude reinvestment of royalties from sale of RADARSAT-1 data estimated at \$4.1 million.

**SPACE MISSION OPERATIONS – EARTH OBSERVATION**

One EO Space Mission Operations Program, with a combination of accomplishments, demonstrates how the expected result outlined below was measured and attained at the program sub-sub-activity level.

**1- EO Satellite Operations – Objective:** Ensure continuity of on-orbit operations of Earth Observation satellites. The program coordinates the conduct of on-orbit operations of Canadian Earth Observation satellites as well as the operation and maintenance of ground infrastructure and systems essential for the production and reception of space data for scientific, commercial and Government usage

<b>EXPECTED RESULT #1</b>	
CSA operational satellite missions are supported in accordance with mission requirements.	
<b>Indicator</b>	<b>Performance</b>
1. Continuity of on-orbit operations of EO satellites as per mission requirements. (Target: Maintained operations of RADARSAT-1 and SCISAT-1)	<b>Target met:</b> Operations undertaken successfully another year beyond the nominal mission for two satellites.
2. Provision of services and infrastructures for operational EO satellite missions as per requirements. (Target: Services for RADARSAT-1, SCISAT-1 and RADARSAT-2 delivered)	<b>Target met:</b> User requirements met.


<b>PERFORMANCE ANALYSIS:</b>	
<u>3-Year Trend</u> No trend could be established since data available for three out of five periods without required consecutiveness.	N/A

<p><b>Expected Result #1</b></p> <p><u>Indicator 1</u></p> <p>For RADARSAT-1:</p> <ol style="list-style-type: none"> <li>1. Spacecraft was protected from space debris.</li> <li>2. The system availability, image quality, data archiving and reporting were maintained as per specs.</li> </ol> <p>For SCISAT-1:</p> <ol style="list-style-type: none"> <li>1. The system availability was maintained as per specs.</li> </ol> <p>Source: Internal documents.</p> <p><u>Indicator 2</u></p> <p>For RADARSAT-1:</p> <ol style="list-style-type: none"> <li>1. The order request handling and data delivery was provided as per user requirements.</li> </ol> <p>For SCISAT-1:</p> <ol style="list-style-type: none"> <li>1. The user requests handling-data delivery was maintained as per user requirements.</li> </ol> <p>For RADARSAT-2:</p> <ol style="list-style-type: none"> <li>1. The order request handling and data delivery was provided as per user requirements.</li> </ol> <p>Source: Internal documents.</p>
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<b>2010-2011 – Financial Resources (\$ in millions)</b>	
<b>Planned Spending</b>	<b>Actual Spending</b>
1.3	4.1
<b>2010-2011 – Human Resources (FTEs)</b>	
<b>Planned</b>	<b>Actual</b>
0.0	12.8

**2- EO Mission Operations – Objective:** Ensure processing, delivery and archiving of operational and scientific data received from Earth Observation satellites. The program contributes to the pursuit of world-class research in the fields of atmospheric environment and climate change phenomena in collaboration with national and international partners; and to the use of data value-added applications developed in partnership with academia, industry, and other space agencies for commercial purposes and for Canadian government operations especially in the fields of environment, resource and land use management, as well as security and foreign policy.

<b>EXPECTED RESULT #1</b>	
EO Space Mission Operations meet user/client needs as per mission requirements.	
<b>Indicator</b>	<b>Performance</b>
1. Number of missions in operational phase associated with science support. (Target: 4)	<b>Target met: 4</b>

<b>PERFORMANCE ANALYSIS:</b>	
<p><u>3-Year Trend</u></p> <p>The 3-year trend is measured for the second time for this indicator based on four consecutive data. Trend analysis is evaluated to be satisfactory since this is the first year this indicator is evaluated individually. Benchmark values were confirmed for this indicator.</p>	 Satisfactory
<p><b>Expected Result #1</b></p> <p><u>Indicator 1</u></p> <p>Science support for this year was completed. 4 missions are still in operation. (SCISAT, MOPITT on Terra, OSIRIS on Odin and CloudSat).</p> <p>Source: Internal documents.</p>	

<b>2010-2011 – Financial Resources (\$ in millions)</b>	
<b>Planned Spending</b>	<b>Actual Spending</b>
12.9	8.6
<b>2010-2011 – Human Resources (FTEs)</b>	
<b>Planned</b>	<b>Actual</b>
21.6	8.9

Note: Planned Spending exclude reinvestment of royalties from sale of RADARSAT-1 data estimated at \$ 4.1 million.

**Highlights of Main Accomplishments – Space Mission Operations (EO)**

- RADARSAT-1 operations continued to supply RADARSAT-1 synthetic aperture radar (SAR) data to the existing client base with a high performance for satellite reliability and image quality. Through the operations of the Government of Canada order desk, RADARSAT-2 data continued to be supplied to meet the needs expressed by other government departments. With two satellites in operation, data continuity and users’ satisfaction, when conflicting needs arose, were better assured. A contingency plan continues to be in place to secure the use of ESA ENVISAT satellite in a situation where Canadian satellites are 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 continued to ensure Canada's commitment, as an official member of the International Charter *Space and Major Disasters*, to use EO satellites in response to disasters. The CSA continued to regularly contribute RADARSAT-1 and 2 data and strategic EO-derived information products upon charter activation.

- The CSA continued to support and operate SCISAT-1, a Canadian mission launched in August 2003. The mission is providing a large amount of very high quality data on more than 30 chemical species in the atmosphere for climate, weather and pollution studies. The mission is in its 8<sup>th</sup> year of its operations and the satellite operation performance is being maintained, fully meeting academic and government users' requirements.
- The CSA continued 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 pollutant while OSIRIS, on the Swedish Odin satellite, measures ozone and aerosols in the stratosphere and mesosphere and provides important data to assess and predict the health of the ozone layer.
- The CSA continued to support the validation of CloudSat data, a NASA satellite launched in 2006 to which Canada contributed important radar components. It is designed to study the water, snow and ice content of clouds, providing data to improve climate models and weather forecasting. The CSA continued collaborating with the Meteorological Service of Canada (MSC) and with the National Research Council of Canada in the development of new products from CloudSat and from the future cloud/precipitation radars (e.g. Earth CARE, SnowSat).
- In 2010, the CSA officially joined the Inter-Agency Space Debris Coordination Committee (IADC) as its twelfth member. IADC is comprised of experts from space agencies who work together to improve our understanding of all aspects of space debris, a serious threat to the sustainability of space for current and future access. The results of the studies, findings, guidelines and recommendations emanating from the Committee are predominantly used by satellite operations teams to mitigate the serious hazard to spacecraft operations by space debris.

## 2.3 SPACE SCIENCE AND EXPLORATION

<b>SPACE SCIENCE AND EXPLORATION 2010-2011 PROGRAM ACTIVITY PERFORMANCE MEASUREMENT</b>	
<b><u>BENEFITS FOR CANADIANS</u></b>	
<p>The CSA sustains and increases Canada's contribution to humankind's scientific knowledge and to the development of space related technologies. Research in physical and life sciences, and in space exploration, has great potential to bring about socio-economic benefits.</p> <p>Space Science and Exploration (SE) endeavours, which invariably involve international partners, position Canada to play an influential role in building strong and mutually beneficial partnerships with an increasing number of space faring countries. In striving to become one of the most advanced, connected and innovative nation in the world, space science and exploration stimulates some of the brightest minds to contribute to the Canadian economy in an increasingly competitive international environment.</p>	
<b><u>EXPECTED RESULT</u></b>	
<p>Participation in Canadian and international missions expands the scientific knowledge base made available to Canadian academia and research and development communities in the areas of astronomy, space exploration and solar-terrestrial relation, as well as in the physical and life sciences.</p>	
<b><u>MAIN ACCOMPLISHMENTS IN 2010-2011</u></b>	
<p>In 2010-2011, all contracts under the <i>Stimulus</i> initiative on space robotics that was announced as part of Canada's Economic Plan were awarded. The <i>Stimulus</i> initiative helped develop terrestrial prototypes of the next generation Canadarm and prototypes of three different rovers and their associated technologies for future Moon and Mars exploration.</p> <p>Through the renewed CSA Class Grant and Contribution Program to support Research, Awareness and Learning in Space Science and Technology, the CSA continued to support the development of science and technology, and fostered the development of a critical mass of researchers and highly qualified people in Canada in areas relevant to the priorities of the CSA.</p> <p>Chris Hadfield was the chosen Canadian astronaut to be assigned for the second Canadian Long-Duration mission to the ISS (C-2). The Canadian Astronaut Corps had to adapt to the new reality of fewer flight opportunities as a result of the Space Shuttle retirement. The CSA continued to utilize the expertise and skill set of flown astronauts to advance and position the Canadian Space Exploration program.</p> <p>The CSA continued to fulfill its obligations for Mobile Servicing System (MSS) operations.</p>	
<b>Indicators</b>	<b>Performance</b>
1. Proportion of active missions relative to the total number of missions supported by Canada in the SE priority areas.	46%; 56 active missions out of 122 missions supported.

2. Number of scientific instruments and technological applications developed as a result of CSA's participation in space missions and/or support to projects/activities in SE.	A combined total of 79 scientific instruments (SI) and technological (TI) applications (56 SI and 23 TI).
3. Number of peer-reviewed papers produced in academia and the R&D community in Canada recognizing CSA's support through its participation in space missions and/or support to projects/activities in SE.	A total of 744 peer-reviewed papers, reports and conference proceedings acknowledging CSA funding were published in 2010-2011.

Indicator 1 – Performance Analysis

At the time of the Departmental Performance Reporting, the Canadian Space Agency presents a list of space missions to which it actually contributes or plans to contribute. The fact that a mission appears on the list does not mean that it will be completed. Any mission must necessarily follow many critical steps depicted in a simple manner as such:

- Mission under review: A mission that is subject to concept of feasibility studies. At the end of this step, a decision is made whether to continue, to cancel or to postpone the participation to the mission.
- Mission in development: The participation implies that activities produce assets which are not yet operational. The final milestones prior to operation are the launch and the full commissioning of the mission.
- Mission in operation: The mission is operational, delivering results until being fully completed. By virtue of being in operation, a mission will spark scientific, technological and operational activities in order to reach its objectives.

SE missions completed (43): \* = 8  
 SE missions at the operation stage (13): \* = 1  
 SE missions at the development stage (20): \* = 6  
 SE missions under review (46): \* = 0

(Year) = Actual or projected launch date or date of completion when known.  
 \* = New missions in 2010-2011 = 13% (15/122)

Descriptions of missions can be found in [Section 2.8](#) – List of Space Missions.

**Space Science and Exploration (SE) missions completed:**

Mission	Status	Field
APEX-Cambium (2010)	Completed, objectives met	Life Sciences

APEX - CSA 2 (2010)	Completed, objectives met	Life Sciences
Aquatic Orgs in $\mu$ g (2010)	Completed, objectives met	Life Sciences
Astronauts: EXPEDITION 20/21 (C1) (2009)	Completed, objectives met	Robert Thirsk, ISS
Astronauts: STS-115 (2006)	Completed, objectives met	Steve MacLean, ISS
Astronauts: STS-118 (2007)	Completed, objectives met	Dave Williams, ISS
Astronauts: STS-121 (2006)	Completed, objectives met	Julie Payette (Capcom), ISS
Astronauts: STS-127 (2009)	Completed, objectives met	Julie Payette, ISS
Astronauts: TMA-6/10S (2005)	Completed, objectives met	Robert Thirsk (Capcom and back-up), ISS
BCAT-5 (2010)	Completed, objectives met	Physical Sciences
BISE (2010)	Completed, objectives met	Life Sciences
BLAST (2007)	Completed, objectives met	Astronomy
CCISS (2010)	Completed, objectives met	Life Sciences
ELERAD (2007)	Completed, objectives met	Life Sciences
eOSTEO (2008)	Completed, objectives met	Life Sciences
ESA-SODI IVIDIL (2010)	Completed, objectives met	Physical Sciences
EVARM	Completed, objectives met	Life Sciences
FUSE (2008)	Completed, objectives met	Astronomy
HAWAII (2010)	Completed	Planetary Exploration
H-Reflex	Completed, objectives met	Life Sciences
ICE-First (2004)	Completed, objectives met	Life Sciences
Matroshka-R (2008)	Completed, objectives met	Space Medicine

* MSS: HTV-2	Completed	ISS
* MSS: Increment 23	Completed	ISS
* MSS: Increment 24	Completed	ISS
* MSS: Increment 25	Completed	ISS
* MSS: Increment 26	Completed	ISS
MSS: STS-114 (2005)	Completed, objectives met	ISS, Technology demonstration
MSS: STS-119 (2009)	Completed, objectives met	ISS
MSS: STS-123 1J/A (DEXTRE) (2008)	Completed, objectives met	ISS
MSS: STS-124 (2008)	Completed, objectives met	ISS
MSS: STS-126 (2008)	Completed, objectives met	ISS
* MSS: STS-131 Flight 19A	Completed	ISS
* MSS: STS-132 Flight ULF4	Completed	ISS
* MSS: STS-133	Completed	ISS
Phoenix (2008)	Completed, objectives met	Planetary Exploration
PMDIS (2009)	Completed, objectives met	Life Sciences
Radi-N 1 (2010)	Completed, objectives met	Space Medicine
SCCO (2009)	Completed, objectives met	Physical Sciences
TRAC (2008)	Completed, objectives met	Life Sciences
TriDAR DTO STS-128 (2009)	Completed, objectives met	Planetary Exploration
TriDAR DTO STS-131 (2010)	Completed, objectives met	Planetary Exploration
WISE (2005)	Completed, objectives met	Life Sciences

Year) = Actual or projected launch date or date of completion when known.

\* = New missions in 2010-2011.

**Space Science and Exploration (SE) missions at the operation stage:**

<b>Mission</b>	<b>Status</b>	<b>Field</b>
CADC/Hubble (2008)	In operation	Astronomy
CGSM (2007)	In operation	Solar-Terrestrial Relation
* ESA-Bed Rest (2006)	In operation	Life Sciences
ESA-Herschel-HIFI/Spire (2009)	In operation	Astronomy
ESA-MICAST (2009)	In operation	Life Sciences
ESA-Planck (2009)	In operation	Astronomy
ESA-SODI DSC	In operation	Physical Sciences
FPEF (2008)	In operation	Physical Sciences
Hypersole (2010)	In operation	Life Sciences
MOST (2003)	In operation	Astronomy
MVIS (2008)	In operation	Physical Sciences
THEMIS (2007-2011)	In operation	Solar-Terrestrial Relation
Vascular (2009)	In operation	Life Sciences

(Year) = Actual or projected launch date or date of completion when known.

\* = New missions in 2010-2011.

**Space Science and Exploration (SE) missions at the development stage:**

<b>Mission</b>	<b>Status</b>	<b>Field</b>
ADAMS (Advanced Astronaut Medical Support )	In development	Space Medicine
* Astronauts: Expedition 34/35 (C2)	In development	Chris Hadfield
ASTRO-H (2009)	In development	Astronomy
BCAT-C1 (2011-12)	In development	Physical Sciences
* BP-Reg (2010)	In development	Life Sciences
BRITE - Constellation (2011)	In development	Astronomy
CASSIOPE-ePOP (2012)	In development	Solar-Terrestrial Relation
EBEX	In development	Astronomy
ESA-Exomars (2016)	In development	Planetary Exploration
ESA-Swarm (2012)	In development	Solar-Terrestrial Relation
JWST-FGS (2014)	In development	Astronomy
MSL-APXS (2011)	In development	Planetary Exploration
* MSS: Increment 27	In development	Planetary Exploration
NEOSSAT (2011)	In development	Planetary Exploration
PRET (2011)	In development:	Space Medicine
* Radi-N 2	In development	Space Medicine

* See-Jitter (2010)	In development	Life Sciences
SPIDER (2012)	In development	Astronomy
* TriDAR DTO STS-135 (2011)	In development	Planetary Exploration
UVIT-ASTROSAT (2010)	In development	Astronomy

(Year) = Actual or projected launch date or date of completion when known.

\* = New missions in 2010-2011.

**Space Science and Exploration (SE) missions under review:**

<b>Mission</b>	<b>Status</b>	<b>Field</b>
CanALSS	Under review	Planetary Exploration
CCAP (2014)	Under review	Life Sciences
CHENNS (2014)	Under review	Life Sciences
CIMEX (2013)	Under review	Physical Sciences
Dark Energy Mission	Under review	Astronomy
DynAMO	Under review	Planetary Exploration
ESA-CrossScale	Under review	Solar-Terrestrial Relation
ESA-NEQUISOL (2013)	Under review	Physical Sciences
EVIS	Under review	Planetary Exploration
FPNS	Under review	Planetary Exploration
GPR	Under review	Planetary Exploration
HALO	Under review	Planetary Exploration
ICAPS	Under review	Physical Sciences
ILN	Under review	Planetary Exploration
Insect Habitat	Under review	Life Sciences
ISRU	Under review	Planetary Exploration
ISWEAT	Under review	Solar-Terrestrial Relation
LEMUR	Under review	Planetary Exploration
LiteArm	Under review	Planetary Exploration
LORE	Under review	Planetary Exploration
LSC	Under review	Planetary Exploration
Lunar Rover	Under review	Planetary Exploration
Luna-Resource-Concept 1	Under review	Planetary Exploration
Luna-Resource - Concept 2	Under review	Planetary Exploration
MEMS LIDAR	Under review	Planetary Exploration
M-FTSIS	Under review	Planetary Exploration
MIM/ATEN	Under review	Physical Sciences
MLM	Under review	Planetary Exploration
MSO-FTIR	Under review	Planetary Exploration
MSO-SAR	Under review	Planetary Exploration

MSR NET (Vision System)	Under review	Planetary Exploration
MWD	Under review	Planetary Exploration
NEW FRONTIERS	Under review	Planetary Exploration
OCLE-DOCLE	Under review	Astronomy
PHEMOS-Auroral Imaging	Under review	Solar-Terrestrial Relation
PHEMOS-Plasma and Radiation	Under review	Solar-Terrestrial Relation
RAO	Under review	Planetary Exploration
RAPIER	Under review	Planetary Exploration
RAVENS	Under review	Solar-Terrestrial Relation
Remote Care Health Providers (Training Development)	Under review	Planetary Exploration
ROSM	Under review	Planetary Exploration
SBIS	Under review	Planetary Exploration
SCOPE	Under review	Solar-Terrestrial Relation
Si Si-Ge alloys	Under review	Physical Sciences
SPICA	Under review	Astronomy
TRACTEUR	Under review	Planetary Exploration
VSE	Under review	Planetary Exploration

(Year) = Actual or projected launch date or date of completion when known.

\* = New missions in 2010-2011.

Descriptions of missions can be found in [Section 2.8](#) – List of Space Missions.

#### Indicator 2 – Performance Analysis

This year's total of 79 scientific instruments and technological applications is associated with 40 missions. This number represents an additional 11 instruments/applications compared to last year. When divided by the number of missions, the number of instruments shows a ratio of 1.98 instrument/application per mission; some having a least one related instrument/application up to a maximum of 10 per mission. These 79 instruments/applications can be divided among 4 different fields: 35 instruments/applications were developed for Astronomy/Planetary Exploration missions (44%); 30 instruments/applications for Solar-Terrestrial Relation missions (38%); 10 instruments/applications were developed for Life/Physical Sciences missions (13%), and, 4 instruments/applications were developed for Space Operational Medicine (5%). Source: Internal documents.

#### Indicator 3 – Performance Analysis

A total of 744 peer-reviewed papers, reports and conference proceedings acknowledging CSA's funding were published in 2010-2011 in Space Astronomy and Exploration, Solar-Terrestrial Relation, and Physical and Life Sciences. This indicator is a good example why Science and Technology community performance indicators need to be assessed over a minimum of a three-year span. This year's number of papers, reports and conference proceedings represents an almost 400% increased compared to last year but represents a lesser increased (200%) when compared with the 397 peer-reviewed documents reported in 2008-2009. The steadily increasing acuity of the method behind the data collection is a contributing factor to the large fluctuations between the numbers reported over the past three years.

Source: Internal reporting documents.

<b>2010-2011 – Financial Resources (\$ in millions)</b>		
<b>Planned Spending</b>	<b>Total Authorities</b>	<b>Actual Spending</b>
185.4	189.4	156.8
<b>2010-2011 – Human Resources (FTEs)</b>		
<b>Planned</b>	<b>Actual</b>	<b>Difference</b>
225.9	202.1	23.8

**The programs under this Program Activity are divided into three Sub-Activities: Enabling Research, Space Mission Development and Space Mission Operations.**

<b>Program Sub-Activity: Enabling Research – Space Science and Exploration</b>
--

**Objective:** Provide leadership, coordination or support to Space Science and Exploration (SE) applied research and experimental development in line with the CSA priorities and stakeholders expectations in order to increase the knowledge base and devise new applications through space missions, and to allow the transfer of intellectual property and proven technologies to Canadian industry, academia, and government organizations.

<b>Expected Result #1</b>	
New project/mission concepts that progress to subsequent development phases related to Agency's priorities.	
<b>Indicators</b>	<b>Performance</b>
1. Ratio of the number of new concepts presented to the number of new concepts retained for subsequent phase.	There were six new concepts qualifying for investment in Space Science and Exploration in 2010-2011.
2. Quality of the concepts retained based on the average evaluation rating obtained according to the Priority Ranking Framework.	Unavailable this year.
<b>Expected Result #2</b>	
The CSA's in-house personnel are highly qualified, with recognized expertise, and are supported by a high-technology infrastructure that is suited to all Enabling Research projects/missions.	
<b>Indicator</b>	<b>Performance</b>
1. Number of consulting requests received by CSA personnel from external sources such as the private sector, academia and other space agencies.	For all program activities combined, the CSA personnel responded to a 121 consulting requests from external sources in 2010-2011.

<b>Performance Analysis</b>
<p><b>Expected Result #1</b></p> <p><u>Indicator 1-2</u></p> <p>The Space Science and Exploration directorate had, for a second consecutive year, new activity investments this year; the number increased from one to six new activities namely, Astronauts: EXPEDITION 34/35 (C2), BP-Reg, MSS: Increment 27, RADI-N 2, See-Jitter, TriDAR DTO STS-135 (06-2011). The priority ranking of these new concepts remains unavailable this year.</p> <p>Source: Internal documents.</p>
<p><b>Expected Result #2</b></p> <p><u>Indicator 1</u></p> <p>The number "121 requests", 45 more than last year, represents an estimation based on an average number of days allocated per request from OGD, universities and industry for rare expertise held by CSA personnel. Examples of such requests are participation in research grant submissions or academic case studies, provision of technical advice to industry and academia on space related projects, and technical evaluation of proposals or documents received by OGDs.</p> <p>Source: Internal documents.</p>


<b>2010-2011 – Financial Resources (\$ in millions)</b>	
<b>Planned Spending</b>	<b>Actual Spending</b>
95.6	87.4
<b>2010-2011 – Human Resources (FTEs)</b>	
<b>Planned</b>	<b>Actual</b>
67.4	74.4

**ENABLING RESEARCH – SPACE SCIENCE AND EXPLORATION**

Four Science and Exploration Enabling Research Programs with a combination of accomplishments demonstrate how the following expected results were measured and attained at the program sub-sub-activity level.

**1- SE Mission Concepts – Objective:** Assume leadership and provide support in enabling research and development of new space mission concepts leading to the realization of CSA or international SE missions.

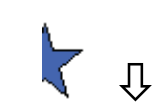
<b>EXPECTED RESULT #1</b>	
Industry, government and academia conduct mission and payload concept and feasibility studies for the CSA to establish the technical and scientific feasibility and relevance of missions or payloads in order to enable CSA decisions on future SE missions.	
<b>Indicators</b>	<b>Performance</b>
1. Number of concept/feasibility (mission and payload), studies initiated, pursued or completed. (Target: 14)	<b>Target exceeded:</b> 17 studies (9 completed, 8 ongoing), RFP (Request for Proposal) for 1 study posted, RFP for 6 studies being completed.
2. Number of terrestrial integrated prototypes for end-to-end mission deployments under way or completed. (Target: 3)	<b>Target exceeded:</b> 6 classes of rovers being developed.

<b>PERFORMANCE ANALYSIS:</b>	
<p><u>3-Year Trend</u></p> <p>The 3-year trend is based for the third time on three consecutive data for indicator #1. This year two sectors contributed to this indicator. Trend analysis upgrades the satisfactory rating to superior for targeted achievements were all met. Benchmark value cannot be established at this time.</p> <p><u>Indicator 1</u></p> <p>9 completed studies: Luna-Resource (2), MLM, MSR-Net, Astro-H (3), Dark Energy and ORBITALS.            8 ongoing studies: Lunar APXS (2), Astro-H Ph.A, MSO, SPICA, PHEMOS Primo, Global UV Imager and UVAMC.            Source: Internal documents.</p> <p><u>Indicator 2</u></p> <p>In addition to the 6 classes of rovers being developed, a series of payloads to be installed on the rovers are in development.            Source: Internal documents.</p>	 <p>Superior</p>

2010-2011 – Financial Resources (\$ in millions)	
Planned Spending	Actual Spending
76.0	69.6
2010-2011 – Human Resources (FTEs)	
Planned	Actual
41.8	48.5

**2- ESA Programs in SE – Objective:** Through key international partnerships, foster the participation of Canadian academia and the demonstration of Canadian space technologies in European SE missions.


EXPECTED RESULT #1	
Successful development and demonstration of advanced technologies, systems, components, or studies provided for in the contracts awarded by ESA to Canadian firms under human and robotics exploration programs, including ISS sciences. (Space Exploration, ELIPS program)	
Indicators	Performance
1. Canadian industrial return in ESA optional programs in SE. (Target: 84% or higher)	<b>Target partially met: 75%</b>

PERFORMANCE ANALYSIS:	
<p><u>3-Year Trend</u></p> <p>The 3-year trend is measured for the fourth time based on six consecutive data. Trend analysis drops the rating to “Opportunity for improvement” for targeted achievement since it was considerably lower to its target. Benchmark is well established among ESA community.</p>	 <p>Opportunity for improvement</p>
<p><u>Indicator 1</u></p> <p>The return coefficient corresponds to the ratio between the actual number of weighted contracts given to a country and the ideal number of contracts to be given to that country according to existing rules. Canadian industrial return coefficients are by Program Activity. The SE optional program is the ELIPS.</p> <p>The industrial return ratio is derived from the combination of the microgravity, exploring/robotics and spaceflight program families.</p> <p>Source: Geographical distribution of contracts ESA/IPC(2010)13, published on March 28 2011, and covering the period between January 1, 2000 to December 31, 2010.</p> <p>The ESA reports are always published with a minimum 3 months delay therefore, the data currently available is as of December 2010.</p>	

2010-2011 – Financial Resources (\$ in millions)	
Planned Spending	Actual Spending
9.9	7.9
2010-2011 – Human Resources (FTEs)	
Planned	Actual
0.0	0.0

**3- SE Programs – Objective:** Coordinate the Canadian SE community in order to pursue world-class research space missions to advance our knowledge of basic physical and chemical processes, the near-Earth space environment and Earth's electromagnetic field, our solar system, the universe and its evolution, as well as the adaptation of humans and other life forms in the weightless environment.

EXPECTED RESULT #1	
Identified opportunities for Canadian scientists to advance exploration readiness and scientific knowledge through CSA, national and international research missions.	
Indicators	Performance
1. Number of scientific publications, reports and conference proceedings acknowledging CSA funding. (Target: 350)	<b>Target exceeded:</b> 972 as of April 29, 2011.
2. Number of Highly Qualified Personnel (HQP) involved in the program. (Target: 400)	<b>Target exceeded:</b> 647 as of April 29, 2011.
3. Number of research partnerships (nationally and internationally). (Target: 80)	<b>Target exceeded:</b> 124 as of April 29, 2011.

PERFORMANCE ANALYSIS:	
<p><u>3-Year Trend</u></p> <p>The 3-year trend is measured for the third time based on five consecutive data for all indicators. Trend analysis upgrades the rating to superior because all indicators surpassed their targets. Benchmark values have yet to reach an appropriate stability.</p> <p><u>Indicator 1</u></p> <p>516 Peer Reviewed Publications acknowledging CSA funding.  36 Non-Peer Reviewed Publications acknowledging CSA funding.  5 Books acknowledging CSA funding.  228 Peer Reviewed Publications Enabled CSA funding.  180 Non-Peer Reviewed Publications Enabled by CSA funding.  7 Books Enabled by CSA funding.</p> <p>Target exceeded due to better management of survey; facilitated principal investigator (PI) responses with a user friendly survey and an easier data management/reporting procedure using ORIS (Organized Research Information System).</p> <p>Source: CSA annual survey of external principal investigators/scientists.</p>	 <b>Superior</b>

Indicator 2

30 Canada Research Chair  
90 Tenure Faculty  
29 Non-Tenured Faculty  
101 Research Associates  
59 Post Doctoral Fellows  
23 Research Assistants  
140 Graduate Students  
63 Undergraduate Students  
61 Engineers/Technicians  
51 Other personnel

Target exceeded due to better management of survey; facilitated principal investigator (PI) responses with a user friendly survey and an easier data management/reporting procedure using ORIS (Organized Research Information System).

Source: CSA annual survey of external principal investigators/scientists.

Indicator 3

17 Astronomy Partnerships  
19 Life Sciences Partnerships  
10 Physical Sciences Partnerships  
5 Planetary Exploration Partnerships  
24 Solar Terrestrial Sciences Partnerships  
48 GRANTS  
1 CARN Partnerships  
60 additional partnerships for Internal Collaborative Arrangements partnerships (MOU, MOA, etc.)

Target exceeded due to better management of survey; facilitated principal investigator (PI) responses with a user friendly survey and an easier data management/reporting procedure using ORIS (Organized Research Information System).

Source: CSA annual survey of external principal investigators/scientists.

<b>2010-2011 – Financial Resources (\$ in millions)</b>	
<b>Planned Spending</b>	<b>Actual Spending</b>
9.8	9.9
<b>2010-2011 – Human Resources (FTEs)</b>	
<b>Planned</b>	<b>Actual</b>
25.6	25.9

## Highlights of Main Accomplishments – Enabling Research (SE)

- The CSA continued 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 2010, the ISECG presented a first architecture for human exploration of the Moon to the Heads of various space exploration programs including the CSA. The group has started to develop scenarios for a Global Exploration Roadmap to which CSA is contributing actively.
- In 2010-2011, all contracts under the *Stimulus* initiative on space robotics that was announced as part of Canada's Economic Plan have been awarded and some amendments are being implemented early in 2011-2012. The *Stimulus* initiative is developing terrestrial prototypes of the next generation Canadarm and prototypes of three different rovers and their associated technologies for future Moon and Mars exploration. The CSA also issued contracts for the development of science instruments and to support analogue mission deployments.
- Through the new CSA Class Grant and Contribution Program to support Research, Awareness and Learning in Space Science and Technology, the CSA has successfully supported the development of science and technology, and fostered the development of a critical mass of researchers and highly qualified people in Canada in areas relevant to the priorities of the CSA. This has been accomplished through continuing support to academic teams engaged in developing new knowledge and information from missions supported by the CSA (Space Science Enhancement Program); by supporting specific projects in areas of priority for the Agency in the field of space astronomy (BRITE, Spider, EBEX); and by announcing two new competitive Announcements of Opportunity to train the next generation of space scientists and engineers (FAST) and create distributed Centres of Excellence in areas of priority for the CSA (Cluster Pilots). In 2010-11, over 1050 scientific publications, report, conference proceedings acknowledging CSA funding were produced; approximately 700 presentations were given presenting CSA-supported activities; approximately 780 Highly Qualified Personnel were involved in the program; and over 145 research partnerships were developed or continued.
- The CSA maintained its human space flight expertise to meet the requirements of the CSA's exploration program. Two Canadian astronaut candidates continued basic training at NASA's Johnson Space Center in preparation for long-duration space flight assignments to the International Space Station. Another Canadian astronaut continued with post-flight activities after a very successful long-duration mission to the ISS (C-1, May-December 2009). The next Canadian astronaut to be assigned for the second Canadian Long-Duration mission to the ISS (C-2) was announced and has started training. The Canadian Astronaut Corps has adapted to the new reality of fewer flight opportunities as a result of the Space Shuttle retirement and continued to utilize the expertise and skill set of flown astronauts to advance and position the Canadian Space Exploration program.

- The CSA has started 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 were analyzed and are being taken into account. The CSA also continued to monitor and coordinate medical support with international partners and actively support the ISS Medical committees.
- CSA has supported international space research coordination through active participation in the International Space Life Sciences Working Group (ISLSWG), and in the International Space Station (ISS) Research Planning Working Group (RPWG). In addition, proposals selected during the International Life Sciences Research Announcement were integrated into an ISS utilization priority review for future implementation.
- The collaboration for ISS science has been formalized in the creation of the Program Science Forum of which Canada is an active member. In the last year, (PSF) has produced Factsheets that document scientific successes on the ISS. The PSF also initiated ad hoc task groups to develop means to coordinate and highlight to the public the aspects of ISS activities that have broad humanitarian impact. Proposals that were selected during the 2009 International Life Sciences Research Announcement will become reality on the ISS in the 2013-2015 timeframe.
- Through partnership with the European Space Agency (ESA), the CSA has continued to position the Canadian industry and scientists in future scientific and technological developments relating to the European Aurora planetary exploration program, the International Berthing and Docking Mechanism activity, bioanalysis instrumentation and to the physical and life sciences ELIPS-2 and ELIPS-3 programs. In addition, Canada has recently joined the ESA Lunar Lander Phase A activities, which will provide Canadian industry the opportunity to continue the development of Canadian niche technologies such as active space vision systems.
- The CSA continued the feasibility studies of the SCOPE mission concept in collaboration with the Japanese Space Agency. The goal of the mission is to understand our magnetosphere by performing measurements at multiple scales.

**Program Sub-Activity: Space Mission Development - Space Science and Exploration**

**Objective:** Provide coordination or support to the development of Space Science and Exploration (SE) space missions in line with CSA priorities and stakeholders' expectations through the definition, critical design, manufacturing, integration, testing and delivery phases leading to launch and early operations of space systems.

<b>Expected Result #1</b>	
Space mission proposals that efficiently, effectively and economically progress to subsequent operations phases in accordance with objectives, requirements, initial or revised specifications.	
<b>Indicator</b>	<b>Performance</b>
1. Percentage of projects requiring more than one EPA (Effective Project Approval) or an amendment to initial EPA over the total number of projects.	There were amendments made to one EPA for the Space Science and Exploration Program Activity in 2010-2011.
<b>Expected Result #2</b>	
The CSA's in-house personnel are highly qualified, with recognized expertise, and are supported by a high-technology infrastructure that is suited to all Space Mission Development projects.	
<b>Indicator</b>	<b>Performance</b>
1. Rate of expertise matrix support to all CSA's program activities.	A 97% rate of planned expertise matrix – all program activities combined.

<b>Performance Analysis</b>
<p><b>Expected Result #1</b></p> <p><u>Indicator 1</u></p> <p>The NEOSat mission obtained its first EPA in October 2005. Since then, additional costs due to delay in the schedule and the increase in the internal market prices for launchers have caused the need for a revised EPA in November 2009.</p> <p>Source: Internal documents.</p>
<p><b>Expected Result #2</b></p> <p><u>Indicator 1</u></p> <p>This 97% rate of planned expertise matrix support represents a significant increase compared to last year's 51%. This increase is due to the new internal structure which created an additional type of matrix called "vertical matrix exchange". This new type along the previously type "horizontal matrix exchange", accounted the time allocation of 235 specialized personnel for a total amount 121 projects/activities identified needing matrix support. This indicator has lost its relevancy in the context of the reorganization and therefore will no longer be measured.</p> <p>Source: Internal reporting documents (E-Ram).</p>

<b>2010-2011 – Financial Resources (\$ in millions)</b>	
<b>Planned Spending</b>	<b>Actual Spending</b>
30.9	15.6
<b>2010-2011 – Human Resources (FTEs)</b>	
<b>Planned</b>	<b>Actual</b>
29.2	23.2

### **SPACE MISSION DEVELOPMENT – SPACE SCIENCE AND EXPLORATION**

One Science and Exploration Space Mission Development Program, with a combination of accomplishments, demonstrates how the expected result outlined below was measured and attained at the program sub-sub-activity level.

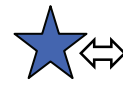
**1- SE Projects – Objective:** Ensure the development, delivery and commissioning of space-qualified systems for SE missions through effective project, quality and engineering management.

<b>EXPECTED RESULT #1</b>	
SE projects' deliverables meet mission objectives at critical steps.	
<b>Indicator</b>	<b>Performance</b>
1. Number of missions/projects associated with science support. (Target: 2)	<b>Target met: 2</b>
<b>EXPECTED RESULT #2</b>	
SE projects' deliverables are met.	
<b>Indicators</b>	<b>Performance</b>
1. Project milestones are met as defined in the detailed work plan. (Target: 75% of milestones achieved versus planned)	<b>Target exceeded:</b> 93% (14/15) milestones have been completed or partially completed (2).
2. Project cost is maintained within authorized levels. (Target: 100%)	<b>Target met:</b> 100%
3. Risks are identified and mitigation plans prepared for each project. (Target: 100%)	<b>Target met:</b> 100%

**PERFORMANCE ANALYSIS:**

3-Year Trend

For the second time, the 3-year trend is measured for all indicators based on four to six consecutive data. Trend analysis maintains the satisfactory rating although all targeted achievements have been met or exceeded. Benchmark values could only be confirmed for three indicators, the other have yet to reach an appropriate stability.



Satisfactory

**Expected Result #1**

Indicator 1

2 Missions are in phase D and will be launched in 2012: ePOP and SWARM

Source : Internal documents.

**Expected Result #2**

Indicator 1

With one milestone postponed for lack of funds and resources (CCAP project initiation). The partial completions are only with respect to the one month delay in approving funding for BCAT-C1 project and the schedule slip in the JWST FGS PFM manufacturing.

In addition to those milestones Executive Committee approval was obtained for 2 projects (MATMOS and CAMS).

Source: Internal documents.

Indicator 2

Documentation available in the financial and planning systems for APXS, JWST and NGC (B-1-1) projects under the responsibility of the Space Exploration Projects teams.

Source: Internal documents.

Indicator 3

APXS and JWST Risk Management is supported and documented by RIAS (Risk Information and Assessment System).

Source: Internal documents.

<b>2010-2011 – Financial Resources (\$ in millions)</b>	
<b>Planned Spending</b>	<b>Actual Spending</b>
30.9	15.6
<b>2010-2011 – Human Resources (FTEs)</b>	
<b>Planned</b>	<b>Actual</b>
29.2	23.2

## Highlights of Main Accomplishments – Space Mission Development (SE)

- Canada is participating in the James Webb Space Telescope (JWST), a major facility-class space observatory. 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 continued in 2010. The CSA delivered the Engineering Model in September 2010. 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 takes part in the Ultra Violet Imaging Telescope (UVIT) onboard the ASTROSAT satellite of the Indian Space Research Organization (ISRO). The Flight detector subsystem will be integrated in the UVIT instrument in 2011. ASTROSAT is scheduled for launch by 2012. The CSA's participation will guarantee 5% of the observing time for Canadian scientists and access to ASTROSAT's astronomic data.
- The CSA continued to provide support to the assembly and test of the Alpha Particle X-ray Spectrometer (APXS) for the Mars Science Laboratory. The Canadian contribution will help scientists to determine the chemical composition of various soil, dust and rock samples on Mars. This activity is nearing completion and the launch by NASA is scheduled for the end of 2011 and arrival on Mars in August 2012.
- The Enhanced Polar Outflow Probe (ePOP) mission, integrated with the CASSIOPE Mission, is scheduled for launch in fiscal year 2011-2012. It 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. Launch of the CASSIOPE spacecraft has been delayed as the selected launch vehicle – Falcon 9 has been under development for many years, culminating with two successful launches in 2010. Scientific preparation for ePOP continued.
- The CSA continued to work with the European Space Agency (ESA) to support the activities of Canadian researchers in science teams that plan to utilize the CSA-developed Microgravity Vibration Isolation System (MVIS), which is part of the ESA's Fluid Science Laboratory on the ISS. The CSA supported Charles Ward, of the University of Toronto, as he collaborated with European scientists and the European Space Agency towards readiness of the CIMEX-1 experiment on the ISS.

- The CSA continued to work with Canadian scientists on activities related to calibration of data from the Canadian Electric Field Instrument that will fly on ESA's 3 Swarm satellites and in preparation for use of the data in conjunction with ePOP instruments and the Canadian GeoSpace Monitoring Program.
- The NEOSSat mission, a joint Canadian Space Agency and Department of National Defence mission, is a combination of the Near Earth Space Surveillance (NESS) and the High Earth Orbit Surveillance (HEOS) projects. It is expected that 50% of NEOSSat time will be used to observe the inner portion of the solar system to discover, track and study asteroids and comets. The other 50% of the operating time will be used to track satellites in high-Earth orbit to update the orbit parameters of known satellites flying over the Canadian territory. Detail design of the NEOSSat spacecraft was completed in fiscal year 2010 and it will undergo manufacture, assembly integration and testing activities during 2011 in order to be ready for launch in late 2011 or early 2012, depending on launch vehicle readiness.
- The TriDAR vision system has been used on a second flight in 2010 for docking the space shuttle to the ISS on STS-133. 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. Given the success of the two demonstrations, NASA allocated a third flight in 2011.
- In partnership with Japan Aerospace and Exploration Agency (JAXA), the CSA is leading the development of Canadian ASTRO-H Metrology System (CAMS) on board Japan's ASTRO-H space astronomy observatory satellite. The initial phase for this project started in 2010. This Canadian technology builds on the heritage from the Space Vision System designed for the Space Shuttle and International Space Station, securing privileged data access to our scientific community, and shedding light on parts of the unseen universe.
- The CSA has initiated 3 mission studies as part of NASA's New Frontier program. 1 of the 3 missions will be selected in 2011 for a 2016 launch to explore our solar system, either to an Asteroid, the Moon or to Venus.
- In partnership with the US Jet Propulsion Laboratory (JPL), the CSA is leading the development of the heart of the MATMOS instrument. MATMOS will study the Martian atmosphere by analyzing its composition and will thus impact our understanding of geology, atmosphere, astrobiology and environment as trace gases are tracers of many processes. The initial phase for this project has started in 2010. MATMOS is planned for launch in 2016.

<b>Program Sub-Activity: Space Mission Operations – Space Science and Exploration</b>
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**Objective:** Provide coordination or support to the operations of Space Science and Exploration (SE) space missions in line with the CSA priorities and stakeholders' expectations through the development and conduct of on-orbit operations, system maintenance and logistic support, as well as data handling and delivery.

<b>Expected Result #1</b>	
The CSA's in-house personnel are highly qualified, with recognized expertise, and are supported by a high-technology infrastructure that is suited to all Space Mission Operations activities.	
<b>Indicators</b>	<b>Performance</b>
1. Annual rate of investment in maintenance and improvement of the infrastructure required for missions in operation phases.	After a second attempt, the data collection for this indicator revealed to be too strenuous; therefore, it will no longer be measured.
2. Quality of the internal expertise specializing in advice and technology-watch to ensure the successful flow of missions reaching operation phases.	After a second attempt, the data collection for this indicator revealed to be too strenuous; therefore, it will no longer be measured.


<b>2010-2011 – Financial Resources (\$ in millions)</b>	
<b>Planned Spending</b>	<b>Actual Spending</b>
58.9	53.8
<b>2010-2011 – Human Resources (FTEs)</b>	
<b>Planned</b>	<b>Actual</b>
129.3	104.5

## **SPACE MISSION OPERATIONS – SPACE SCIENCE AND EXPLORATION**

Three Science and Exploration Space Mission Operations Programs with a combination of accomplishments demonstrate how the following expected results were measured and attained.

**1- International Space Station (ISS) – Objective:** Provide required CSA operations, training and engineering services to the ISS Program.

<b>EXPECTED RESULT #1</b>	
The Canadian Space Station Program (CSSP) meets the requirements of the International Space Station Program (ISSP) in accordance with the Intergovernmental Agreement (IGA) and the NASA/CSA Memorandum of Understanding (MOU).	
<b>Indicators</b>	<b>Performance</b>
1. Continuity of on-orbit operations of MSS to meet the ISSP requirements and to fulfil the CSSP mandate. (Target: Scheduled MSS operations conducted in accordance with ISSP requirements)	<b>Target met:</b> Supported operations for 19A, ULF-4, ULF-5, HTV-2, Soyuz, Progress and stage activities supported.
2. Delivery of MSS generic training to international astronauts and ground personnel. (Target: ISSP training requirements met)	<b>Target met:</b> All scheduled courses conducted.
3. Delivery of MSS engineering and technical support (personnel and facilities) for the MSS. (Target: Scheduled MSS operations supported in accordance with ISSP requirements)	<b>Target met:</b> Flights 19A, ULF4, HTV-1 and ULF5 were all supported including all stage requirements.

<b>PERFORMANCE ANALYSIS:</b>	
<p><u>3-Year Trend</u></p> <p>All indicators were newly introduced in the 2009-2010 RPP. Only indicator 2 could be inferred to previous indicators reported. Therefore the trend analysis maintains the rating to satisfactory since it could only be done for indicator 2. Benchmarks are well established as targets are set at the International Space station Program level.</p> <p><u>Indicator 1</u></p> <p>ISS operations are scheduled in advance of an increment in the Increment Definition Requirements Document. Once the increment starts, modifications to the operational plan are managed through the Current Stage Requirements Document. Finally, for very short term changes to the operational plan a CHIT system is used to manage day to day modifications. CSA participated in the planning and supported all ISS operational activity where required.</p> <p>Source: Internal documents.</p>	 <p>Satisfactory</p>

Indicator 2

7 MSS MRO Parts 1& 2 were conducted (7 students / 2 observers)  
2 SPDM MRO Courses Part 1 & 2 (2 students)  
2 MSS MMC Part 1 (11 students)  
1 MSS MMC Part 2 (5 students / 2 observers)  
1 CAPCOM course (5 students)

Source: Internal documents.

Indicator 3

No comment

Source: Internal documents.


2010-2011 – Financial Resources (\$ in millions)	
Planned Spending	Actual Spending
45.7	41.7
2010-2011 – Human Resources (FTEs)	
Planned	Actual
95.5	75.6

**2- SE Mission Operations – Objective:** Operate the space and ground segment for SE missions carried out in partnership with academia, industry, and other space agencies to optimize returns of scientific data and knowledge within the following scientific fields: astronomy, life sciences, physical sciences, space exploration and solar-terrestrial relations.

**EXPECTED RESULT #1**

SE Space Mission Operations meet mission objectives and user/client expectations.

Indicators	Performance
1. Number of missions in operational phase associated with science support. (Target: 2)	<b>Target met:</b> 2 missions (CGSM and THEMIS) are in operational phase.
2. Quantity of projects supported through the provision of expertise to fulfill the needs of internal sponsoring organizations for payload projects throughout their development and operation. (Target: Planned payload operations of 5 projects are supported as defined in operational plan)	<b>Target partially met:</b> A total of 4 projects were fully supported. Only 4 projects were available to support.

<b>PERFORMANCE ANALYSIS:</b>	
<p><u>3-Year Trend</u></p> <p>Indicator 2 was newly introduced in the 2010-2011 RPP and indicator 1 is measured for the fourth time. Therefore the trend analysis maintains the rating to satisfactory since it could only be done for one indicator showing four consecutive data. Benchmark cannot be established at this time since available values did not reach appropriate stability.</p> <p><b>Expected Result #1</b></p> <p><u>Indicator 1</u></p> <p>No comment.</p> <p>Source: Internal documents.</p> <p><u>Indicator 2</u></p> <p>Only four projects were available to support. BIASE, APEX-CAMBIUM, VASCULAR and HYPERSOLE. One project, Blood Pressure Regulator, was still in the early development phase within the developing organization and there were no requests for support during the fiscal year.</p> <p>Source: Internal documents.</p>	 <p>Satisfactory</p>

<b>2010-2011 – Financial Resources (\$ in millions)</b>	
<b>Planned Spending</b>	<b>Actual Spending</b>
6.9	6.6
<b>2010-2011 – Human Resources (FTEs)</b>	
<b>Planned</b>	<b>Actual</b>
15.0	9.5

**3- Human Space Flight Mission Operations – Objective:** Enhance human space flight expertise and returns of scientific knowledge in life science and operational space medicine from the Astronaut Corps and its professional support team. The program provides Canadian Astronauts with clinical, medical, operational and human behavior support, contributes to research in radiation, nutrition and cross-cultural training, and promotes the transfer of knowledge gained to medical specialists to improve the delivery of health care services provided to Canadians.

<b>EXPECTED RESULT #1</b>	
Maintain a healthy, trained, and versatile Astronaut Corps and professional support team to meet the needs of the Canadian space science and human exploration programs.	
<b>Indicators</b>	<b>Performance</b>
1. Delivery of ongoing training plan for the Astronaut Corps and its professional support team as per international agreements. (Target: training requirements met for astronauts and professional support team)	<b>Target met:</b> 25 distinct conferences or training events were attended by astronauts and professional staff.

2. Provision of operational support to missions. (Target: pre-flight support to C-2 long duration mission to the ISS)	<b>Target met:</b> Astronaut C2 Mission Specific Training is planned, monitored and on schedule.
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<b>Performance Analysis</b>	
<u>3-Year Trend</u> New indicator introduced in 2009-2010 RPP and measured for the second time therefore no trend analysis available.	N/A
<b>Expected Result #1</b> <u>Indicator 1</u> Astronaut candidates (Jeremy Hansen and David Saint-Jacques) continue to receive basic training course at JSC. Assigned Astronaut Chris Hadfield continues to receive ISS Mission specific training. Source: Internal documents. <u>Indicator 2</u> No comment. Source: Internal documents.	

<b>2010-2011 – Financial Resources (\$ in millions)</b>	
<b>Planned Spending</b>	<b>Actual Spending</b>
6.3	5.4
<b>2010-2011 – Human Resources (FTEs)</b>	
<b>Planned</b>	<b>Actual</b>
18.8	19.4

### Highlights of Main Accomplishments – Space Mission Operations (SE)

- ESA’s Herschel space telescope was successfully launched in May 2009. The Heterodyne Instrument for the Far Infrared (HIFI) included the Local Oscillator Source Unit (LSU) contributed by Canada. The satellite carries an infrared telescope and three scientific instruments that allow Canadian scientists to address key science questions such as how galaxies were formed in the early universe and how stars have been forming throughout the history of time.
- CSA continued to provide critical support for Canada’s role in the Spectral and Photometric Imaging Receiver (SPIRE) instrument on board ESA’s Herschel space observatory satellite launched in 2009. The extraordinary data received by Herschel to date is providing scientists unprecedented insight into the birth of stars and galaxies while looking for the presence of water in remote parts of the Universe.

- The CSA continued to support 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 and improving our ability to forecast the impacts of solar activity on satellites and on ground infrastructure (e.g. power grids). The CGSM serves also to collect and distribute high quality science data used by other government departments and in support of satellite missions including ePOP, PCW and THEMIS.
- ESA's Planck satellite launched at the same time as the Herschel space telescope. The satellite is the most sensitive telescope ever designed to study the microwave background radiation which are remnants from the Big Bang 13 billion years ago. Canada participated in Planck by developing rapid interpretation software and the real-time analysis software for microwave surveys of the sky. CSA has continued to support the science involvement in this mission.
- The CSA continued to support the Canadian Principal Investigator (PI)-led MOST micro-satellite mission to measure the intensity of light from distant stars. MOST was launched in 2003 to study 10 stars on a CSA mission that was expected to last one year. Now, eight years later, MOST is still functioning well and has observed more than 2,000 stars. Among many targets selected for study last year by the science team, MOST discovered an exotic super-Earth named "55 Cancri". This discovery is considered to be one of the most significant breakthroughs in the study of planet evolution.
- The CSA continued to fulfill its obligations for Mobile Servicing System (MSS) operations. This involved maintaining and providing technical support for the MSS hardware and software, continuing hardware repair and overhaul, 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 continued to maintain MSS operational preparedness to carry out ISS assembly and maintenance operations. This resulted in the development and certification of new flight products and procedures to support MSS operations. The CSA also continued the upgrade of its ground control operations for Canadarm2 to enable the handling of heavy payloads as scheduled. This development of expanded ground control capabilities for future Dextre operations will enable more efficient on-orbit commissioning of this new element and thereby significantly reduce astronaut time requirements.

- The CSA conducted concept studies for Dextre compatible tools in order to expand on-orbit use of Dextre. In parallel, the CSA continued to prepare for the evolution of MSS operations from highly planned and concisely tested assembly operations, towards more generic and less predictable maintenance operations.
- The CSA released the MSS-6.2 software version, which provides further capabilities for Canadarm2 to capture Japanese (HTV-II) and commercial American (Dragon) free flying space vehicles.
- The CSA has completed the technical activities to assess the feasibility to extend the operating life of the Mobile Servicing System to 2025. This technical assessment will be published later in 2011. Initially, the MSS was designed to operate for a 15 year period.
- The CSA prepared and launched the spare Dextre arm to the International Space Station using the Space Shuttle. The spare Dextre arm was then pre-positioned on the ISS structure in order to react to any possible failure of a Dextre arm. The Space Shuttle, expected to retire in mid 2011, is essential due to the size of the Dextre arm.
- The CSA has supported the following experiments and educational activities on the ISS:
  - APEX-CAMBIUM: The recovery of the Cambium wood experiment from the ISS for redistribution to the research team. The completion of the ground control run will allow precise comparison of the wood development in space and on Earth.
  - APEX CSA2: White spruce trees were successfully grown on ISS, giving Natural Resources Canada information on the relationship between tree development and gravity that would be impossible to obtain on Earth.
  - BIASE: Operations of the bodies in the space environment experiment on the ISS were successfully completed, giving the scientists at York University an unprecedented depth of data on the changes in human perception that occur in the space environment.
  - VASCULAR: The experiment was completed with three test subjects, with the acquisition of unique data on the extent of inflammatory activity within the cardiovascular system of ISS crew-members.
  - CCISS: Post-flight data collection from ISS crewmembers was completed. This experiment was aimed at understanding the fundamental nature of the physiological changes that occur when the human being is exposed to the space environment.
  - Hypersole: Six crew-members of space shuttles servicing the ISS completed the CSA-sponsored Hypersole experiment. This study of changes of the sensitivity of skin to touch has potential applications to space medicine and to understanding changes in balance control that occur in the elderly.

- BCAT-5: The Canadian part of this series of experiments on the physics of colloid behaviour was completed on the ISS. The Canadian scientists, based at Simon Fraser University are currently analyzing the data obtained from this multinational collaboration.
- The CSA continued to explore how the Advanced Astronaut Medical Support (ADAMS) project can contribute to human exploration. More specifically, the CSA continued to explore solutions to the delivery of health care on future long duration exploration-class missions and how these solutions can help improve healthcare delivery on Earth through the transfer of space technology. CSA continued to develop collaborative projects with academia and industry and use analog environments for requirements definition and proofs of concept. As part of the ADAMS project, the CSA is investigating the development of a tool called PRET (Performance Readiness Evaluation Tool) 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. The PRET prototype is being tested in the Russian Mars500 Isolation study since September, 2010.

## 2.4 SATELLITE COMMUNICATIONS

<b>SATELLITE COMMUNICATIONS 2010-2011 PROGRAM ACTIVITY PERFORMANCE MEASUREMENT</b>	
<b><u>BENEFITS FOR CANADIANS</u></b>	
<p>Satellite Communications facilitates the linking of all Canadians by increasing the delivery of non-commercial services to Canadian remote communities, and support federal government department's program delivery.</p> <p>Space infrastructure allows access and dissemination of timely health, cultural, security and safety related information to all Canadians wherever they live in Canada. Satellite communication is essential to provide Canadians living in remote areas with timely access to expert knowledge and expertise related to health and education through a range of non-commercial services including: e-government, e-learning, tele-justice, tele-education, as well as tele-medicine.</p>	
<b><u>EXPECTED RESULT</u></b>	
<p>State-of-the-art systems and applications are developed to satisfy the needs of the Canadian Government and population in order to ensure that Canada remains a world leader in satellite communications.</p>	
<b><u>MAIN ACCOMPLISHMENTS IN 2010-2011</u></b>	
<p>The CSA completed the ground segment infrastructure upgrade needed for the utilization of the Government of Canada capacity credit of the Anik F2 satellite by northern communities.</p> <p>The mission and preliminary system requirements for the Polar Communications and Weather mission have started in order to meet the needs for full-time communications coverage over Canada up to the North Pole.</p> <p>The CSA successfully completed a preliminary study for a new mission of constellation of micro-satellites to provide an automatic identification system (AIS) for ships with the objective of improving maritime monitoring of the Canadian coasts.</p>	
<b>Indicators</b>	<b>Performance</b>
1. Proportion of active missions relative to the total number of missions supported by Canada in the SC priority areas.	One of the 9 missions reached an Operational stage in 2010-2011
2. Number of technological applications developed as a result of CSA's participation in space missions and/or support to projects/activities in SC.	10 applications.

### Indicator 1 – Performance Analysis

At the time of the Departmental Performance Reporting, the Canadian Space Agency presents a list of space missions to which it actually contributes or plans to contribute. The fact that a mission appears on the list does not mean that it will be completed. Any mission must necessarily follow many critical steps depicted in a simple manner as such:

- Mission under review: A mission that is subject to concept of feasibility studies. At the end of this step, a decision is made whether to continue, to cancel or to postpone the participation to the mission.
- Mission in development: The participation implies that activities produce assets which are not yet operational. The final milestones prior to operation are the launch and the full commissioning of the mission.
- Mission in operation: The mission is operational, delivering results until being fully completed. By virtue of being in operation, a mission will spark scientific, technological and operational activities in order to reach its objectives.

SC missions at the operation stage (1) = \*

SC missions at the development stage (4)

SC missions under review (4): \* = 1

(Year) = Actual or projected launch date or date of completion when known.

\* = New Missions in 2010-2011.

Descriptions of missions can be found in [Section 2.8](#) – List of Space Missions.

#### **Satellite Communications (SC) missions at the operation stage:**

<b>Mission</b>	<b>Status</b>	<b>Field</b>
* Anik F2 Utilization (2011)	In operation	Satellite Communications

(Year) = Actual or projected launch date or date of completion when known.

\* = New missions in 2010-2011.

#### **Satellite Communications (SC) missions at the development stage:**

<b>Mission</b>	<b>Status</b>	<b>Field</b>
CASSIOPE/Cascade (2012)	In development	Satellite Communications
ESA – Alphasat	In development	Satellite Communications
ESA - Galileo SAT	In development	Search and Rescue
M3MSat (2011)	In development	Security, Satellite Communications

(Year) = Actual or projected launch date or date of completion when known.

\* = New missions in 2010-2011.

**Satellite Communications (SC) missions under review:**

<b>Mission</b>	<b>Status</b>	<b>Field</b>
* AIS Constellation	Under review	Satellite Communications
Next Gen – Advanced Broadband payload #1 (2014)	Under review	Satellite Communications
PCW (telecommunications' aspect) (2016)	Under review	Security and Foreign Policy, Economic Development
QuickSat	Under review	Satellite Communications

(Year) = Actual or projected launch date or date of completion when known.

\* = New missions in 2010-2011.

Descriptions of missions can be found in [Section 2.8](#) – List of Space Missions.

**Indicator 2 – Performance Analysis**

A total of 10 applications, compared to 8 in 2009-2010, were identified for the 9 missions listed above: Anik F2 ruggedized ground infrastructure and terminal servicing, Cascade (data storage unit) on board CASSIOPE, Antennas and filters for ESA-Alphasat (2), the MEOSAR instrument on board Galileo satellite and the RSS-GEMS for traffic identification (2), 2 Automatic Identification System related applications for M3MSat and 2 new application developments that consist of a maritime monitoring technology for Canada's Coastline and another for high speed communications in the Arctic; 67% of those applications (2/3) were related to Communications whereas the other 33% supported were related to Security/Search and Rescue. All applications, except one, served national objectives; MEOSAR which is developed in collaboration with ESA will serve the international community

Source: Internal documents.

<b>2010-2011 – Financial Resources (\$ in millions)</b>		
<b>Planned Spending</b>	<b>Total Authorities</b>	<b>Actual Spending</b>
19.7	21.7	16.6
<b>2010-2011 – Human Resources (FTEs)</b>		
<b>Planned</b>	<b>Actual</b>	<b>Difference</b>
13.6	16.3	(2.7)

**The programs under this Program Activity are divided into three Sub-Activities: Enabling Research, Space Mission Development and Space Mission Operations. However, no Space Mission Operations are mentioned in this report since CSA is not operating communications satellite.**

**Program Sub-Activity: Enabling Research – Satellite Communications**

**Objective:** Provide leadership, coordination or support to Satellite Communications (SC) applied research and experimental development in line with the CSA priorities and stakeholders expectations in order to increase the knowledge base and devise new applications through space missions, and to allow the transfer of intellectual property and proven technologies to Canadian industry, academia, and government organizations.

<b>Expected Result #1</b>	
New project/mission concepts that progress to subsequent development phases related to Agency's priorities.	
<b>Indicators</b>	<b>Performance</b>
1. Ratio of the number of new concepts presented to the number of new concepts retained for subsequent phase.	There was one new concept retained in 2010-2011.
2. Quality of the concepts retained based on the average evaluation rating obtained according to the Priority Ranking Framework.	Unavailable this year.
<b>Expected Result #2</b>	
The CSA's in-house personnel are highly qualified, with recognized expertise, and are supported by a high-technology infrastructure that is suited to all Enabling Research projects/missions.	
<b>Indicator</b>	<b>Performance</b>
1. Number of consulting requests received by CSA personnel from external sources such as the private sector, academia and other space agencies.	For all program activities combined, the CSA personnel responded to a 121 consulting requests from external sources in 2010-2011.

<b>Performance Analysis</b>
<p><b>Expected Result #1</b></p> <p><u>Indicators 1-2</u></p> <p>The Satellite Communications Program Activity had one new activity investment this year, namely AIS-Constellation. The priority ranking of this new concept remains unavailable this year.</p> <p>Source: Internal documents.</p> <p><b>Expected Result #2</b></p> <p><u>Indicator 1</u></p> <p>The number "121 requests", 45 more than last year, represents an estimation based on an average number of days allocated per request from OGD, universities and industry for rare expertise held by CSA personnel. Examples of such requests are participation in research grant submissions or academic case studies, provision of technical advice to industry and academia on space related projects, and technical evaluation of proposals or documents received by OGDs.</p> <p>Source: Internal documents.</p>

<b>2010-2011 – Financial Resources (\$ in millions)</b>	
<b>Planned Spending</b>	<b>Actual Spending</b>
12.6	14.9
<b>2010-2011 – Human Resources (FTEs)</b>	
<b>Planned</b>	<b>Actual</b>
8.7	9.8

**ENABLING RESEARCH – SATELLITE COMMUNICATIONS**

Three Satellite Communications Enabling Research Programs with a combination of accomplishments demonstrate how the following expected results were measured and attained at the program sub-sub-activity level.

**1- SC Mission Concepts:** Assume the leadership and support in the enabling research and development of new mission concepts.


<b>EXPECTED RESULT #1</b>	
Industry, government and/or academia conduct mission and payload concept and feasibility studies to establish the user requirements for new missions and to evaluate the technical and scientific feasibility and the relevance of these proposed missions to the government priorities in order to enable a decision on future SC space missions.	
<b>Indicator</b>	<b>Performance</b>
1. Number of concept/phase 0 and phase A studies completed. (Target: 2)	<b>Target met: 2</b>

<b>PERFORMANCE ANALYSIS:</b>	
<u>3-Year Trend</u> No trend could be established since data available for three out of five periods without required consecutiveness.	N/A
<u>Indicator 1</u> 2 studies completed: AIS-C Phase 0, PCW Phase A. Source: Internal documents.	

<b>2010-2011 – Financial Resources (\$ in millions)</b>	
<b>Planned Spending</b>	<b>Actual Spending</b>
2.7	5.7
<b>2010-2011 – Human Resources (FTEs)</b>	
<b>Planned</b>	<b>Actual</b>
7.2	7.8

**2- ESA Programs in SC – Objective:** Through key international partnerships, enhance the Canadian industry's technological base and provide access to European market for value added products and services in the field of SC.

<b>EXPECTED RESULT #1</b>	
Successful development and demonstration of advanced technologies, systems, components, or studies provided for in the contracts awarded by ESA to Canadian firms under the SC programs. (ARTES, Galileosat and GNSS (Global Navigation Satellite System) Evolution programs)	
<b>Indicator</b>	<b>Performance</b>
1. Canadian industrial return in ESA optional programs in SC. (Target: 84% or higher)	<b>Target exceeded: 105%</b>

<b>PERFORMANCE ANALYSIS:</b>	
<p><u>3-Year Trend</u></p> <p>The 3-year trend is measured for the fourth time based on six consecutive data. Trend analysis maintains the superior rating for targeted achievements were consistently exceeded. Benchmark is well established among ESA community.</p> <p><u>Indicator 1</u></p> <p>The return coefficient corresponds to the ratio between the actual number of weighted contracts given to a country and the ideal number of contracts to be given to that country according to existing rules. Canadian industrial return coefficients are by Program Activity. The SC optional programs are: ARTES, Galileosat and GNSS (Global Navigation Satellite System) Evolution programs. This total includes the statistics from the navigation and telecommunications groupings.</p> <p>Source: "Geographical distribution of contracts" [ESA/IPC(2010)13], published on March 28 2011, and covering the period between January 1, 2000 to December 31, 2010.</p> <p>The ESA reports are always published with a minimum 3 months delay therefore, the data currently available is as of December 2010.</p>	 <p>Superior</p>

<b>2010-2011 – Financial Resources (\$ in millions)</b>	
<b>Planned Spending</b>	<b>Actual Spending</b>
8.3	6.0
<b>2010-2011 – Human Resources (FTEs)</b>	
<b>Planned</b>	<b>Actual</b>
0.0	0.0

**3- SC Application Development Programs – Objective:** Enhance Canada's ground segment telecommunications technologies, develop and demonstrate Satellite Communications (SC) applications for commercial use and Canadian government operations.

<b>EXPECTED RESULT #1</b>	
Northern Communities access and utilization of the Anik F2 Government of Canada Capacity Credit (GoCCC).	
<b>Indicator</b>	<b>Performance</b>
1. Number of communities using the Government of Canada Capacity Credit for government applications and services. (Target: Between 5 and 10 users)	<b>Target exceeded: 24</b>

<b>PERFORMANCE ANALYSIS:</b>	
<u>3-Year Trend</u> New indicator introduced in 2009-2010 RPP and measured for the second time therefore no trend analysis available.	NA
<u>Indicator 1</u> 21 communities through the support of the Nunavut Arctic College. 3 communities in British-Columbia. Source: Internal documents.	

<b>2010-2011 – Financial Resources (\$ in millions)</b>	
<b>Planned Spending</b>	<b>Actual Spending</b>
1.7	3.3
<b>2010-2011 – Human Resources (FTEs)</b>	
<b>Planned</b>	<b>Actual</b>
1.5	2.1

### Highlights of Main Accomplishments – Enabling Research (SC)

- The CSA continued to work towards the 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 and in specific areas of interest to other government departments. A Call for Interest to potential end-users in the northern communities was prepared and will be issued in 2011, followed by the beginning of the utilization in early 2012.
- A Mission Definition Study for the Polar Communications and Weather (PCW) mission, initiated in November 2008 and conducted in collaboration with Department of National Defence (DND) and Environment Canada, was completed in March 2011. The Concept of the Polar Communications and Weather Mission is to put a constellation of two satellites in highly elliptical orbit

over the North Pole to monitor weather and provide broadband communication services in the Arctic area of interest to Canada.

- The CSA successfully completed a preliminary study for a constellation of micro-satellites to provide an automatic identification system (AIS) for ships with the objective of improving maritime monitoring of the Canadian coasts.
- The CSA continued its preparation of an enhanced Satellite Communications Applications Program aimed at developing applications and space based services in close relationship with the user communities. In particular, satellite data was purchased to support the future development of Automatic Identification System (AIS) applications
- With the successful completion of an initial concept study for a V-Band Next Generation Satellite Communications Payload, the CSA performed risk mitigation activities on key technologies required for this mission which aims at developing and demonstrating advanced, world-leading broadband services to Canadians living in remote areas.
- The CSA worked with other government departments such as National Resources Canada (NRCan), the Department of Foreign Affairs and International Trade (DFAIT) and the Department of National Defence (DND) to improve the governance structure of global navigation satellite system (GNSS) activities within the federal government. To this extent, a new structure was proposed and is under consideration by various other government departments.
- The CSA has continued to assess the telecommunications requirements of federal government users and evaluate how future telecommunication satellite systems can respond to identified needs. This has been done through studies with other government departments actively providing their inputs.
- Canada's participation in the European Space Agency (ESA) programs allowed 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. For example, in satellite navigation, the CSA continued 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.

**Program Sub-Activity: Space Mission Development – Satellite Communications**

**Objective:** Provide coordination or support to the development of Satellite Communications (SC) space missions in line with CSA priorities and stakeholders' expectations through the definition, critical design, manufacturing, integration, testing and delivery phases leading to launch and early operations of space systems.

<b>Expected Result #1</b>	
Space mission proposals that efficiently, effectively and economically progress to subsequent operations phases in accordance with objectives, requirements, initial or revised specifications.	
<b>Indicator</b>	<b>Performance</b>
1. Percentage of projects requiring more than one EPA (Effective Project Approval) or an amendment to initial EPA over the total number of projects.	There was one new EPA submitted to TB for the Satellite Communications Program Activity in 2010-2011.
<b>Expected Result #2</b>	
The CSA's in-house personnel are highly qualified, with recognized expertise, and are supported by a high-technology infrastructure that is suited to all Space Mission Development projects.	
<b>Indicator</b>	<b>Performance</b>
1. Rate of expertise matrix support to all CSA's program activities.	A 97% rate of planned expertise matrix – all program activities combined.

<b>Performance Analysis</b>
<p><b>Expected Result #1</b></p> <p><u>Indicator 1</u></p> <p>The M3MSAT mission obtained its first EPA in July 2009. Previous to this EPA, the mission had obtained from the TB its preliminary project approval (PPA) in July 2007. Since then, additional costs due to the increase in the international market prices for launchers had to be taken into consideration.</p> <p>Source: Internal documents.</p>
<p><b>Expected Result #2</b></p> <p><u>Indicator 1</u></p> <p>This 97% rate of planned expertise matrix support represents a significant increase compared to last year's 51%. This increase is due to the new internal structure which created an additional type of matrix called "vertical matrix exchange". This new type along the previously type "horizontal matrix exchange", accounted the time allocation of 235 specialized personnel for a total amount 121 projects/activities identified needing matrix support. This indicator has lost its relevancy in the context of the reorganization and therefore will no longer be measured.</p> <p>Source: Internal reporting documents (E-Ram).</p>

<b>2010-2011 – Financial Resources (\$ in millions)</b>	
<b>Planned Spending</b>	<b>Actual Spending</b>
7.0	1.7
<b>2010-2011 – Human Resources (FTEs)</b>	
<b>Planned</b>	<b>Actual</b>
4.9	6.3

### **SPACE MISSION DEVELOPMENT – SATELLITE COMMUNICATIONS**

One Satellite Communications Space Mission Development Program, with a combination of accomplishments, demonstrates how the expected result outlined below was measured and attained at the program sub-sub-activity level.

**1- SC Projects – Objective:** Ensure the development, delivery and commissioning of space-qualified systems for SC missions including search and rescue, and satellite navigation through effective project, quality and engineering management.

<b>EXPECTED RESULT #1</b>	
SC projects' deliverables are met.	
<b>Indicators</b>	<b>Performance</b>
1. Project milestones are met as defined in the detailed work plan. (Target: 75% of milestones achieved versus planned)	<b>Target met: 75%</b>
2. Projects costs is maintained within authorized levels. (Target: 100%)	<b>Target met: 100%</b>
3. Risks are identified and mitigation plans prepared for each project. (Target: 100%)	<b>Target met: 100%</b>

**PERFORMANCE ANALYSIS:**

3-Year Trend

The 3-year trend is measured for the second time based on four consecutive data for each indicator. Trend analysis maintains the superior rating for targeted achievements have all been met. Benchmark values could only be confirmed for two indicators, the others have yet to reach an appropriate stability.



Indicator 1

PCW met its target. All other project milestones are delayed to next fiscal year.

Source: Internal documents.

Indicator 2

All projects costs were maintained within authorized levels.

Source: Internal documents.

Indicator 3

Risks were identified and mitigation plans were prepared for all projects. RIAS database was used.

Source: Internal documents.

<b>2010-2011 – Financial Resources (\$ in millions)</b>	
<b>Planned Spending</b>	<b>Actual Spending</b>
7.0	1.7
<b>2010-2011 – Human Resources (FTEs)</b>	
<b>Planned</b>	<b>Actual</b>
4.9	6.3

## **Highlights of Main Accomplishments – Space Mission Development (SC)**

- In 2004-2005, as part of the CASSIOPE Mission Contribution Program, the CSA initiated the development and demonstration of the Cascade telecommunications payload on a small satellite bus. This small satellite spacecraft has been fully designed and constructed by Canadian companies and is scheduled to be launched during the fiscal year 2011-2012. 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. Launch of the CASSIOPE spacecraft has been delayed as the selected launch vehicle – Falcon 9 – has been under development for many years, culminating with two successful launches in 2010. Periodic testing and software updates were implemented on the spacecraft during the year.
- CSA and the Department of National Defence 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 program and with DND's Polar Epsilon program. Detailed design continued through the year and will be finalized and manufacturing will start in fiscal year 2011-2012. The launch is planned for September 2012 and the mission demonstration should end in 2014.

## 2.5 GENERIC TECHNOLOGICAL ACTIVITIES IN SUPPORT OF EO, SE AND SC

<b>GENERIC TECHNOLOGICAL ACTIVITIES IN SUPPORT OF EO, SE AND SC 2010-2011 PROGRAM ACTIVITY PERFORMANCE MEASUREMENT</b>	
<p><b><u>BENEFITS FOR CANADIANS</u></b></p> <p>Through its R&amp;D investments and the resulting transfers of applications to the private and public sectors, the CSA's programs and activities attract highly educated and highly skilled labour that contributes to Canada's knowledge-based economy; helps enhance the Canadian space industry's competitiveness by encouraging dynamic trade relationships with other nations; and increases Canada's ability to compete in the global marketplace.</p>	
<p><b><u>EXPECTED RESULT</u></b></p> <p>Canada's industrial technological capabilities can meet the needs of future space missions and activities.</p>	
<p><b><u>MAIN ACCOMPLISHMENTS IN 2009-2010</u></b></p> <p>In 2010-2011, the CSA and NSERC continued to foster closer collaboration between industry, universities and government in space research and technology development. Twelve agreements in relation to this program were either initiated or continued in 2010-2011.</p> <p>In the meantime, the CSA increased the accessibility and availability of the David Florida Laboratory facilities to academia and the Canadian space industry while assembling and testing in priority sequence the hardware for CSA's priority projects.</p>	
Indicators	Performance
1. Ratio of the number of priority technologies identified for future EO, SE and SC missions to the number of priority technologies developed in GTA.	Performance unavailable this year.
2. Number of priority technologies supported that are ready to be used.	One out of the 31 prioritized technologies.

<p><b><u>Indicator 1 – Performance Analysis</u></b></p> <p>The measurement of this indicator is unavailable this year.</p> <p>Source: Internal reporting documents.</p>
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Indicator 2 – Performance Analysis

In order to be considered “ready to be use”, a technology must reach a level of readiness (TRL) of “6” or higher on the scale developed by NASA. As a new technology proceeds to a higher level of maturity, the risk associated with its implementation in a space mission lessens substantially. Each level represents a development milestones, such as:

- TRL 6: System model or prototype demonstration in a relevant environment;
- TRL 7: System prototype demonstration in a space environment;
- TRL 8: Actual system completed and “flight qualified” through test and demonstration; and,
- TRL 9: Actual system “flight proven” through successful mission operations.

It takes time and investment for a new technology to reach these levels of readiness and therefore the priority selection often precedes the actual need and eventual use by several years. Only one of the newly prioritized technologies reached the “readiness” stage in 2010-2011: RF Filters for Reconfigurable payloads.

Source: Internal reporting documents.

2010-2011 – Financial Resources (\$ in millions)		
Planned Spending	Total Authorities	Actual Spending
46.2	48.6	45.0
2010-2011 – Human Resources (FTEs)		
Planned	Actual	Difference
120.4	115.4	5.0

**The programs under this Program Activity are divided into three Sub-Activities: Enabling Research, Space Mission Development and Space Mission Operations. However, no Space Mission Operations are mentioned in this report, since CSA is not carrying out generic space mission operation activities.**

**Program Sub-Activity: Enabling Research – Generic Technological Activities in support of EO, SE and SC**

**Objective:** Provide leadership, coordination or support to Earth Observation (EO), Space Science and Exploration (SE) and Satellite Communications (SC) applied research and experimental development in line with the CSA's priorities and stakeholders' expectations in order to increase the knowledge base and devise new applications through space missions, and to allow the transfer of intellectual property and proven technologies to Canadian industry, academia, and government organizations.

<b>Expected Result #1</b>	
Space technology concepts that support projects/missions related to Agency's priorities.	
<b>Indicator</b>	<b>Performance</b>
1. Ratio of adherence to the technology development plan/track records.	The track record is not available yet.
<b>Expected Result #2</b>	
Canadian industries and research organizations that are actively involved in space R&D.	
<b>Indicators</b>	<b>Performance</b>
1. Number of requests received vs. the number of requests accepted.	66 received vs. 38 accepted – 58%
2. Number of requests received vs. the number of requests funded.	66 received vs. 26 funded – 39%

<b>Performance Analysis</b>
<p><b>Expected Result #1</b></p> <p><u>Indicator 1</u></p> <p>A technology development plan was finalized this year and therefore, the reporting of its tracking will begin next year.</p> <p>Source: Internal reporting documents.</p> <p><b>Expected Result #2</b></p> <p><u>Indicators 1-2</u></p> <p>More than 55% of the requests received were considered acceptable from a series of strict criteria and rigorous selection process; and more than one out of every three ideas were actually funded; compared to last year, a 2% decline in the number of accepted but identical percentage of funded requests.</p> <p>Source: Internal reporting documents.</p>

<b>2010-2011 – Financial Resources (\$ in millions)</b>	
<b>Planned Spending</b>	<b>Actual Spending</b>
39.7	38.4
<b>2010-2011 – Human Resources (FTEs)</b>	
<b>Planned</b>	<b>Actual</b>
80.0	75.8

**ENABLING RESEARCH – GENERIC TECHNOLOGICAL ACTIVITIES IN SUPPORT OF EO, SE AND SC**

One Generic Enabling Research Program, with a combination of accomplishments, demonstrates how the expected results outlined below were measured and attained at the program sub-sub-activity level.

**1- Space Technology Development Program:** Support the development and transfer of advanced space technologies by industry, government, and academia in support of EO, SE and SC activities.


<b>EXPECTED RESULT #1</b>	
Development of advanced space technologies by industry, government, academia, and not-for-profit organizations in support of EO, SE and SC activities.	
<b>Indicators</b>	<b>Performance</b>
1. Number of technologies chosen to enable future space missions of interest to Canada. (Target: 2)	<b>Cancelled</b>

<b>PERFORMANCE ANALYSIS:</b>	
<u>Year Trend</u> No trend could be established since no data was available for this year.	N/A
<u>Indicator 1</u> There were two technologies that were identified to fly on QuickSat Planned Collaborative Mission with Spain (Membrane Antenna and Single Cell EPC) but Spanish Government cancelled the mission. Source: Internal documents.	

<b>2010-2011 – Financial Resources (\$ in millions)</b>	
<b>Planned Spending</b>	<b>Actual Spending</b>
19.4	15.4
<b>2010-2011 – Human Resources (FTEs)</b>	
<b>Planned</b>	<b>Actual</b>
29.8	24.3

**2- ESA Programs in Generic Space Technologies:** Through key international partnerships, enhance the Canadian industry's technological base and provide access to European market for value added products and services in the field of generic space technologies. This is achieved through a financial contribution by the Agency to optional ESA programs in the field of generic space technologies.


<b>EXPECTED RESULT #1</b>	
Successful development and demonstration of advanced technologies, systems, components or studies provided for in the contracts awarded to Canadian firms under mainly two ESA Programs.	
<b>Indicator</b>	<b>Performance</b>
1. Canadian industrial return in ESA optional programs, and at the overall level. (Target: Overall Canadian industrial return in ESA optional program (GSTP) and mandatory programs of 94% or higher)	<b>Target exceeded: 106%</b>

<b>PERFORMANCE ANALYSIS:</b>	
<p><u>3-Year Trend</u></p> <p>The 3-year trend is measured for the fourth time based on six consecutive data. Trend analysis maintains the superior rating for targeted achievements were consistently exceeded. Benchmark is well established among ESA community.</p>	 <p>Superior</p>
<p><u>Indicator 1</u></p> <p>The global return coefficient is calculated on all the mandatory activities and the optional programs, to take into account the program refills in which Canada does not participate.</p> <p>Source: "Geographical distribution of contracts" [ESA/IPC(2010)13], published on March 28 2011, and covering the period between January 1, 2000 to December 31, 2010.</p> <p>The ESA reports are always published with a minimum 3 months delay therefore, the data currently available is as of December 2010.</p>	

<b>2010-2011 – Financial Resources (\$ in millions)</b>	
<b>Planned Spending</b>	<b>Actual Spending</b>
11.1	13.3
<b>2010-2011 – Human Resources (FTEs)</b>	
<b>Planned</b>	<b>Actual</b>
3.0	3.8

**3- Commercialization and Transfer of Technologies:** Promote the commercial potential and support the transfer of space technologies to maximise the social and economic benefits for Canadians.


<b>EXPECTED RESULT #1</b>	
Transfer of space technologies generated by the CSA in support of EO, SE and SC activities to industry, government, academia and not-for-profit organizations.	
<b>Indicator</b>	<b>Performance</b>
1. Number of licenses granted for space technologies owned by the CSA. (Target: 5)	<b>Target partially met:</b> 4 licences granted and 5 still under negotiation.

<b>PERFORMANCE ANALYSIS:</b>	
<p><u>3-Year Trend</u></p> <p>The 3-year trend is measured for the third time based on five consecutive data. Trend analysis maintains the satisfactory rating for targeted achievement was almost met. Benchmark value could not be confirmed, it has yet to reach an appropriate stability.</p> <p><u>Indicator 1</u></p> <p>No comment.</p> <p>Source: Internal documents.</p>	 Satisfactory

<b>2010-2011 – Financial Resources (\$ in millions)</b>	
<b>Planned Spending</b>	<b>Actual Spending</b>
1.7	1.6
<b>2010-2011 – Human Resources (FTEs)</b>	
<b>Planned</b>	<b>Actual</b>
6.2	6.6

**4- Mission Related Expertise and Technology Development:** Ensure the development and maintenance of scientific and technical expertise in the CSA, the government, industry and universities to initiate projects and provide support to EO, SE and SC missions.

<b>EXPECTED RESULT #1</b>	
Maintenance of in-house scientific and technical expertise, within the CSA and for the benefit of government, industry and universities, in support of EO, SE and SC activities.	
<b>Indicator</b>	<b>Performance</b>
1. Number of specialized personnel across the Agency supporting CSA projects and/or programs. (Target: 80)	<b>Target partially met:</b> 46 specialized personnel (excluding PDFs, students, and administrative staff).

<b>PERFORMANCE ANALYSIS:</b>	
<p><u>3-Year Trend</u></p> <p>The 3-year trend is measured for the second time based on four consecutive data. Trend analysis drops to “Opportunity for improvement” rating because for the first time targeted achievement was not met. This is partly due to an overestimation of the target. Benchmark value could not be confirmed, it has yet to reach an appropriate stability.</p>	 <p>Opportunity for improvement</p>
<p><u>Indicator 1</u></p> <p>Overall, the 46 specialists in SST-ED, spent 84% of their time providing in-house scientific and technical expertise in support of dozens of space activities within CSA, or in collaboration with Academia/industry (and only 16% on management or other activities).</p> <p>Source: Internal documents.</p>	

<b>2010-2011 – Financial Resources (\$ in millions)</b>	
<b>Planned Spending</b>	<b>Actual Spending</b>
7.5	8.1
<b>2010-2011 – Human Resources (FTEs)</b>	
<b>Planned</b>	<b>Actual</b>
41.0	41.1

**Highlights of Main Accomplishments – Enabling Research - Generic Technological Activities in support of EO, SE and SC**

- The CSA has produced a draft long-term roadmap for space technology development based on the needs of future missions. Niche areas have been identified after initial consultations with Government, industry and academia. This process has started the process to foster partnerships between academia, industry and government and to enhance the coordination of technology development activities throughout federal government departments. This process is expected to accelerate in the next fiscal year.
- The Space Technology Development Program (STDP) has continued to provide opportunities for Canadian industry and research organizations to propose innovative technologies in order to retire risk on the critical technologies required for future missions of Canadian interest, and contribute to the enhancement of Canadian capabilities. Examples of STDP activities in 2010-2011 were:
  - The technical challenges of developing the critical technologies required to build an indigenous launch vehicle have been identified and summarized in a

report. CSA and DRDC (DND research branch) are coordinating their effort by implementing a dedicated working group to this area. Budgetary constraints have put the development of these technologies on hold for now.

- The STDP program has issued three competitive Requests for Proposals (RFP) for critical technologies for High Elliptical Orbits Missions similar to the proposed Polar Communication and Weather (PCW) mission. The proposals have been evaluated and contracts will be issued in the spring of 2011.
  - A 100% Canadian, high accuracy shaped reflector made in composites was successfully developed. A complete qualification program was developed in order to commercialize it on the worldwide communication market and improve the Canadian capability for other potential Low Earth Orbit applications.
  - A Picosecond Laser Technology was developed for quantitative natural resource prospecting from space. It addresses national security/sovereignty issues, including measurements of the infinitely sensitive main and trace atmospheric components, greenhouse gases, hydrocarbons.
  - An ultra miniature, high efficiency, high frequency, current switching, low cost, radiation hardened electric power converter (EPC) module converged to a final design. The EPC will be universal in nature and can be used on any spacecraft using photovoltaic solar cells as the source of power. The new Single Solar Cell EPC will revolutionize the way power is distributed to the spacecraft and significantly reduce the risk associated with conventional solar cell string failure.
- 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 continued to foster closer collaboration between industry, universities and government in space research and technology development. Twelve agreements in relation to this program were either initiated or continued in 2010-2011.
  - Partnering with Canadian Industry and NSERC, the CSA continued its support to the highly successful Industrial Research Chair (IRC) Program. Two ongoing and one new IRC were supported with a number of other Chairs under discussion.
  - In collaboration with Industry and Post-Doctoral Fellows (10) from NSERC, the Collaborative Technology Development Program has continued to develop generic, enabling and innovative technologies (11) and conducted technology investigations (3) for use in future missions.
  - The CSA updated its policies pertaining to intellectual property (IP) management and streamlined its procedures to facilitate access to IP assets through licensing or dissemination. CSA also reviewed half of its current portfolio of technologies and conducted 15 commercial studies on the most promising ones to find potential licensees.

**Program Sub-Activity: Space Mission Development Generic Technological Activities in support of EO, SE and SC**

**Objective:** Provide coordination or support to the development of Earth Observation (EO), Space Science and Exploration (SE) and Satellite Communications (SC) space missions in line with CSA's priorities and stakeholders' expectations through the definition, critical design, manufacturing, integration, testing and delivery phases leading to launch and early operations of space systems.

<b>Expected Result #1</b>	
The CSA's in-house personnel are highly qualified, with recognized expertise, and are supported by a high-technology infrastructure that is suited to all Space Mission Development projects.	
<b>Indicator</b>	<b>Performance</b>
1. Number of aerospace related missions, projects/activities supported by David Florida Laboratory (DFL) facilities.	A total of 13 missions/projects/activities for the CSA, other governmental departments and the private companies were supported.

<b>Performance Analysis</b>
<p><b>Expected Result #1</b></p> <p><u>Indicator 1</u></p> <p>From those 13 missions, 7 were government related (the CSA and DND) and 6 were privately sponsored by 24 external organizations; the number of missions and external organizations supported this year are slightly lower than those of last year where 18 missions and 31 external organizations benefited from DFL's services.</p> <p>Source: Internal reporting documents.</p>


<b>2010-2011 – Financial Resources (\$ in millions)</b>	
<b>Planned Spending</b>	<b>Actual Spending</b>
6.4	6.6
<b>2010-2011 – Human Resources (FTEs)</b>	
<b>Planned</b>	<b>Actual</b>
40.4	39.5

**SPACE MISSION DEVELOPMENT – GENERIC TECHNOLOGICAL ACTIVITIES IN SUPPORT OF EO, SE AND SC**

One Generic Space Mission Development Program, with a combination of accomplishments, demonstrates how the expected result outlined below was measured and attained.

**1- David Florida Laboratory (DFL) supporting the Canadian Space Plan – Objective:** Provide world-class space qualification services on a national scale, including facilities and expertise in support of the Canadian Space Program and international EO, SE and SC missions.

<b>EXPECTED RESULT #1</b>	
Development, provision of expertise and supply of space qualification services, functional, and environmental testing of space hardware primarily for CSA sponsored programs and projects, and subsequently to the Canadian space industry and other private and public sector clients.	
<b>Indicator</b>	<b>Performance</b>
1. Percentage of satisfied clients. (Target: Based on client feedback and customer satisfaction surveys, achieve a client satisfaction rating of 95% or more)	<b>Target exceeded: 96%</b>

<b>PERFORMANCE ANALYSIS:</b>	
<p><u>3-Year Trend</u></p> <p>The 3-year trend is measured for the fourth time based on six consecutive data. Trend analysis maintains for the third time the superior rating for targeted achievements were consistently exceeded. Benchmark is well established and supported through the ISO9001:2000 processes.</p>	 <b>Superior</b>
<p><u>Indicator 1</u></p> <p>DFL achieved a 96% overall client satisfaction rating for the fiscal year. 81 surveys were issued and 30 were received back for an approximate return rate of 37%. The overall satisfaction rating has been very positive, around 96%. No new client issues were raised, although we did receive some suggestions for service improvement which we identified and included in our overall continuous improvement plan.</p> <p>Source: Internal documents.</p>	

<b>2010-2011 – Financial Resources (\$ in millions)</b>	
<b>Planned Spending</b>	<b>Actual Spending</b>
4.9	6.6
<b>2010-2011 – Human Resources (FTEs)</b>	
<b>Planned</b>	<b>Actual</b>
40.4	39.5

## **Highlights of Main Accomplishments – Space Mission Development – Generic Technological Activities in support of EO, SE and SC**

- The David Florida Laboratory (DFL) continues to be upgraded in order 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 increased the accessibility and availability of the facilities to academia and the Canadian space industry. The hardware for many priority projects in 2010-2011 were assembled and tested at DFL. Programs supported during the fiscal year included:
  - Space Systems Loral/MDA Intelsat 17, Telstar T14R, and Quetzsat
  - JWST FGS engineering test unit for ComDev/CSA Space Utilization plus initiation of testing on the flight unit
  - Sapphire
  - NEOSSat
  - M3MSat
  - Alphasat and Astra-1 for MDA, Ste. Anne
  - EarthCare for ComDev
  - SWARM for ComDev
  - CF-18 nose cone radomes for L3 Communications/DND
  - TEMMI microscope, Exploration Surface Mobility Program for MDA/CSA
  - TRIDAR Program for Neptec

Highlights for Science and Exploration are as follows:

- On JWST, DFL performed ETU-Electro Optical performance testing, EMC testing on ETU FGS, bake out of flight harness cables, vibration testing of etalon unit. Following the conclusion of these tests, the FGS ETU was shipped from the DFL on September 7, 2010 for transport to NASA Goddard Space Flight Centre. Following the shipment of the FGS ETU work began in earnest on the environmental test campaign on the flight model unit. Testing of the flight model unit will continue into next fiscal year.
- On NEOSSat, DFL completed bake out of the flight panels. The remainder of NEOSSat test activities were deferred to next fiscal year.
- Also, DFL performed EMC testing on the TEMMI microscope as part of the Exploration Surface Mobility Program.

Highlights for Satellite Communications are as follows:

- DFL completed thermal and flash characterization tests on the M3MSat solar panels and RF testing on TINSAT and LDR antenna also for M3MSat. Slips in the program schedule will defer the majority of the

spacecraft level testing into the next fiscal year. Other satellite communications activities included RF testing on the Automatic Identification System (AIS) antenna.

Highlights for Earth Observation are as follows:

- Delays in the Phase-C contract awards for RADARSAT constellation mission has moved test activities into the next FY.
- On JC2Sat, DFL performed RF testing on UHF antennas.
- Commercial Programs supported by DFL during the fiscal year included:
  - MDA/Space Systems Loral. Completed thermal vacuum testing on Intelsat 17, Telstar 14R, and Quetzsat for MDA/Space Systems Loral.
  - TenXc Wireless (CPS Antennas) – RF testing completed on base station antenna.
  - MDA Ste. Anne – Completed environmental and functional testing on Alphasat and ASTRA-1 antennas.
  - ComDev – Completed environmental testing on EarthCare Program and SWARM.
  - NEPTEC Design Group – Completed environmental testing on TRIDAR Program.
- DFL assisted University of Ottawa with RF testing on C-Band patch antenna and Ku-band ISOFLEX antennas.
- Other government departments programs supported by DFL during the fiscal year included:
  - Department of National Defence (DND) (Sapphire). On Sapphire completed sub-system thermal and thermal vacuum testing on flight units.
  - DND and L3 Communications (CF-18 Radome Characterization Projects). Performed RF testing on a series of CF-18 radome antennas for DND L3 Communications.
  - Completed vibration testing on driver viewing enhancement system for DND.
  - Supported far-field C-Band and X-Band transmitter trials for DRDC/DND.
  - Initiated RF testing on Through Wall Synthetic Aperture Radar Program for DRDC/DND.
- In late 2010, CSA staffed 8 ENG-02 positions as part of the 2-year Engineering Development Program for junior engineers (ENG-02). The ENG-02 Development Program aims to be the feeding pool for all CSA engineering disciplines.

- The CSA continued technology development for the QuickSat microsatellite bus and presented the multi-mission Smallsat/Microsat bus platform roadmaps along with 4 candidate payloads for the flight opportunity offered by QuickSat, (namely EMM – ElectroMagnetic Monitoring, TICFIRE – Thin Ice Clouds Far Infrared Experiment, ISWEAT – Impacts of Space Weather Effects in the Auroral Thermosphere, LEOSAR – Low Earth Orbit Search And Rescue).
- The John H Chapman Laboratories and Machine Shop have been maintained in order to continue to provide cost-effective engineering development facilities as well as research facilities in space science and technology, including assembly and test facilities for many priority projects.
- The CSA has completed Phase 0/A of a Concurrent Design Facility 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.
- In fiscal year 2010-2011, CSA expanded the technical proficiency of its workforce by delivering specialized training in space science and technology, including 8 formal courses, 2 CNES lectures, 3 seminars for the ENG-02 Program and numerous training/certifications for all laboratory personnel.

## 2.6 SPACE AWARENESS AND LEARNING

<b>SPACE AWARENESS AND LEARNING 2010-2011 PROGRAM ACTIVITY PERFORMANCE MEASUREMENT</b>	
<b><u>BENEFITS FOR CANADIANS</u></b>	
The CSA fosters science and technology literacy as a mean to influence the career choices of young Canadians towards science and technology.	
<b><u>EXPECTED RESULT</u></b>	
Targeted level of awareness of space among Canadians is reached.	
<b><u>MAIN ACCOMPLISHMENTS IN 2010-2011</u></b>	
The number of visitors to the CSA's interactive website increased by 27% from 1.050 million in 2009-2010 to 1.332 million in 2010-2011.	
A total of 100 public events were conducted in communities throughout Canada, including 59 specifically involving Canadian astronauts, and 3 traveling exhibits were loaned for display with science center partners to raise awareness of space science and technology.	
A total of 690 educators received professional development in workshops conducted in provinces across the country and at annual conferences of teachers in four provinces: British Columbia, Alberta, Ontario and Prince Edward Island.	
A total of 460,071 students from across the country were reached through workshops and learning materials developed by the CSA and still others in activities and events supported by the Space Learning Grants and Contributions Program.	
<b>Indicator</b>	<b>Performance</b>
1. Survey results obtained every 3 years.	No National Public Opinion survey was conducted.

<b>2010-2011 – Financial Resources (\$ in millions)</b>		
<b>Planned Spending</b>	<b>Total Authorities</b>	<b>Actual Spending</b>
8.1	8.1	7.3
<b>2010-2011 – Human Resources (FTEs)</b>		
<b>Planned</b>	<b>Actual</b>	<b>Difference</b>
28.8	25.7	3.1

The programs under this Program Activity are divided into two Sub-Activities: Awareness and Learning.

<b>Program Sub-Activity: Awareness</b>
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**Objective:** To increase public awareness and understanding of how space programs affect and improve the quality of life.

<b>Expected Result #1</b>	
Target audiences are reached through outreach activities.	
<b>Indicator</b>	<b>Performance</b>
1. Number of initiatives according to targeted audiences.	<b>Target exceeded:</b> 87 events.

<b>Performance Analysis</b>
<p><b>Expected Result #1</b></p> <p><u>Indicator 1</u></p> <p>Last year, 81 events (media and public) took place. This explains why the target was exceeded this year.</p> <p>Source: Internal documents.</p>

<b>2010-2011 – Financial Resources (\$ in millions)</b>	
<b>Planned Spending</b>	<b>Actual Spending</b>
5.7	5.2
<b>2010-2011 – Human Resources (FTEs)</b>	
<b>Planned</b>	<b>Actual</b>
24.8	20.4

## **Highlights of Main Accomplishments – Awareness**

In 2010-2011, the Canadian Space Agency conducted a series of awareness campaigns to heighten interest and expand knowledge on the benefits that flow from Canada's leading role and achievements in space:

- The Agency supported the visit of the Minister of Industry to Kennedy Space Center for the launch of the Space Shuttle Atlantis. This visit in the company of the President of the CSA offered an opportunity to meet with NASA Administrator Charles Bolden, and with representatives of Canada's space industry. These meetings explored the longstanding relationship between Canada and the United States that has been forged through nearly five decades of collaboration and excellence pursued through space science and technology to serve the mutual interest of both nations.
- The Minister of Industry also participated in the signing of an Agreement between the Canadian Space Agency and the Ministry of Education of the Province of Nova Scotia. This Agreement will advance the use of space focused learning materials, experience-based educational activities and distance learning to ignite an interest in the sciences and technology among youth and educators in the Province of Nova Scotia.

### *Canada-Europe Collaboration:*

- Canada renewed its 30-year Cooperation Agreement with the European Space Agency for another ten years. A series of high-level events and media activities supported the announcement of the extension of the Agreement. Attention was drawn to the legacy of this premier program and the outstanding partnership that continues to leverage access to space by Canada's science community and showcase Canadian technological expertise with European space companies. As an example, in the past year Canada's contribution to the European Space Agency's flagship Herschel/Planck space telescope mission has been highlighted through both web and media activities to broaden interest and knowledge of Canada's contribution to the global astronomy community and space exploration.

*Astronaut Appearances:*

- In 2010-2011 the Agency supported 59 astronaut events in tours throughout Canada. The post-flight tours of Dr. Robert Thirsk and Julie Payette crossed the country in the company of international Astronauts and Cosmonauts, who worked and lived with them on the International Space Station and during a Space Shuttle mission. Astronaut Chris Hadfield also toured the country following the announcement that he will begin training in Russia in anticipation of a six-month stay aboard the Space Station in 2012-2013. During this extended stay and for a period of two months, Chris Hadfield will become the first Canadian Commander of the International Space Station.
- These CSA Astronaut tours reached more than 19,000 Canadians in communities across Canada. Video conferences and messages offered by our Astronauts reached over 2,500 primary and high school students in schools throughout the nation. CSA Astronauts also conducted some 200 interviews with national and regional media while touring the country. In support of the CSA Astronaut Program and outreach, a number of partnerships have been created to enhance the visibility and attractiveness of advanced education and careers in the sciences and technology among Canada's youth.

*Speakers' Bureau – Outreach and Awareness:*

- The Canadian Space Agency supported 41 speaking opportunities, many of them addressing public audiences in communities throughout Canada. A number of events attracted broad public audiences, reaching more than 11,830 youth and families at kiosks and demonstrations where speakers offered presentations on the role of the CSA and Canada's achievements in space: *Tremblant under the Stars; Sciencefête; Science on the Hill; Winterlude; World Energy Conference; 24 heures des sciences; Canada Day on Parliament Hill; Expo Canada*. A number of strategic partnerships were developed with other government departments and organisations engaged to promote greater awareness of the impact of government science and technology on the lives of Canadians. (*Natural Resources Canada, Canadian Centre for Remote Sensing, National Research Council, Parks Canada, National Capital Commission*, as well as, the *Museum Consortium* representing the *Canada Science and Technology Museum, the Canada Air & Space Museum* and *Experimental Farm*).
- Still other events focused on raising awareness and interest among Canada's youth and educators: *Colloque Les Sciences et l'Ecole; Atlantic Canada Association of Science Educators; Canadian Association of Science Centres; Congrès de l'Association pour l'enseignement de la science et de la technologie au Québec; Atlantic Teachers Association Conference; CSA Educators Conference*; and the annual convention of the *Science Teachers of Ontario*.

*Travelling Exhibitions:*

- Throughout the year several space-focused exhibitions made their way to reach Canadians in communities where they live, work and play: *Cosmomania*; *La conquête spatiale en images*; and *Sports in Space*, while the *Landing Blanket* of Dr. Bob Thirsk was developed as a standing exhibit, and an Astronaut mural was installed at the Agency, and at the newly inaugurated Canada Air and Space Museum in Ottawa. These travelling exhibitions reached some 133,000 Canadians in a number of communities including: Fredericton (New Brunswick); Sherbrooke (Quebec); Vernon, (British Columbia); Windsor (Ontario); Chicoutimi (Quebec); St. John's (Newfoundland); and, Sudbury (Ontario).
- Three planned awareness campaigns were postponed due to the rescheduling of launch dates for each of these satellites:
  - Neossat, the world's first space telescope designed to track asteroids, satellites and debris in the lower Earth orbit;
  - Canada's M3MSat, which will demonstrate the viability of space-based automatic identification system for maritime traffic monitoring; and,
  - Canada's hybrid small satellite mission CASSIOPE, which contains a high-speed large-capacity data communications module (Cascade), and an atmospheric science instrument (ePOP).

<b>Program Sub-Activity: Learning</b>
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**Objective:** To direct a sustained, multi-dimensional, interactive learning program to build knowledge and enhance interest in space science and technology.

<b>Expected Result #1</b>	
Canadian educators and students further their learning related to science and technology through space theme.	
<b>Indicators</b>	<b>Performance</b>
1. Number of educators reached through professional development initiatives.	<b>Target exceeded:</b> 60 educators reached.
2. Number of students reached through learning activities.	<b>Target exceeded:</b> 17,348 students reached.

<b>Performance Analysis</b>
<b>Expected Result #1</b>
<u>Indicator 1</u>
Actual data can't be compared with previous year performance because of changes in measurement parameters. Source: Internal documents.
<u>Indicator 2</u>
Actual data can't be compared with previous year performance because of changes in measurement parameters. Source: Internal documents.

<b>2010-2011 – Financial Resources (\$ in millions)</b>	
<b>Planned Spending</b>	<b>Actual Spending</b>
2.4	2.1
<b>2010-2011 – Human Resources (FTEs)</b>	
<b>Planned</b>	<b>Actual</b>
4.0	5.3

## **Highlights of Main Accomplishments – Learning**

The major learning activities focused on the following:

- Signature of Memorandum of Agreement with the Ministries of Education of the Province of Alberta, and the Province of Nova Scotia enhancing collaboration and use of space-science-and-technology-focused curriculum, tele-learning, and educator development activities.
- Professional development workshops and teaching initiatives such as satellite enabled or Web-based assisted tele-learning opportunities for educators.
- Partnered initiatives with schools, youth organizations and other institutions to expand student and educator access to the space science and technology community and space-focused learning materials.
- Targeted space-focused learning materials and teaching modules for educators and students at the primary and secondary level.
- Targeted grants, contribution and sponsorship programs in partnership with other federal departments and agencies to support awareness, research, development and training in space science and technology.

## 2.7 INTERNAL SERVICES

<b>INTERNAL SERVICES</b>	
<b>2010-2011 PROGRAM ACTIVITY PERFORMANCE MEASUREMENT</b>	
<b><u>BENEFITS FOR CANADIANS</u></b>	
<p>The CSA strengthen accountability for results by implementing the Government's commitment to modern public service management. Improvement of internal services at all levels of management raises the overall level of organizational performance by providing an added value to CSA managers in the performance of their duties.</p>	
<b><u>MAIN ACCOMPLISHMENTS IN 2010-2011</u></b>	
<p>The CSA has integrated its new Program Activity Architecture and Performance Measurement Framework as well as its reviewed organizational structure in all corporate operational and financial management systems for the planning and monitoring of all programs starting fiscal year 2011-2012.</p> <p>The CSA has approved its 2010-2013 Integrated Corporate Human Resources Plan in line with the Program Activity Architecture which addresses government priorities and CSA specific issues.</p> <p>The CSA updated its policies pertaining to intellectual property management and streamlined its procedures to facilitate access to intellectual property assets through licensing or dissemination. CSA also reviewed half of its current portfolio of technologies and conducted 15 commercial studies on the most promising ones to find potential licensees.</p>	
<b><u>EXPECTED RESULT #1</u></b>	
Internal Services provide an added value to CSA managers in the performance of their duties.	
<b>Indicator</b>	<b>Performance</b>
1. CSA's rating against Management Accountability Framework criteria based on Round VIII assessment.	<p>There were 11 areas of management assessed The ratings were: Strong = 1; Acceptable = 3; Opportunity for improvement = 6; and, Attention required = 1</p> <p>The MAF results have declined as compared with 2009-2010.</p>

Indicator 1 – Performance Analysis

The Management Accountability Framework (MAF) is a key instrument for management oversight that provides informed opinions about the state of management in federal government organizations. The MAF is used by deputy heads to improve management performance.

The MAF results have declined as compared with 2009-2010. Two areas of management have improved, 5 have remained the same, and 4 have declined. The CSA has demonstrated its strength in the areas of management *Evaluation* and *People Management*.

Although there are a number of opportunities for improvement, in the short term the CSA is expected to make progress in the areas of management *Managing for Results* and *Citizen-Focused Services*.

Sustained effort will be spread out in priority areas of management *Security*, *Risk Management* and *Investment Planning*.

The assessment reveals that cross-cutting initiatives such as the review of the CSA governance and risk management started in 2010-2011 will have a positive effect on the performance across many areas of management.

Source: Round VIII 2010-2011 Management Accountability Framework Assessment. (May 2011).

EXPECTED RESULT #2

The two highest priority risks identified in the CSA Corporate Risk Profile are addressed and mitigated.

<b>Indicator</b>	<b>Performance</b>
1. Mitigation action plans are implemented against the corporate risks identified as highest priorities.	Overall, 6 out of 17 (35%) risk mitigation actions were completed. Seven (41%) actions were initiated with a planned completion in 2011-2012. The last 4 (24%) actions were kept on-hold and are under review.

Indicator 1 – Performance Analysis

There were 10 actions planned to mitigate the corporate risk *Integration and implementation* defined as “The capacity of CSA to align its strategies, planning, priorities, funding levels, operations and capacity to deliver, and to obtain clear understanding and buy-in from managers and staff at all levels”. Only one (10%) out of 10 actions was completed. Five (50%) actions were initiated and will be completed in 2011-12 with a focus set on the development new governance structure to strengthen planning, decision-making and accountability processes.

There were 7 actions planned to mitigate the corporate risk *Workforce* defined as “The capacity of CSA to hire and maintain a qualified workforce of public servants to deliver its mandate.” The corporate risk assessment concluded that this risk remains a high priority and a mitigation action plan was developed. Five (72%) out of the 7 actions were completed. Two actions were initiated and will be completed in 2011-12 as planned.

The CSA initiated a full review of the its corporate risk analysis and mitigation action planning in accordance with the TBS Framework for the Management of Risk. The implementation will be in time for the planning of fiscal year 2012-2013.

Source: CSA Corporate Risk Profile (Internal document).

2010-2011 – Financial Resources (\$ in millions)		
Planned Spending	Total Authorities	Actual Spending
42.8	44.8	50.6
2010-2011 – Human Resources (FTEs)		
Planned	Annual	Difference
269.9	271.8	(1.9)

**Program Sub-Activity: Internal Services**

**This Program Activity has three program sub-activity levels: Governance and Management Support, Resources Management Services and Asset Management Services. However, the sub-activity Asset Management Services is not presented in this report.**

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

**Objective:** Implement the Government's commitment to modern public service management in the area of governance and management support in accordance with the Management Accountability Framework's expectations.

2010-2011 – Financial Resources (\$ in millions)	
Planned Spending	Actual Spending
10.8	11.2
2010-2011 – Human Resources (FTEs)	
Planned	Actual
63.2	67.9

**Program Sub-Activity: Resources Management Services**

**Objective:** Implement the Government's commitment to modern public service management in the area of resource management support in accordance with the Management Accountability Framework's expectations.

<b>2010-2011 – Financial Resources (\$ in millions)</b>	
<b>Planned Spending</b>	<b>Actual Spending</b>
18.3	21.2
<b>2010-2011 – Human Resources (FTEs)</b>	
<b>Planned</b>	<b>Actual</b>
172.6	169.3

### **Main Expected Accomplishments – Internal Services**

- Several initiatives were started in order for the CSA to have its management practices meet the standards set by the Government-wide policies and provide added value to planning, decision-making and accountability processes:
  - 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 development of an integrated planning approach in order to align human, financial and technical resources with the management of program operations for fiscal year 2011-2012.
  - The development of a five-year Evaluation Plan starting in 2012-2013 as directed by Treasury Board Secretariat *Policy on Investment Planning, Assets and Acquired Services*.
  - The review of the CSA’s external and internal governance structure in time for the planning of fiscal year 2012-2013. The CSA has put in place a Working Group to review the current governance regime and develop a new one which is reflective of the CSA’s renewal and responsive to the new Treasury Board policies on Investment Planning, Assets and Acquired Services, and on the Management of Projects as well as to recommendations from other sources such as latest MAF assessment, internal and external audit reports.
  - In response to external and internal audits the CSA has begun the review of its management of corporate risks which entails the development: of an Integrated Risk Management Policy and Procedures as well as a new Corporate Risk and Opportunity Profile. All these will culminate in the fall of 2011.

- In order to attract and retain a qualified workforce to deliver its mandate, the CSA tabled its 2010-2013 Integrated Corporate Human Resources Plan in line with the Program Activity Architecture. The proposed human resources strategies and management activities integrate the key leadership competency profile when appropriate and aim to:
  - Increase organizational (HR) capacity and representation of designated groups to meet the requirements for LTSP approval and the needs identified in certain occupational categories (CR, AS, EX, PE, EN, EG, EL, CS).
  - Increase and strengthen leadership/management capacity in response to the need for management succession at all levels.
  - Respond to issues identified in the 2008 Public Service Employee Survey and MAF expectations in the area of people management.
- The Human Resources directorate reviewed its business processes and work organization in order to meet current and future human resources management needs. The CSA is engaged in the implementation of the common human resources management process with the assistance of the Office of the Chief Human Resources Officer;
- Several initiatives were started under the 2010-2013 Integrated Corporate Human Resources Plan to foster career advancement like the implementation of learning and continuous development programs for specific scientific, technical and professional positions (ENG, EG, EL, CS, PE).
- A corporate strategy in response to issues raised by the 2008 Public Service Commission Survey was approved by senior management and a subsequent action plan was developed in consultation with CSA employees.

## **2.8 LIST OF 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 health care on future long duration exploration-class missions and how these solutions can help improve health care delivery on Earth through the transfer of space technology.

### **AIS Constellation**

Description in preparation.

### **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 Dr. Jean Beaulieu of 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 Japanese 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, Dr. Thirsk was assigned to the crew of Expedition 20/21 21 also known as C1 Mission the first Canadian mission onboard Soyuz for ISS. This Expedition represents a milestone for the Canadian Space Program since it will be the first time a Canadian takes part in a long duration mission. Robert Thirsk will have the privilege to expand the boundaries of space exploration by living and working onboard 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 will assume responsibilities for the maintenance and repair of the ISS, while conducting experiments on behalf of Canadian and international researchers.

### **Astronauts: Expedition 34/35 (C2)**

Description in preparation.

### **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 22nd shuttle trip to the ISS, and the 20th 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 Chief Astronaut Julie Payette was the lead Station Capsule Communicator acting as the orbiting astronauts' sole voicelink with Mission Control.

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

The main goal of this ambitious mission is to deliver the final permanent components of the Japan Aerospace Exploration Agency's (JAXA) contribution to the station program. Astronauts will complete 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 is 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 onboard Soyuz. During the mission the Canadian Astronaut Robert Thirsk was a communications coordinator with 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 (mission C1), 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 (ISS).

### **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.

### **BP-Reg**

Description in preparation.

### **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 CSA instrument and a companion instrument on a small satellite that will provide solar occultation measurements that address issues of stratospheric ozone recovery and impacts of climate change. CASISS is the implementation of the same CSA instrument on the International Space Station.

### CASSIOPE

The **Cascade** Demonstrator, Smallsat Bus and Ionospheric Polar Explorer (CASSIOPE) is a small hybrid satellite that includes the telecommunication 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 the first space-based radar allowing for the 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 clouds and light precipitation.

### **Dark Energy Mission**

Description in preparation.

### **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-Bed Rest**

Description in preparation.

### **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-2 measures 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 (Japanese Space 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. After providing useful data to many scientific teams for 16 years, ERS02 has been retired in July 2011. Canada participated in development of the satellite for ERS-1 and ERS-2. This participation also played an important role in the building of Canadian 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 Hyberia off the East coast of Canada. This European-led long-duration mission onboard 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 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 science, 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 re-usable 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.

### **ISWEAT**

The Ionospheric Space Weather Effects in the Auroral Thermosphere (ISWEAT) micro-satellite is an instrument to measure thermospheric composition, density and velocity of solar winds. The primary objective of ISWEAT is to use these measurements to study the effects of thermospheric expansion and associated ionospheric changes on “anomalous” satellite drags at auroral latitudes during magnetic storms and sub storms.

### **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 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: HTV-2**

Description in preparation.

### **MSS: Increment 23**

Description in preparation.

### **MSS: Increment 24**

Description in preparation.

### **MSS: Increment 25**

Description in preparation.

### **MSS: Increment 26**

Description in preparation.

### **MSS: Increment 27**

Description in preparation.

### **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 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.

### **MSS: STS-132 Flight ULF4**

Description in preparation.

### **MSS: STS-133**

Description in preparation.

### **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.

### **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 OnBoard 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.

### **PROBA-2**

Description in preparation.

### **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 (RCM)**

The RADARSAT Constellation 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 1 and 2**

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 CARE HEALTH**

The CSA concept study entitled "Training Development and Maintenance of a Competence Program for Remote Care Health 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.

### **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.

### **See-Jitter**

Description in preparation.

### **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 onboard 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 & 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**

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.

### **SWOT**

Description in preparation.

### **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.