ESTIMATES

Canadian Space Agency

Performance Report

For the period ending
March 31, 1999

Canada

Improved Reporting to Parliament
Pilot Document

The Estimates of the Government of Canada are structured in several parts. Beginning with an overview of total government spending in Part I, the documents become increasingly more specific. Part II outlines spending according to departments, agencies and programs and contains the proposed wording of the conditions governing spending which Parliament will be asked to approve.

The *Report on Plans and Priorities* provides additional detail on each department and its programs primarily in terms of more strategically oriented planning and results information with a focus on outcomes.

The *Departmental Performance Report* provides a focus on results-based accountability by reporting on accomplishments achieved against the performance expectations and results commitments as set out in the spring *Report on Plans and Priorities.*

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Foreword

On April 24, 1997, the House of Commons passed a motion dividing on a pilot basis what was known as the annual *Part III of the Estimates* document for each department or agency into two documents, a *Report on Plans and Priorities* and a *Departmental Performance Report.*

This initiative is intended to fulfil the government's commitments to improve the expenditure management information provided to Parliament. This involves sharpening the focus on results, increasing the transparency of information and modernizing its preparation.

This year, the Fall Performance Package is comprised of 82 Departmental Performance Reports and the government's report *Managing for Results* - Volumes 1 and 2.

This ***Departmental Performance Report,*** covering the period ending March 31, 1999, provides a focus on results-based accountability by reporting on accomplishments achieved against the performance expectations and results commitments as set out in the department's pilot *Report on Plans and Priorities* for 1998-99. The key result commitments for all departments and agencies are also included in Volume 2 of *Managing for Results.*

Results-based management emphasizes specifying expected program results, developing meaningful indicators to demonstrate performance, perfecting the capacity to generate information and reporting on achievements in a balanced manner. Accounting and managing for results involve sustained work across government.

The government continues to refine and develop both managing for and reporting of results. The refinement comes from acquired experience as users make their information needs more precisely known. The performance reports and their use will continue to be monitored to make sure that they respond to Parliament's ongoing and evolving needs.

This report is accessible electronically from the Treasury Board Secretariat Internet site: http://www.tbs-sct.gc.ca/tb/key.html

Comments or questions can be directed to the TBS Internet site or to:

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CANADIAN SPACE AGENCY

Performance Report
for the period ending
March 31, 1999

John Manley
Minister of Industry

EXECUTIVE SUMMARY

The Canadian Space Agency (CSA) manages Canada's investment in space. It secures Canada's role in new and growing fields, and obtains economic, social, and environmental benefits for Canada from space activities. The Canadian Space Agency is responsible for coordinating all policies and programs of the Government of Canada in civil space-related research, science and technology, industrial development and international cooperation.

Canada ranks eighth among space-faring nations, with a reputation for pioneering leadership that extends back to the launch of Alouette I thirty five years ago, making Canada the third country - after the United States and Russia - to design and build a satellite. Canada had the world's first commercial telecommunications system in geostationary orbit, and the first direct-to-home broadcast satellite.

Today, the Canadian space sector is internationally competitive, export-oriented, and at the leading edge of the shift of Canada's economy from natural resources to information and high technology. The Canadian space industry, composed of some 250 firms from across Canada, employs over 5,500 people. Some 45% of its $1.2 billion annual revenues are from exports - the highest percentage in the world. Building on areas of industrial and technological competency, the Canadian Space Program seeks to foster an internationally competitive, export-oriented Canadian space sector, open to a growing number of firms, often small and medium-sized enterprises.

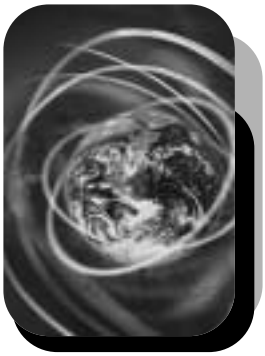
Industry, universities, and other public sector agencies across Canada are vital partners in the work of researching new knowledge from space, in developing new space-based technology, and in finding new applications for this knowledge and technology here on Earth. The Agency and its partners contribute to the sustainable development of Canada by linking Canadians from coast to coast, by enhancing the management of our environment and natural resources, and by learning how phenomena in space affect life on Earth.

Canada's space activities are largely part of international efforts, involving the United States, Europe, Japan and others. By sharing costs and benefits, Canada can achieve goals which might otherwise be unattainable, while maximizing spinoffs for the Canadian space industry and the economy. In 1998-1999, negotiations were under way with the European Space Agency (ESA) on the renewal of the cooperation agreement, first signed in 1978. Bilateral cooperation was also discussed with the United States, Australia, Germany, France and Japan.

Solid funding, renewed organization. Over the past year, several events contributed to putting the Agency on a more solid basis for effective planning and operations. These include: the approval of a new Long Term Space Plan, the addition of $41 million of new funding for 1999-2000, and the establishment of a stable, ongoing funding base.

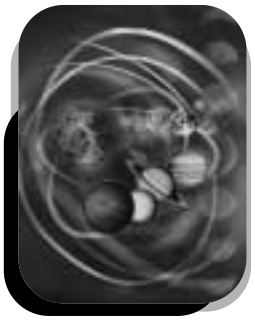
The Agency reorganized under a single business line called "Space Knowledge, Applications and Industry Development". Its new structure moves away from project-oriented business lines and reflects a more service-oriented space sector, with greater emphasis on terrestrial applications and benefits of space activities. This structure also responds to the increasing globalization of space efforts, in which Canadian space programs have strategic roles in global partnerships and consortiums.

Under this single business line are seven service lines:



Earth and Environment - using space technologies to understand, monitor, predict and protect the Earth and its environment, and ensuring that Canadian industry maintains its world leadership in the emerging global Earth observation market.

Earth observation is becoming a major Canadian knowledge industry, through the use of *RADARSAT-1* data and the development of *RADARSAT-2* in partnership with industry. In 1998-99, this sector included some 175 companies selling products and services for an estimated $350 million. Employment and revenues are growing at a sustained rate of 20% annually, with at least 40% of revenues from export sales. *RADARSAT-2*, currently under development for launch in 2002, will offer improved quality of data images to meet this growing world demand for Earth observation information.

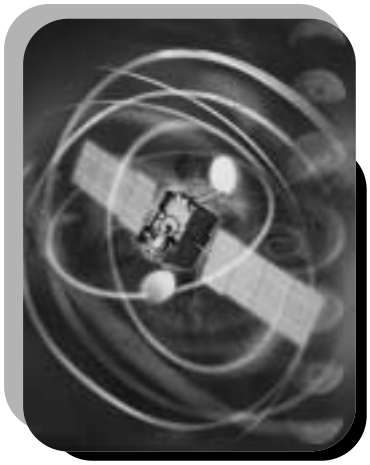


Space Science - advancing scientific knowledge in areas of strategic importance for Canada by providing Canadian scientists access to the unique environment of space.

Several hundred Canadian scientists are involved in space science projects. They are achieving major advances in astronomy and astrophysics; new understanding of critical global concerns such as ozone depletion and global warming; improved public health through advances in life sciences and biotechnologies; and internationally competitive industries through new materials and better manufacturing technologies. For example, three experiments aboard Space Shuttle flight STS-95 (Osteoporosis Experiment in Orbit, Phase Partitioning Experiment, Protein Crystal Growth - CIBX-1) were successfully conducted in October 1998. These experiments supply unique and valuable data to medical researchers in Canada.

Human Presence in Space - providing Canada's contribution to international efforts to establish a human presence in and beyond low Earth orbit. This effort sustains Canada's world leadership in space robotics. It is achieving international recognition through Canada's role in the International Space Station (ISS); and it earns Canada's share of the research benefits to be obtained from the space station. Some $6 billion of economic benefits are expected to result from Canada's International Space Station participation and 70,000 person-years of employment. Contracts of $919 million have been awarded to industry to date, generating $2.8 billion in benefits and 32,000 person-years of employment.

Canada's astronauts perform vital, demanding and high-profile roles in the space program. 1998-1999 was a busy period in this sector, with accomplishments including the successful Space Shuttle flight of Astronaut Dave Williams on STS-90 Neurolab in April 1998, the preparation for Astronaut Julie Payette's flight on STS-96 (May 1999), and the assignment of Astronaut Marc Garneau to STS-97 (March 2000). Important components of the International Space Station were completed, notably the Space Station Remote Manipulator System (SSRMS), delivered to Kennedy Space Centre in March 1999.



Satellite Communications - ensuring that all Canadians have access to new communications technologies and services, and positioning Canadian industry to capture a significant part of the new global communications markets.

This field best demonstrates the evolution of space activities from pioneering government-led operations to the creation of new business opportunities for Canadians, as the world seeks Canadian space expertise, and as terrestrial applications are developed and proven in the marketplace.

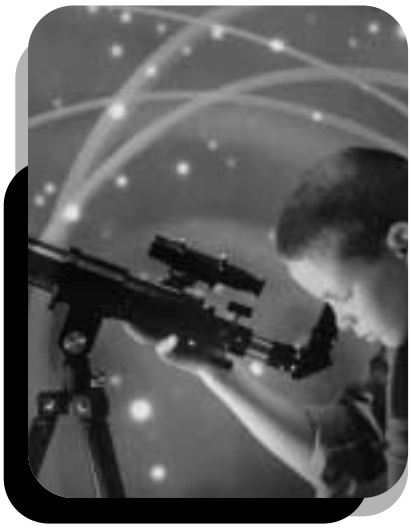
In 1998-1999 results were achieved by several companies working on the Advanced Satcom program, under contracts awarded by the CSA in cooperation with the Communications Research Centre of Industry Canada. For example, Nortel, along with subcontractors EMS and Norsat, won a $25 million contract with SES Astra for its new ASTRA-NET multimedia satellite system in Europe. New Advanced Satcom expenditures were limited in 1998-99, pending a resolution of *RADARSAT-2* launch issues.

Generic/Enabling Space Technologies - developing innovative and emerging technologies to ensure the growth and competitiveness of the Canadian space industry. This includes innovative leapfrog technologies essential to meeting future Canadian needs and ensuring an internationally competitive space industry, as well as technologies that reduce the risk and cost of future programs.

In 1998-1999, this included initiatives in optical and data processing technologies (including atmospheric ozone levels), Synthetic Aperture Radar (SAR) antenna technologies, satellite switching technology, laser scanning, interactive multimedia services for tele-education and tele-medicine, and others. Direct spin-off commercial sales of space technologies were over $20 million.

Detailed view of a component of Canada's Mobile Servicing System for the International Space Station undergoing testing at the Canadian Space Agency David Florida Laboratory in Ottawa.

Space Qualification Services – providing a world-class space qualification facility capable of meeting the current and emerging needs of Canadian industry and the larger space community at large. In 1998-1999, this included completing all space qualification testing of the Space Station Remote Manipulator System (SSRMS).



Comptrollership and Awareness - ensuring that the Agency performs its role as the leader of the Canadian Space Program. This service line articulates strategic direction for the Agency, coordinates program development, furnishes management, financial and other administrative support services, and ensures the necessary integration of all activities of the Canadian Space Program, to make the space program meet the needs of the Canadian public, accountable to Parliament.

In 1998-1999, major Canada-wide public and media events were set up to help Canadians become more aware of Canada's space achievements and benefits, including the STS-90 and STS-96 Space Shuttle missions, National Space Day and the 10th Anniversary of the Canadian Space Agency. These were closely coordinated with other government departments and external partners to achieve greater results. Space awareness activities also focussed on the active participation of Canadian youth, their parents and their teachers in science and technology.

To improve the Agency's own performance in planning, performance assessment and reporting, the Planning and Performance Assessment cycle was fully implemented. A series of human resources measures were also implemented to create a stimulating work environment through clearer recognition and rewards for achievements.

Challenges ahead. In the upcoming months, CSA will face major issues and challenges relating to cost increases in the Canadian Space Station Project, the implementation of *RADARSAT-2* and the renewal of the Cooperation Agreement with the European Space Agency (ESA).

Cost increases continue to be a concern for space hardware projects still governed by "cost-plus" contracts. For instance, apart from the Special Purpose Dextrous Manipulator, Canadian Space Station program components are encountering difficulties that are resulting in unforeseen cost increases.

Two important recent developments in the US have delayed the construction of *RADARSAT-2* and generated additional costs. First, NASA informed the CSA that it will not launch *RADARSAT-2* in exchange for a percentage of the satellite's data. Second, the US government has yet to give full approval of the Technical Assistance Agreement to allow Orbital Sciences Corp. to supply the bus for the satellite.

The current Cooperation Agreement with the ESA expires on December 31, 1999. CSA has initiated efforts to negotiate a new Agreement with ESA. Negotiations on this new Agreement are proceeding well and should be completed in October 1999.

The progress achieved in 1998-1999 will help the Canadian Space Agency to deal effectively with these challenges, and to ensure that Canada continues to achieve the maximum benefits from its investment in space.

CHART OF KEY RESULTS COMMITMENTS

The results of the Canadian Space Program are demonstrated in terms of economic development, understanding of the environment and contribution to sustainable development, as well as contributions to the quality of life. They are demonstrated by the development and diffusion of technology, world-class space research, social and educational benefits to Canadians, as well as in public awareness of the Canadian Space Program and the responsiveness of the space program to the needs of Canadians.

The following chart shows the key results commitments of the Canadian Space Program[1].

Figure 1. Key Results Commitments

The Canadian Space Agency:

Provides Canadians with:	as demonstrated by:	Achievements reported in:
significant economic, social, and environmental benefits from the application of space technology and space-based research and knowledge and core competencies in space sciences	economic benefits to Canadian industry	$1.25 billion and 5500 people employed in Canada see Page 17
	understanding of the environment and contribution to sustainable development	Page 18
	contributions to the quality of life	Page 19
	technological development & diffusion	Page 19
	world-class space research	Page 19
	social and educational benefits to Canadians	Page 20
	effective promotion and awareness of the Canadian Space Program	Page 20
	responsiveness of the Canadian Space Program to the needs of Canadians	Page 21

[1]This chart was extracted from Volume 2 of the Annual Report to Parliament: (*Managing for Results, 1999*) which summarizes the results commitments of the 84 federal Departments and Agencies that report directly to Parliament. It is also included in the CSA's Performance Reporting and Accountability Structure (PRAS).

SECTION 1: MESSAGE

1.1 MINISTER'S PORTFOLIO MESSAGE

At the dawn of the new millennium, Canada, with its strong and dynamic economy, is well positioned to take a lead role in the global knowledge-based economy and to realize its benefits for all Canadians. The new global economy is fundamentally different from the one we have known for most of this century: its key building blocks are knowledge, information, innovation and technology, and it is changing at an unprecedented pace. Today, it is important for businesses and individuals to be connected to the Information Highway, but tomorrow it will be essential. Electronic communications are breaking the barriers of time and distance, and the effects are being felt everywhere in Canada, from the largest cities to remote areas where the Information Highway is the only highway.

To keep Canada in the vanguard of this global economy, the government is investing heavily in knowledge, innovation, and connectedness, in order to generate well-paying jobs and a higher standard of living for Canadians. As Minister of Industry, I am responsible for a Portfolio which brings together most of the federal departments and agencies responsible for promoting innovation through science and technology and advancing knowledge. With over 40% of federal spending on S&T, a wide range of programs to help businesses -- especially small- and medium-sized businesses -- in every region of the country, a world-leading electronic commerce framework, and flexible support for exporters, the Industry Portfolio represents a powerful toolkit to help Canada make the transition to the knowledge-based economy and society of the 21st century.

The Industry Portfolio is ...

Atlantic Canada Opportunities Agency
Business Development Bank of Canada*
Canadian Space Agency
Competition Tribunal
Copyright Board Canada
Canada Economic Development for Quebec Regions
Industry Canada
National Research Council Canada
Natural Sciences and Engineering Research Council of Canada
Social Sciences and Humanities Research Council of Canada
Standards Council of Canada*
Statistics Canada
Western Economic Diversification Canada

* Not required to submit Performance Reports

The trend towards globalization also poses other challenges to Canada, which has one of the most open economies in the world. The Industry Portfolio is working with partners in the public and private sector and in academia to help Canadian companies respond and adapt to these challenges, so they can become and remain competitive in the global market. The government's agenda is based on seizing the opportunities presented by the global economy to create jobs and wealth for Canadians, and the Industry Portfolio has a key role in delivering this agenda.

I am pleased to present this Performance Report for the Canadian Space Agency (CSA). This report shows the contribution that CSA is making to the government's agenda by setting out the commitments that Canadian Space Agency has made and measuring its success in meeting these commitments over the 1998-1999 fiscal year.

The Canadian Space Agency continues to support the Canadian space industry. Today, the Canadian space sector is composed of some 250 firms and employs 5,500 people. Some 45% of its $1.2 billion annual revenues are from exports – the highest percentage in the world. In 1998-1999, the Canadian Space Agency selected MacDonald Dettwiler & Associates to build and operate *RADARSAT-2*. This agreement creates an innovative partnership with industry, in order to meet the growing world demand for Earth observation data. The Agency also delivered the first component of its contribution to the International Space Station, the Space Station Remote Manipulator System. Astronaut Dave Williams flew on STS-90 Neurolab in April 1998 and numerous science experiments were successfully conducted in space, notably experiments related to Osteoporosis in Orbit and Protein Crystal Growth. Significant progress was also made in the competitiveness and growth of the Canadian satellite communications and space technologies sectors.

I am proud of the contribution the Industry Portfolio makes toward the government's priorities of building a stronger Canada, creating opportunities for Canadians, and investing in knowledge and innovation.

The Honourable John Manley

SECTION 2: AGENCY OVERVIEW

2.1 MANDATE, MISSION AND OBJECTIVES

2.1.1 Legislative Mandate

The legislated mandate of the CSA, from the Canadian Space Agency Act, SC. 1990, c. 13, *is... to promote the peaceful use and development of space, to advance the knowledge of space through science and to ensure that space science and technology provide social and economic benefits for Canadians.*

2.1.2 Mission

The Canadian Space Agency is committed to leading the development and applications of space knowledge for the benefit of Canadians and humanity. To achieve this, the CSA:

- Pursues excellence collectively.
- Advocates a client-oriented attitude.
- Supports employee-oriented practices and open communications.
- Commits itself to both empowerment and accountability.
- Pledges to cooperate and work with partners to our mutual benefit.

2.1.3 Objectives

The principal objectives of the Canadian Space Program are: to develop and apply space science and technology to meet Canadian needs and aspirations; and to foster an internationally competitive space industry.

2.1.4 Space Policy Framework

The Space Policy Framework, approved by the Government of Canada in 1994, confirms the strategic importance of space in Canada's transition to a knowledge-based economy and to the social, scientific, sovereignty, security and foreign policy objectives of the Government. It identifies the CSA's responsibility for coordinating all policies and programs of the federal government in civil space-related research, science and technology, industrial development and international cooperation.

Key elements of strategic direction in the Space Policy Framework include giving priority to technology development and applications, Earth observation and satellite communications. Leverage of federal funds is to be maximized through partnerships.

More firms, particularly small and medium-sized enterprises, would be brought into space related activities. Greater synergy is to be promoted between civil and nonaggressive defence space activities. Sustainable industrial regional development is pursued with current regional distribution guidelines, and a country-wide communications and space awareness campaign is to be undertaken.

2.2 OPERATING ENVIRONMENT

2.2.1 Facing New Opportunities

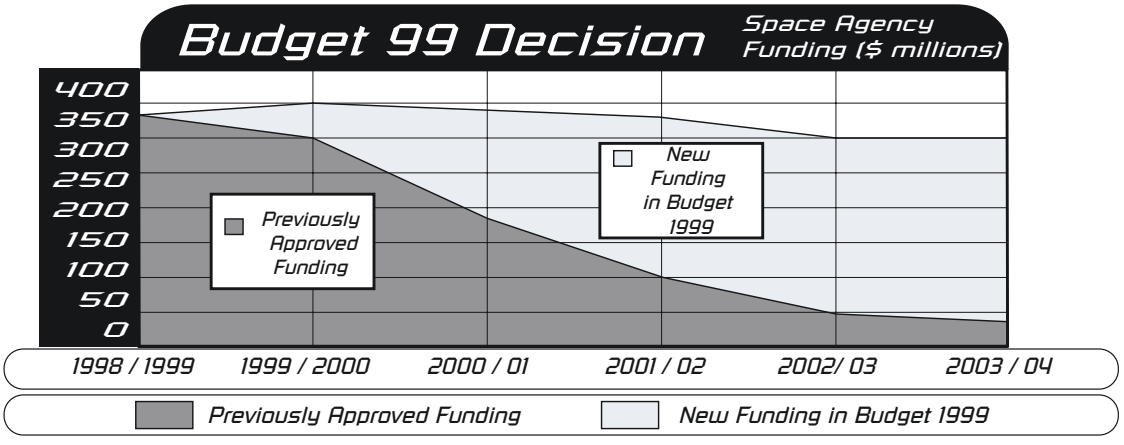
In Budget 99, the Government provided the Canadian Space Agency with additional funding of $430 million over the next three fiscal years and an envelope of $300 million annually thereafter. This provides the Agency for the first time with stable, ongoing funding; a more solid base for planning; and a greater ability to adapt programs to the rapidly evolving environment.

Facing new opportunities, with a fresh focus and a stable budget, the Canadian Space Agency is planning and implementing programs for each of its service lines to:

- Understand, monitor, predict and protect the Earth through enhanced upper atmospheric and environmental research.
- Maintain Canadian industry leadership in radar-based technologies by strengthening satellite data receiving infrastructure and application developments.
- Advance knowledge about space microgravity and life science, and participate in new international space astronomy and planetary exploration missions, thereby offering new challenges to the scientific community and industry.
- Secure Canada's leadership in space robotics, through participating in the construction and use of the International Space Station, and provide regular flight opportunities for Canadian astronauts.
- Contribute to the national effort in making Canada the most connected nation in the world and ensure that Canadians will keep developing and have access to the world's most advanced satellite communication technologies.
- Develop innovative and emerging technologies for the space program that stimulate Canadian space industry, and maximize the commercialization of space technologies in both space and non-space applications.
- Enhance Canada's international visibility in science and technology and instil a sense of pride amongst all Canadians.
- Promote scientific literacy and inspire the younger generation to pursue careers in science and technology.

The cash flow chart (below) displays the long-term funding envelope for the CSA that resulted from Budget 99.

Figure 2. Space Agency Funding



2.2.2 Managing Risks

The risks of investing in space are implicit in the long-term scope of the space programs, the international dimension of most of Canada's space programs (which limits the ability of any one country to fully control schedule, design and cost changes), the uniqueness of the space hardware to be developed, the very stringent quality control requirements and the rapidly advancing technology. In the face of these risks and uncertainties, program cost control and budget flexibility are dominant concerns for all space faring nations.

Until recently, the Canadian government absorbed all the risks and cost increases of Major Crown Projects (e.g. *RADARSAT-1*, International Space Station). Current practice can be described as a more balanced, risk-sharing framework including the CSA and industry (i.e., the contractor). Examples of this approach in major projects now under way include the fixed cost contract for the "Canada Hand" or Special Purpose Dextrous Manipulator (SPDM), the assumption of development and operation risks of *RADARSAT-2* by the private sector, and the limitation of the federal government contribution to the Advanced SatCom Program to $50 million.

2.2.3 Implementing Strategic Priorities

Considering global trends and market opportunities, the CSA has set four main priorities:

- Delivering Canada's contribution to the International Space Station (ISS).
- Operating *RADARSAT-1* and building *RADARSAT-2*.
- Delivering the Advanced Satellite Communications Initiatives.
- Implementing key initiatives from the new Canadian Space Plan.

2.2.4 Maintaining Links With Other Departments, Co-Deliverers and Stakeholders

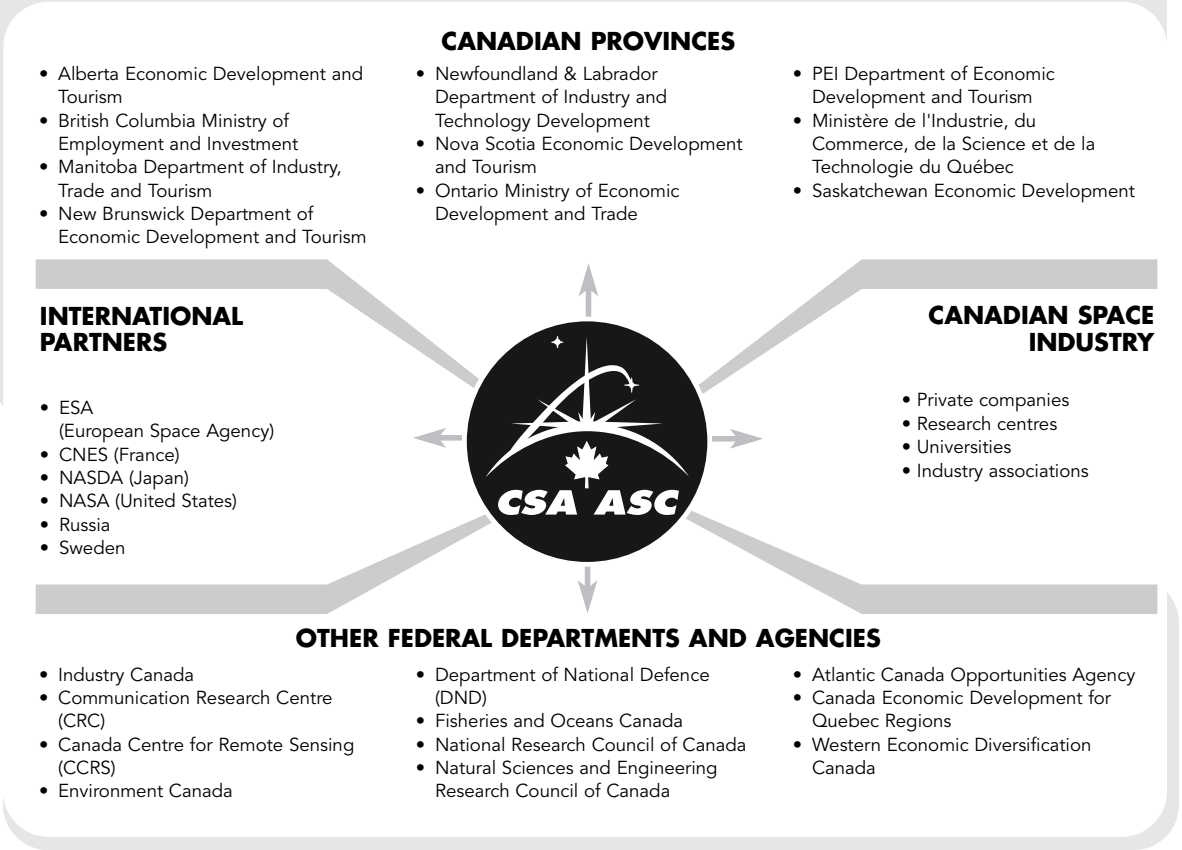
The Canadian Space Agency works with stakeholders to identify the priorities and strategic objectives for Canada's space activities. To formalize their involvement, the Agency has defined a new Management Framework for the Canadian Space Program - the structure and process by which it interacts with its stakeholders. This new framework ensures ongoing consultation and partnerships among federal government departments, provincial governments, the private sector, academia and special interest groups. It provides for direct stakeholder input and visibility in major resource allocation decisions.

The CSA works closely with the Canada Centre for Remote Sensing (CCRS), which has two satellite stations in Gatineau, Quebec, and Prince Albert, Saskatchewan. CCRS is also responsible for the development of ground-based technologies and applications with Canadian industry. The Canadian Space Agency works with a growing number of government departments and agencies, from Natural Resources Canada for forest monitoring to the Department of National Defence, for disaster management and other space applications increasingly required to deliver essential services. There is also an ongoing dialogue between the Canadian Space Agency and the Department of National Defence to promote more synergies between their respective space activities.

The United States, Europe and Japan account for roughly 90 per cent of the entire space market. International cooperation is therefore crucial to promoting a competitive space industry, and implementing Canadian space projects. International partners of the Canadian Space Agency include the National Aeronautics and Space Administration (NASA), the European Space Agency (ESA) and its fourteen Member States, as well as the National Space Development Agency of Japan (NASDA). Canada also has bilateral cooperation agreements for space research and development with several countries, including Japan, France, Russia, Sweden, China, Germany, Thailand, and Ukraine.

Figure 3. The Canadian Space Agency's Main Partners and Stakeholders

Canada's space program involves many agencies, departments, companies, institutions and organizations across Canada. The following chart provides an outline of how the Canadian Space Agency works with them.



Since its creation in 1989, the Canadian Space Agency has worked with provincial governments in carrying out its policy of stimulating a sustainable space industry in all regions of the country.

To a large extent, national academic institutions constitute the backbone of Canada's future in space. With space as a frontier of discovery, university researchers rely on the Canadian Space Agency to build and launch scientific instruments to generate data for advanced Research & Development (R&D) in areas such as astronomy, solar terrestrial relations, atmospheric monitoring, microgravity, life sciences and surface environment. In turn, the Agency relies on the results of university researchers to carry out Canadian Space Program activities.

2.3 CHALLENGES

2.3.1 Implementing Program Cost Pressures

The CSA remains confronted with a situation where completing all of its programs within approved funds is challenging. Cost increases continue to be a concern for space hardware projects still governed by "cost-plus" contracts. For instance, apart from the Special Purpose Dextrous Manipulator (SPDM), components of the Canadian Space Station program have been encountering difficulties that are resulting in unforeseen cost increases. In the case of *RADARSAT-1*, royalties from the sales of data are not reaching the level projected when the program was approved several years ago. Cost increases and revenue shortfalls have been covered by equivalent budget reductions in other areas.

2.3.2 Addressing International Cooperation Issues

RADARSAT-2

Two important recent developments in the US have seriously delayed the construction of *RADARSAT-2* by MacDonald Dettwiler and Associates (MDA) and generated additional costs. First, NASA informed the Canadian Space Agency that it will not launch *RADARSAT-2* in exchange for a percentage of the satellite's data as agreed in 1994. Issues cited to explain this position are possible national security implications and the commercial nature of *RADARSAT-2*. Second, the US government has yet to give full approval of the Technical Assistance Agreement (TAA), requested by Orbital Sciences Corporation (OSC), MDA's parent company, to supply the bus for the satellite. The Technical Assistance Agreement is required to allow a free exchange of technical specifications and data between OSC and MDA. National security has been cited as the reason for this delay. These *RADARSAT-2* implementation delays mean that *RADARSAT-1* will need to continue operations for at least an additional year.

With no firm date for approval of a full Technical Assistance Agreement, CSA and MDA are actively developing program options that do not include the need for US satellite equipment and launch.

EUROPEAN SPACE AGENCY

Canada is the only non-European country to have a close cooperation agreement with the European Space Agency (ESA). This long cooperation has enabled several industrial, program and political benefits for Canada and ESA. For instance, MDA, EMS, Com Dev and dozens of other Canadian space companies have grown through procurement opportunities and strategic alliances provided by the ESA relationship.

The current Cooperation Agreement expires on December 31, 1999. The Canadian Space Agency has initiated efforts to negotiate a new 10-year agreement with the European Space Agency. Negotiations are proceeding well and should be completed in October 1999, for agreement to be submitted for approval by the ESA Council and the Government of Canada.

SCIENTIFIC MISSIONS

Space Science and Environment related programs are almost all international in nature. In most cases, Canada is dependent on priorities and schedules of the lead agency. Delays were encountered in the launches of the NASA Terra satellite and Sweden Odin satellite to which Canada is providing the Measurement of Pollution in the Troposphere (MOPITT) and Optical Spectrograph and Infrared Imaging (OSIRIS) instruments, respectively. This could affect the availability of the scientific and technical expertise for the early part of the missions, when in-orbit commissioning is done. This problem is being somewhat alleviated through the development at the University of Toronto of an airborne sensor version of the Measurement of Pollution in the Troposphere instrument (MOPITT) to support the validation activities of the space mission.

The delay in completing negotiations with NASA on SCISAT-1, the first Canadian scientific satellite to be built since the Alouette/ISIS series in the 1960s-early 1970s, could lead to a tight development schedule with increased financial and technical risks. The launch of SCISAT-1 is now expected in early to mid 2002, rather than December 2001.

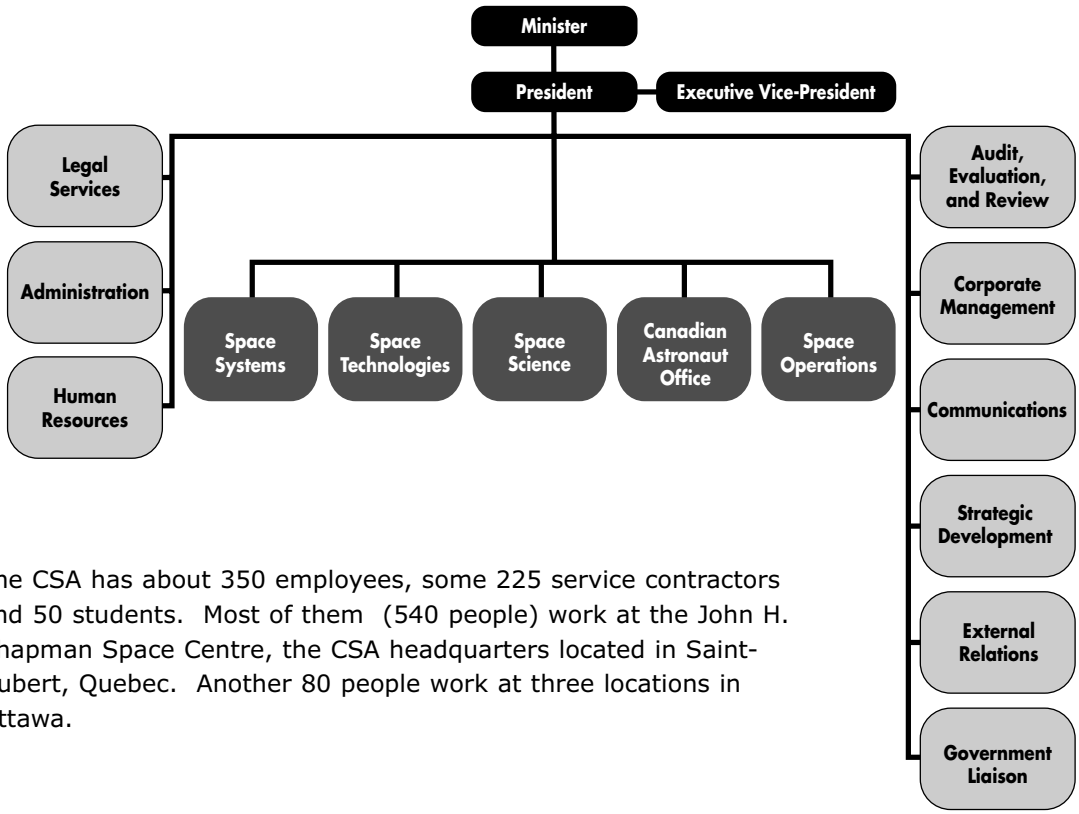
Prior to Budget 99, there were uncertainties surrounding the continuation of the Life Science and Microgravity Sciences disciplines after 31 March 1999, which led to delays with respect to the development of facilities and payloads for the ISS.

2.4 AGENCY ORGANIZATION AND BUSINESS LINE STRUCTURE

2.4.1 Organization

Established in 1989, the Canadian Space Agency (CSA) derives its authority from the Canadian Space Agency Act, S.C. 1990, c.13. Reporting to the Minister of Industry, the Chief Executive Officer of the CSA is the President, under whom there are five core functions: Space Systems, Space Technologies, Space Science, Canadian Astronaut Office, and Space Operations; six executive functions: Audit, Evaluation and Review, Corporate Management, Communications, Strategic Development, External Relations and Government Liaison; and three Corporate functions: Legal Services, Administration, and Human Resources.

Figure 4. CSA Organization Chart



The CSA has about 350 employees, some 225 service contractors and 50 students. Most of them (540 people) work at the John H. Chapman Space Centre, the CSA headquarters located in Saint-Hubert, Quebec. Another 80 people work at three locations in Ottawa.

2.4.2 Crosswalk from Old Structure

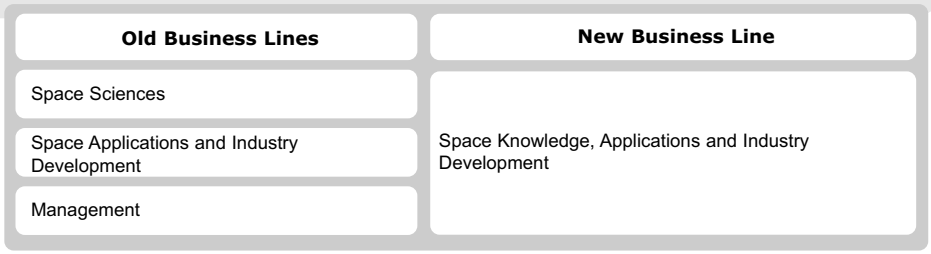
The CSA has moved from three to one business line as shown below.

The new structure reflects a changing environment for space programs. Many space activities are becoming more service-oriented, with their future often tied to end-users on the ground, or to the integration of their technology in terrestrial applications. Future investment will ensure that the needs and aspirations of Canadians are met, that key manufacturing niches remain in Canada, and increasingly, will seek significant business opportunities back on earth for Canadian industry.

Furthermore, the globalization of world space efforts means that today's needs -- whether they are commercial, humanitarian or environmental -- are met by international entities. Accordingly, Canadian space programs are predicated on playing a leading role in global partnerships and consortia.

Through a single business line, the Agency has moved away from project oriented business lines and positioned itself to know how well it is performing in meeting these challenges. The following table compares the old and new structures. The financial cross-walk is shown in Table 4 of Section 5.

Figure 5. Evolution of Business Lines



2.4.3 Business Line

The Canadian Space Agency has a single business line called "Space Knowledge, Applications and Industry Development".

Through this business line, the Canadian Space Agency works with universities, industry, other government agencies and other partners across Canada to contribute to and facilitate the advancement of space knowledge; the development of new processes, technologies and applications; and the use and application of space science and technology.
The CSA supports the development of an internationally competitive, export-oriented Canadian space equipment and services sector.

In collaboration with other public sector organizations, or on its own, the Canadian Space Agency contributes to the sustainable development of Canada by linking Canadians from coast to coast, by enhancing the management of our environment and natural resources, and by learning how phenomena in space affect life on Earth.

The business line creates better awareness of the importance of space technology in all regions of Canada and improves cooperation and relationships with space sector organizations throughout the world.

The business line involves all initiatives that ensure that the Agency performs its role as the leader of the Canadian Space Program. This is achieved through seven service lines as follows:

- Earth and Environment
- Space Science
- Human Presence in Space
- Satellite Communications
- Generic/Enabling Space Technologies
- Space Qualification Services
- Comptrollership and Awareness

A description of these service lines is included in Annex 1.

SECTION 3: AGENCY PERFORMANCE

3.1 SUMMARY OF PERFORMANCE EXPECTATIONS AND ACCOMPLISHMENTS

The following tables summarize performance expectations and accomplishments of the Canadian Space Agency for 1998-1999.

Results Sought	1998-1999 Targets	1998-1999 Accomplishments
Economic Benefits		
Significant benefits to the economy, environment, and society from the application of space technology and space-based research.	10% annual increase in the number of firms in Canadian remote sensing industry exploiting commercially Earth observation satellite data.	RADARSAT International Inc. (RSI) has roughly 15% of the global remote sensing market for EO data. Return on RADARSAT User Development investment is at 1.8 times contract values. Total 1998-1999 revenues from commercial RADARSAT products and services exceeded $15 million.
Improved technical capabilities, competitiveness, global relevance and economic benefits to Canadian industry in all regions of Canada from the use and application of space science and technology.	$6.4 billion of economic benefits and 70,000 person-years of employment resulting from the Canadian Space Station Program over the life of the program. Economic benefits regionally distributed in space technologies.	Many Canadian small and medium companies gained technology, capabilities and competitiveness (survey of economic benefits will be completed by the next reporting period). Canadian space industry generated revenues of over $1.25 billion and employed 5500 people throughout all regions of Canada (1997 data). This represents an increase of over 30% in total sector-wide revenues and an increase of close to 11% in total employment from the previous year.
Participation of Canadian Small and Medium Enterprise companies (SMEs) in all regions of Canada in space technology development programs and development by SMEs of technologies for space applications.	Actual revenues to the Consolidated Revenue Fund from David Florida Laboratory. $201 million worth of contracts given to Canadian industry. 40% annual increase in royalty revenue from the operation of *RADARSAT-1*. Successful negotiation and signing of contract with industry for the *RADARSAT-2* mission.	David Florida Laboratory (DFL) contributed $969 thousand to the Consolidated Revenue Fund. Over $200 million worth of contracts given to industry either directly by the CSA or by sub-contractors to Canadian space firms, e.g.: - 18 ESA Satcom contracts for over $4 million won by Canadian companies; - 10 contracts for the International Mobile Program awarded totalling $3.8 million; - Over 40 new space technology contracts awarded for a value exceeding $11 million. *RADARSAT-1* royalty revenue has increased from less than $2 million in 1997-1998 to $2.1 million in 1998-1999, a 5% increase - the slow increase was due in part to recent uncertainties in the Asian economy. *RADARSAT-2* Master Agreement signed with MDA in December 1998.
Understanding of the environment and contribution to sustainable development		
Improved resource management and disaster management, and improved techniques for the prediction of climate and pollution problems through the application of space technology and space-based research	Attributions to the CSA of processes, materials, medical procedures, and improvements in space weather, climate and pollution prediction techniques. Meeting the RADARSAT images requirements of the Canadian Ice Service estimated at 2,000 images annually. Completion of the mapping of the Canadian landmass (RADARSAT standard mode) as part of the Background Mission. Completion of acquisition of global landmass coverage (RADARSAT ScanSAR mode) as part of the Background Mission. Achieving an imaging performance index of equal or greater than 95%. Initiation of the Global Observation of Forest Cover Project with national and international partners. Number of geomatic databases available on-line will be increased by 50% over a one-year period.	Continued utilization of data from space and atmospheric environment instruments by space and atmospheric modelling research and forecasting teams. More than 4,000 images were provided to the Canadian Ice Service. Mapping of North America was completed. First coverage of all continents, their continental shelves and polar caps completed. Average of 96% imaging performance index frequently surpassed and improvements achieved in robustness of spacecraft attitude control. The Global Observation of Forest Cover Project completed its design phase in December 1998. CEONet realized an 180% increase in on-line databases; 102% increase in content; and seven-fold increase in the number of user sessions per day (times logged on per day).

Results Sought	1998-1999 Targets	1998-1999 Accomplishments
Contribution to the quality of life		
Participation of Canadian industry in Science & Technology programs on an international scale.	Improvement in technology, skills and management in industry.	Successful continuation of collaborations through delivery of new Canadian instrumentation (Terra and Odin missions) and continued operation of instrumentation and delivery of data to science investigation teams (UARS, Interball and Akebono missions).
	Addition of two RADARSAT foreign stations to the RADARSAT international network over a one-year period.	Four new RADARSAT Network stations (Australia, Japan, South Korea and Saudi Arabia) were certified.
	Three new applications of RADARSAT data successfully transferred to industrial or operational users over a one-year period.	New RADARSAT applications: Stereo-assisted DEM generation, land use maps for cloud-covered tropical areas, rice crop monitoring.
	Successful on-orbit commissioning of SSRMS, MBS and Special Purpose Dextrous Manipulator (SPDM) with real-time support from the MSS Operations Complex.	Space Station Remote Manipulator System delivered to Kennedy Space Centre in May 1999 rather than February 1999. Special Purpose Dextrous Manipulator (SPDM) Critical Design Review was completed in December 1998. STVF Critical Design Review completed in March 1999. Artificial Vision Unit delivered to KSC in December 1998.
	Tens of technologies enhanced or demonstrated and proven.	25 significant new technologies developed in house or in collaboration with other researchers e.g., data compression of hyperspectral data; fiber optics eye safe laser; battery pack/solar panel deployment mechanism for QuickSat multi-channel fibro-optic vibrometer for testing satellite antennas.
	Sustained trend in the number of licenses negotiated.	11 new space technologies patents were filed and 4 were issued, while 13 new licenses were negotiated compared to 11 patents filed and 21 licenses negotiated in 1997-1998.
Improved health of Canadians from the application of space technology and space-based research. Medical improvements from space research leading to the health, well-being and productivity of humans in space.	The existence of a successful and active Canadian Operational Space Medicine program.	Successful conduct of Visual Cues and VCF experiments aboard Neurolab (STS-90) and of Osteoporosis Experiment in Orbit aboard STS-95. Space Station technology has been transferred to develop digital imaging system for medical radiology. Supported pancreatic cell research and breast cancer research.
Technological development and diffusion		
A better understanding of space, the universe and basic physical and chemical processes.	Approximately 20 Canadian research projects performed on shuttle missions. Dozens of experimental/payloads and data generated.	Successful conduct of Protein Crystal growth-CIBX aboard STS-95. Visual Cues and Visuo-Coordination Facility experiments completed. Several tens of scientific papers published in peer-reviewed journals.

3.1 SUMMARY PERFORMANCE EXPECTATIONS AND ACCOMPLISHMENTS (continued)

The following tables summarize performance expectations and accomplishments of the Canadian Space Agency for 1998-1999.

Results Sought	1998-1999 Targets	1998-1999 Accomplishments
World-class research		
Opportunities for research in space for Canadians scientists in universities and in industry.	Instruments and spacecraft systems developed in industry. Hundreds of Canadian scientists involved in the program.	Start of development of SCISAT-1 mission, MOST micro-satellite and build of GEODESIC sounding rocket and instrumentation. Directed contracts to Canadian industry, spacecraft antenna material samples to Spar (EMS) for SICRAL Program. Hundreds of Canadian scientists involved in the program.
International recognition of Canada's leadership in space technology and research.	15 large and dozens of small experiments launched. The continued existence of a strong contingent of healthy and active Canadian astronauts. Participation by Canadian companies in international consortia.	Launch of TPA instrument aboard Japanese PLANET-B. Launch of the ACTIVE sounding rocket. Two balloon experiments in atmospheric sciences and space astronomy. Astronaut Dave Williams flew on STS-90 Neurolab. The following assignments were secured for astronauts: Julie Payette assigned to ISS Mission STS-96, launched in May 1999; Marc Garneau assigned to ISS Mission STS-97 scheduled for launch March 2000; Chris Hadfield assigned to ISS Mission STS-100 scheduled for launch in July 2000. BESTLAB initiative started by Canadian consortium (Telesat, Spar (EMS), Com Dev, CRC). Canadian companies allied with several European companies in ventures (e.g. Spar (EMS) with Alenia Spazio (Italy); Dasa and Daimler Benz (Germany); Aerospatiale, Alcatel, Thomson CSF and Matra Marconi (France); and with companies in Belgium, Norway and Spain. Many worldwide industrial partnerships created, e.g., Com Dev & Ball Aerospace created Laser Communications International; Spar (EMS) & Com Dev joined Skybridge consortium (France) as equity partners; Nortel acquired Bay Networks to form Nortel Networks.
Social and educational benefits		
Canadian scientists with skills and expertise in space R&D.	Hundreds of scientific papers textbooks and patents contributed.	Over 70 peer reviewed technical and scientific papers produced.
National pride as a result of the public awareness of the role of S&T in Canada's future, of the CSA and the Canadian Space Program.	Greater awareness of Canadians, especially scientists as a result of media events. Awareness of the Canadian public of the Canadian technological contribution (MSS) and ongoing benefits of Canada's involvement in ISS. Increased media reports as a result of public awareness campaigns.	A March 1999 public opinion poll demonstrated that the strong level of support for the Canadian Space Program has been maintained with 84% of Canadians demonstrating strong support for Canadian involvement in ISS. Overall knowledge of the CSA and Canadian Space Program remained at 4% among the general public. General and media inquiries and requests for CSA participation in various public events have increased by 50 per cent. Comprehensive media strategies implemented for STS-90, STS- 91, STS-95, National Space Day, ISS, *RADARSAT-2*, CSA 10th Anniversary and STS-96 resulted in major media attendance at 23 press events, extensive coverage at the local, regional and national level including live TV coverage. Media inquiries increased by 50 %. A media survey indicated positive feedback to proactive media relations campaigns and on increased media awareness of the CSA and CSP.
Youth involvement in S&T through increased interest in space activities.	Increase in the number of Canadian graduates hired by Canadian firms and governments for space-related work. Dozens of graduates who received scholarships for graduate studies working in the fields of science and technology sectors in Canada. Increased interest in space as a result of Canadian astronaut visits and briefings. Youth are encouraged to get involved in S&T projects and careers through various public relations activities.	175 students and youth interns trained at the Canadian Space Agency. Of these, 89 (51%) were in science and engineering and 35 (20%) were in Information Technology. 23 S&T positions were staffed from outside the federal public service, 7 by young graduates. 25 Ph.D. and Master level students benefited from financial support or from projects awarded to universities. Canadian Astronauts participated in 86 public events educating over 30,000 Canadians of all ages on the importance of pursuing careers in S&T. Space mission downlinks, student challenges, contests and education material helped stimulate greater interest among teachers and youth. Initiatives included a student visits program by astronauts. National Space Day involved over 5,000 students across Canada in S&T related activities.

Results Sought	1998-1999 Targets	1998-1999 Accomplishments
Social and educational benefits (continued)		
Awareness and understanding of the space program by Parliament and the Canadian public. Effective communications strategies and plans that satisfy the needs of the Agency, departments in the Industry Portfolio, and space stakeholders.	CSA educational material found useful by school teachers. Youth and educators gain greater knowledge and understanding of Canadian space activities (e.g. Space Station, astronaut flights). Space knowledge is diffused to enhance the interest and awareness of the general public for science and technology. Increased awareness of the Canadian Space Program (CSP) through the Canadian astronaut visits programs in Canada. 20% increase in requests for information from educators, youth and the public across Canada and access to the CSA web site. Greater awareness of the advantages of Canada's participation in space activities and a 6% increase in the level of awareness of CSA, its programs among the public, media, SMEs and stakeholders. Positive feedback from internal and external stakeholders.	Challenges, contests and educated material have facilitated greater awareness among teachers and youth. Positive feedback received from teachers on STS- 90 teacher support material. Advertising and feature articles of CSA messages in key publications reached an audience of over 1 million people in Canada and abroad. Sponsorship and partnership initiatives resulted in over 200 new partners involved in space related public awareness initiatives such as National Space Day involving Mayors, stakeholders, community organizations across the country. Canadian Astronauts participated in 86 public events educating over 30,000 Canadians of all ages on CSP benefits. 50 % increase in the number of media inquiries as well as published reports carrying key messages to the public. 50 % increase in the number of inquiries from members of the general public. 25 % increase in requests from teachers and 20 % increase in participation of students in space related events. The CSA web site had an average of 500 visitors a day. Average visit time of 12 minutes indicates reading and interest in the web site information by visitors. March 99 public opinion poll showed strong levels of support for the CSP maintained. 84 % of Canadians polled felt that Canadian involvement in ISS was very important. Knowledge of CSA at 4% among the general public. Increasing awareness of and interest in the CSA/CSP by certain publics, with a 34 - 50 % increase in requests for information. Positive feedback from CSA personnel, Industry Portfolio, Privy Council Office, Minister's Office, and external partners on results of CSA Communications strategies, plans and public awareness initiatives. Media surveys show positive reaction to proactive media relations campaigns (eg. STS 90, 10th CSA anniversary).
Highly qualified personnel available to the public sector and the high-tech industry.	Dozens of graduates who received scholarships for graduate studies working in the Science and Technology sectors in Canada. Grant three scholarships for graduate studies in Earth observation over a one-year period.	Dozens of graduate students , 6 post-doctoral students and 18 summer students supported. The scholarship program was terminated following budget reduction in the Earth Observation Support Programs.
Promotion of the Canadian Space Program		
Effective, results-based, open, and transparent relations between the Agency and stakeholders. Improved relationships with governmental, academic and private sector space organizations in Canada and throughout the world.	Increase Canadian space sector exports. Successful industrial alliances with European industry. Positive feedback from 80% of stakeholders on the state of CSA relations.	In 1997, 45% of Canadian space industry revenues were generated by exports, the world's largest export ratio. Negotiations continued with ESA on the renewal of the Cooperation Agreement and enhancement of bilateral cooperation with France and Japan. Positive feedback received from National Space Sector Team participants.
Cost-effective management of the Canadian Space Program.	Parliamentarians and senior officials are satisfied with the results of the LTSP II. Approval of LTSP III.	A new Space Plan has been approved, with $41million of new funding in 1999-2000.
A representative, motivated, capable, innovative and productive workforce. Canadian Space Agency employees having the appropriate knowledge, tools, processes, and systems to do their jobs.	Positive feedback from internal & external stakeholders. Level of implementation by managers of CSA values. CSA executives use performance assessment framework in decisions.	A second employee survey will be conducted in September 1999. CSA improvement plan fully implemented (23 measures). Planning and performance assessment process fully implemented. All components of Integrated Financial Management System have been implemented successfully.

3.2 DETAILED PERFORMANCE ACCOMPLISHMENTS

Space Knowledge, Applications and Industry Development

Financial information 1998-1999 (in dollars)

Planned Spending	273,037,000
Total Authorities	352,001,622
Actual	**341,289,855**

Nota: 1) Planned Spending corresponds to Main Estimates budget.
2) Total Authorities are Main Estimates plus Supplementary Estimates plus other authorities.
3) Amounts include contributions to the employees' social benefit fund

3.2.1 Space Knowledge, Applications and Industry Development

This section presents Agency performance in terms of the Key Results Commitments shown in Figure 1.

ECONOMIC BENEFITS TO CANADIAN INDUSTRY

The Canadian space industry has largely realigned as a premium supplier of high quality niche products and services to international prime contractors. Now employing over 5,500 Canadians in all regions of the country, the industry is made up of some 250 firms from across Canada. It generates approximately $1.25 billion per year, of which 45% are in the form of exports - the highest percentage in the world (1997 data)[2]. Global space industry revenues are expected to reach $US 117 billion by 2001, up from $US 88 billion in 1998[3], and competition will also increase.

The Canadian Space Agency promotes a competitive space industry by contracting out some 80% of its overall budget. Space programs are designed to optimize the positioning of the Canadian space industry on world markets, particularly in areas of strategic importance such as the commercial exploitation of remote sensing data and the development of next generation satellite communication applications. Mostly small and medium-sized enterprises, Canadian firms have captured a significant share of world markets in certain space niches. Examples include:

- Satellite and ground communications systems and sub-systems manufactured by EMS (antennas), Com Dev Limited (switches, multiplexers), Nortel and Spacebridge (terminals).

[2]Statistics extracted from the CSA document "Characterization of the Canadian Space Sector for 1997".
This document is produced on a yearly basis and 1998 statistics will be available in March 2000 at www.space.gc.ca.
[3]Data from State of the Space Industry 1998, Space Publications & A.T. Kearney Management Consultants.

- Earth observation ground stations supplied by MacDonald Dettwiler and Associates (MDA).
- RADARSAT and other satellite data distributed by RADARSAT International.
- Space robotics developed by MacDonald Dettwiler Space and Advanced Robotics (MDSAR).
- Sounding rockets and instrument payloads supplied by Bristol Aerospace.
- Telemetry, tracking and command equipment manufactured by SED Systems.

The recent merger of important Canadian companies with US interests presents our industry with access to significant new markets for their products and services. Examples such as US-based Orbital Science (which bought MacDonald Dettwiler and Associates, and more recently through MDA, Spar's robotics division in Brampton, Ontario) and EMS (which bought CAL Corporation of Ottawa and more recently Spar's satellite division in Ste-Anne-de-Bellevue, Quebec) are positive developments given the increased globalization of the space industry. These companies have demonstrated their intent to invest in Canada, open new markets and increase revenues for our industry. Given this new industrial context, the CSA is working vigilantly to protect publicly funded intellectual property and ensure its exploitation in Canada.

Regional development efforts have sought to stimulate the space industry throughout Canada. Specifically, in Atlantic Canada where there was almost no space industrial activity a decade ago, it now makes its contribution to this $2.4 billion dollar industry.

Indirect benefits, not reflected in the above statistics, include enhancing government efficiency and improving the productivity of the industry. *RADARSAT-1* data, for example, save millions of dollars annually at the Canadian Ice Services (Department of Environment) while improving the quality of service to users such as the Canadian Coast Guard and the marine transportation and fishery industry.

International cooperation provides many economic benefits. Joining with international partners levers Canada's investment in space by focussing resources on specific technologies of strategic importance to Canada (rather than, for example, major launch systems). Canada's 20-year participation in the European Space Agency (ESA) as a Cooperating State has improved our ability to develop and access key technologies and applications. It opens European markets, secures participation in international industrial alliances, and provides an alternative to over-dependence on the US (NASA) to carry out key initiatives.

UNDERSTANDING OF THE ENVIRONMENT AND CONTRIBUTION TO SUSTAINABLE DEVELOPMENT

For decades, Canadian space scientists have contributed to the global knowledge base, particularly to the understanding of Earth environment and more recently in response to the worldwide concern for the monitoring and protection of the environment.

For instance, Canada has developed two instruments to monitor air pollution from space: Measurement of Pollution in the Troposphere (MOPITT), to be flown on NASA's EOS satellite, measures carbon monoxide and methane in the troposphere; and Optical Spectrograph and Infrared Imaging (OSIRIS), to be flown on Sweden's Odin satellite, helps to study stratospheric ozone depletion.

RADARSAT is uniquely capable of responding to disasters around the world. The system can support the operational mapping and monitoring of natural disasters in four critical ways: prevention, preparedness, emergency response and recovery. Since its launch in 1995, RADARSAT has acted on more than 40 emergency requests. In 1998 alone, data was acquired on floods, landslides, earthquakes, droughts, storms, forest fires, volcanic eruptions and avalanches. Antarctic Mapping Mission-1, conducted in 1997, has generated exciting new maps and scientific findings including: the first synoptic map of all the Antarctic ice streams, the discovery of new ice stream systems in East Antarctic, the first radar-derived map of ice divides and catchment areas, the discovery of extensive mega-snowdune fields and the production of interferometrically derived ice velocities to determine whether the ice cap is shrinking. *RADARSAT-2*, currently under development for launch in 2002, will offer improved quality of data images to meet the growing world demand for Earth observation information.

CONTRIBUTIONS TO THE QUALITY OF LIFE

The availability of a competitive communications infrastructure is the "nervous system of a knowledge-based economy". Satellite communications developments have taken roots in Canadian needs, and the Canadian Space Program continues to ensure that Canadians from all regions benefit from the services made possible by advanced satellite communications technologies, including future commercial delivery of multi-media services such as high-speed Internet access and two-way video communications, high speed data communications highways and mobile/personal communications services. This will help Canada become the most connected nation in the world.

TECHNOLOGICAL DEVELOPMENT AND DIFFUSION

The Canadian Space Agency pursues Canada's interests in advancing technologies in the areas of Satellite Communications, Earth Observation and Space Robotics. Its programs help Canadian high-technology firms enhance their R&D and manufacturing capabilities, and they encourage economic development through the transfer and application of space technologies to other industrial sectors.

Canadarm is the most famous Canadian space technology accomplishment, and has led to new accomplishments in robotics and automation. The Space Station Remote Manipulator System (SSRMS), the first component of the Mobile Servicing System (MSS) for the International Space Station, was completed, received an array of tests at the David Florida Laboratory, and was delivered to NASA. Development began on another robotic contribution to space station, the Special Purpose Dextrous Manipulator (SPDM), and CSA astronauts Marc Garneau, Chris Hadfield and Julie Payette were confirmed to fly missions to assemble the International Space Station in 1999 and 2000.

Canada is a world leader in the exploitation of radar technologies for Earth observation. RADARSAT is the most advanced commercial radar-based satellite system ever deployed.

WORLD-CLASS SPACE RESEARCH

Canada maintains a position of excellence in the worldwide scientific exploration and utilization of space. With space as a frontier of discovery, university researchers rely on the CSA to build and launch scientific instruments to generate data for advanced R&D in areas such as astronomy, solar terrestrial relations, atmospheric monitoring, microgravity, life

sciences and surface environment. In turn, the CSA relies on the renewed knowledge that university researchers provide to carry out Canadian Space Program activities. Canadian scientists pioneered research in solar-terrestrial physics and upper atmospheric chemistry with the Alouette and ISIS satellite programs in the 1960s and 1970s. Today those disciplines remain among the hallmarks of space science in Canada. The Canadian Space Agency's R&D, space technology and transfer activities have produced companies that are world leaders in market niches such as Earth Observation ground station stations (MDA), satellite communications multiplexing systems (Com Dev), and space robotics systems (Spar/now MDSAR).

SOCIAL AND EDUCATIONAL BENEFITS TO CANADIANS

Space activities contribute to the health and safety of Canadians. Experiments conducted under a microgravity environment, notably by Canadian astronauts, have improved understanding and treatment of certain diseases. For instance, the Life Sciences experiments conducted aboard the Neurolab mission by the Astronaut Dave Williams will help develop new treatments for medical disorders such as insomnia, motion sickness, blood pressure regulation and inner-ear ailments. Satellite-based research and rescue activities enhance safety and help save human lives.

The unique appeal of space serves to improve scientific literacy among students, educators and the general public. CSA uses its activities, particularly those relating to Canadian astronauts, to improve science literacy and inspire the younger generation to aim for excellence and pursue careers in science and technology. The Agency's Space Awareness Program is tapped into a Canada-wide network of learning establishments, from resource centres to museums, to provide information on the many aspects of working and studying in the field of space. A network of five Canadian space resource centres located in Halifax, Montreal, Toronto, Saskatoon and Vancouver provides easy access to print and multi-media information material and activities related to space. The CSA technology programs support students pursuing advanced studies in space science and engineering at educational institutions, as well as provide training opportunities. The Agency also subsidizes the participation of students in the summer program of the International Space University.

EFFECTIVE PROMOTION AND AWARENESS OF THE CANADIAN SPACE PROGRAM

The United States, Europe and Japan account for roughly 90 per cent of the entire space market. International cooperation with these partners is therefore crucial to promoting a competitive space industry and to the implementation of Canadian space projects. A substantial portion of the CSA's activities involves cooperation with the National Aeronautics and Space Administration (NASA), the European Space Agency (ESA) and its fourteen Member States, as well as the National Space Development Agency of Japan (NASDA). Of particular importance is Canada's participation in the International Space Station, the world's largest international high technology collaboration program that includes the US, members of the ESA, Japan, Canada and Russia. Canada also has bilateral cooperation agreements for space research and development with several countries, including Japan, France, Russia, Sweden, China, Germany, Thailand, and Ukraine.

Given the relatively young age of the Canadian Space Agency and its low awareness level with the general public, raising this profile and increasing public awareness of the achievements and benefits of the Canadian Space Program is a basic challenge. This is done by promoting key space events such as Canadian Astronauts' missions, launches

of space science instruments and by organizing special activities like the national space day. The Millennium offers opportunities to create further awareness of Canada's achievements in space, as well as to increase the interest of young people in S&T.

RESPONSIVENESS OF THE CANADIAN SPACE PROGRAM TO THE NEEDS OF CANADIANS

Canada's vast continent-wide geography made this country a space pioneer, seeking new ways to communicate over large distances and manage a broad range of natural resources.

The combination of widely separated settlements, rugged terrain, and harsh climate means that conventional methods of communications prior to the Space Age were unreliable, or prohibitively expensive. In less than a generation, all that has changed. Technological innovation in satellite communications in Canada led to comprehensive state-of-the-art services to meet these Canadian needs. Canadian satellite communications systems have become a model for other large countries.

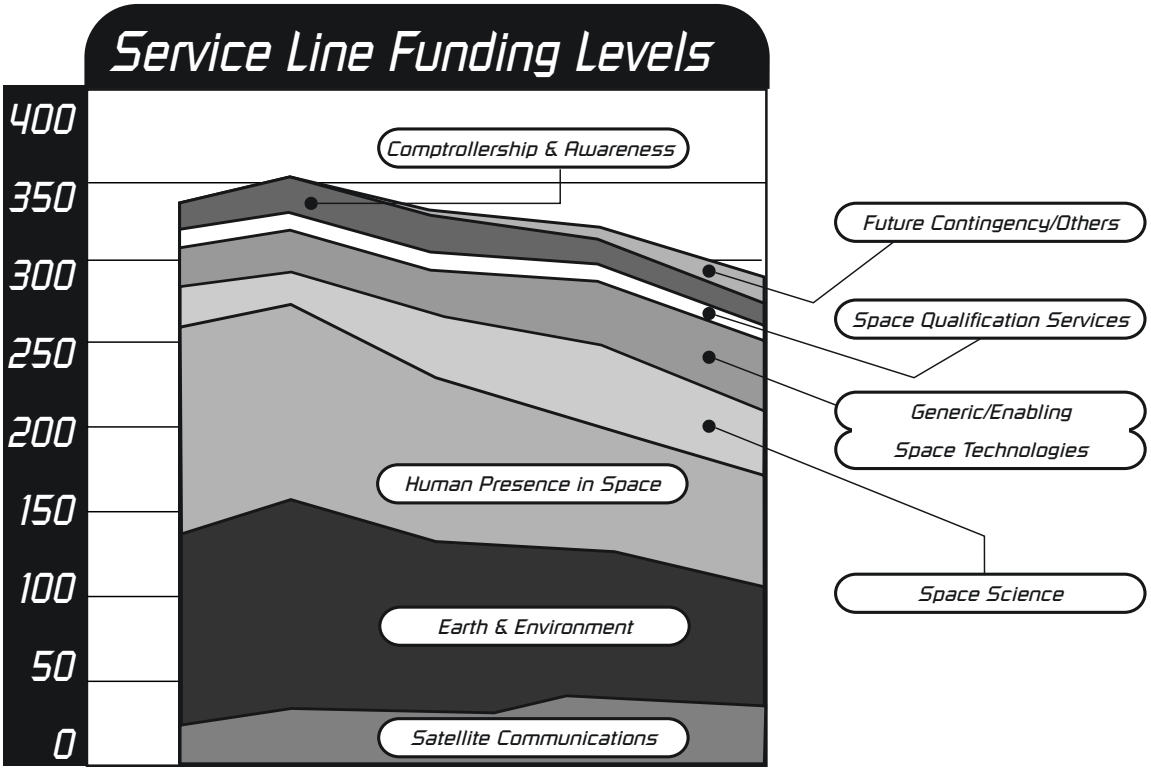
The development of remote sensing has also been a priority for Canada, for monitoring the natural resources of an immense country, and for environmental concerns. Earth observation programs such as RADARSAT ensure Canadian leadership in the emerging international market for remote sensing products and services while meeting domestic environmental monitoring and resource management needs.

Further, Canada's space program is a building block of the new knowledge-based economy contributing to developing high technology enterprises creating high-quality jobs across all regions of the country. As such, space will be an important instrument for social and economic development in the New Millennium and space programs will play a significant role in securing a prominent place for Canada among technologically advanced nations.

3.2.2 Accomplishments by Service Lines

This section presents Agency performance highlights by service line. Figure 6 shows funding levels in each service line, and the remainder of the section deals with each service line individually. Additional details on the CSA's performance at the service line level are available at www.space.gc.ca.

Figure 6. Service Lines Funding Levels ($ millions)



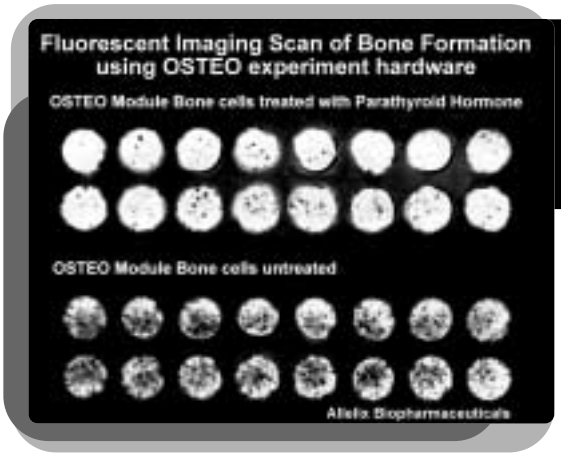
	1998-99	1999-2000	2000-01	2001-02	2002-03	2003-04
Future Contingency /Others	0	0	5	8	13	24
Comptrollership & Awareness	26	27	30	26	26	26
Space Qualification Services	8	7	7	7	7	7
Generic/Enabling Space Technologies	28	19	26	36	39	39
Space Science	24	11	29	39	42	42
Human Presence in Space	127	129	102	75	53	45
Earth & Environment	103	129	113	96	85	82
Satellite Communications	26	30	25	39	36	36

SPACE SCIENCE

Space Science activities ensured the participation of more than one hundred Canadian scientists in the best projects to meet the country's needs. Space Science investigations delivered new knowledge of space phenomena and addressed the effects of gravity on materials and on biological and physiological processes.

The Thermal Plasma Analyzer (TPA) conceived by researchers from the University of Calgary and developed by ComDev Limited from Cambridge, Onatrio, was launched aboard the Japanese *PLANET-B* satellite (renamed NOZOMI) in July 1998. In December 1998, the NOZOMI satellite completed an Earth orbit before its long journey to Mars where it will study the upper atmosphere of that planet. However, some difficulties were experienced when leaving Earth orbit. The Institute of Space and Astronautical Science (ISAS) of Japan had to devise another orbit scenario to ensure the craft could be placed into a Mars orbit at the end of its long journey. The new scenario will lead to a significant delay in the completion of the scientific objectives of this mission as the satellite will be reaching Mars in December 2003 rather than in October 1999. CSA is exploring with University of Calgary and The Institute of Space and Astronautical Science the possibility of turning on the TPA instrument sooner during the extended journey from Earth to Mars, to collect additional scientific data.

Artist rendering of the FUSE spacecraft with Canadian Fine-Error Sensors (FES) on board.



Picture taken during pre-launch tests of the OSTEO hardware, the above scans show increased bone growth (shown as white areas) in cells treated with parathyroid hormone, compared to those not treated.

The Fine-Error Sensors (FES) camera developed by ComDev Limited was delivered to the Far Ultraviolet Spectroscopic Explorer (FUSE) project at NASA in fall 1998 and is now providing information to the earth-orbiting astronomical observatory. Several Canadians astronomers will be using this new facility which is expected to lead to many new astronomical discoveries.

Two Life and Microgravity Sciences experiments (Visual Cues and Visuo-Coordination Facility) were successfully completed aboard Neurolab in April 1998. In October 1998, three Canadian experiments aboard STS-95 (Osteoporosis Experiment in Orbit, Phase Partitioning Experiment, Protein Crystal Growth - CIBX-1) were successfully conducted. The data collected from these experiments are being analyzed by the leading researchers in academia and the results will be published in peer-reviewed scientific journals.

Canadian Get-Away-Special payloads flew on STS-91 and additional flight opportunities are currently being sought.

EARTH AND ENVIRONMENT

In Space Environment, the CANOPUS network of ground-based optical and radar instruments continued to provide a wealth of data in support of numerous space missions ("The best source of correlative ground-based measurements available" according to NASA). The successful launch and data acquisition from the ACTIVE sounding rocket experiment, in April 1998, demonstrated innovative measurement techniques to be used by the Thermal Plasma Analyser (launched in July 1998) and Optical Spectrograph and Infrared Imaging (OSIRIS - scheduled for launch in February/March 2000).

In Atmospheric Environment, a high-altitude balloon flight (MANTRA) of a series of instruments aimed at measuring an abundance of chemicals participating in stratospheric ozone chemistry, was successfully conducted in August 1998. Data analysis is now being performed to provide further insights into long-term changes in the stratosphere. The Canadian Wind Imaging Interferometer (WINDII) instrument, aboard NASA's Upper Atmospheric Research Satellite (UARS) launched in 1991, continued to successfully acquire data on the upper atmosphere dynamics.

***SCISAT-1* Spacecraft - In the *SCISAT-1* mission, three competing conceptual design studies were completed in August 1998 and the Atmospheric Chemistry Experiment (ACE) mission was selected in November 1998.**

In the *SCISAT-1* mission, three competing conceptual design studies were completed in August 1998 and the Atmospheric Chemistry Experiment (ACE) mission was selected in November 1998. Subsequent industrial design activities were initiated in March 1999 through contracts to ABB Bomem from Quebec City for the design of the scientific instrumentation and to Bristol Aerospace Limited of Winnipeg for the development of the craft.

In Earth Observation, using data from *RADARSAT-1*, a major Canadian knowledge industry is emerging. In 1998-1999, this sector included some 175 companies selling products and services for an estimated $350 million. At least 40% of its revenues are derived from export sales.

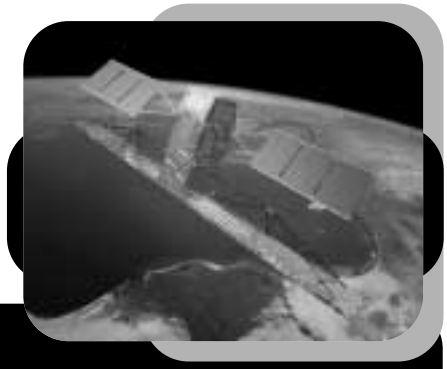
RADARSAT International Inc. (RSI) has won a 15 per cent share of the competitive space-based information products market, in just three years. In 1998-1999, RADARSAT commercial data orders grew to more than $15 million, based on approximately 8,000 scenes processed for all clients including the Canadian government. RADARSAT International Inc. (RSI) and its team of 75 international distributors and eight certified network stations serve 500 clients in 52 countries. Royalties, while still significantly below original projections, grew to $2.1 million.

In Earth Observation, using data from *RADARSAT-1*. A major Canadian knowledge industry is emerging.

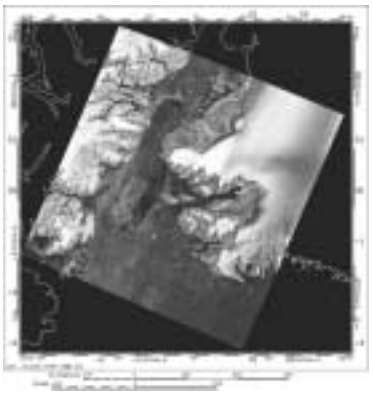
With operational maturity, RADARSAT operating costs decreased significantly in 1998-1999. At the same time, several major enhancements improved performance. For example, with the certification of two new ground stations, the RADARSAT network now covers most of the Earth's landmass. Telecommunications for the ground stations were improved, with data compression techniques that bring near real-time delivery to customers, and the capability to transfer low resolution browse imagery electronically from the receiving stations to the CCRS web-accessible service in Ottawa. There was a complete upgrade of the hardware and production software of the Mission Management Office / Data Base Management planning system.

New Earth Observation (EO) services include the "Disaster Watch", in which CSA acquires data on an anticipated basis to meet growing interest in RADARSAT services for emergency response. There was also a successful test of SENTRY, a transportable RADARSAT data receiving and processing ground station, in an operational demonstration during a NATO military training exercise in Nova Scotia. This equipment, which provides real-time delivery, processing and interpretation of RADARSAT-based surveillance data, opens up a range of new markets for RADARSAT.

The RADARSAT Background Mission has launched a second continental coverage program as the next step in creating an archive of seasonal RADARSAT data as well as providing stereo coverage. In 1998, over 4,000 RADARSAT images were provided to the Canadian Ice Service (CIS) for crucial task of monitoring offshore ice, saving the CIS an estimated $7 million in data acquisition costs.



In Febuary 1998, MacDonald Dettwiler & Associates (MDA) was selected as the prime contractor to build and operate *RADARSAT-2*.



A well-developped North Water Polynya in Northern Baffin bay is shown in this ScanSAR Wide image. In 1998, over 4,000 RADARSAT images were provided to the Canadian Ice Service (CIS) for crucial task of monitoring offshore ice, saving the CIS an estimated $7 million in data acquisition costs.

In February 1998, MacDonald Dettwiler & Associates (MDA) was selected as the prime contractor to build and operate *RADARSAT-2*. The Master Agreement, signed December 1998, has a firm fixed price contract with a government contribution of $225 million in exchange for data. MDA is investing $80 million, and is responsible for spacecraft operations and business development. The CSA is responsible for arranging the launch and maintaining a national archive of *RADARSAT-2* data.

Under the RADARSAT User Development Program (RUDP), four contracts were completed out of the 21 active projects. The average return on investment for the 39 projects approved to date is 1.8. Highlights include PCI Geomatics Group achieving $2.3 million in revenue from a $300,000 contract and Atlantis Scientific Systems Group generating over $3.5 million from global sales of products and services to provide digital elevation models and subsidence/absidence studies.

The RADARSAT Application Development and Research Opportunity (ADRO) program has addressed data applications, particularly in hydrology, surveillance, agriculture, environment, and mapping. ADRO's activities culminated with its final symposium in October 1998 in Montreal, attended by over 300 delegates from industry, government and academic organizations from 39 countries who presented findings from some 200 projects.

CEONet provides users with real-time Internet access to satellite sensor data databases. In 1998-1999, CEONet realized an 18% increase in product databases and archives (5,742 products), a 21% increase in organizations involved (now estimated at 1,155 suppliers), a 130% increase in searchable databases (109), and a sevenfold increase in user sessions per day. The EO Pilot Projects program supports the operational use of data to improve resource management and environmental protection, and to assist the industry in promoting its products and services. In 1998-1999, the program funded 20 RADARSAT based projects. The User Education and Training Initiative program demonstrates the role of remote sensing data in operational environments. For instance, in 1998-1999, a CD-ROM was developed to cover basic imaging radar theory and RADARSAT application examples for researchers and educators.

In 1998-1999 a number of Canadian proposals for atmospheric and surface environment missions were submitted to the European Space Agency under the Earth Explorer Opportunity Program and the Earth Watch Program. Nine new contracts, valued at $1.8 million, were awarded to Canadian companies by ESA in the Earth Observation sector. The ESA Envisat satellite, in which Canadian industry is participating, is now scheduled for launch in November 2000.

HUMAN PRESENCE IN SPACE

Canada's astronauts, as multi-talented, very dedicated individuals, are standard bearers for the space program. In 1998-1999 they made frequent public appearances at media events, professional associations and educational institutions. They visited thousands of students across Canada, giving high visibility to the space program and providing role models inspiring young people to pursue careers and interests in space.

Canadian Space Agency (CSA) astronaut Chris Hadfield (left) and Mr. Alain Dubeau, MSS Manager(Mobile Servicing System) (CSA) examine the Canadian SSRMS components delivered to NASA at the Space Station Processing Facility (SSPF).

Canada's participation in the International Space Station, which extends the human presence in space, is expected to generate some $6 billion of economic benefits, and 70,000 person-years of employment. Contracts of $919 million have been awarded to industry to date, generating $2.8 billion in benefits and 32,000 person-years of employment.

Canada's new space robotic arm, the Space Station Remote Manipulator System (SSRMS), was delivered to NASA's Kennedy Space Center in Florida, Sunday May 16, 1999.

In 1998-1999, Canada delivered the first part of its contribution, the Space Station Remote Manipulator System (SSRMS), to the Kennedy Space Center (KSC) in May 1999 (with a three month slippage due to unexpected technical problems). Work on the Mobile Base System (MBS) was slowed down to support the SSRMS delivery, and a new MBS schedule is being developed. Critical Design Review of the Special Purpose Dextrous Manipulator was successfully completed in December 1998. The Artificial Vision Unit was delivered to Kennedy Space Center in December 1998, and the STVF Critical Design Review was completed in March 1999.

Astronaut Dave Williams flew on STS-90 Neurolab in April 1998 and was approinted Director Space and Life Science in August 1998.

Astronaut Dave Williams flew on STS-90 Neurolab in April 1998 and was appointed Director Space and Life Science in August 1998. Astronauts Steve Maclean and Julie Payette graduated as Mission Specialists in April 1998. Astronaut Julie Payette's flight on STS-96 was launched in May 1999. Astronaut Marc Garneau was assigned to STS-97 scheduled for launch in March 2000 and Astronaut Bjarni Tryggvason joined Mission Specialist training class in September 1998.

Terrestrial applications and utilization of space robotics have been observed and documented in several fields of activity as a result of Canada's International Space Station participation. Examples include:

Hazardous Environments - Spar Aerospace from Brampton, Ontario worked with the US Department of Environment to supply light and medium duty utility arms for radioactive environments, robotic excavators, and robotic inspection and maintenance vehicles.

Food Inspection - Canpolar East Inc. of St. John's, Newfoundland developed a high speed, high resolution vision system whose primary application will be automated groundfish fillet inspection. The Parasensor system combines machine vision and expert system technologies.

Automobile Refuelling - International Submarine Engineering Ltd, from Port Coquitlam, BC, developed the first autonomous robotic automobile refuelling robot. It is now being installed at a new Shell service centre in Sacramento, California. With more than 6,000 eligible self-serve gas stations in the US alone, Shell expects it will become the largest production consumer robot in the world.

Television Equipment - Miranda Recherches Inc., from Ville St-Laurent, Quebec, developed Espace, a product which allows the visualization of up to four video images on a single high resolution monitor, and to manage and modify these images in real-time through a Windows™ type graphical interface.

Transport Planning - Dynacon Enterprises Ltd., from Downsview, Ontario, developed an automated expert system operation planning software. The software was used in cooperation with a major food supply company to plan the routes, schedules and loading sequence of delivery trucks which supply a network of supermarkets.

Medical Radiology - CIFRA Medical Inc., from Ste-Foy, Quebec, has developed a digital imaging system for medical radiology. The High End Medical Imaging System can offer numerical medical X-ray images in real time.

SATELLITE COMMUNICATIONS

Last year, the Canadian Space Agency, in cooperation with the Communications Research Centre of Industry Canada awarded contracts to five companies (CAL Corp., Com Dev, Nortel, EMS, and Telesat) under the Advanced SatCom program. Most of the 5 contracts have now achieved system requirement preliminary design reviews, and tangible results are being achieved.

For example, Nortel, along with subcontractors EMS and Norsat, won a $25 million contract with SES Astra for the Ka-band return channel system (ARCS), comprising the gateway and a number of user terminals for their new ASTRA-NET multimedia satellite system in Europe.

Last year, the Canadian Space Agency, in cooperation with the Communications Research Centre of Industry Canada awarded contracts to five companies (CAL Corp., Com Dev, Nortel, EMS, and Telesat) under the Advanced Satcom Program. Most of the 5 contracts have now achieved system requirement preliminary design reviews, and tangible results are being acheived.

There is a limitation on government obligations (LOGO) for the Advanced SatCom program funding until the *RADARSAT-2* launch issue is resolved. This LOGO has not been fully lifted and this situation is creating a challenge to the continuity of the program. This LOGO explains why SatCom expenditures ($25.6 million) were significantly below budget ($33.5 million) in 1998-1999.

In the European Space Agency (ESA) SatCom programs, Canada has seven projects ongoing (in ESA ARTES-3 and 5) totalling $6.3 million, and 18 projects worth over $4 million were won by Canadian companies in 1998-1999.

Under the International Mobile Program, a new Request For Proposals was issued, and ten contracts were awarded totalling $3.8 million in government funds over the next two years. The companies, EMS (Cal Corp and Spar Aerospace), Narrowband, Skywave Mobile Communications and ITS Electronics, estimate that the spin-offs derived from these contracts could reach $10 million.

In the European Space Agency (ESA) SatCom programs, Canada has seven projects on-going (in ESA ARTES-3 and 5) totalling $6.3 million, and 18 projects worth over $4 million were won by Canadian companies in 1998-1999. Examples include the innovative REMSAT project of MacDonald Dettwiler & Associates and the BC Forest Service, which combines Satcom, Earth Observation and Global Positioning System to manage disasters in remote areas. Recently, SPAR (now EMS) won a $2.3 million contract for the development of a multimedia satellite demultiplexer in partnership with Italy's Alenia Aerospazio.

GENERIC/ENABLING SPACE TECHNOLOGIES

This Service Line supports space hardware programs and industrial development through focussed in-house R&D and industry contracting-out projects.

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Contracted research is the main support to R&D in industry. It includes various stages of technology development from initial concepts to product testing and implementation. Most of this research is conducted by Small and Medium Enterprises (SME), and involves joint funding from other government organizations, private groups and foreign partners. Two major initiatives addressed Canadian participation in future resource management and atmospheric pollution measurement missions:

- A series of 9 contracts were awarded notably for optical and data processing technologies for participation in hyperspectral missions (i.e. ARIES, SIMSA).

- A collaborative Optech, Spar (now EMS) and Passat Inc. effort is developing large deployable telescope and detection technologies for the joint CSA/NASA LaRC ORACLE project to measure ozone profiles in the atmosphere.

The following are examples of R&D projects funded by the Contracted-Out Programs:

- CAL Corp (now EMS) has developed a very large area antenna concept using deployable double membrane technology, which reduces the weight and cost of Synthetic Aperture Radar (SAR) satellites.

- CIS Scientific Inc is developing a magnetically driven micro-electromechanical microwave switch for very high reliability operations and a substantial reduction in spacecraft resource requirements (mass, volume, and power).

- Hymac Ltd has a new approach to automated laser digitizing called RapidScan, for application in space vision systems and robotic controls as well as terrestrial scanning of objects to create digital models.

- EMS is developing a system that will provide interactive multimedia services via satellites. Applications include tele-instruction, tele-medicine, access to multimedia databases and general public entertainment.

- Xiphos and Dynacom are developing technologies to operate remotely located equipment via satellite and Internet communications links. The first application is an open-pit excavator operated by Syncrude in Alberta; a second application will be a space testbed robot, located at MacDonald Dettwiler & Associates in Brampton, Ontario.

Demonstrating new technologies in space missions and gaining space-qualified status are critical goals for this Service Line. Several exciting new technology developments expected to fly on up-coming space flights were started or advanced during 1998-1999. Further, planning has started for the launch of a micro-satellite every two years to provide a platform for space qualification. The following are examples of projects supported by this program:

- A group made of the Communications Research Centre (CRC), QTEC Hybrid Systems, Telesat Canada, Future Workshops, Network Technologies and Memorial University has set up and run tele-education and tele-medicine pilot operations using new satellite technologies such as Internet via satellite and interactive satellite multimedia systems.

- A collaboration involving the National Optics Institute, Neptec Design, and Optech is developing technologies for space qualified laser vision system to prepare for the next generation of vision systems aimed at assisting with docking and servicing tasks on the Shuttle and the International Space Station.

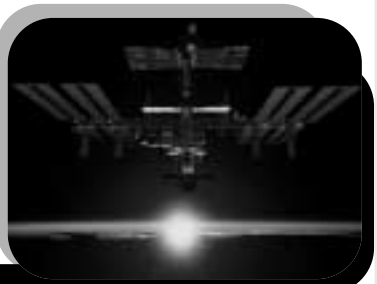
- SED Systems is designing and building a deep space S\X-band antenna system for the ESA's telemetry, tracking & command facilities in Australia.

The Commercialization Office manages over 120 active patent and licensing files. In 1998-1999, it emphasized expanding the markets of our space companies and applying space technology to other applications. The results: over $20 million in direct spin-off commercial sales, 22 licences for CSA-owned technologies, and 15 patents.

Following the sale of Spar Aerospace (Brampton) to MacDonald Dettwiler & Associates (MDA), the Office successfully renegotiated the International Space Station technology licensing agreements which led to a stronger industry commitment to commercially exploit this technology.

The Space Technology In-House programs act as scientific and program authorities for some $60 million worth of projects involving over 250 companies, universities and research centres. The In-House program also supports the training of young engineers and technicians. In 1998-1999, 20 students were sponsored to work at the CSA on various technology development projects.

General budget return on the European Space Agency (ESA) programs has improved to 96% following the award of the "Harsh Environments Initiative" contract to C-CORE and the contract to SED Systems to supply ESA's second antenna in Perth, Australia. The C-CORE mid-term review was completed with great success and this project is regarded by the European Space Agency as a model for technology transfer.



The International Space Station (ISS), the largest international scientific program, is being jointly built by Canada, the United States, Russia, Japan, and 11 European member states of ESA (European Space Agency). Its solar arrays will generate 110 kw. Its laboratory and habitation modules will support a permanent international crew of seven astronauts. It will be a platform for Earth and space observation, and for investigations leading to new materials and medicines possible only with microgravity.

SPACE QUALIFICATION SERVICES

The David Florida Laboratory (DFL) continued to support the delivery of Canada's space hardware and to provide Canadian industry, especially SMEs, direct and ready access to its state-of-the-art environmental test facility.

Among the notable accomplishments in 1998-1999 was the completion of environmental qualification testing of the Space Station Remote Manipulator System (SSRMS).

A notable accomplishment in 1998-1999 was the completion of environmental qualification testing of the Space Station Remote Manipulator System (SSRMS). Thermal, thermal vacuum, vibration and electro-magnetic qualification testing was performed on joints, latching end effectors and motor modules. Also, preliminary tests were conducted on the Special Purpose Dextrous Manipulator.

For *RADARSAT-2*, discussions to firmly establish DFL's role were held with representatives of MDA/Orbital Sciences about the spacecraft bus, with EMS about the spacecraft payload, and the *RADARSAT-2* Project Office. Discussions were also under way with Orbital Sciences regarding possible assembly, integration and test support work on other programs of this company.

Internationally, the David Florida Laboratory sought off-shore partnerships both for cost recovery and spin-offs to Canadian companies. The response to date has been positive with several foreign clients such as Alenia Spazio (Italy), CASA (Spain), Com Dev (Europe), and Orbital Sciences (US) committing to work at the DFL.

In enhancing its test technology, the David Florida Laboratory has responded to client/program requests and requirements by:upgrading radio frequency measurement capabilities in the higher end extremely high frequency (EHF) band; beginning development of a photogrammetry test capability for measuring thermal distortion of large reflector systems; improving ambient pressure thermal test capability to permit combined environment testing; planning and starting a cylindrical near field antenna measurement system; installing a new temperature/humidity chamber; and developing a new temperature/vibration test capability. Initiatives such as these will ensure that Canadian companies continue to have access to the latest in qualification test technology.

While anticipated work from SCISAT, Advanced Shape Antenna System and Skybridge did not yet materialize; they may require DFL support in the coming year. Fortunately, other programs not anticipated during the fiscal year such as EMS (formerly CAL Corp) CALTRAC Startracker, Koreasat antennas (Telesat Canada/Spar), and the ESA's SICRAL Program served to ensure that the David Florida Laboratory remained fully loaded.

COMPTROLLERSHIP AND AWARENESS

In Budget 99, the Canadian Space Agency received additional funding of $430 million over three years and a stable envelope of $300 million annually thereafter. This decision ensures that Canada will continue to be active in space in the new century.

On the international scene, negotiation were under way regarding the renewal of the cooperation with France and Japan, and Canadian participation in the UNISPACE III Conference on space. (From left to right:) Lara C. Hayter, Communications Consultant for CSA, and Jacqueline Bannister, Director of Communications, CSA stand in front of the Canadian pavilion at UNISPACE III, in Vienna in July 1999.

UNISPACE III brought together leaders in the aerospace industry and was visited by nearly 2,000 senior company officers and political representatives from 185 member states of the United nations. The Canadian Space Agency hosted 12 of its partners at the Canada Pavilion. (From right to left:) Mr. Hugues Gilbert, President's Office and Mr. Mac Evans, President, Canadian Space Agency, discuss with guests and industry representatives at the Canada Pavilion.

On the international scene, negotiations were under way regarding the renewal of the cooperation agreement with the European Space Agency, the enhancement of bilateral cooperation with France and Japan, and Canadian participation in the UNISPACE III Conference. Strategies to support space exports and international marketing efforts of numerous companies were developed and implemented. Strategic reports on the "State of the Canadian Space Sector for the year 1997" and "Global Sectoral Market Trends" were published, and the 1998 report on the regional distribution of government space-related contracts was developed. Strategic industrial policies were directed towards specific space sub-sectors.

The Canadian Space Agency raised awareness among Canadians of their country's space achievements and the benefits of space activities. Major Canada-wide public and media events were carried out in support, among others, of STS-90 with Dave Williams, STS-96 with Julie Payette, construction of the International Space Station and for the national SpaceDay. (CSA astronaut Chris Hadfield addresses students during national Space Day 1998 at CSA headquarters in Saint-Hubert, Quebec.)

The Canadian Space Agency raised awareness among Canadians of their country's space achievements and the benefits of space activities. Major Canada-wide public and media events were carried out in support of: STS-90 and 96; the construction of the International Space Station; Canadian payload science missions aboard STS-95; *RADARSAT-1*; and for the National Space Day. A major effort was mounted for the CSA's 10th anniversary, combined with preparations for Mission STS-96 involving astronaut Julie Payette. Coordinating with other government departments and involving external partners greatly added to the CSA's outreach and allowed for more citizen-focussed communication efforts.

The CSA encouraged studies and careers in science and technology through activities for primary, secondary and post-secondary students. Contests, scholarships, challenges and community events encouraged the active participation of Canadian youth, their parents and their teachers in science and technology. The five Canadian Space Resource Centres supported regional outreach programs.

In corporate management, the Planning and Performance Assessment cycle has been fully implemented, giving CSA a better and improved capacity for planning, assessing performance and reporting to Central Agencies. The SAP/R3 financial system has been completely installed, with interfaces redefined with the clients, contract and information groups.

In Human Resources, a series of measures aimed at creating a work environment that is stimulating and where employees are recognized for their contributions and rewarded for their achievements, were implemented.

All software and equipment were inventoried and verified for Y2K compliance; necessary upgrades are in progress. In addition, the risk analysis of Saint-Hubert installations and an audit of health and security in the workplace were completed.

SECTION 4: CONSOLIDATED REPORTING

4.1 YEAR 2000 READINESS

Year 2000 preparations began in September 1997. In addition to potential Y2K problems in software, the issue of embedded systems in control, testing and laboratory equipment has been considered. A Y2K Challenge Task Force was formed in April 1998 to better coordinate the activities of all areas of the Canadian Space Agency in addressing this issue, avoid duplication and ensure that all aspects, including legal and contractual issues, are considered. Key individuals from all branches of the Agency have been assigned to participate in the Task Force, and substantial efforts have been dedicated to ensuring that CSA systems and infrastructures will be Year 2000 compliant.

To date, all departmental mission-critical systems have been tested and changes made to be Year 2000 compliant. Certification documents have been obtained from the main contractors for the in-flight and ground segment components of the International Space Station, and CSA installations have been tested. RADARSAT satellite operations systems have confirmed compliance of mission control and an end-to-end demonstration involving the CSA partners is scheduled for October 1999. No major problems have been encountered.

Contingency Plans and Business Continuity Plans have been developed for all areas of the Agency.

More information on the Year 2000 status can be obtained from the CSA Year 2000 Project Co-ordinator, Daniel J. Marion at 450-926-4861.

SECTION 5: FINANCIAL PERFORMANCE

5.1 FINANCIAL PERFORMANCE OVERVIEW

As can be seen in the tables which follow, actual spending in 1998-1999 was $68.3 million more than originally planned due to :

- implementation of *RADARSAT-2* program;
- the need to compensate for lower than anticipated royalty revenue within the *RADARSAT-1* program;
- unforseen increase in costs associated with the Canadian Space Station program.

In the 1999 Budget, the Government announced its decision to provide the CSA with stable ongoing funding.

The budget provides additional funding of $430 million over the next three fiscal years; thereafter funding will be stabilized at a level of $300 million annually.

5.2 FINANCIAL SUMMARY TABLES

Table 1: Summary of Voted Appropriations

A. Authorities for 1998-1999 - Part II of the Estimates

Financial Requirements by authority ($ millions)

Vote		1998-1999 Planned Spending	Total Authorities	Actual
	Canadian Space Agency			
30	Operating Expenditures	72.9	79.3	**72.9**
35	Capital Expenditures	172.4	244.6	**240.2**
40	Grants and Contributions	23.0	23.2	**23.2**
(S)	Contributions to Employee Benefit Plans	4.8	5.0	**5.0**
	Total Agency	**273.0**	**352.0**	**341.3**

Nota: 1) Planned Spending corresponds to Main Estimates budget.
2) Total Authorities are Main Estimates plus Supplementary Estimates plus other authorities.
3) Difference between Planned Spending and Total Authorities is mostly due to supplementary budgets obtained during the fiscal year for the Major Crown Project *RADARSAT 1* , *RADARSAT 2* and for the Canadian Space Station Program.
4) Difference between Total Authorities and Actual Spendings is mostly due to the reprofiling of funds in 1999-2000 in the Advanced Satellite Communications Program and in the Canadian Space Station Program.

Table 2: Comparison of Total Planned Spending to Actual Spending

Departmental Planned versus Actual Spending ($ millions)

Business Line	1998-1999 Planned Spending	Total Authorities	Actual
FTEs	357	391	324
Operating	77.7	84.3	77.9
Capital	175.2	247.4	242.3
Voted Grants & Contributions	23.0	23.2	23.2
Subtotal: Gross Voted Expenditures	275.8	354.8	343.4
Statutory Grants and Contributions	0.0	0.0	0.0
Total Gross Expenditures	275.8	354.8	343.4
Less:			
Respendable Revenues	(2.8)	(2.8)	(2.1)
Total Net Expenditures	273.0	352.0	341.3
Other Revenues and Expenditures			
Non-respendable Revenues	(0.4)	(0.4)	(1.1)
Cost of services provided by other departments	1.4	1.4	1.6
	1.0	1.0	0.5
Net Cost of the Program	**274.0**	**353.0**	**341.8**

Nota: 1) Due to rounding, figures may not add to totals shown.
2) Operating and Capital Expenditures include contributions to Employee Benefit Plans.
3) Total Authorities are Main Estimates plus Supplementary Estimates plus other authorities.
4) Difference between Total Authorities and Actual Spendings is mostly due to the reprofiling of funds in 1999-2000 in the Advanced Satellite Communications Program and in the Canadian Space Station Program.
5) Difference between Total Authorities and Planned Spending is mostly due to reprofiling of funds in the Major Crown Projects *RADARSAT 1* , *RADARSAT 2* and the Canadian Space Station Program.

Table 3: Historical Comparison of Total Planned Spending to Actual Spending

Planned Spending versus Actual Spending by Business Line ($ millions)

			1998-1999		
	Actual 1996-1997	Actual 1997-1998	Planned Spending	Total Authorities	Actual
Canadian Space Agency	251.0	228.9	273.0	352.0	**341.3**
Total	**251.0**	**228.9**	**273.0**	**352.0**	**341.3**

Nota: 1) Includes contributions to Employee Benefit Plans.
2) Due to rounding, figures may not add to totals shown.
3) Total Authorities are Main Estimates plus Supplementary Estimates plus other authorities.
4) Difference between Total Authorities and Planned Spending is mostly due to the reprofiling of funds for the Major Crown Projects *RADARSAT 1* , *RADARSAT 2* and the Canadian Space Sation Program.
5) Difference between Total Authorities and Actual Spending is mostly due to the reprofiling of funds in Advanced Satellite Communication and Canadian Space Station.

Table 4A: Crosswalk between Old Structure and New Structure/Planned Spending 1998-1999

Crosswalk between Old & New structures ($ millions)

	New Structure	Old Structure		
Old Structure	Space Knowledge, Applications and Industry Development	Total ($$$)	FTEs	% of Total
Space Science	32.1	32.1	40	11.8%
Space Applications and Industry Development	220.0	220.0	180	80.6%
Management	20.9	20.9	137	7.6%
New Structure Total ($$$)	273.0	273.0		
FTEs	357		357	
% of Total	100.0%	100.0%		100.0%

Nota: 1) Includes contributions to Employee Benefit Plans.
2) Due to rounding, figures may not add to totals shown.

Table 4B: Crosswalk between Old Structure and New Structure/Total Authorities 1998-1999

Crosswalk between Old & New Structures ($ millions)

	New Structure	Old Structure		
Old Structure	Space Knowledge, Applications and Industry Development	Total ($$$)	FTEs	% of Total
Space Science	30.9	30.9	43	8.8%
Space Applications and Industry Development	298.2	298.2	192	84.7%
Management	22.9	22.9	156	6.5%
New Structure				
Total ($$$)	352.0	352.0		
FTEs	391		391	
% of Total	100.0%	100.0%		100.0%

Nota: 1) Includes contributions to Employee Benefit Plans.
2) Due to rounding, figures may not add to totals shown.

Table 4C: Crosswalk between Old Structure and New Structure / Actuals 1998-1999

Crosswalk between Old & New structures ($ millions)

	New Structure	Old Structure		
Old Structure	Space Knowledge, Applications and Industry Development	Total ($$$)	FTEs	% of Total
Space Science	30.0	30.0	38	8.8%
Space Applications and Industry Development	288.5	288.5	153	84.5%
Management	22.9	22.9	133	6.7%
New Structure Total ($$$)	341.3	341.3		
FTEs	324		324	
% of Total	100.0%	100.0%		100.0%

Nota: 1) Includes contributions to Employee Benefit Plans.
2) Due to rounding, figures may not add to totals shown.

Table 5: Resource Requirements by Organization and Business Line

Comparison of 1998-1999 Planned Spending, and Total Authorities to Actual Expenditures by Organization and Business Line ($ millions)

Organization	1998-1999 Planned Spending	1998-1999 Total Authorities	1998-1999 Actual
Executive Office	1.0	1.0	**1.0**
Space Systems	130.5	194.9	**190.8**
Space Technology	82.5	82.9	**77.2**
Space Science	26.1	23.8	**23.2**
Canadian Astronaut Office	5.4	6.4	**6.1**
Space Operations	6.3	18.6	**18.6**
Corporate Functions	10.8	12.0	**11.9**
Executive Functions	10.5	12.5	**12.5**
TOTAL	273.0	352.0	**341.3**
% of TOTAL			**100.0%**

Nota: 1) Due to rounding, figures may not add to totals shown.
2) Difference between Total Authorities and Actual Spendings is mostly due to the reprofiling of funds in 1999-2000 in the Advanced Satellite Communications Program and in the Canadian Space Station Program.
3) Difference between Total Authorities and Planned Spending is mostly due to reprofiling of funds for the Major Crown Projects *RADARSAT 1* , *RADARSAT 2* and the Canadian Space Station Program.

Table 6: Respendable Revenues

Respendable Revenues ($ millions)

	Actual 1996-1997	Actual 1997-1998	1998-1999 Planned Revenues	1998-1999 Total Authorities	1998-1999 Actual
Canadian Space Agency	6.1	6.5	2.8	2.8	2.1
Total Respendable Revenues	**6.1**	**6.5**	**2.8**	**2.8**	**2.1**

Nota: 1) Variance between Total Authorities and Actual Revenues is mostly due to adverse external market forces affecting RADARSAT revenues.

Table 7: Non-Respendable Revenues

Non-Respendable Revenues ($ millions)

			1998-1999		
	Actual 1996-1997	Actual 1997-1998	Planned Revenues	Total Authorities	Actual
Canadian Space Agency	2.8	1.4	0.4	0.4	**1.1**
Total Non-Respendable Revenues	**2.8**	**1.4**	**0.4**	**0.4**	**1.1**

Nota: 1) Variance between Total Authorities and Actual Revenues is due to an increase in testing services provided on other space programs.

Table 8: Transfer Payments ($ millions)

			1998-1999		
	Actual 1996-1997	Actual 1997-1998	Planned Spending	Total Authorities	Actual
GRANTS					
Canadian Space Agency					
Grants for Space Reasearch Partnerships	0.3	0.1	0.6	0.3	**0.3**
Grants for Scholarships for space-related research	0.1	0.1	0.2	0.1	**0.1**
Grants for postdoctoral Fellowships	0.0	0.0	0.1	0.1	**0.1**
International Space University	0.2	0.2	0.2	0.2	**0.2**
Grants for the Youth Awareness Program	0.0	0.0	0.1	0.1	**0.0**
Grants to Ryerson Polytechnical University	0.2	0.2	0.0	0.0	**0.0**
Total Grants	**0.8**	**0.6**	**1.1**	**0.7**	**0.6**
CONTRIBUTIONS					
Canadian Space Agency					
Contribution to the Earth Observationnn Preparatory Program of ESA (EOPP)	1.1	1.2	0.8	1.3	**1.3**
Contribution to the European Remote Sensing Satellite Program II of ESA (ERS-02)	3.8	3.5	3.2	2.5	**2.5**
Contribution to the Preparatory Program of the First Polar Orbit Earth Observation Mission Program of ESA (POEM/ENVISAT)	12.3	5.1	6.5	6.7	**6.7**
Contribution to Data Relay and Technology Mission Program of ESA (DRTM)	1.4	0.6	0.1	0.2	**0.2**
Contribution to the Advanced Systems and Technology Program of ESA (ASTP-4)	1.2	3.3	0.0	0.0	**0.0**
Contribution to the Advanced Research in the Telecom. Systems Program of ESA (ARTES).	3.6	4.9	6.5	4.5	**4.5**
Space Science Enhancement Program.	0.0	0.0	0.0	0.2	**0.2**
Contribution to the General Support Technology Program of ESA (GSTP)	0.4	0.4	0.6	0.6	**0.6**
Contribution to the general budget of the European Space Agency (ESA)	8.1	5.5	3.8	6.0	**6.0**
Contribution for the Youth Awareness Program	0.0	0.3	0.3	0.5	**0.5**
Contributions for the Promotion of the Canadian Space Program and the Commercial Exploitation of Space Technology	0.2	0.0	0.0	0.0	**0.0**
Total Contributions	**32.0**	**24.7**	**21.9**	**22.5**	**22.5**
Total Transfer Payments	**32.8**	**25.3**	**23.0**	**23.2**	**23.2**

Nota: Due to rounding, figures may not add to totals shown.

Table 9: Capital Spending

Capital Spending ($ millions)

			1998-1999		
	Actual 1996-1997	Actual 1997-1998	Planned Spending	Total Authorities	Actual
Canadian Space Agency	165.8	140	176.5	248.6	**243.6**
Total Capital Spending	**165.8**	**140**	**176.5**	**248.6**	**243.6**

Nota: 1) Includes contributions to Employee Benefit Plans for the Canadian Space Station and RADARSAT Major Crown Projects.
2) Due to rounding, figures may not add to totals shown.
3) Difference between Total Authorities and Actual Spendings is mostly due to the reprofiling of funds in 1999-2000 in the Canadian Space Station Program.
4) Difference between Total Authorities and Planned Spendings is mostly due to the reprofiling of funds for the Major Crown Projects *RADARSAT 1* , *RADARSAT 2* and the Canadian Space Station Program.

Table 10: Capital Projects

Capital Projects ($ millions)

				1998-1999		
	Current Estimated Total Cost	Actual 1996-1997	Actual 1997-1998	Planned Spending	Total Authorities	Actual
Canadian Space Agency						
Space Science Projects		35.7	26.5	23.9	20.5	**20.3**
Canadian Space Station Program (1)	1,433.3	89.4	70.1	112.6	125.0	**121.0**
RADARSAT I (1)	609.3	14.1	14.0	1.0	12.8	**12.1**
RADARSAT 2 (2)	242.1	6.4	3.1	17.2	69.1	**69.1**
EO Support Program	54.6	12.6	14.8	12.7	12.2	**12.0**
STEAR		4.4	6.12	5.2	5.2	**5.2**
Building refit/ DFL	8.0	1.5	2.6	2.5	1.8	**2.1**
Other Capital Projects		1.6	2.2	1.4	2.0	**1.7**
Misc. Capital Projects		0.0	0.5	0.0	0.0	**0.0**
Total Capital Projects		**165.8**	**140.0**	**176.5**	**248.6**	**243.6**

Nota: 1) For the major Crown Projects, the sums include contributions to Employee Benefit Plans.
2) Due to rounding, figures may not add to totals shown.
3) Difference between Total Authorities and Planned Spending is mostly due to the reprofiling of funds for the Major Crown Projects *RADARSAT 1* , *RADARSAT 2* and the Canadian Space Station Program.
4) The difference between Total Authorities and Actual Spending is mostly due to the reprofiling of funds in Canadian Space Station Program.

Table 11: Status of Major Crown Projects

Canadian Space Station Program

1. Overview

On January 25, 1984, the President of the United States directed NASA to develop and place into orbit a permanently staffed space station. Friends and allies of the United States were invited to participate in its development and use, to share the benefits, and to promote peace, prosperity and freedom through this cooperative venture. In September 1988, Canada signed a formal agreement with the governments of the United States, member states of the European Space Agency, and Japan to participate in the International Space Station Program. Canada's contribution includes the design, construction, and operation of the Mobile Servicing System (MSS), plus responsibilities for the MSS operations during the ten year planned life of the facility and use of the Space Station.

The Canadian Space Station Program received Effective Project Approval in February, 1990. The program defines all the activities necessary to discharge Canada's obligations, including completion of the on-orbit testing and commissioning of the Mobile Servicing System (MSS), and its operation and utilization for the life of the International Space Station. By contributing the MSS to the International Space Station (ISS), Canada gains the right to use the station for scientific and technological research.

2. Lead and Participating Departments

Sponsoring Agency:	Canadian Space Agency
Contracting Authority:	Public Works and Government Services Canada
Participating Departments:	None

3. Prime and Major Sub-Contractors

Prime

Spar Aerospace (now MDR)	Toronto, Ontario

Sub-Contractors

EMS	Ste-Anne de Bellevue, Québec
MacDonald Dettwiler & Associates	Richmond, British Columbia
SED Systems	Saskatoon, Saskatchewan
IMP	Halifax, Nova Scotia
CAE	St-Laurent, Québec
Calian	Kanata, Ontario

4. Major Milestones

The following table outlines the international milestones driving the Canadian Space Station Program:

Canadian Space Station Program	Date
First Space Station element launch (FGB)	Nov 1998
SSRMS delivery to NASA	May 1999
Three person permanent international human presence capability	Mar 2000
First MSS element launch (SSRMS)	July 2000
Second MSS element launch (MBS)	May 2001
Third MSS element launch (SPDM)	May 2003
Six person permanent international human presence capability	May 2004
Seven person permanent international human presence capability	Nov 2004

5. Progress Report and Explanations of Variances

The Mobile Servicing System (MSS) consists of equipment and facilities located on the Space Station and on the ground. The on-station elements include the Space Station Remote Manipulator System (SSRMS) - a sophisticated space "arm" - and its Mobile Remote Servicer Base System (MBS), a mobile platform to support the SSRMS. Canada will also be providing the Special Purpose Dextrous Manipulator (SPDM) - a robotic "hand" that works in conjunction with the SSRMS.

The Space Station Remote Manipulator System (SSRMS) was successfully completed and delivered to the Kennedy Space Center (KSC) in May 1999. The work on the Mobile Base System has been minimized to support the delivery of the SSRMS, and a new MBS schedule is being developed. The Special Purpose Dextrous Manipulator (SPDM) Critical Design Review (CDR) was successfully completed in December 1998 and the Artificial Vision Unit was delivered to KSC in December 1998. Delays in the program since its inception are due to the complexity of accomplishing such an endeavour at the international level. This results in schedule slips at NASA which impact on the Canadian contribution.

6. Industrial Benefits

Since 1984, the program has issued about 750 contracts ($919 million), with expenditures benefiting all regions of the country, accruing socio-economic benefits of $2.8 billion and creating 32,000 jobs.

The mission of Canada's space program is to develop and apply knowledge for Canadians and humanity. Companies are already adapting Space Station technology to capture opportunities on the ground. The Strategic Technologies for Automation and Robotics (STEAR) program is actively transferring Space Station technology to firms in many different industries. STEAR was established in 1987 and it supports industry-led projects to develop dual-use automation and robotic technology, that can be applied on Earth and in space. Following are just a few examples of how companies are using their STEAR experience to create new products and processes.

Hazardous Environments - Each day, hundreds of drums containing toxic waste are produced throughout North America. In many cases, they must be stored prior to disposal. Storage warehouses can contain 12,000 or more drums, each of which must be constantly monitored to prevent leaks. Kinetic Sciences Inc. has used STEAR funding to develop the "Eagle Eye" 3-D machine vision system. Eagle Eye is mounted on a mobile robot that can roam a warehouse to identify small changes in storage drums that may signal impending failure. Spar Aerospace from Brampton, Ontario worked with the US Department of Environment applying light and medium duty utility arms for radioactive environments, robotic excavators, and robotic inspection and maintenance vehicles.

Food Inspection - Canpolar East Inc. of St. John’s, Newfoundland developed a high speed, high resolution vision system whose primary application will be automated groundfish fillet inspection. The Parasensor system combines machine vision and expert system technologies to detect irregular fillets.

Automobile Refuelling - The Shell Smart Pump, considered as one of the world's first and most sophisticated consumer robots, is a triumph of Canadian technological innovation. International Submarine Engineering Ltd, from Port Coquitlam, BC, developed the first autonomous robotic automobile refuelling robot and it is now being installed at a new Shell service centre in Sacramento, California. Shell, with more than 6,000 eligible self-serve gas stations in the US alone, expects this to become the largest production consumer robot in the world.

Television Equipment - Miranda Recherches Inc., from Ville St-Laurent, Quebec, developed Espace, a product for visualizing up to four video images on a single high resolution monitor, and managing and modifying these images in real-time through a Windows™ type graphical interface.

Transport Planning - Dynacon Enterprises Ltd., from Downsview, Ontario, developed an automated expert system operation planning software. The software was used in cooperation with a major food supply company to plan the routes, schedules and loading sequence of delivery trucks which supply a network of supermarkets.

Medical Radiology - CIFRA Medical Inc., from Ste-Foy, Quebec, has developed a digital imaging system for medical radiology. The High End Medical Imaging System can offer numerical medical X-ray images in real time. The Microgravity program provides funds for Aastra Aerospace - a small company - to see if the process for encapsulating pancreatic islet cells could be improved in microgravity. Experiments by Dr. Lin at Laval University, are using microgravity crystallization to aid breast cancer research. Dr. Lin is studying the structure of a human protein that is critically important in the conservation of sex hormones. The protein is a significant target of researchers working on cures for breast and prostate drug therapy.

Agriculture-Farmers apply large amounts of herbicides to prevent and reduce weeds in crops. Reducing herbicide use would reduce costs and improve the health of farmers - and the environment. APRO Applied Robotics of Saskatoon has developed an automated agricultural sprayer that uses machine vision to detect the presence of weeds. Now, farmers can spray only when they detect weeds, and greatly reduce their herbicide use. APRO used Strategic Technologies for Automation and Robotics (STEAR) support to develop the core technology, for use on the Space Station to identify objects outside the station.

RADARSAT 1

1. Overview

RADARSAT-1 is a Canadian-led project involving the private sector, all of the provinces, and the United States. It is the only fully operational civilian remote sensing satellite that carries Synthetic Aperture Radar. It was launched in November 1995 and is expected to operate for up to seven or eight years. It covers most of Canada every 72 hours, the Arctic every 24 hours. It operates day and night, in all weather, regardless of cloud cover, smoke, haze and darkness, to acquire high quality images of the earth. *RADARSAT-1* can gather the data needed for more efficient resource management as well as ice, ocean and environmental monitoring, disaster management and Arctic and offshore surveillance.

RADARSAT also supports fishing, shipping, oil and gas exploration, offshore drilling, mapping and ocean research. The development and operation of this system are expected to provide more than $1 billion in benefits to the Canadian private and public sectors. In addition, $56.9 million is expected in revenues to support the development and operations of *RADARSAT-1*. This includes $16.5 million in royalties on worldwide sales of data, $10.0 million from RADARSAT International Inc. for equipment, and $30.4 million from provincial governments for work related to satellite construction. *RADARSAT-1* royalty revenue has increased from less than $2.0 million in 1997-1998 to $2.1 million in 1998-1999.

2. Lead and Participating Departments

Sponsoring Agency:	The Canadian Space Agency
Contracting Authority:	Public Works & Government Services
Participating Departments:	Environment Canada Natural Resources Canada

3. Prime and Major Sub-Contractors

Prime

Spar Aerospace (EMS)	Ste-Anne de Bellevue, Québec

Sub-Contractors

SED Systems	Saskatoon, Saskatchewan
Lockheed Martin	Longueuil, Québec
EMS	Ste-Anne de Bellevue, Québec
MacDonald Dettwiler & Associates	Richmond, British Columbia
Com Dev	Cambridge, Ontario
RADARSAT International Inc. (RSI)	Richmond, British Columbia
Ball Aerospace	Boulder, Colorado, USA

4. Major Milestones

Phase	Description	Date
A	Preliminary studies	Completed
B	Feasibility and concept definition	Completed
C1	Systems requirement and preliminary design	Completed
C2	Development and testing up to Qualification Test Review	Completed
D1	Manufacture of the proto flight subsystems up to acceptance testing of the subsystems	Completed
D2	Assembly and integration of the subsystems up to Flight Readiness Review, plus post-launch and commissioning activities up to System Acceptance	Completed
E	Operations	April 1996 to March 2001 or later
	First Antarctic mission	Completed

5. Progress Report and Explanation of Variances

Effective Program Approval was obtained for *RADARSAT-1* in March 1991. It was launched in November 1995 and began operations in April 1996. The initial system included receiving stations for Synthetic Aperture Radar (SAR) data in Prince Albert (Saskatchewan), Gatineau (Québec) and Fairbanks (Alaska). CSA and RADARSAT International Inc. have since signed agreements with network stations in Australia, Norway, the United Kingdom, Singapore, China, South Korea, Saudi Arabia, Thailand and Japan for the direct reception of the RADARSAT data.

Routine operations of *RADARSAT-1* commenced in April 1996, following a commissioning period. *RADARSAT-1* has supplied timely and high quality data to RADARSAT International Inc., the private sector company that sells this data worldwide, and to the program partners (federal and provincial government departments, NASA and the National Oceanic and Atmospheric Administration). RADARSAT has fulfilled a total of 51,567 user requests. An estimated 99,837 minutes of data from over 17,768 orbits has been acquired. Average system performance is 96%. The worldwide client base includes more than 500 commercial and government users from 50 countries.

Operational improvements made to the RADARSAT system in 1998 include cutting payload command data (RCD) delivery timeframe from more than 50 hours to 29, and improving the response time and robustness of the spacecraft's attitude control system. There was a complete upgrade of the hardware and production software of the Mission Management Data Base Management (MMO/DBM) planning system, resulting in a faster and more powerful system which is now accessible 24 hours a day (up from 12 hours in 1998) for request transmittal and tracking to the eight international network stations and five order desks. A new Disaster Watch was also created in order to prepare a database for possible disasters in Canada and abroad.

The RADARSAT system is designed to provide four-hour turnaround in the electronic delivery of images to the Canadian Ice Service for producing ice charts for the Canadian Coast Guard. In operation, delivery time is averaging 1.2 hours from the time the image is acquired by the satellite, and is often within one hour. During 1998, the Canadian Ice Service used over 4,000 image frames of RADARSAT data and supplied more than 64,000 image products and 9,000 charts to its 300 clients. It has been estimated that RADARSAT is saving more than $7 million per year in data acquisition costs to the Canadian Ice Service.

The RADARSAT Background Mission is archiving substantial volumes of images for future use. This includes the first Synthetic Aperture Radar coverage of the world's continents, their continental shelves and the polar ice caps, as well as some islands and their surrounding oceanographic features. RADARSAT is creating an archive of global multi-mode and multi-season SAR data. The Background Mission is also supplying a global stereo data set of the world's landmass. Nearly 75 per cent of North America and Western Europe has been covered, providing data suitable for mapping a wide range of terrain conditions. Fine beam coverage of the world's capital and major cities began in April 1998. One hundred cities have been covered and 50 others will be done in 1999.

The first mapping of Antarctica by RADARSAT, the Antarctic 1 Mapping Mission, took place between September 9, 1997 and October 20, 1997. It has been a resounding success, far exceeding NASA's expectation both in completeness of coverage and in quality of the images. RADARSAT acquired a total of 8,000 images, 2,000 more than originally planned. The data is used to study the effects of climatological, glaciological, geological and human activity processes on the Antarctic continent. It has revealed new ice stream systems in East Antarctic, and achieved the first radar-driven map of ice division and catchment areas and extensive mega-snow dune fields. The Antarctic Mapping Mission fulfils a CSA commitment to NASA and National Ocean and Atmospheric Administration (NOAA) in return for launching *RADARSAT-1* in 1995.

RADARSAT International is using the Internet to improve access and delivery of products. To open new markets, new products and services have been introduced: RADARMaps, large area mosaics, emergency response subscription service, per km2 pricing, monitoring services and RADARSAT-derived Digital Elevation Models.

6. Industrial Benefits

SPAR and its Canadian subcontractors created over 2,000 person-years of high technology employment during the construction phase of *RADARSAT-1*. Ongoing mission operations employ 75 people at CSA Saint-Hubert, 7 in Saskatoon,15 at the ground stations in Prince Albert and Gatineau, as well as more than 80 at RADARSAT International (RSI) in Richmond BC. In a highly competitive marketplace for space-base information, RSI has won roughly 15% of the world's space borne remote sensing market in just three years. In 1998, RADARSAT commercial data orders grew to more than $10.6 million based on 8,800 scenes. RADARSAT International Inc. (RSI) and its team of 75 international distributors and eight certified network stations serve 500 clients in 52 countries. Total 1998-1999 revenues from commercial RADARSAT products and services exceeded $15 million.

The RADARSAT User Development Program has supported 37 contracts worth more than $11.4 million for the development of new applications using SAR data. To date this investment has helped bring 21 products and services to market resulting in over $11.4 million in revenues (excluding data sales) and leveraging an estimated $3 million in RADARSAT data sales. Since 1995 the User Education and Training Initiative has funded 34 projects to develop and market educational and training Earth observation materials. The Earth Observation Pilot Projects Program has supported 21 projects to transfer Earth observation technology to a broader base of industrial and operational users.

RADARSAT-2

1. Overview

RADARSAT-1, Canada's first Earth Observation satellite, launched in 1995, established Canada among the world leaders in satellite remote sensing technology. The RADARSAT system provides imagery to government and commercial users, primarily for resource management and environmental monitoring. *RADARSAT-1* has a life expectancy of 6 years.

In June 1994, the government directed the Canadian Space Agency to develop "an arrangement with the private sector for the development and operation of a RADARSAT follow-on program to maintain continuity of data following *RADARSAT-1*." In 1998, following a formal Request for Proposal, MacDonald Dettwiler and Associates (MDA) was selected to construct and manage *RADARSAT-2*.

The *RADARSAT-2* project pertains to the design, development, test, deployment and operation of a space-borne Synthetic Aperture Radar (SAR) to provide global coverage of terrestrial phenomena as a follow-on to *RADARSAT-1*. *RADARSAT-2* will continue to provide all-weather, day and night coverage of the entire globe, and to support fishing, shipping, oil and gas exploration, offshore drilling, mapping and ocean research. The long-term objective is to create a commercial industrial satellite remote sensing business in Canada. *RADARSAT-2* design and construction improves upon *RADARSAT-1* with new capabilities to ensure Canada's continued leadership in the satellite remote sensing global marketplace.

The total project cost is an estimated $305.5 million, with the government's financial contribution limited to $225 million and the balance of $80.5 million to be provided by MDA (along with any cost escalations).

2. Lead and Participating Departments

Sponsoring Agency:	The Canadian Space Agency
Contracting Authority:	Public Works & Government Services
Participating Departments:	Natural Resources Canada Environment Canada Atlantic Canada Opportunities Agency Western Economic Diversification Canada Economic Development for Quebec Region Industry Canada Fisheries and Oceans National Defence Foreign Affairs and International Trade Justice

3. Prime and Major Sub-Contractors

Prime

MacDonald Dettwiler & Associates	Richmond, British Columbia

Sub-Contractors

EMS	Ste-Anne de Bellevue, Québec
OSC	Dulles, USA
RSI	Richmond, British Columbia

4. Major Milestones

Phase	Description	Date
A and B	Requirement Definition	December 1998
C and D1	Subsystem Design and Construction	October 2000
D2	Integration and Test	June 2001
E1	Pre-Launch Preparations	November 2001
E2	LEOP and Commissioning	May 2002
E3	Operations	March 2002 to 2009

5. Progress Report and Explanation of Variances

In February 1998, MacDonald Dettwiler & Associates (MDA) was selected as the prime contractor to build and operate *RADARSAT-2*. The Canadian Space Agency and MacDonald Dettwiler & Associates signed a Master Agreement in December 1998 for the *RADARSAT-2* mission, under a firm price contract in which the government contribution is $225 million, in exchange for data. MDA is to invest $80 million. The company is also responsible for spacecraft operations and business development, while the CSA is responsible for arranging the launch and maintaining the long-term national archive of *RADARSAT-2* data. CSA will provide an additional "in-kind" contribution of certain assets, plus the services of the David Florida Laboratory and the Institute of Aerospace Research Laboratory for spacecraft integration and testing.

During 1998-99 MDA initiated a number of subcontracts with key subsystem suppliers. The requirement review for the mission and the satellite system, and the preliminary design review for the bus and the payload were completed during the past year. *RADARSAT-2* development continues on schedule.

The two main challenges facing *RADARSAT-2* are: to negotiate an alternate launch arrangement, since NASA has decided not to provide a launch; and to develop a suitable data distribution policy for *RADARSAT-2* given the potential uses of high resolution radar data.

6. Industrial Benefits

A major objective of the project is the transition of the Earth Observation business from pubic sector to the private sector. It builds on the SAR data and value-added markets established with *RADARSAT-1* to strengthen the Canadian industry's position as suppliers of SAR-related technology, systems and value-added products and services.

Specifically, manufacturing potential and competitiveness will be developed in Canadian industry in the areas of phased array antenna design/manufacture, high performance receiver/transmitter design and manufacture and enhanced structure design. Additionally, opportunities will be created for the export of small, low cost ground stations. The new capabilities also make possible new applications, creating new and expanded markets for data sales and value-added products.

The MDA proposal estimates the total industrial benefit resulting from *RADARSAT-2* at $2 billion, of which 30% is projected for small business and 60% expected to derive from export sales. This is ten times greater than the CSA's investment and represents an enormous opportunity for this business sector. Of this figure, 84% results directly from activities associated with the construction, operation and data distribution of *RADARSAT-2* with the balance coming from the use of the technology that is developed on other similar programs.

After precursor items worth $7.5 million (pre-dating the MDA) the remaining construction cost of *RADARSAT-2* spacecraft and ground segment upgrades is estimated at $298 million, of which $194 million or 65% is the objective for Canadian content.

Table 12: Contingent Liabilities

Contingent Liabilities ($ millions)

List of Contingent Liabilities	**Amount of Contingent Liability**		
	March 31 **1997**	March 31 **1998**	**Current as of** March 31-99
Claims and Pending and Threatened Litigation			
Litigations:			
T-2056/96	0.7	0.0	0.0
T-1452/97	0.0	0.7	0.0
500-05-042325-98	0.0	0.0	6.0
Total - Litigations	**0.7**	**0.7**	**6.0**
Total	**0.7**	**0.7**	**6.0**

Nota: An out-of-court settlement has occurred during the fiscal year 1996-97 concerning file T-2056/96. The cost of this settlement was $652,000.

An out-of-court settlement has occurred on March 2nd 1999 concerning file T-1452/97. The cost of this settlement was $1,573,188.

Legal proceeding in damages to the amount of $6,000,000 was initiated in June 1998 for rights infringement on an invention (file 500-05-0423525-98). Defense to the amended declaration was produced by the Crown on 29 January 1999. Discussions are presently on between the parties to try to settle the litigation. The amount of the Contingent Liabilities is estimated to $6,000,000.

6.1 CONTACTS FOR FURTHER INFORMATION & WEB SITE

Web Site: www.space.gc.ca

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Human Presence in Space
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Generic/Enabling Space Technologies
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Director General, Space Technology
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Space Qualification Services
Rolf Mamen
Director General, Space Operations
613-998-2873/450-926-6530

Comptrollership and Awareness
Jacques Bruneau
Director, Corporate Management
450-926-4407

6.2 LEGISLATION ADMINISTERED AND ASSOCIATED REGULATIONS

Canadian Space Agency Act (S.C. 1990, c. 13)

6.3 LIST OF STATUTORY ANNUAL REPORTS AND OTHER AGENCY REPORTS

Agency Performance Report for the period ending March 31 1998

1999-200 Report on Plans and Priorities

can be found at: www.space.gc.ca/ENG/Publications/menu.html

6.4 ABBREVIATIONS AND ACRONYMS

ACE	Atmospheric Chemistry Experiment
ACOA	Atlantic Canada Opportunities Agency
ADRO	Application Development and Research Opportunity
ASVS	Advanced Space Vision System
CCRS	Canada Centre for Remote Sensing
CDR	Critical Design Review
CEONet	Canadian Earth Observation Net
CIS	Canadian Ice Services
CNES	Centre National d'Études Spatiales (France)
CPA	Cold Plasma Analyser
CRC	Communications Research Centre
CSA	Canadian Space Agency
CSP	Canadian Space Program
CSVS	Canadian Space Vision System
DFL	David Florida Laboratory
DND	Department of National Defence
DUP	Data User Program
EHF	Extremely High Frequency
EMC	Elecromagnetic Compatibility
EOPP	Earth Observation Preparatory Program
EPA	Effective Program Approval
ERS	European Remote Sensing
ESA	European Space Agency
FTE	Full Time Equivalent
FUSE	Far Ultraviolet Spectroscopic Explorer
GDP	Gross Domestic Product
GSTP	General Support Technology Program
HR	Human Resources
IFMS	Integrated Financial Management System
IGA	Intergovernmental Agreement
IML	International Microgravity Laboratory
IR	Infra Red
ISAS	Institute of Space and Astronautical Science of Japan
ISIS	International Satellite for Ionospheric Sounding
ISS	International Space Station
KSC	Kennedy Space Center

LMS	Life and Microgravity Spacelab
LTSP	Long-Term Space Plan
MANTRA	Middle Atmosphere Nitrogen Trend Assessment
MBS	Mobile Base System
MCP	Major Crown Project
MDA	MacDonald Dettwiler & Associates
MEIT	Multi-Element Integration Testing
MIM	Microgravity Isolation Mount
MMLC	Multimedia Learning Centre
MMO/DBM	Mission Management Data Base Management
MOC MSS	Operations Complex
MOPITT	Measurement of Pollution in the Troposphere
MOTS	Mobile Operations Training Simulator
MSAT	Mobile Satellite
MSP	Microgravity Sciences Program
MSS	Mobile Servicing System
MSTP	European Manned Space Program
MTPE	Mission To Planet Earth
NASA	National Aeronautics and Space Administration (United States)
NASDA	National Space Development Agency (Japan)
NOAA	National Oceanic & Atmospheric Administration (United States)
NRC	National Research Council of Canada
NSERC	Natural Sciences and Engineering Research Council of Canada
NSPO	National Space Program Office
NSTS	National Sector Team for Space
OSIRIS	Optical Spectrograph and Infrared Imaging
OSC	Orbital Sciences Corporation
OSM	Operational Space Medicine
PAS	Program Activity Structure
PIM	Passive Intermodulation Measurement
POEM/ENVISAT	Polar Orbit Earth Observation Mission
PPA	Preliminary Project Approval
PSDE	Payload and Spacecraft Development and Experimentation
PWGSC	Public Works and Government Services Canada
QUELD	Queen's University Experiment on Liquid Diffusion
R&D	Research and Development
RF	Radio Frequency
RSI	RADARSAT International Inc.
RUDP	RADARSAT User Development Program
S&T	Science and Technology
SAP R/3	(Systems, Products, and Programs in Data Processing - Realtime System version 3)
SAR	Synthetic Aperture Radar
SIFAC	Space Industry Forum in Atlantic Canada
SME	Small and Medium Sized Enterprise
SMS	Supra Thermal Ion Mass Spectrometer
SOSC	Space Operations Support Centre
SPDM	Special Purpose Dextrous Manipulator
SRMS	Shuttle Remote Manipulator System
SSRMS	Space Station Remote Manipulator System

STACI	Space Technology Atlantic Canada Initiative
STEAR	Strategic Technologies for Automation and Robotics
STS	Space Transportation System
SVS	Space Vision System
TAA	Technical Assistance Agreement
TMI	Telesat Mobile International
TPA	Thermal Plasma Analyser
TRE	Torso Rotation Experiment
UARS	Upper Atmospheric Research Satellite
VCF	Visual Coordination Facility
WINDII	Wind Imaging Interferometer
Y2K	Year Two Thousand

ANNEX 1: SERVICE LINE DESCRIPTIONS

Earth and Environment - the Canadian Space Agency uses space technologies to understand, monitor, predict and protect the Earth and its environment and ensures that Canadian industry maintains its world leadership in capturing the emerging global Earth observation market. In essence, it uses space to respond successfully to the challenges of a changing planet. This contributes to the achievement of CSA results in the following areas:

- Understanding, monitoring and predicting the Earth's environment and global climate change in accordance with international commitments.
- Maintaining Canada's position as the world leader in commercial sales of space borne radar sales.
- Enhanced management of Canada's natural resources.
- Satellite information services for disaster management and marine surveillance.

Space Science - the Canadian Space Agency advances scientific knowledge in areas of strategic importance for Canada by providing Canadian scientists access to the unique environment of space. This contributes to the achievement of CSA results in the following areas:

- Major advances in astronomy and astrophysics.
- Better understanding of our solar system in relation to the origins of life and the Earth's environment.
- Improved public health by advancing life sciences and biotechnologies.
- Internationally competitive industries by developing new materials and improving manufacturing technologies.

Human Presence in Space - the Canadian Space Agency provides a meaningful and visible contribution to international efforts aimed at establishing a human presence in and beyond low Earth orbit, ensuring this contribution will bring tangible benefits to Canada. This contributes to the achievement of CSA results in the following areas:

- World leadership in space robotics.
- International recognition of Canada's essential role in the Space Station.
- Commercial exploitation of knowledge and technologies developed.
- Ongoing participation in future human space missions.

Satellite Communications - the Canadian Space Agency ensures that all Canadians have access to new communications technologies and services, and positions Canadian industry to capture a significant part of the new global communications markets. This contributes to the achievement of CSA results in the following areas:

- Strategic niche technologies for next generation satellite services.
- Increasing revenues for the Canadian SatCom industry.

Generic/Enabling Space Technologies - the Canadian Space Agency develops innovative and emerging technologies to ensure the growth and competitiveness of the Canadian space industry, to meet potential needs of the Canadian Space Program and to maximize commercialization of space technologies in both space and non-space applications. This contributes to the achievement of CSA results in the following areas:

- Innovative leapfrog technologies essential to meeting future Canadian needs and for ensuring an internationally competitive space industry.
- Technologies that reduce the risk and cost of future programs.

Space Qualification Services - the Canadian Space Agency provides an environmental test facility capable of meeting the current and emerging needs of Canada's space community and the nation's space related objectives. This contributes to the achievement of CSA results in the following areas:

- Recognition of Canada's leadership in space technology and research.
- Provision of solutions to the demands of space clients.

Comptrollership and Awareness - the Canadian Space Agency ensures that the Agency performs its role as the leader of the Canadian Space Program. It articulates strategic direction for the Agency, coordinates program development, furnishes management, financial and other administrative support services, and ensures the necessary integration of all activities of the Canadian Space Program. This contributes to the achievement of CSA results in the following areas:

- A Space Program that is responsive to the needs of the Canadian public.
- Accountability to Parliament and ultimately the Canadian public for the management of government resources dedicated to the Canadian Space Program.
- Effective decision-making through a focus on results, flexible control systems, objective performance assessment and thorough risk identification and management.
- Awareness of the importance of space technology in all regions of Canada.
- Domestic and foreign partnerships to support the implementation of the Canadian Space Program.
- Support for the space industry's domestic and export development efforts.
- Equitable regional industrial development.