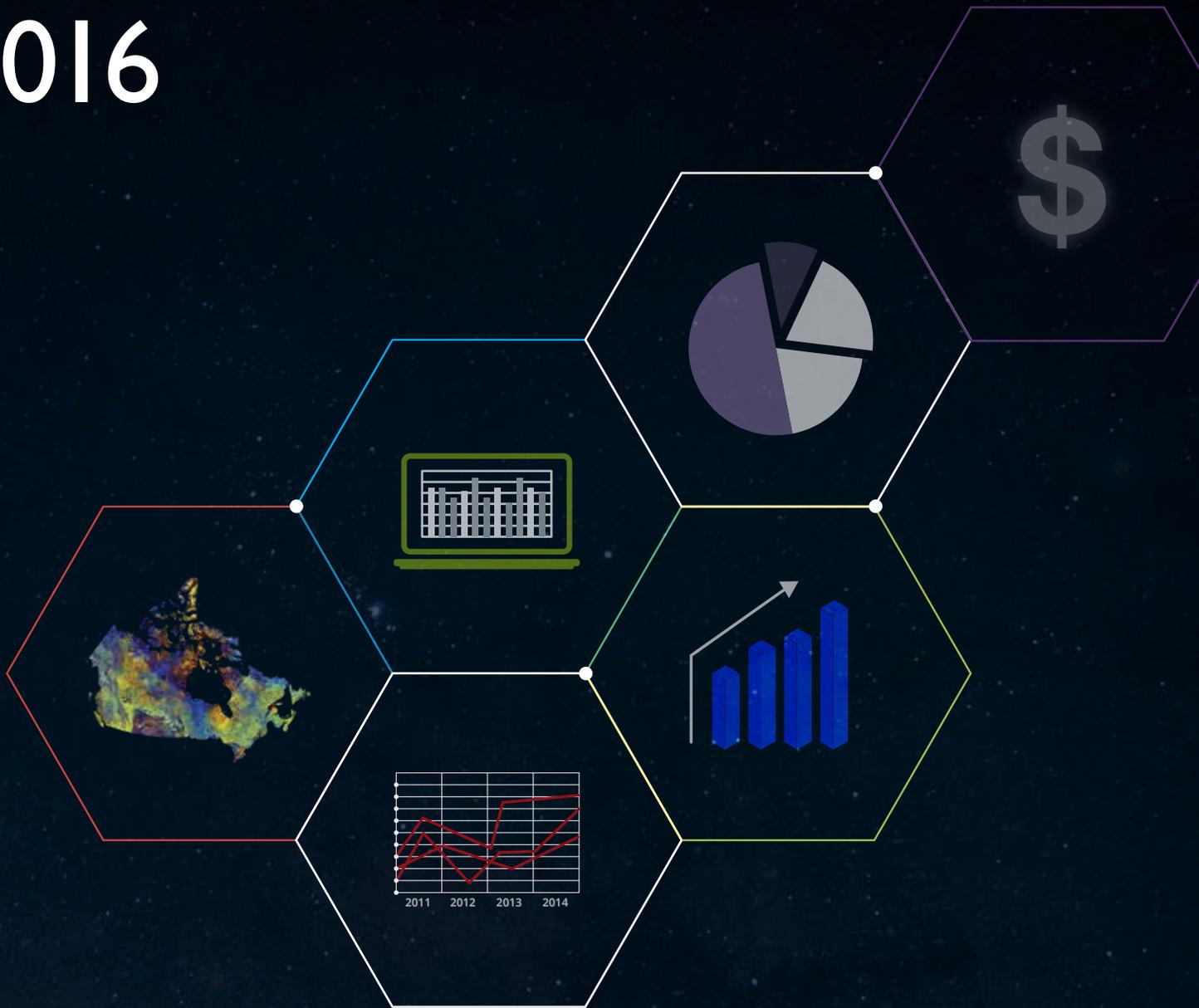




STATE OF THE CANADIAN SPACE SECTOR REPORT 2016



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TABLE OF CONTENTS

■	ABOUT THIS REPORT	2
	Objective	2
	About the Authors	2
■	PRESIDENT'S MESSAGE	3
■	EXECUTIVE SUMMARY	4
■	ECONOMIC IMPACT ANALYSIS	7
	Economic Impact – Gross Domestic Product	7
	Economic Impact – Jobs Created	8
■	OVERALL RESULTS	9
	Total Revenues	9
	Total Workforce	10
	Regional Distribution and Trends	13
	Revenues by region	14
	Workforce by region	17
■	RESULTS BY TYPES OF ORGANIZATIONS	18
	Canada's Leading Space Organizations	18
	Small and Medium-Sized Enterprises (SMEs)	18
	Universities and Research Centres	19
■	REVENUES BY MARKETS AND CUSTOMERS	21
	Market Share by Value-Chain Category	21
	Market Share by Sector of Activity	22
	Market Share by Customer Location	26
	Export regions	27
	Market Share by Customer Type	28
■	INNOVATION	31
	Business Expenditures on R&D (BERD) (Companies Only)	31
	R&D Intensity Level (Companies Only)	32
	Commercialization of Externally Funded R&D Projects (All Organizations)	32
	Inventions and Patents (All Organizations)	32
	Patents in Space: Highlighting Innovation in the Canadian Space Sector	33
■	ANNEX A: ECONOMIC TRENDS 2014–2016	37
■	ANNEX B: METHODOLOGY	43
	Economic Impact Analysis	43
■	ANNEX C: DEFINITIONS	45
	Definition of Canada's Space Sector	45
	Definition of Space Value-Chain Categories	45
	Definition of Sectors of Activity	46

ABOUT THIS REPORT

OBJECTIVE

The *State of the Canadian Space Sector Report* provides factual information about the Canadian space sector. The report, which is now in its 20th edition, is based on a questionnaire sent to organizations involved in space activities across Canada, including companies, not-for-profit organizations, research centres and universities. This year's report is based on data from 150 organizations.

The Report includes data on the number of organizations active in the sector and their composition, the sectors of activity, the Canadian space workforce and its composition, research and development (R&D) and innovation. In this edition, data on economic trends are reported for the 2014–2016 period. Readers should consult previous editions (available on the Canadian Space Agency website) for information regarding results prior to 2014.

The organization-specific information used to compile this report remains strictly confidential and will not be released in any manner other than aggregate form. Consequently, in certain circumstances, a detailed explanation or in-depth reporting of the results cannot be provided in order to protect the confidentiality of the respondents.

ABOUT THE AUTHORS

Policy Branch

This report is produced by the Economic Analysis and Research Team, Policy Branch, at the Canadian Space Agency.

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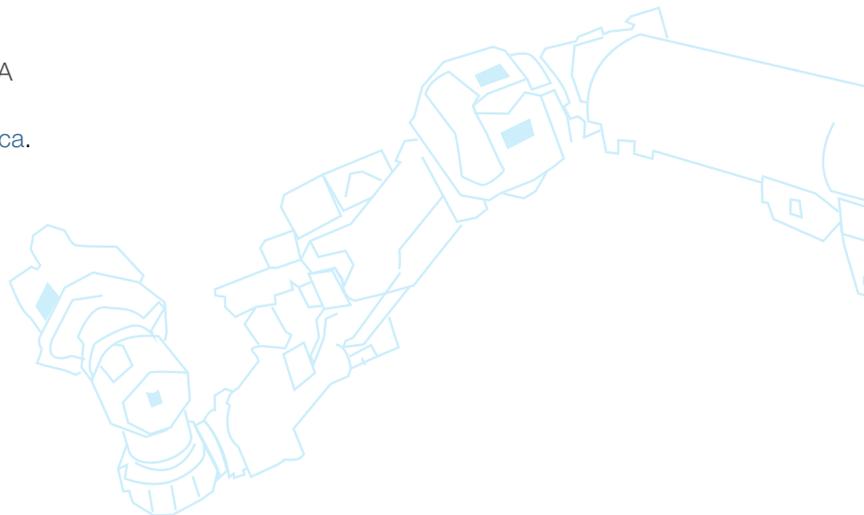
Please send media inquiries to CSA
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FOR MORE INFORMATION

For more information about the Canadian space sector, or for an electronic copy of this report, please go to www.asc-csa.gc.ca/eng/publications.

ACKNOWLEDGMENTS

The CSA wishes to acknowledge all those who responded to the questionnaire. Without them, this report would not have been possible.



PRESIDENT'S MESSAGE

As the President of the Canadian Space Agency (CSA), I am pleased to present the *State of the Canadian Space Sector Report*, covering the results from our 2016 survey. The annual *State of the Canadian Space Sector Report*, which is now in its 20th edition, is the primary reference on the Canadian space sector. It contributes to our understanding of the sector by providing policy-makers and stakeholders with reliable and authoritative data.

The 2016 report is based on information gathered from 150 organizations involved in space activities from across Canada, including small businesses, multinational space companies, not-for-profit organizations, research centres and universities. It details the economic activity generated in the Canadian space sector and highlights the impact of space investments on the economy.

The survey results indicate that the space sector generated revenues of \$5.5B with a workforce of nearly 10,000. Upstream segment activities related to research, engineering and manufacturing generated revenues of \$0.9B, while downstream segment operations, products and services accounted for \$4.6B. Export sales emerged as a significant area of growth in 2016, while domestic revenues decreased slightly from 2015. Overall, the space sector contributes \$2.3B to Canada's GDP and supports close to 22,000 jobs in the greater national economy.

The space sector is highly innovative and generates products and services that benefit Canadians every day. The 2016 survey results show that Business Expenditures on Research and Development (BERD) remained stable, with investments of \$254M in R&D. Industry commercialization of R&D projects that were initially funded by public monies more than doubled in 2016, reaching \$123M. The academic sector also continued to be an important part of the space sector, representing nearly 20% of the workforce and three of the sector's top 30 space organizations in terms of space-related revenues or research funding.

I trust you will find this publication informative and useful. I would like to thank all those who contributed to the 2016 survey. This publication would not be possible without the generous collaboration and input of members of the Canadian space industry and academia.



EXECUTIVE SUMMARY

KEY TAKEAWAYS

- > In 2016, the space sector contributed \$2.3B to Canada's GDP and supported a total of 21,654 jobs.
- > In 2016, total revenues in the Canadian space sector came to \$5.5B.
- > The Canadian space workforce totalled 9,883 space-related full-time equivalents (FTEs), of which 41% are HQP.
- > Business Expenditures on R&D (BERD) settled at \$254M in 2016, a minor decline from the previous year.
- > In 2016, Canadian space companies derived \$123M in revenues through the commercialization of externally funded R&D projects, a significant growth from 2015.
- > Space sector organizations reported a total of 183 inventions in 2016, of which 42% were patented.

In 2016, total revenues in the Canadian space sector came to \$5.5B, representing an overall increase of 4%, or \$232M, year-over-year. The average annual growth rate of the space sector between 2014–2016 was relatively low, at 1.36%.

Domestic revenues decreased by 4% year-over-year and totalled \$3.5B in 2016. Non-government revenue, at 87%, continued to make up the majority of domestic revenues. The remaining 13% of domestic revenues were derived from Canadian governments (federal, provincial and municipal), mostly through federal funding.



NASA

April 19, 2016, marked the 15th anniversary of the launch of Canada's iconic second-generation robotic technology, Canadarm2. (2016-04-19)



CSA

It was announced on May 16, 2016, that Canadian astronaut David Saint-Jacques will be the next Canadian to fly to space in 2018. This mission will be David's first time in space and will mark the 17th space flight for the Canadian astronaut corps. (2016-05-16)

Export revenues in 2016 increased by 24%, totalling nearly \$2B. Export revenues increased in all regions except Quebec, where exports declined for a third year in a row. Ontario organizations accounted for 54% of Canadian space exports, followed by the Atlantic region with 14%. Non-government customers were the most important market segment abroad, accounting for 92% of upstream segment revenues and 90% of downstream segment revenues.

The workforce totalled 9,883 space-related full-time equivalents (FTEs) in 2016, of which 41% are classified as highly qualified personnel (HQP). Overall, the workforce was relatively evenly divided between the upstream and downstream segment organizations with 51% and 49% of the total workforce, respectively. The profile of the workforce is different in the upstream and downstream segment. In the upstream segment, 57% of the workforce were HQP, while in the downstream segment, 25% of workforce were HQP. Academic organizations contributed 19% of the total space sector workforce with 1,871 full-time equivalents, of which 54% were highly qualified personnel (HQP) such as engineers, scientists and technicians.

In terms of sectors of activity, revenue growth occurred in Navigation, Earth Observation and Satellite Communication in 2016. Decreased revenues occurred in Space Science, Space Exploration and Other.

The upstream segment accounted for \$0.9B in revenues. Revenues derived from manufacturing activities (a subset of the upstream segment) totalled \$711M, representing a 6% growth over 2015 results. The downstream segment accounted for the majority of revenues at \$4.6B in 2016. Of note, broadcasting service revenues were \$2.5B in 2016, representing a 53% share of the downstream segment.

In 2016, the top 30 Canadian space organizations generated 97% of total space revenues and 79% of space employment, a pattern consistent with previous years despite changes in the composition and rank of the top 30 space organizations.

Small and medium-sized enterprises (SMEs) accounted for 92% of all Canadian space companies in 2016, 67% of which were upstream segment companies and 33% were downstream segment companies. Together, SMEs accounted for 44% of Canadian space sector revenues and 29% of all employees.

Research and development (R&D) expenditures totalled \$254M in 2016, with 63 organizations undertaking space R&D projects. This represents a slight decrease over 2015 results, with R&D expenditures down by \$2M. Downstream organizations were responsible for the majority of R&D spending, accounting for 58% of total space sector business expenditures on research and development (BERD).

Upstream organizations accounted for the majority of inventions and patents, with 70% of all inventions reported and 60% of patents filed. However, downstream organizations patented a higher share of their inventions. In 2016, 56% of inventions from downstream organizations were patented, while only 36% of inventions were patented in upstream organizations.

In 2016, the space sector was estimated to have contributed \$2.3B to Canada's GDP and supported a total of 21,654 jobs in Canada's greater economy.



On June 17, 2016, the CSA announced a new astronaut recruitment campaign, which ended with the announcement of two new Canadian astronauts in the summer of 2017. (2016-06-17)

ECONOMIC IMPACT ANALYSIS

KEY TAKEAWAYS

- > In 2016, the space sector contributed \$2.3B to Canada's GDP and supported a total of 21,654 jobs.

The methodology used for the following economic impact analysis is detailed in Annex B

ECONOMIC IMPACT – GROSS DOMESTIC PRODUCT

In 2016, the space sector contributed \$2.3B to Canada's GDP, which represents the value of all *final* goods and services produced by the space sector *within* Canada. Total GDP contribution was broken down into the following:

- > \$1.21B in space sector impacts;
- > \$0.58B in supply industry impacts; and
- > \$0.54B in impacts related to consumer spending by associated employees.

The space sector creates benefits in the larger economy with a GDP multiplier of 1.92 (Total GDP Impact / Space Sector GDP Impact). In other words, every dollar that the space sector contributes to the GDP generates another \$0.92 in GDP contribution from other organizations in the economy.



On June 21, 2016, Canada's Maritime Monitoring and Messaging Microsatellite (M3MSat) was launched successfully by the Indian Space Research Organisation. M3MSat's mission is to improve Canada's space-based capabilities to detect ships and manage marine traffic. (2016-06-22)

ISRO

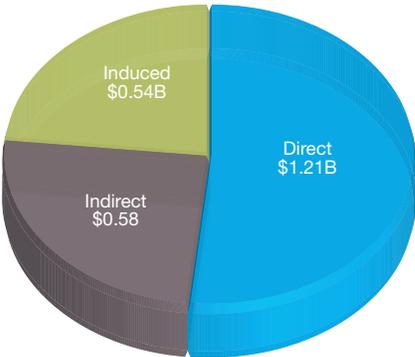
ECONOMIC IMPACT – JOBS CREATED

In 2016, the space sector supported a total of 21,654 jobs in Canada. The total workforce contribution was broken down into the following:

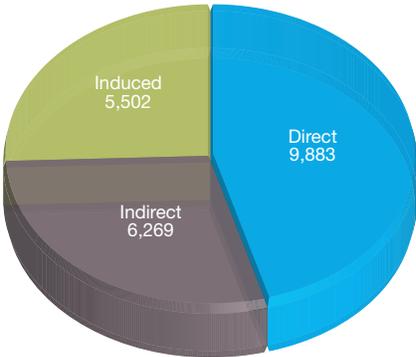
- > 9,883 space sector jobs;
- > 6,269 supply industry jobs; and
- > 5,502 jobs created and supported as a result of consumer spending by associated employees.

The space sector therefore creates jobs in the larger economy with a workforce multiplier of 2.19 (Total Workforce Impact / Space Sector Workforce Impact). In other words, every job in the space sector supports another 1.19 jobs in the economy.

Total GDP Impact: 2016



Total Workforce Impact: 2016



OVERALL RESULTS

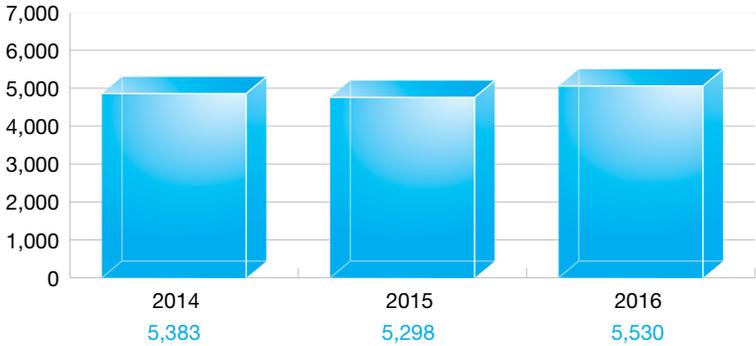
KEY TAKEAWAYS

- > In 2016, total revenues in the Canadian space sector came to \$5.5B, a 4% increase over 2015 results.
- > The Canadian space workforce remained stable, with a total of 9,883 space-related full-time equivalents (FTEs).
- > Highly Qualified Personnel (HQP) positions experienced a slight decline of 4%, totalling 4,085 FTEs. HQP represent 41% of the total Canadian space workforce.
- > While Ontario and Quebec are the two provinces with the highest space revenues, Atlantic Canada and British Columbia experienced the highest growth in 2016.
- > Quebec and Ontario account for the majority of space sector jobs.

TOTAL REVENUES

In 2016, total revenues in the Canadian space sector came to \$5.5B, representing an increase of 4%, or \$232M, year-over-year. The average annual growth rate of the space sector between 2014 and 2016 was moderate, at 1.36%.¹ A detailed analysis of the source of this growth can be found in the section of this report on Revenues by Markets and Customers.

Total Space Revenues: 2014–2016

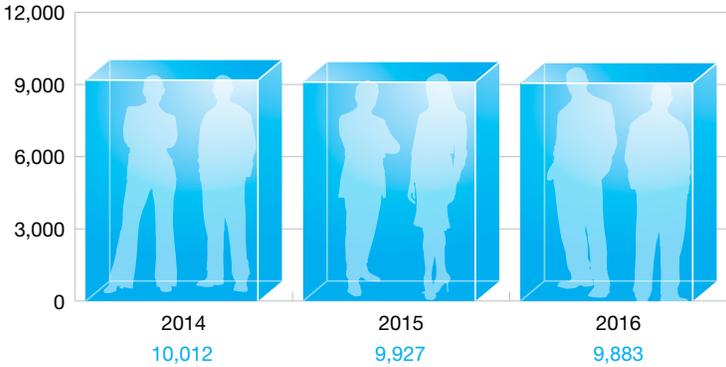


¹ Calculated using Compound Annual Growth Rate (CAGR).

TOTAL WORKFORCE

In 2016, the Canadian space workforce remained stable, decreasing by less than 1%, with a total of 9,883 space-related full-time equivalents (FTEs). Overall, the space sector workforce is almost evenly divided between upstream and downstream segment organizations with 51% and 49% of the total workforce, respectively. Note that workforce data does not include government employees.

Workforce: 2014–2016

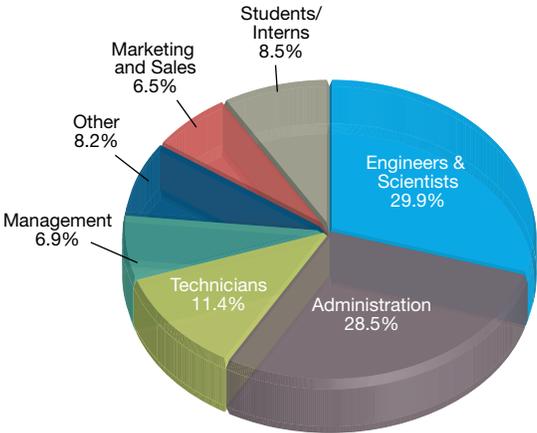


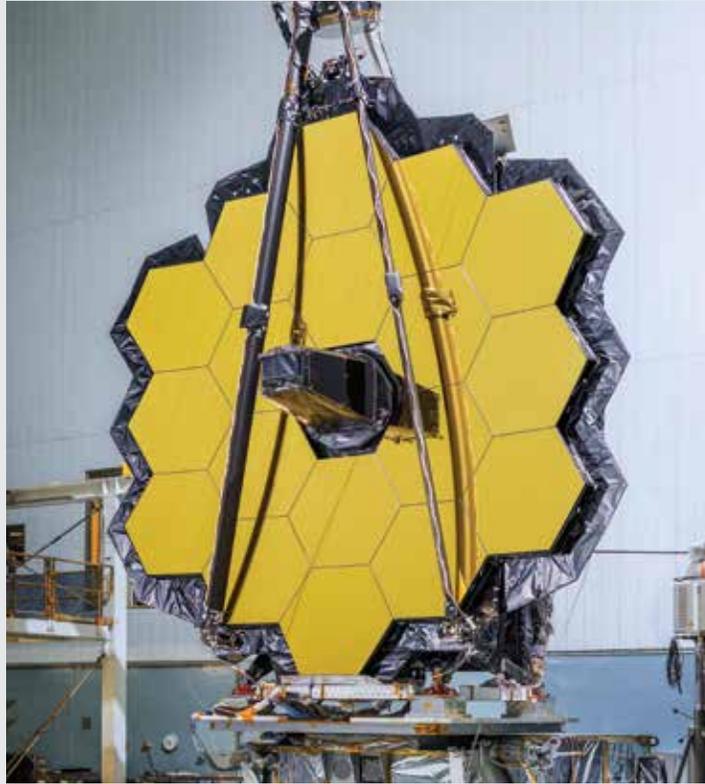
Workforce Groups

In 2016, engineers and scientists comprised the largest category of employment with 2,954 FTEs, representing 30% of the total space workforce. Employees in the administration category made up the second largest group with 2,820 FTEs and 29% of the total workforce. Technicians came third with 1,131 FTEs and 11% of the total workforce. Management, marketing and sales, and other employees made up the remainder.

The charts and graphs below provide a breakdown of the space sector workforce in 2016.

Workforce by Space Employment Category: 2016





NASA / Chris Gunn

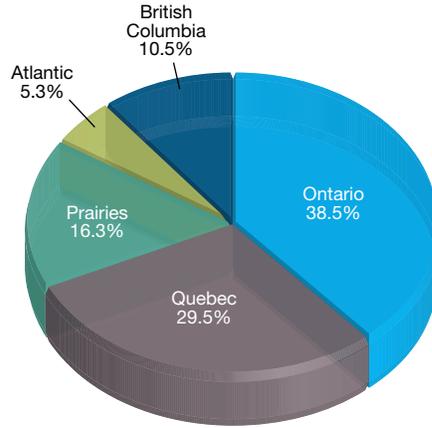
On October 31, 2016, NASA completed the construction of the James Webb Space Telescope. Extensive testing on the telescope will follow to prove that it will work in space. The Webb telescope is an international collaboration between NASA, the European Space Agency (ESA) and the CSA and is the most complex and powerful telescope ever built. (2016-10-31)

Highly Qualified Personnel (HQP)

The HQP measurement tracks the number of engineers, scientists and technicians employed in the space sector. In 2016, HQP positions experienced a slight decline of 4%, settling at 4,085 FTEs. HQP represent 41% of the total Canadian space workforce. In terms of upstream and downstream segments, the share of HQP is an important indicator that differentiates the profile of the workforce. In the upstream segment, 57% of the workforce are HQP, while 25% of the workforce in the downstream segment are HQP.

- > 39% of Canada's total space HQP work in **Ontario** while 36% of Ontario's space workforce are HQP;
- > 29% of Canada's total space HQP work in **Quebec** while 37% of Quebec's space workforce are HQP;
- > 16% of Canada's total space HQP work in the **Prairies** while 74% of the Prairies' space workforce are HQP;
- > 10% of Canada's total space HQP work in **B.C.**, while 69% of B.C.'s space workforce are HQP;
- > 5% of Canada's total space HQP work in **Atlantic** Canada while 31% of Atlantic Canada's space workforce are HQP.

Highly Qualified Personnel Space Workforce in Canada 2016

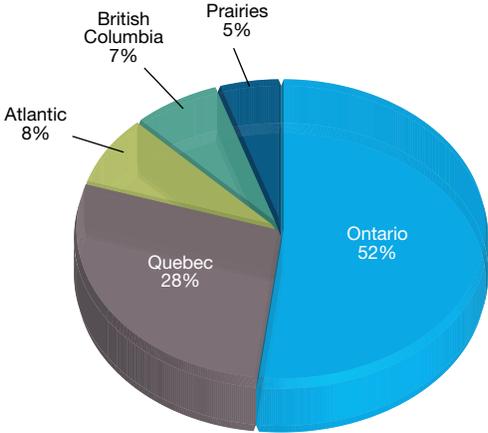


HQP: 2016				
	Total Workforce	Total HQP	% of HQP Relative to its own Region	% of HQP Relative to National HQP
B.C.	624	428	68.6%	10.5%
Prairies	894	664	74.3%	16.3%
Ontario	4,407	1,574	35.7%	38.5%
Quebec	3,256	1,204	37.0%	29.5%
Atlantic	702	215	30.6%	5.3%
Total	9,883	4,085		

REGIONAL DISTRIBUTION AND TRENDS

The proportional share of total revenues and employment by province remained relatively stable from year to year.

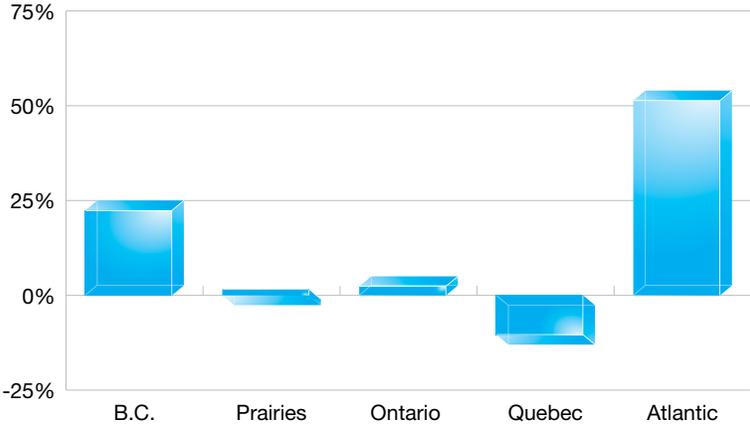
Regional Proportion of Total Revenues: 2015–2016



Revenues by Region, Domestic vs. Export (in M\$): 2015–2016

	2015		2016	
	Export	Domestic	Export	Domestic
B.C.	106	174	201	186
Prairies	192	68	225	41
Ontario	916	1,841	1,066	1,784
Quebec	225	1,442	220	1,339
Atlantic	156	179	273	195

Percentage Change of Total Revenues by Region: 2014–2016



REVENUES BY REGION

British Columbia

In 2016, British Columbia had revenues of \$387M, representing an increase of 38% (\$106M) over 2015 revenues. Domestic revenues increased by 7%, or \$12M, from \$174M in 2015 to \$186M in 2016. Export revenues increased by 89%, or \$95M, from \$106M to \$201M between 2015 and 2016.

Between 2014 and 2016, B.C.'s total revenues increased by 25% from \$309M to \$387M. This growth was driven by export revenue, which increased from \$83M to \$201M, while domestic revenues decreased by 18%, from \$226M to \$186M, over the same period.

Seven percent of Canadian space sector revenues can be attributed to B.C., where the number of upstream and downstream segment respondents is approximately equal. Contrary to other regions, upstream segment organizations generated more revenues (55%) than downstream segment organizations (45% of revenues).



CSA, Neptec

The Canadian Space Agency (CSA) has commissioned the design of an advanced vision system for Dextre, the International Space Station's (ISS's) robotic handyman. Roughly the size of a microwave oven, the vision system combines a 3D laser, a high-definition camera and an infrared camera to reveal damage that is hidden to the naked eye and in places that are hard to reach or difficult to see in the harsh lighting conditions on board the ISS. (2016-01-07)

Prairies (Alberta, Saskatchewan and Manitoba)

Revenues in the Prairies grew by 2%, or \$6M, over last year, totalling \$266M in 2016. Domestic revenues decreased by 39%, or \$27M, from \$68M in 2015 to \$41M in 2016; export revenues increased by 17%, from \$192M in 2015 to \$225M in 2016.

- > Alberta revenues increased by 5%, or \$9M, from \$169M to \$178M;
- > Saskatchewan revenues increased by 19%, or \$11M, from \$59M to \$70M;
- > Manitoba revenues decreased by 45%, or \$14M, from \$31M to \$17M.

Between 2014 and 2016, total revenues in the region remained stable, with a slight decrease of 1%. Revenues totalled \$268M in 2014 compared to \$266M in 2016. Domestic revenues declined from \$101M in 2014 to \$41M in 2016, while exports grew by 35%, from \$167M to \$225M in the same period.

Five percent of Canadian space sector revenues can be attributed to the Prairies. Forty percent of space revenues in the province came from the upstream segment, while 60% came from the downstream segment.

Ontario

Revenues in Ontario grew by 3%, or \$92M, over last year and totalled \$2.9B in 2016. Domestic revenues decreased by 3%, or \$58M, from \$1.84B in 2015 to \$1.78B in 2015; exports grew by 16%, from \$916M in 2015 to \$1.1B in 2016.



CSA

The Canadian Space Agency (CSA) tested the autonomous navigation software developed by MDA, a Canadian company. From Canada, thousands of kilometres from the field site, the Mars Exploration Science Rover (MESR) operations team sent commands to the robot to test the software's capabilities. (2016-11-18)

Total revenues in Ontario increased by 5% between 2014 and 2016. This growth was driven by export revenues, which grew by 17%, from \$913M to \$1.1B, with domestic revenues remaining stable at \$1.8B.

Fifty-two percent of Canadian space sector revenues can be attributed to Ontario. There are more than twice as many upstream segment organizations as downstream segment organizations represented in the survey for the Ontario region. However, downstream segment organizations account for 88% of revenues in the province due to significant revenue in satellite operations, manufacturing of satellite communication hardware (such as satellite terminals), and broadcasting services. Upstream organizations account for the remaining 12% of revenues.

Quebec

Revenues in Quebec declined by 6%, or \$107M, over last year, settling at \$1.56B in 2016. Domestic revenues decreased by 7%, or \$102M, from \$1.44B in 2015 to \$1.34B in 2016; exports declined by 2%, from \$225M in 2015 to \$220M in 2016.

Between 2014 and 2016, Quebec's total revenues decreased by 13% from \$1.8B to \$1.6B. This decline was driven by a 14% decline in domestic revenues, which went from \$1.6B in 2014 to \$1.3B in 2016. Export revenues also decreased by 7%, from \$238M to \$220M, over the same period.

Twenty-eight percent of Canadian space sector revenues can be attributed to Quebec. Quebec has four times as many upstream segment organizations as downstream segment organizations, while revenues are heavily concentrated in the downstream segment (86%) rather than in the upstream (14%).

Atlantic Canada (New Brunswick, Newfoundland, Nova Scotia and PEI)

In 2016, revenues in the Atlantic region increased by 40%, or \$133M, settling at \$468M. With an increase of 75%, or \$117M, from \$156M in 2015 to \$273M in 2016, export revenues drove growth. Domestic revenues grew by 9%, or \$16M, from \$179M in 2015 to \$195M.

- > Newfoundland accounted for the revenue growth in the region, with an increase of 72% year-over-year, and revenues reaching \$305M.
- > Revenues in New Brunswick grew by 5% year-over-year, with revenues totalling \$158M.
- > Revenues in Nova Scotia decreased by 29%, settling at \$6M.

Between 2014 and 2016, total revenues in the Atlantic region grew by 54%, or \$164M, which can be attributed to growth in both domestic and export revenues. Domestic revenues grew by 32%, from \$148M in 2014 to \$195M in 2016, while export revenues grew by 75%, from \$156M in 2014 to \$273M in 2016.

Eight percent of Canadian space sector revenues can be attributed to the Atlantic region. In Atlantic Canada, there are a few small to medium-sized upstream segment players, which are mainly academic, and a handful of downstream segment organizations. Downstream segment organizations account for 97% of revenues and upstream segment organizations the remaining 3%.

WORKFORCE BY REGION

- > **British Columbia:** 6% (624 FTEs) of Canada's space workforce, a growth of 6%, or 34 employees, over last year.
- > **Prairies:** 9% (894 FTEs), an increase of 3% (27 employees).
- > **Ontario:** 45% (4,407 FTEs), a decrease of 4% (-174 employees).
- > **Quebec:** 33% (3,256 FTEs), a decrease of 1% (-42 employees).
- > **Atlantic Canada:** 7% (702 FTEs), an increase of 19% (111 employees).

Workforce Group by Region: 2016									
	Management	Engineers & Scientists	Technicians	Marketing and Sales	Administration	Other	Students/ Interns	Total	
B.C.	60	318	110	28	53	0	55	624	6.3%
Prairies	62	601	64	4	29	41	94	894	9.0%
Ontario	317	1,065	509	298	1,261	494	464	4,407	44.6%
Quebec	202	834	371	223	1,325	138	164	3,256	32.9%
Atlantic	41	137	78	90	153	142	61	702	7.1%
Total	682	2,954	1,131	643	2,820	815	838	9,883	100%



Engineers inspect the second of three RCM satellite buses in the Magellan facility. Batteries are visible in the foreground, wrapped in thermal blankets. A reaction wheel is on the left. (2016-02-11)

RESULTS BY TYPES OF ORGANIZATIONS

KEY TAKEAWAYS

- > Canada's top 30 companies account for 97% of revenues and 79% of the workforce.
- > 92% of Canadian space companies are SMEs. They account for 44% of Canadian space sector revenues and 29% of all employees.
- > Universities and research centre revenues amounted to \$107.3M in 2016, representing 1.9% of total revenue. They contributed 19% of the total space sector workforce in 2016 with 1,871 full-time equivalents.

CANADA'S LEADING SPACE ORGANIZATIONS

In 2016, Canada's top 30 space organizations generated 97% of space revenues and 79% of space employment, a pattern consistent with previous years despite changes in the composition and rank of the top 30 space organizations. Most of the top 30 organizations are companies; however, several academic organizations are also represented. Half of the top 30 companies are in the upstream segment and the other half are in the downstream.

By comparison, the top 10 organizations accounted for 83% of total space revenues and 50% of employment. Revenue and workforce concentration in the top 10 organizations was similar to 2015, when those organizations accounted for 90% of revenues and 50% of workforce. Eight of the top 10 are downstream segment companies.

Large companies, classified as having 500 employees or more, are rare in the space sector. Only 8% of the company survey population were classified as large enterprises.

Sixty-four organizations reported space revenues in excess of \$1M during 2016.

SMALL AND MEDIUM-SIZED ENTERPRISES (SMEs)

Ninety-two percent of Canadian space companies are SMEs, and indeed many of Canada's top space companies are SMEs (defined as employing 1 to 499 workers). SMEs are concentrated most heavily in research, engineering and consulting activities in the upstream segment and in the production of value-added products, applications and services in the downstream segment: 67% of the SMEs surveyed are upstream segment companies, while 33% are downstream segment companies. Together SMEs accounted for 44% of Canadian space sector revenues and 29% of all employees in 2016.

Space SMEs are highly innovative, corresponding to 65% of all space business expenditures on R&D (BERD). Upstream segment space SMEs account for 9% of total BERD, while downstream segment SMEs account for 57% of total BERD in the space sector. Space SMEs are also export-driven, with 64% of their sales reaching customers abroad. The downstream segment is significantly more export oriented, with 57% of revenues destined abroad, compared to 7% in the upstream segment.

The SME workforce is highly skilled and specialized with 50% of its workforce classified as HQP (compared to 32% of the workforce in large firms).

UNIVERSITIES AND RESEARCH CENTRES

Universities and research centre revenues amounted to \$107.3M in 2016, representing 1.9% of total revenue, with three universities making it into Canada's top 30 space organizations. Universities and research centres received \$100.1M in domestic funds, mostly from government: \$80.3M from the federal government and \$8.6M from provincial governments. The remainder came from private foundations or companies.

In addition, universities and research centres accessed \$7.1M in funding from foreign sources. American organizations were an important source of support for space-related activities in Canadian universities and research centres, with funds totalling \$2M. European organizations were the second largest contributor, with funds totalling \$0.8M (half of which came from the European Space Agency). The remaining funding came from other world regions.

Academic organizations contributed 19% of the total space sector workforce in 2016 with 1,871 FTEs, of which 54% are HQP. An additional 41% of the university and research centre workforce was comprised of students, mostly at the graduate level, who were in receipt of wages or a stipend from their university for work as research assistants, teaching assistants, or other employee-type situations.



NASA/Goddard Space Flight Center

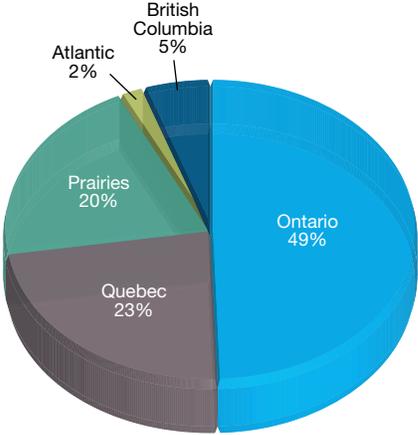
Approximately two weeks following its launch, OSIRIS-REx's five science instruments, including Canada's OLA, were powered up and operated for the first time – a crucial step in confirming that the spacecraft survived the rigours of launch. (2016-09-30)

Regarding regional distribution, universities and research centres in Ontario captured 49% of space-related funding and 43% of the workforce. Organizations in Quebec accounted for 23% of space-related funding and for 25% of workforce. Universities and research centres in the Prairies accounted for 20% of space-related funding and for 21% of workforce. B.C. and Atlantic regions captured 5% and 2% of space-related funding, respectively, and they both accounted for 6% of workforce. The pie charts below illustrate the regional distribution trends.

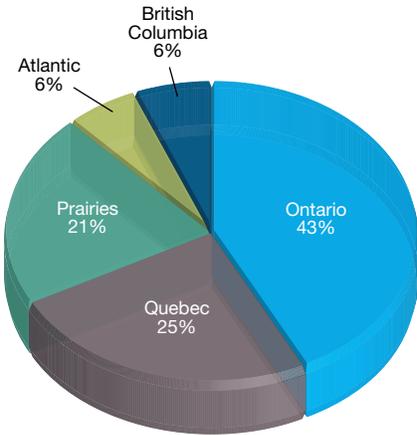
Of the 36 university and research centre respondents, seven reported coming up with inventions in 2016, four of which filed for patents. In total, Canadian universities and research centres generated 27 inventions and filed 10 patents.

Universities and research centres are categorized as part of the upstream segment of the value chain, as they are mostly engaged in research and engineering. However, it is important to note that some universities and research centres also participate in downstream segment activities, such as satellite operations and the development of software and algorithms to transform space data into a space solution.

Regional Distribution of Space-Related Funding at Universities and Research Centres: 2016



Regional Distribution of Space-Related Workforce at Universities and Research Centres: 2016



REVENUES BY MARKETS AND CUSTOMERS

KEY TAKEAWAYS

- > In 2016, the upstream segment generated roughly \$0.9B in revenues, while the downstream segment generated \$4.6B in revenues.
- > While the services sub-segment accounted for the majority of revenues in 2016, growth mostly occurred in the ground system manufacturing and value-added products and applications segments.
- > In terms of sectors of activities, most revenues came from Satellite Communication. However, Earth Observation experienced the highest growth in 2016.
- > In 2016, Canadian space exports increased by 24%, reaching \$1.98B. That growth was driven by Canadian exports to Europe, although the U.S. remained the main export destination.
- > Overall, 12% of the space revenues in 2016 were derived from government sources and 88% from non-government sources.

MARKET SHARE BY VALUE-CHAIN CATEGORY

Space sector revenues can be broken down into value-chain segments and sub-segments based on the type of work that the organization is carrying out in order to produce goods and services. The two main segments are upstream and downstream activities. The upstream segment in Canada – comprised of the research, engineering and consulting as well as space and ground segment manufacturing sub-segments – was worth roughly \$0.9B in 2016. The downstream segment – comprised of the satellite operations, manufacturing of products (e.g. terminals), development of software applications, and the provision of services (e.g. broadcasting) sub-segments – was worth \$4.6B in 2016. A detailed description of the value-chain categorization is provided in Annex C.

Revenues in each sub-segment can be broken down as follows:

- > Research, Engineering and Consulting amounted to \$209M in 2016, a 2% growth (\$4M) from 2015. This sub-segment accounts for 4% of total revenues.
- > Space Segment Manufacturing amounted to \$514M in 2016, a 5% decline (\$27M) from 2015. It accounts for 9% of total revenues.
- > Ground Segment Manufacturing amounted to \$196M in 2016, a 55% growth (\$70M) from 2015. It accounts for 4% of total revenues.
- > Satellite Operations amounted to \$935M in 2016, a 5% decline (\$50M) from 2015. It accounts for 17% of total revenues.
- > Products and Applications amounted to \$916M in 2016, a 47% growth (\$291M) from 2015. It accounts for 17% of total revenues.
- > Services amounted to \$2.8B in 2016, a 2% decline (\$57M) from 2015. It accounts for 50% of total revenues.

MARKET SHARE BY SECTOR OF ACTIVITY

In terms of sectors of activity, revenue growth occurred in Navigation, Earth Observation and Satellite Communication in 2016. Decreased revenues were felt in Space Science, Space Exploration and Other. Trends for the 2014–2016 period are detailed below. As with findings presented throughout this report, the breakdown is provided at current market prices (i.e. unadjusted for inflation).

Satellite Communication

Of the \$4.6B in Satellite Communication revenues, the vast majority (91%) was derived from activities in the downstream segment, broken down as follows:

- > Satellite Operations: \$926M
- > Applications and Products (e.g. antennas): \$590M
- > Broadcasting Services: \$2.45B
- > All other telecommunication services: \$250M

The remainder of Satellite Communication revenues was related to upstream segment activities:

- > Research, Engineering and Consulting: \$47M
- > Space Segment Manufacturing: \$240M
- > Ground Segment Manufacturing: \$136M

Satellite Communication revenues grew by 4%, or \$180M, between 2015 and 2016, and account for 84% of total space revenues. Between 2014 and 2016, Satellite Communication revenues experienced a slight growth of 3%, or \$138M, from \$4.5B to \$4.6B.

Earth Observation (EO)

In 2016, EO revenues reached \$495M, the majority of which were in the upstream segment:

- > Research, Engineering and Consulting: \$52M
- > Space Segment Manufacturing: \$224M
- > Ground Segment Manufacturing: \$57M

The remainder of revenues was related to activities in the downstream segment:

- > Satellite Operations: \$7M
- > Applications and Products: \$138M
- > Services: \$17M

EO revenues grew by 17%, or \$73M, from 2015 to 2016, and account for 9% of total space revenues. Between 2014 and 2016, EO revenues experienced a slight decline of 4%, or \$20M, from \$516M to \$495M.

Space Exploration

Space Exploration revenues settled at \$102M in 2016. This sector of activity is almost exclusive to the upstream segment with 99% of revenues, as follows:

- > Research, Engineering and Consulting: \$58M
- > Space Segment Manufacturing: \$42M
- > Ground Segment Manufacturing: \$1M

The remainder of activities, which relate to the downstream segment, amounts to roughly \$1M from Satellite Communication and products or applications that use exploration themes or data.

Space Exploration revenues decreased by 9%, or \$10M, from 2015 to 2016, and account for 2% of total space revenues. Between 2014 and 2016, revenues from Space Exploration decreased by 10%, or \$11M, from \$113M to \$102M.

Navigation

In 2016, Navigation revenues totalled \$216M. Navigation is almost exclusively in the downstream segment in Canada. Products, Applications and Services are driven by consumer, business and government end-user demand. The downstream segment accounts for 96.6% of the Navigation market, broken down as follows:

- > Products and Applications: \$181M
- > Services: \$34M

The remainder of activities, which relate to the upstream segment, amounts to roughly \$1M from research, engineering and consulting.

From 2015 to 2016, revenues increased by 5%, from \$206M to \$216M, and amounted to 4% of total space revenues. Between 2014 and 2016, revenues from Navigation increased by 14%, or \$26M, from \$190M to \$216M.

Space Science

In 2016, Space Science revenues totalled \$61M. The market for Space Science is split in favour of upstream segment activities:

- > Research, Engineering and Consulting: \$46M
- > Space Segment Manufacturing: \$2M
- > Ground Segment Manufacturing: \$2M

With the remainder in the downstream segment:

- > Satellite Operations: \$1M
- > Products and Applications: \$4M
- > Services: \$6M



CSA

The Honourable Marc Garneau, Minister of Transport (second from right), visits Carré Technologies in Montreal to unveil a next-generation technology designed for human space flight. He is accompanied by (from left to right) Pierre-Alexandre Fournier, CEO of Carré Technologies; Canadian Space Agency astronaut David Saint-Jacques; and Jean-François Roy, CTO of Carré Technologies. (2016-09-21)

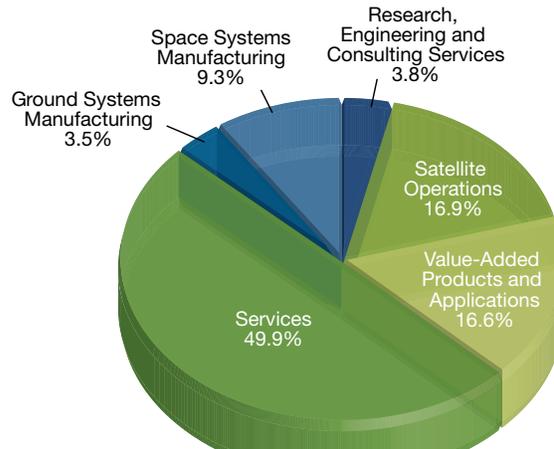
Revenues decreased by 13%, or \$9M, from \$70M in 2015 to \$61M in 2016. Space Science represents 1% of total space revenues. Between 2014 and 2016, revenues from Space Science increased by 28%, or \$13M, from \$48M to \$61M.

Other Revenues

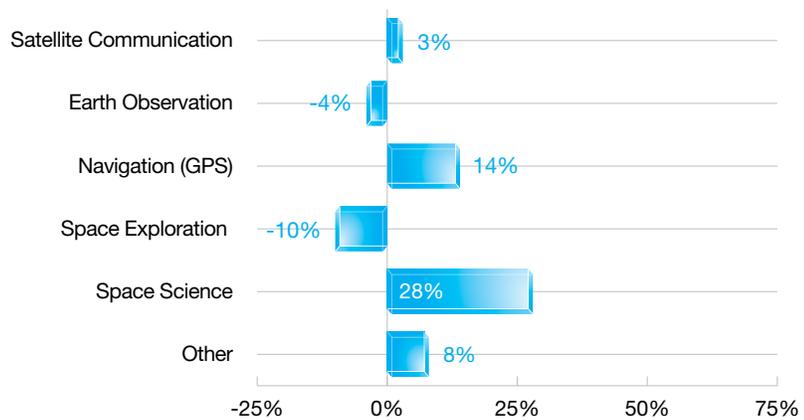
From 2015 to 2016, other revenues decreased by 44%, from \$27M to \$15M, which is 0.3% of total space revenues. Activities that fall into the “Other” sector are by nature variable and subject to re-categorization; therefore, changes in this sector may be less statistically relevant than in the sectors noted elsewhere.



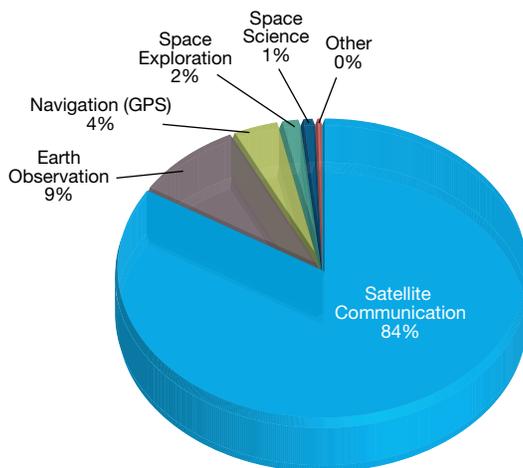
Proportion of Revenues by Space Category: 2016



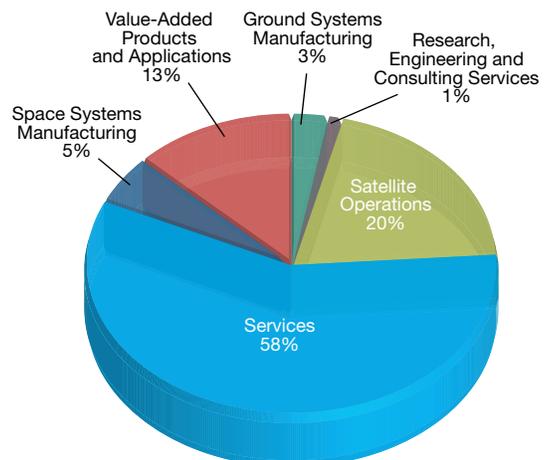
Percentage Change of Revenues by Sector of Activity: 2014-2016



Proportion of Revenues by Sector of Activity: 2016



Breakdown of Satellite Communication Revenues: 2016



MARKET SHARE BY CUSTOMER LOCATION

Domestic vs. Export Revenues

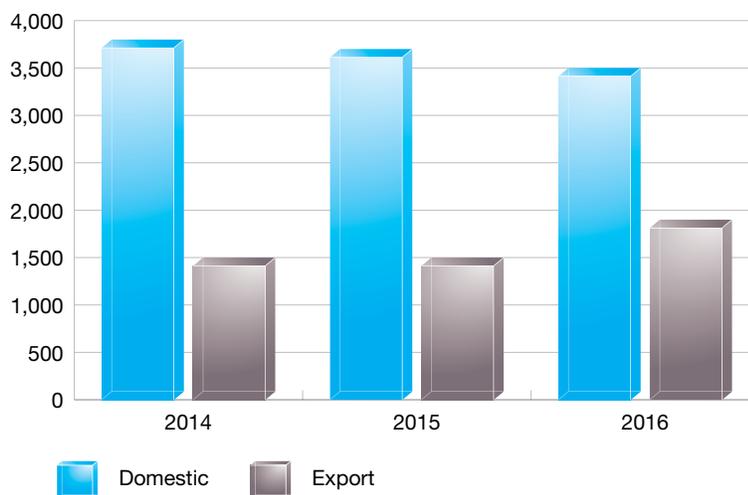
In 2016, total revenues for the Canadian space sector were \$5.5B. Domestic revenues totalled \$3.5B, a 4% decrease, or \$159M, year-over-year. They accounted for 64% of total space revenues. Exports increased by 24% from 2015 to 2016 and represented 36% of revenues.

The average growth rate between 2014 and 2016 was +1.4%² for the entire space sector, -3.7% for domestic revenues, and +13% for exports.

When excluding broadcasting, total revenues generated by the Canadian space sector grew from \$2.7B in 2014 to \$3.1B in 2016. With the exclusion of broadcasting, the average growth rate between 2014 and 2016 was +6.5% for the entire space sector, -2.9% for domestic revenues and +13% for exports.

See the data tables on page 38 for more information regarding inflation-adjusted amounts.

Domestic vs. Export Revenues in \$M: 2014–2016



	2014	2015	2016
Domestic Revenues	3,826,446,289	3,704,150,826	3,545,430,399
Export Revenues	1,556,602,010	1,594,323,346	1,984,715,754

² Calculated using Compound Annual Growth Rate (CAGR).

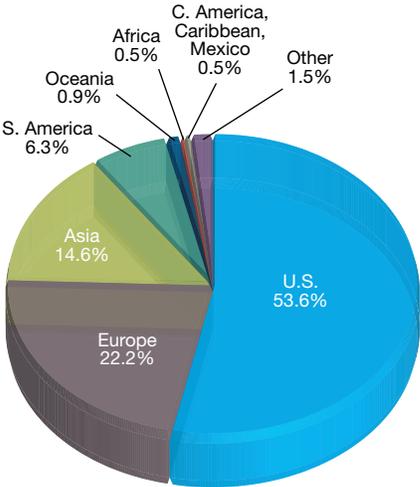
EXPORT REGIONS

In 2016, export revenues reached \$1.98B, a 24% increase, or \$390M, year-over-year. Generally, the longitudinal data show a growing export market for Canadian space-related goods and services. Growth in the export market between 2014 and 2016 was significant, with a Compound Annual Growth Rate (CAGR) of 13%.

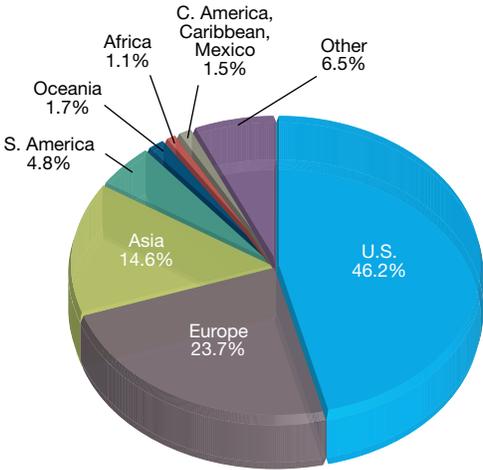
Segmentation of the \$1.98B in total exports for 2016 is as follows:

- > U.S.: 46%, or \$918M;
- > Europe: 24%, or \$470M;
- > Asia: 15%, or \$289M;
- > South America: 5%, or \$96M;
- > Oceania: 2%, or \$34M;
- > Africa: 1%, or \$21M;
- > Central America, the Caribbean and Mexico: 1%, or \$29M; and
- > Unallocated exports: 6%, or \$128M.

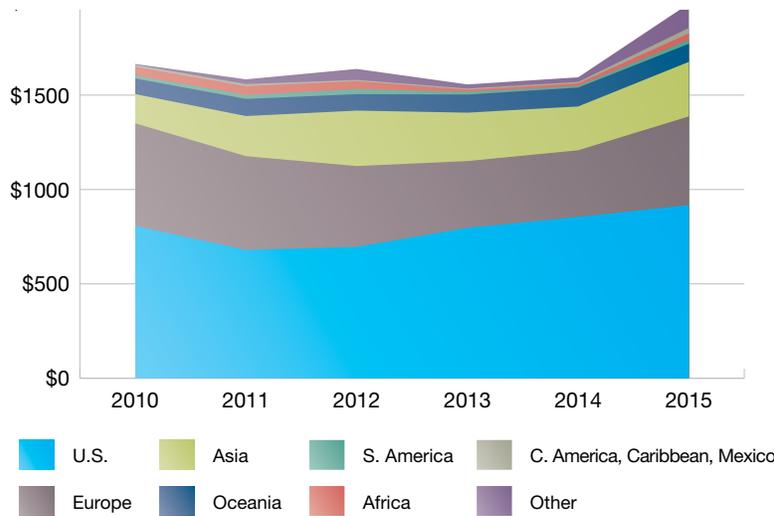
Proportion of Export Revenues: 2015



Proportion of Export Revenues: 2016



Sources of Export Revenues (CAN\$M)



The **U.S.** remained the main destination for Canadian space exports in 2016, with 46% of total exports. Revenues derived from exports to the U.S. grew by 7%, or \$64M, from \$854M in 2015 to \$918M in 2016.

However, in 2016, the growth in Canadian exports was driven by Europe. Canadian exports to **Europe** grew by 33%, or \$116M, from \$354M in 2015 to \$470M in 2016. Revenues derived from Europe accounted for 24% of total exports.

Exports to **Asia** grew by 24%, or \$57M, from \$232M in 2015 to \$289M in 2016. Asia accounted for 15% of total exports.

In 2016, exports to **South America** declined by 4%, or \$4M, from \$100M in 2015 to \$96M in 2016. The region accounted for 5% of total exports.

Exports to **Oceania** in 2016 totalled \$34M, increasing by 141%, or \$20M, over 2015. Oceania accounted for 2% of total export revenues.

Export revenues from **Africa** increased by 154%, or \$13M, from \$8M in 2015 to \$21M in 2016. Generally speaking, export growth to Africa has been uneven; years of strong growth have been followed by declines and vice versa. Africa accounted for less than 1% of total Canadian space export revenues.

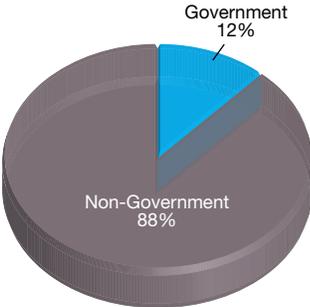
MARKET SHARE BY CUSTOMER TYPE

Customers can be categorized as either government or non-government. Government customers include domestic governments (municipal, provincial, federal) and foreign governments. Non-government customers include businesses, individual consumers and non-profit organizations or foundations (both domestic and foreign).

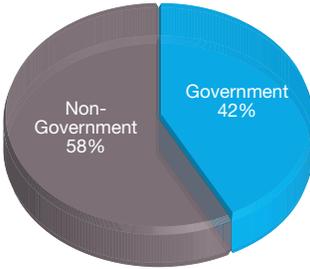
Overall, 12% of the space revenues in 2016 were derived from government customers and 88% from non-government customers. It is important to note that government customers make up the majority of market share in some sectors, such as Space Exploration and Space Science, whereas Satellite Communication customers are primarily non-government.

Upstream segment organizations are much more reliant on government funding than downstream segment organizations, which derive their revenues almost exclusively from non-government clients. The upstream segment derived 58% of revenues from non-government clients in 2016, whereas the downstream segment derived 94% of revenues from non-government clients. It is worth noting that some downstream segment SMEs are also heavily reliant on government as an anchor client, such as value-adding players in the Earth Observation sector. In that respect, they face similar drivers and challenges to SMEs in the upstream segment.

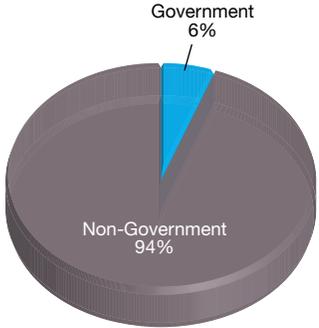
Market Share by Customer Type in the Canadian Space Sector: 2016



Market Share by Customer Type in the Upstream Segment: 2016



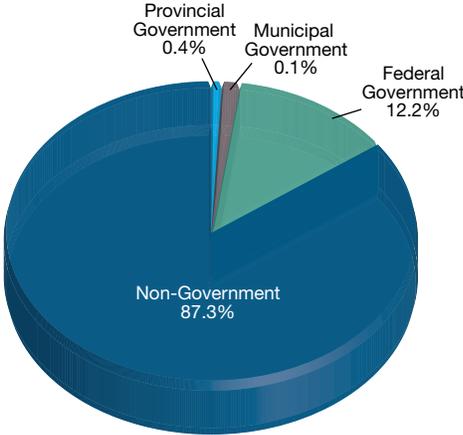
Market Share by Customer Type in the Downstream Segment: 2016



Domestic Customer Breakdown by Type

In 2016, non-government revenues were the most significant part of the domestic market at 87% of revenues. Non-government customers can be individuals, as is the case with subscribers to television and radio broadcasting services – the largest component of domestic space-related activity. Other non-government customers include businesses, where space-derived information products are integrated into business operations (e.g. Navigation and Earth Observation data). A small portion of non-government revenues is tied to financing or sales to non-profit organizations and foundations.

Proportion of Revenues by Domestic Customer



Government customers make up the remainder of the domestic market and are focused in two areas: the upstream segment for research, engineering and manufacturing of space assets; and the downstream segment to ensure day-to-day government operations and services to the public. Government customers represent the majority of domestic upstream revenue, where they constitute 88% of revenues. Non-government revenues constitute the remaining 12%. In the domestic downstream segment, the situation is reversed as government customers account for only 4% of revenues. The majority of government funding comes from federal sources. The top five sources of federal government revenue reported by space organizations in 2016 were the CSA, the Natural Sciences and Engineering Research Council (NSERC), the Department of National Defence (DND), Shared Services Canada (SSC), and Public Services and Procurement Canada (PSPC).

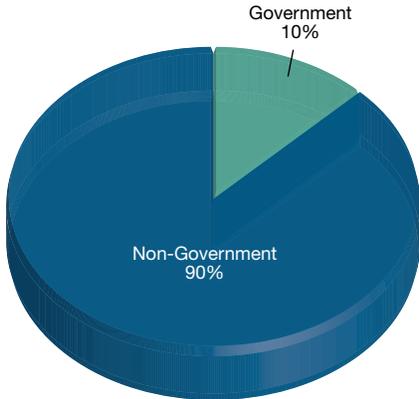
Foreign Customer Breakdown by Type

Non-government customers make up 90%, or \$1.8B, of export revenues, while government clients make up 10%, or \$195M, of exports. Non-government customers are, therefore, the largest market segment abroad, just as they are domestically. This is equally true for both the upstream and downstream segments, where non-government revenues account for 92% and 90% of revenues, respectively.

Non-government exports are strong in three main areas of the value chain: Manufacturing, Satellite Operations, and Products and Applications. In terms of manufacturing, several companies are producing components and parts for foreign prime companies through global value chains, with very occasional sales related to manufacturing of complete end-to-end space systems. Satellite Operations primarily include sales related to operations for commercial telecommunications systems. Products and Applications sold to non-government customers are mostly related to antennas, receivers and other ground equipment in the Navigation and Satellite Communication sectors. Non-government exports for Earth Observation are limited, but a small market does exist for data and software applications.

There is also a small portion of non-government organizations, mainly foundations, which provide funding to Canadian universities and research centres. This is a relatively small amount, and it is categorized as export revenue in the consolidated analysis of the Canadian space sector.

Proportion of Revenues by Foreign Customer: 2016



INNOVATION

KEY TAKEAWAYS

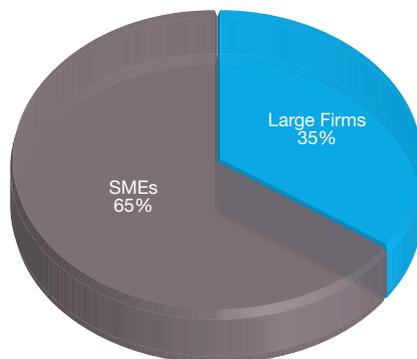
- > Business Expenditures on R&D (BERD) settled at \$254M in 2016, a minor decline from the previous year.
- > Overall, space sector R&D intensity is 25%. R&D intensity for space manufacturing was eight times higher than the average for manufacturing in Canada.
- > In 2016, Canadian space companies derived \$123M in revenues through the commercialization of externally funded R&D projects, a significant growth from 2015.
- > Space sector organizations reported a total of 183 inventions in 2016, of which 42% were patented.
- > Patented inventions have an impact on a company's future revenues. The share of patents filed by downstream segment organizations over the past 20 years has been increasing.

BUSINESS EXPENDITURES ON R&D (BERD) (COMPANIES ONLY)

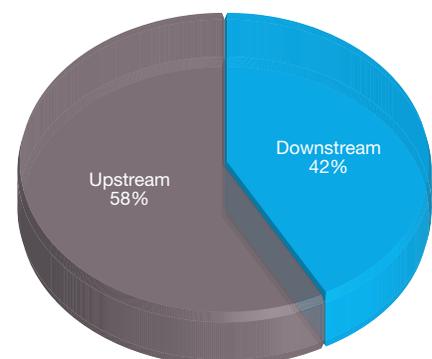
In 2016, there were 63 companies engaged in R&D activities. Total spending was \$254M, a minor decrease over R&D spending reported in 2015 (\$256M). Downstream organizations were responsible for 58% of total space sector BERD.

R&D spending was financed through internal sources (e.g. company profits reinvested in R&D) or through external funding sources (e.g. government grants and contributions). Internally company-funded R&D represented the larger portion of spending at \$141M, or 55%, of BERD in 2016. Externally funded R&D represented 45%, or \$113M, of BERD in 2016.

Business Expenditures on R&D
by Firm Size: 2016



Business Expenditures on R&D
by Market Segment: 2016



R&D INTENSITY LEVEL (COMPANIES ONLY)

R&D intensity is the proportion of BERD compared to the GDP contribution of the space sector. It serves as an indicator of the level of effort and investment by a company (or by an industry as a whole in this case) in innovative activities such as the creation of new products, services, technologies or the improvement of business functions such as production techniques. Overall, space sector R&D intensity is 25%. If we consider only the manufacturing segment, R&D intensity is 26%. This is eight times higher than the average for manufacturing in Canada.

COMMERCIALIZATION OF EXTERNALLY FUNDED R&D PROJECTS (ALL ORGANIZATIONS)

Organizations report on the level of commercialization of projects that were initially funded by government (externally funded R&D). In 2016, 36 organizations derived \$123M in revenues through the commercialization of externally funded R&D projects, more than double the \$56M reported in 2015. The vast majority of commercialization revenues takes place through companies (94%), with the remainder of commercialization taking place through universities and research centres.

INVENTIONS AND PATENTS (ALL ORGANIZATIONS)

In 2016, 45 organizations reported having made an invention and 23 organizations registered a patent. A total of 183 inventions were reported, of which 42% were patented.

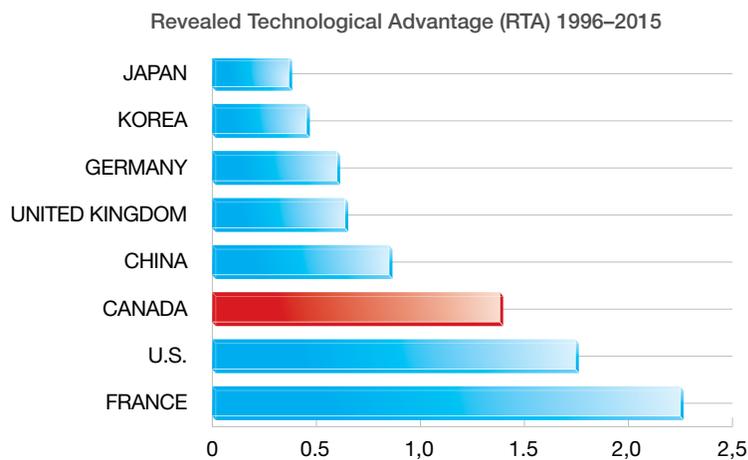
Upstream organizations accounted for the majority of inventions and patents, with 70% of all inventions reported and 60% of patents filed. This is a reflection of the composition of survey respondents, with almost three-quarters of respondents in the upstream segment. However, downstream organizations patent more of their inventions. In 2016, 56% of inventions from downstream organizations were registered as patents, while only 36% of inventions from upstream organizations were registered as patents.

2016 was the first year for which companies were asked the exact number of inventions and patents produced. Previously, companies were asked to provide a range (1 to 5, 6 to 10, 11 to 20, etc.) of the number of inventions and patents. Because of this shift in methodology, no long-term trends are available. However, in 2016, most organizations involved in inventing and patenting made between 1 and 5 inventions and filed for 1 to 5 patents, which is consistent with the trend of the past five years.

PATENTS IN SPACE: HIGHLIGHTING INNOVATION IN THE CANADIAN SPACE SECTOR

In 2016, the CSA, in collaboration with the Canadian Intellectual Property Office (CIPO), conducted a study on patents in the Canadian space sector. For this research, 128 companies and research institutions operating in the Canadian space sector and having registered patents between 1980 and 2015 were identified using the International Patent Classification (IPC) system and a list of keywords and expressions related to the space industry.

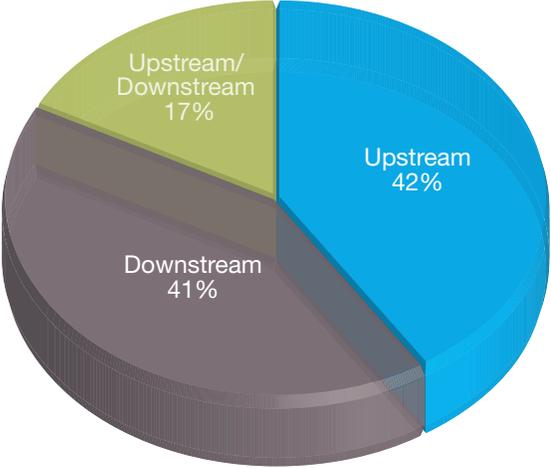
The Revealed Technological Advantage (RTA) index – developed by the Organisation for Economic Co-operation and Development (OECD) – was used to better understand Canada’s competitive status in relation to patenting in the global space sector. The RTA provides a ratio of each country’s share of patents within the space technology sector as a share of the country’s total patents produced within a given timeframe. Canada has a value greater than one, suggesting a technological advantage in the space sector. The result presented below is corroborated by previous results from the OECD in their Space Economy at a Glance 2014 report.³



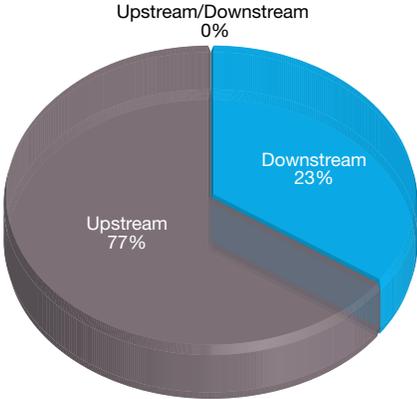
³ <http://www.oecd.org/sti/the-space-economy-at-a-glance-2014-9789264217294-en.htm> (p. 70)

The CIPO patent data show the share of patents filed by downstream segment organizations over the past 20 years has been increasing. Between 1996 and 2000, the downstream segment only represented 23% of Canadian patents related to the space sector. However, between 2011 and 2015, it accounted for 60% of Canadian space-related patents.

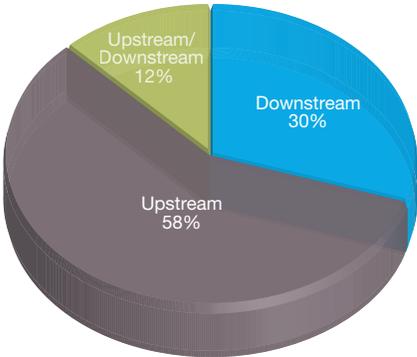
Patent Stream of Activity – 1980–2015



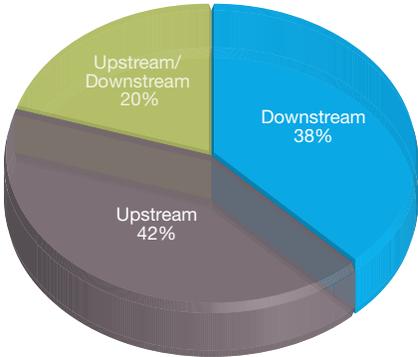
Patent Stream of Activity – 1996–2000



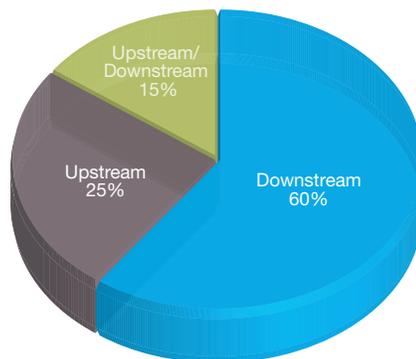
Patent Stream of Activity – 2001–2005



Patent Stream of Activity – 2006–2010



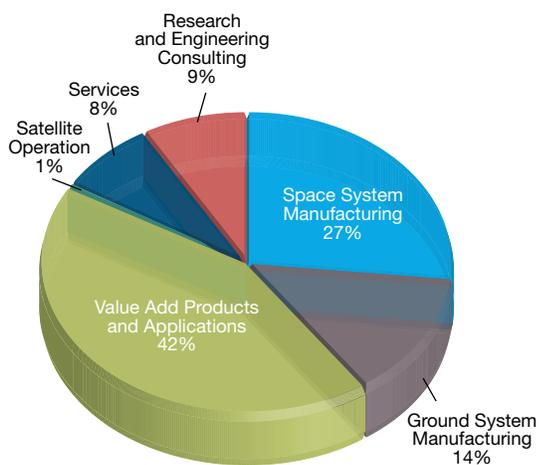
Patent Stream of Activity – 2011–2015



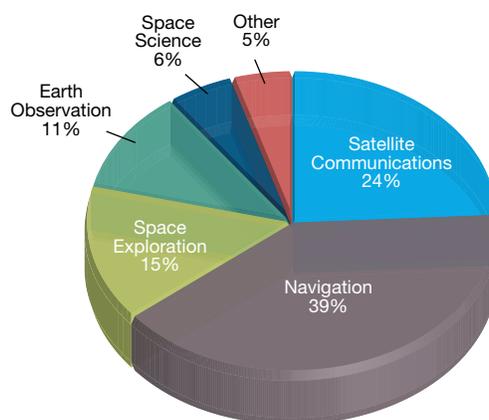
Between 1980 and 2015, in the upstream segment, Research & Engineering, and Consulting services accounted for 9% of patents, Ground System Manufacturing accounted for 14%, and Space Systems Manufacturing 27%. During the same period, in the downstream segment, there were almost no patents in the Satellite Operations segment. However, this is unsurprising as this category is relatively new. Value-added products and applications accounted for the highest proportion of patents, at 42% of patenting activities. Finally, the Services sub-segment accounted for only 8% of patented inventions.

Between 1980 and 2015, organizations linked to Navigation tend to patent the most (39%), followed by Satellite Communication (24%), Space Exploration (15%), Earth Observation (11%), Space Science (6%) and Other (5%).

Patents by Value-Chain Segments



Sector of Activity Patenting



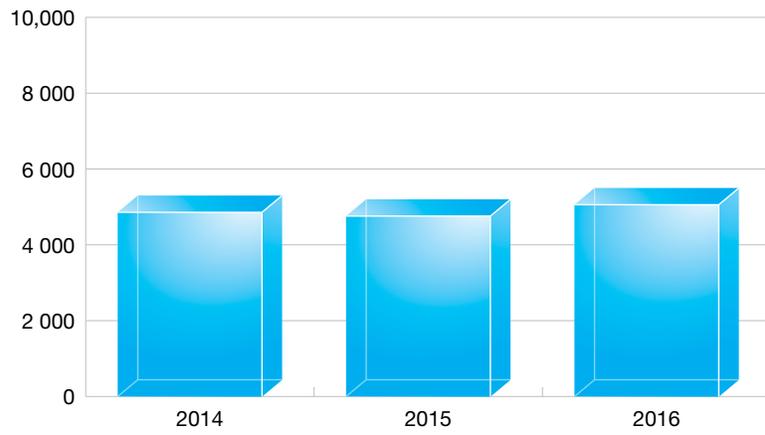
An econometric analysis found positive correlations between R&D expenditures and annual patent family filings, R&D employee levels and annual patent family filings, revenues and R&D expenditures, revenues and R&D employee levels, and R&D expenditures and R&D employee levels. This suggests that patenting activity has a positive correlation with spending on R&D and revenues in the Canadian space sector.⁴

⁴ For more information, please consult the report “Patent in Space: Highlighting Innovation in the Canadian Space Sector,” which will be published on the CSA’s website in August 2018.



ANNEX A ECONOMIC TRENDS 2014–2016

TOTAL SPACE REVENUES 2014–2016 (CAN\$M)



Domestic vs. Export Revenues 2014-2016						
Year	Overall	Domestic		Export		Workforce
	(CAN\$)	(CAN\$)	%	(CAN\$)	%	#
2016	5,530,146,153	3,545,430,399	64.1	1,984,715,754	35.9	9,883
2015	5,298,474,172	3,704,150,826	69.9	1,594,323,346	30.1	9,927
2014	5,383,048,299	3,826,446,289	71.1	1,556,602,010	28.9	10,012

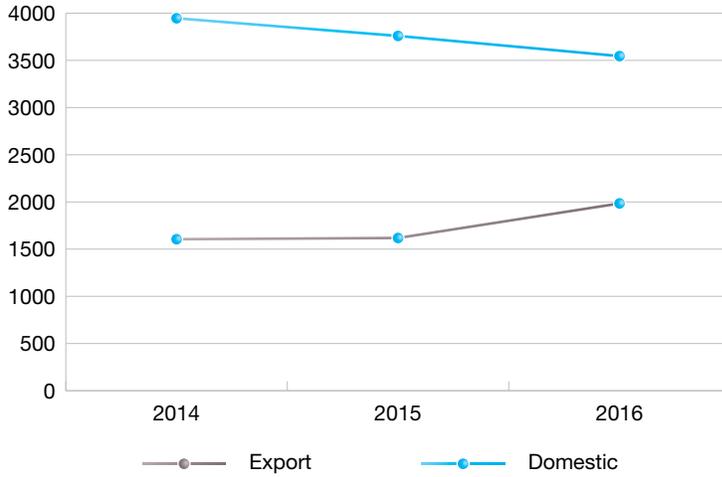
*This chart reflects values that are not adjusted for inflation.

Inflation-Adjusted Revenues: 2014–2016

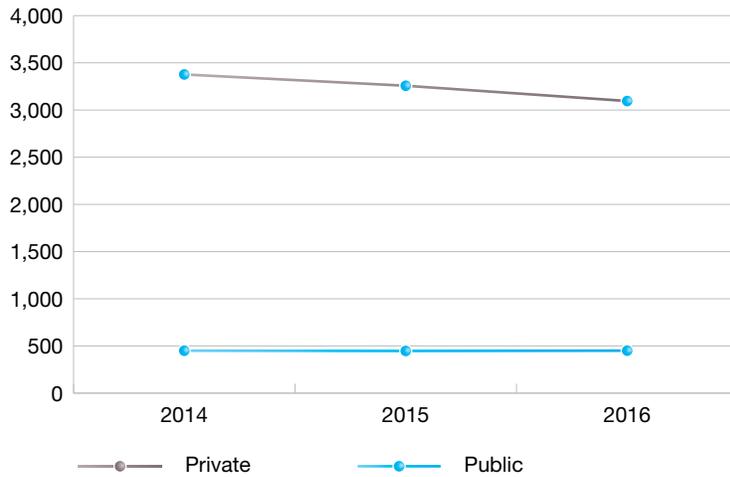
Year	Total Revenues	Domestic Revenues	Export Revenues
2016	\$5,530,146,153	\$3,545,430,399	\$1,984,715,754
2015	\$5,378,055,998	\$3,759,786,293	\$1,618,269,705
2014	\$5,551,673,908	\$3,946,310,872	\$1,605,363,037

*Bank of Canada Rates of Inflation-Adjusted Revenues (Consumer Price Index data)

DOMESTIC VS. EXPORT REVENUE 2014–2016 (CAN\$M)

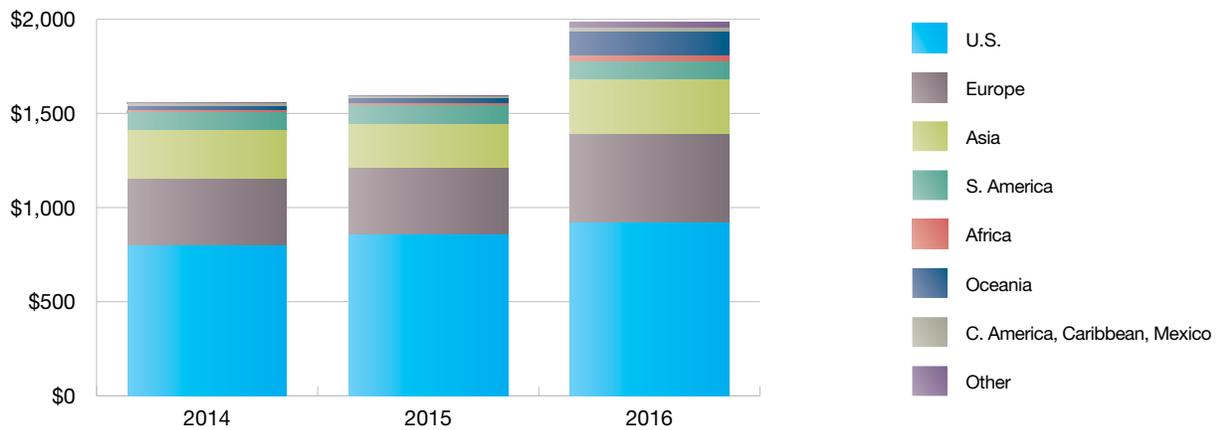


SOURCES OF DOMESTIC REVENUES PUBLIC VS. PRIVATE: 2014–2016 (CAN\$M)



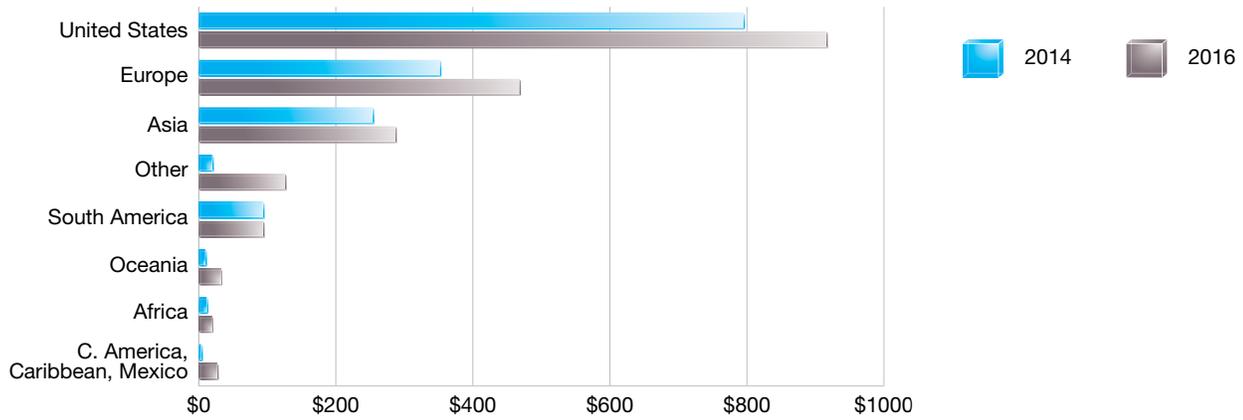
Sources of Domestic Revenues Public vs. Private: 2014–2016 (CAN\$M)			
	2014	2015	2016
Public	449.79	447.16	450.31
Private	3376.65	3256.99	3095.12

SOURCES OF EXPORTS REVENUES 2014–2016 IN MILLIONS

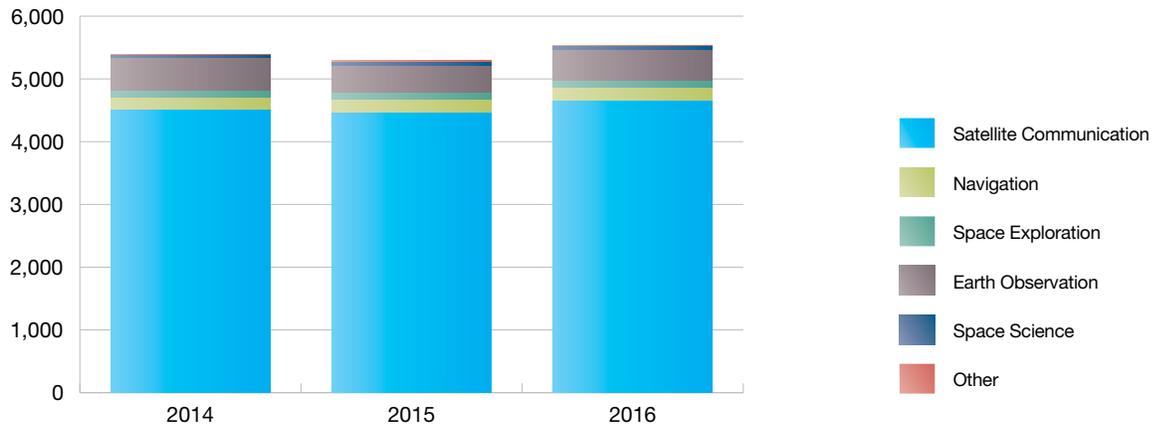


	2014	2015	2016
United States	796.93	854.28	917.77
Europe	353.67	353.58	469.63
Asia	256.46	232.10	288.85
South America	95.82	100.10	95.67
Africa	14.15	8.40	21.32
Oceania	12.02	14.09	33.92
C. America, Caribbean, Mexico	6.01	7.36	29.17
Other	21.54	24.41	128.38

SOURCES OF EXPORTS REVENUES IN MILLIONS

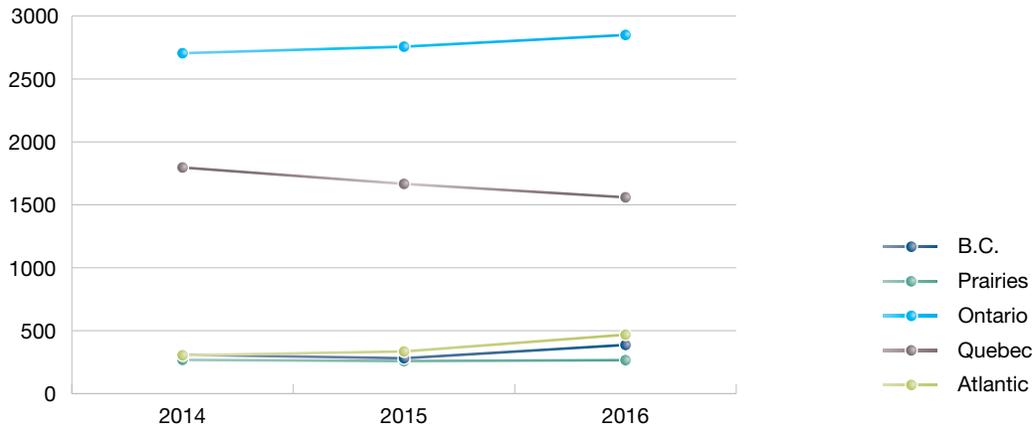


REVENUES BY SECTORS OF ACTIVITY: 2014-2016 (CAN\$M)



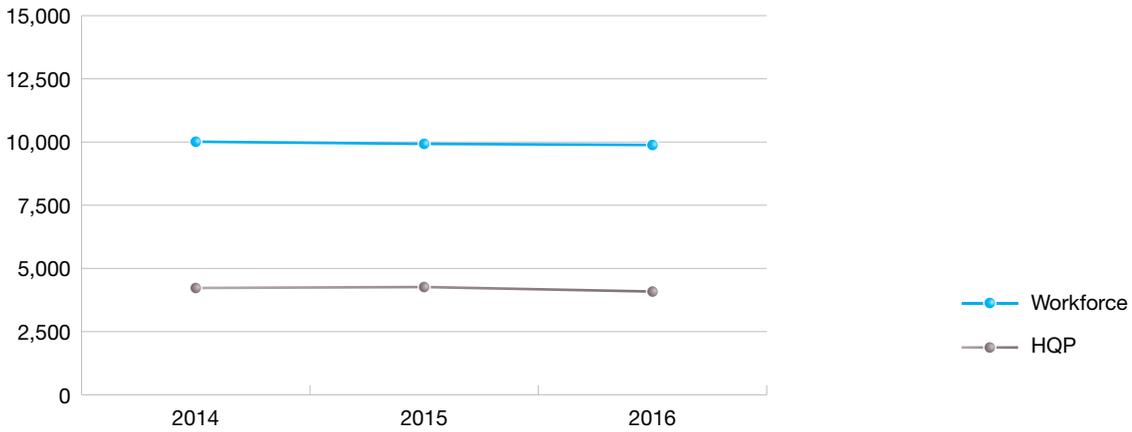
	2014	2015	2016
Satellite Communication	4,503	4,461	4,641
Navigation (GPS)	190	206	216
Space Exploration	113	112	102
Earth Observation	516	423	495
Space Science	48	70	61
Other	14	27	15

REVENUES BY CANADIAN REGION: 2014–2016 (CAN\$M)



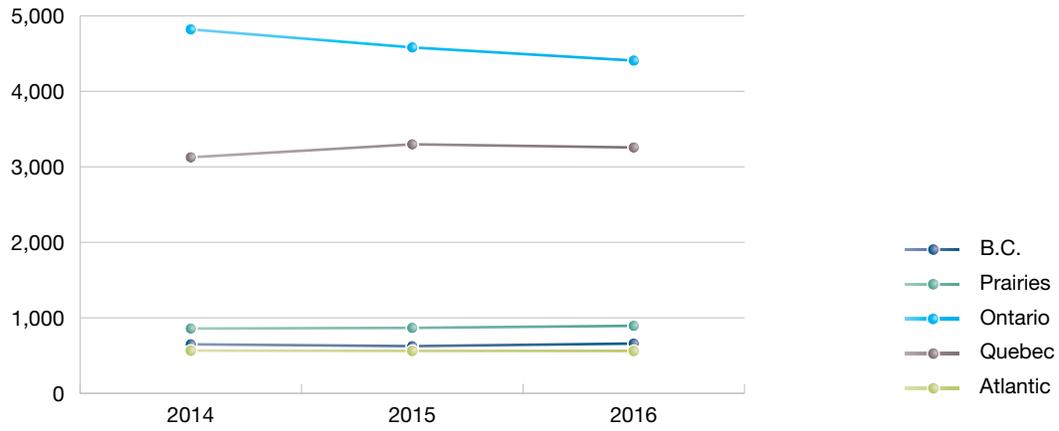
	2014	2015	2016
B.C.	309	281	387
Prairies	268	259	266
Ontario	2,705	2,757	2,850
Quebec	1,797	1,667	1,560
Atlantic	304	335	468

WORKFORCE BY TYPE OF EMPLOYMENT: 2014–2016

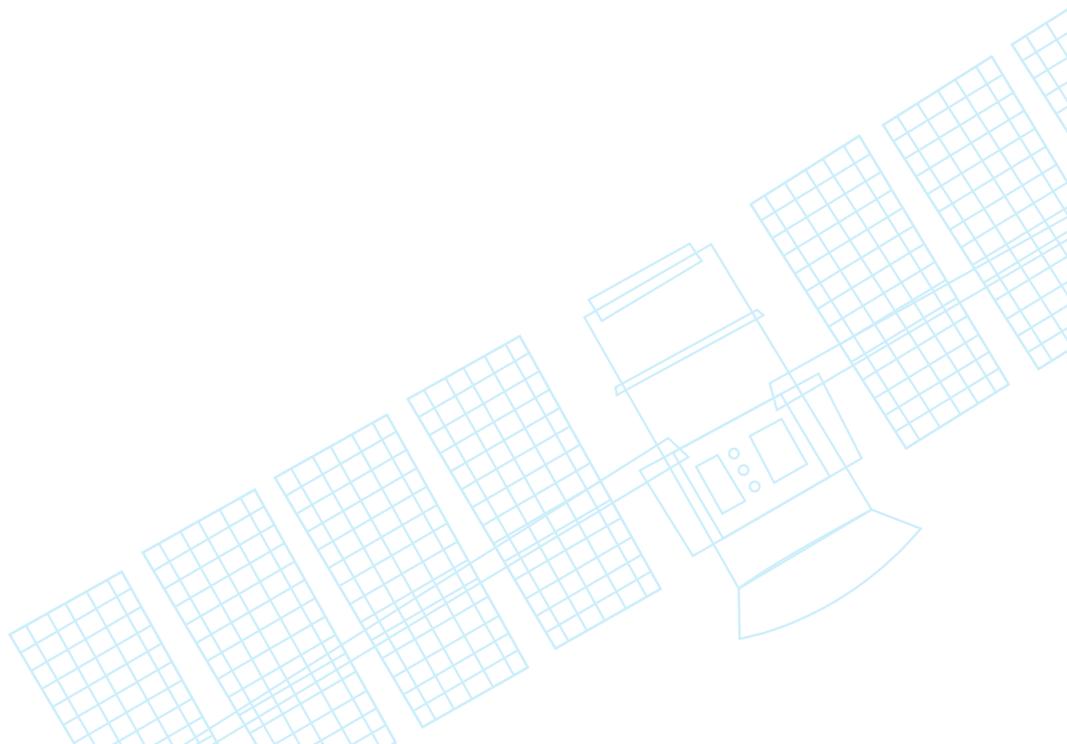


	2014	2015	2016
Workforce	10,012	9,927	9,883
HQP	4,226	4,264	4,085

WORKFORCE BY CANADIAN REGION: 2014–2016



	2014	2015	2016
B.C.	614	590	624
Prairies	858	867	894
Ontario	4,820	4,581	4,407
Quebec	3,126	3,298	3,256
Atlantic	595	591	702
Total	10,012	9,927	9,883



ANNEX B METHODOLOGY

QUESTIONNAIRE

In order to measure the changes taking place in Canada's space sector each year, the CSA uses a questionnaire to collect baseline data. Questionnaires are sent to private sector enterprises, not-for-profit organizations, research organizations and universities in Canada that engage in space activities. The questionnaire follows a census model and therefore aims to be as inclusive and exhaustive as possible.

Most organizations that responded to the 2016 questionnaire reported on a fiscal year (generally ending March 31, 2017), with the remainder reporting on a calendar year, from January 1 to December 31, 2016. As in previous years, the questionnaire had a high response rate covering 150 organizations, including all major space players.

Additionally, the CSA performs quality control measures on the survey data to ensure the accuracy of the findings.

Attribution

Data are also added based on CSA transfer payments (Contracts, Grants, and Contributions) in cases where this information has not been included as part of the survey responses.

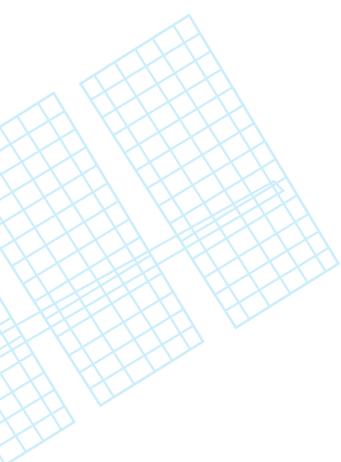
In addition, there are a limited number of cases where data are compiled from publicly disclosed reports (e.g. for publically traded companies) and verified through consultation with company officials.

Economic Trends

In the 2014 edition of this report, the CSA made changes to the methodology, whereby downstream segment organizations were added to the survey population. This led space sector revenues to grow significantly between 2013 and 2014. This change specifically impacted indicators for domestic revenues, Satellite Communication revenues, government vs. non-government funding, and workforce. For that reason, the economic trend analysis for this report only looks back at the past three years (2014–2016). For information on the economic trends prior to 2014, readers are invited to consult previous editions of this report.

ECONOMIC IMPACT ANALYSIS

As described in the OECD's 2012 *Handbook on Measuring the Space Economy*, measuring economic impacts in the space sector is a challenging task, as there is no single industrial classification for space activities. In order to overcome this difficulty, a model was developed jointly by the CSA and Innovation, Science and Economic Development Canada (ISED) to calculate the space sector's contribution to GDP (gross domestic product or value added). This process involved taking into account the various industrial classifications, weighing them and categorizing them using a value-chain approach, in order to develop a set of multipliers based on Statistics Canada's Input-Output tables. These multipliers are used to determine the impacts on GDP and employment of the space sector, the suppliers to the space sector, and the consumer spending by employees associated with both the space sector and its supply industry.



A detailed explanation of the Economic Impact Model follows:

- 1.** North American Industry Classification System (NAICS) codes were retrieved for each space company through Statistics Canada's Business Register. This exercise generated a list of 11 separate industrial classifications that covered all active Canadian space sector companies.
- 2.** Canadian space companies were categorized into a value-chain model based on the goods and services they provide: Research, Engineering and Consulting Services; Manufacturing; Satellite Operations; Value-added Service Providers; and Broadcasting Services.
- 3.** Universities, research centres and associations were grouped together under Research, Engineering and Consulting, as in most cases their space sector activities are related to R&D.
- 4.** The grouping of NAICS codes in each of the value-chain categories were then weighted for their relative importance within that particular category. Weighting was established on the basis of workforce tied to each NAICS code. The more workforce associated with organizations in a particular NAICS code, the heavier that NAICS code was weighted relative to the grouping of NAICS codes in that value-chain category.
- 5.** Customized economic multipliers were then built for each value-chain category based on Statistics Canada's input-output accounts for existing NAICS codes. These multipliers are at three levels: space sector, supply industry and consumer spending by associated employees.
- 6.** Employment levels for each value-chain segment of the space sector (collected directly from companies through the questionnaire) are entered in the Economic Impact Model. The customized economic multipliers are then applied to generate the space sector's total GDP and workforce impact numbers.

The "multiplier effect" refers to the total impacts (space sector, supply industry and consumer spending by associated employees) divided by the initial space sector impact. This gives the reader an idea of the impact that one job or one dollar in the space sector has on the wider economy.

Note: Two types of primary inputs can be used in an input-output model: revenues or employment. Employment has been chosen here, as it provides a more accurate portrait of the true level of economic activity being performed within Canada's borders. The results of this analysis can be considered a conservative estimate of Canada's space sector impact, particularly when compared to third-party studies or comparative international reports, which may use different methodologies.

ANNEX C DEFINITIONS

DEFINITION OF CANADA'S SPACE SECTOR

The Canadian space sector is defined as organizations (private, public and academic) whose activities include the development and use of space assets and/or space data.

DEFINITION OF SPACE VALUE-CHAIN CATEGORIES

This report uses a methodology developed by the OECD's Space Forum, of which the CSA is a Steering Committee member, to characterize Canadian space activities on the basis of a value-chain approach. The definitions of space sector categories were updated in the 2014 edition of this report as per the value-chain approach, with findings presented on the basis of upstream and downstream segment activities. This re-categorization is intended to improve the measurement of the space sector and enable international comparisons.

Under this value-chain approach, data have been organized into categories that align with the stages of producing space goods and services: Research, Engineering and Consulting; Space Segment Manufacturing; Ground Segment Manufacturing; Satellite Operations; Products and Applications; and Services. This approach replaces the space categories used in the annual *State of the Canadian Space Sector Reports* from 1996–2013.

Upstream Segment

The upstream segment refers to the effort required to design, test, build, integrate, and launch⁵ assets into space.

- > **Research, Engineering, Testing and Consulting:** Research and Development (R&D) related to non-commercial or pre-commercial activities; applied science; design and testing of spacecraft, satellites and payloads or components thereof; support services directed at enabling other space sector actors throughout the value chain, including outreach activities, legal services, insurance provision, market research, policy and management services.
- > **Space Manufacturing:** Building and integration of spacecraft, satellites, payloads or any component thereof.
- > **Ground Manufacturing:** Building and integration of facilities and equipment on Earth for Satellite Operations, often known as “ground stations.”

Downstream Segment

The downstream segment refers to the effort required for the day-to-day operation of space assets, manufacturing of products and software applications that transform space data and signals into useful end products, and services provided to end-users.

- > **Satellite Operations:** Day-to-day management of satellites and spacecraft once they are in space, e.g. telemetry, tracking and command; monitoring, recovery operations and collision avoidance; mission planning for satellite passes; uplinks and downlinks for signal processing to reception facility; lease or sale of satellite capacity.

⁵ Note that launch-related activities do not represent a significant area of activity in the Canadian space sector, hence why it is not included as a separate value-chain category in this report. Launch-related activities include the building and integration of space transportation vehicles (rockets), launch pads, space ports and related technologies, as well as launch service provision.

- > **Products and Applications:** Manufacturing/development of software or hardware that enable the transformation of space-derived resources into a usable/useful format, e.g. computer software applications, chipsets, Very Small Aperture Terminals and other terminals, antennas, satellite phones, video and audio receivers-decoders, and GPS devices. This category also includes publishing digital or print books, atlases and maps using space-based data.
- > **Services:** Provision of services which are dependent on space-based signals or data to various end-users (individual consumers, government departments, or businesses), e.g. subscriptions to satellite radio, phone, television or Internet services; engineering, architectural and environmental consulting based on the processing and analysis of Positioning, Navigation and Timing (PNT) or Earth Observation (EO) data; support services provided to users of space-based products and applications, such as provision of computer consulting and facilities management, data processing, Web hosting and portals, and streaming services.

DEFINITION OF SECTORS OF ACTIVITY

The activities of space organizations can also be broken down, as has been done in previous reports, according to the ultimate use or purpose of the research carried out or the goods and services produced. Space sector activities can serve commercial, civil or military purposes, and refer to activities across the value chain:

- > **Navigation:** The development and use of satellites for localization, positioning and timing services. Navigation is used for air, maritime and land transport, or the localization of individuals and vehicles. It also provides a universal referential time and location standard for a number of systems.
- > **Satellite Communication:** The development and use of satellites to send signals to Earth for the purpose of fixed or mobile telecommunications services (voice, data, Internet, and multimedia) and broadcasting (TV and radio services, video services, Internet content).
- > **Earth Observation (EO):** The development and use of satellites to measure and monitor Earth (including its climate, environment and people) for a number of purposes such as resource management, mineral exploration, disaster assessment, security and defence
- > **Space Exploration:** The development and use of manned and unmanned spacecraft (space stations, rovers and probes) to investigate the reaches of the universe beyond Earth's atmosphere (e.g. the Moon, other planets, asteroids). The International Space Station and astronaut-related activities are considered in this sector.
- > **Space Science:** The various science fields that relate to space flight or any phenomena occurring in space or on other planets (e.g. astrophysics, planetary science, space-related life science).
- > **Other:** Generic technologies or components that are not destined for use on a specific space system or for a specific space application. This could be the case for early-phase research, small off-the-shelf components used in various systems, or services based on integrated applications.

THE *STATE OF THE CANADIAN SPACE SECTOR REPORT* PROVIDES INSIGHT FOR DECISION-MAKERS IN GOVERNMENT AND INDUSTRY TO HELP MAKE INFORMED, STRATEGIC CHOICES FOR THE FUTURE.



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