



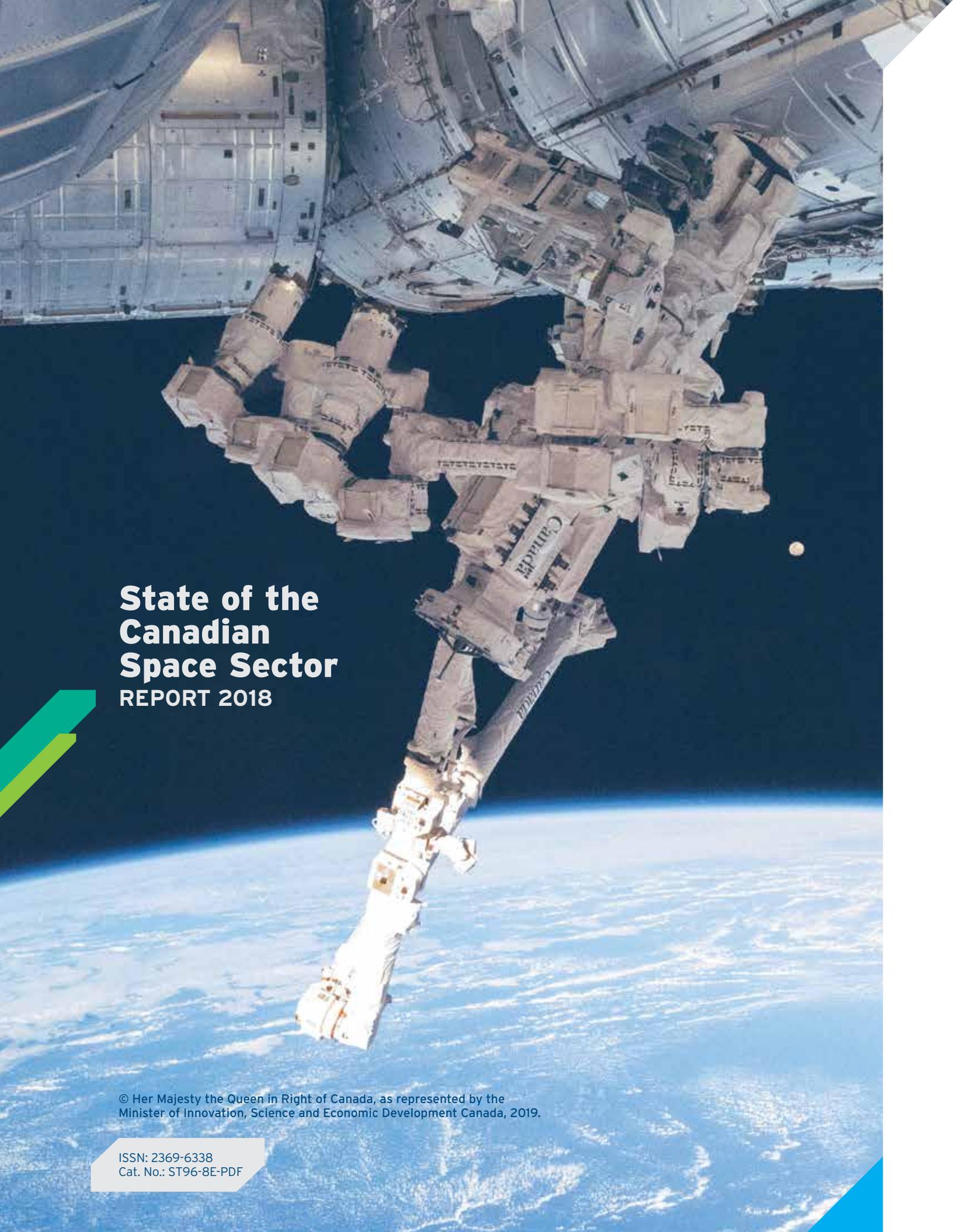
State of the Canadian Space Sector REPORT 2018

Facts and Figures 2017



Canadian Space Agency / Agence spatiale canadienne





State of the Canadian Space Sector REPORT 2018

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ISSN: 2369-6338
Cat. No.: ST96-8E-PDF

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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 21st edition, is based on a questionnaire sent to companies, not-for-profit organizations, research centres and universities with space-related activities in Canada. This year's report is based on data from 192 organizations.

To align with international practices, the publication going forward will be identified by the year in which the survey took place (2018). However, the *2018 State of the Canadian Space Sector Report* only includes data for 2017.

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 2014–2017 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.

Of note, the numbers presented throughout the report may not add up precisely to the totals provided due to rounding.

ABOUT THE AUTHORS

Policy Branch

This report is produced by the Economic Analysis and Research Team, Policy Branch, at the Canadian Space Agency (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 proud to present the *2018 State of the Canadian Space Sector Report*, covering the results from our 2018 survey. The report, which we have been publishing since 1996, provides comprehensive information on the economic activity generated in the Canadian space sector and highlights the impact of space investments on the economy. The report contributes to our understanding of the sector by providing reliable and authoritative data, as well as long-term trend analysis.

In 2017, the space sector produced revenues of \$5.6B and contributed \$2.3B to GDP. Upstream segment activities related to research, engineering and manufacturing accounted for \$0.9B, while downstream segment operations, products and services accounted for \$4.7B. Satellite Communication was the sector of activity with the most revenues in 2017, generating \$4.7B of the total space revenues. However, Navigation experienced the highest growth, with revenues increasing by \$53M in 2017, to \$269M. In 2017, R&D expenditures reached a total of \$363M, a \$109M increase from the previous year. Space sector organizations reported a total of 203 inventions and 118 patents in 2017.

The Canadian space workforce level was maintained at nearly 10,000 jobs, while activities in the space sector supported close to 12,000 additional jobs in the wider Canadian economy. The CSA has also added a new question on labour force, this year. The results helped determine what skills Canadian space companies will be looking for in the next five years, such as skills related to electrical engineering systems and software development.

I trust you will find this publication useful. I would like to convey my thanks and gratitude to all those who contributed to the 2018 survey. The *State of the Canadian Space Sector Report* would not be in its 21st edition without the generous collaboration and input of members of the Canadian space industry and academia.

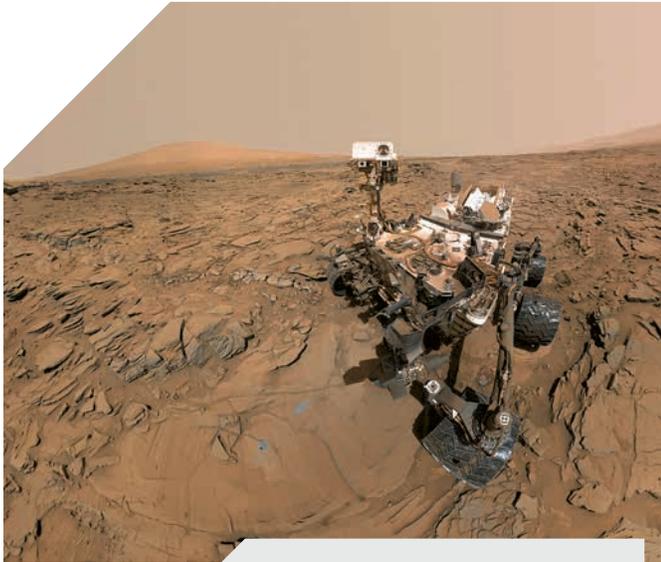


Sylvain Laporte,
President of the Canadian Space Agency (CSA)

1 Executive Summary

KEY RESULTS

- In 2017, the space sector contributed **\$2.3B** to Canada's GDP and supported a total of **21,828 jobs**.
- Total revenues in the Canadian space sector reached **\$5.6B**.
- The Canadian space workforce totalled **9,942 space-related full-time equivalents (FTEs)**, of which **43%** were highly qualified personnel (HQP).
- Business Expenditures on R&D (BERD) reached **\$363M**, a **43%** increase from the previous year.
- Canadian space companies derived **\$330M** in revenues through the commercialization of externally funded R&D projects, a significant growth from 2016.
- Space sector organizations reported a total of **203 inventions** and **118 patents**.
- Canada's top 30 space organizations accounted for **97%** space revenues, **81%** of space employment, **88%** of BERD, **65%** of patents, but only **32%** of inventions.



Canada extends its participation in the Mars Science Laboratory mission

The Canadian instrument APXS, on the Curiosity rover, is being used on a regular basis to collect key information about the rocks and soil of the red planet. (2017-05-05)

Credit: NASA

In 2017, revenues in the Canadian space sector remained stable, totalling \$5.6B. The average annual growth rate of the space sector between 2014 and 2017 was at 1.3%.¹ In 2017, the space sector was estimated to have contributed \$2.3B to Canada's GDP and supported a total of 21,828 jobs in the greater Canadian economy (including space sector jobs, supply industry jobs and jobs created as a result of consumer spending).

The upstream² segment accounted for \$0.9B in revenues. Revenues derived from manufacturing activities (a subset of the upstream segment) totalled \$726M, representing a 2% growth over 2016 results. The downstream³ segment accounted for the majority of revenues at \$4.7B in 2017. Of note, broadcasting services revenues were \$2.3B in 2017, representing a 50% share of the downstream segment. Every sector of activity experienced growth in 2017, with the exception of Earth Observation (EO), which declined by 21%.

¹ Calculated using Compound Annual Growth Rate (CAGR).

² The upstream segment includes research, engineering and consulting activities as well as space segment and ground segment manufacturing.

³ The downstream segment includes satellite operations, manufacturing of products (e.g. terminals), development of software applications, and the provision of services (e.g. broadcasting).

Domestic revenues decreased by 2% year-over-year and totalled \$3.5B in 2017. Commercial revenue, at 88%, continued to make up the majority of domestic revenues. The remaining 12% of domestic revenues were derived from Canadian governments. The federal government accounted for 95% of domestic government funding for space, with the remaining 5% coming from provincial and municipal governments.

Export revenues in 2017 increased by 7%, totalling \$2.1B. Export revenue growth occurred in all regions except British Columbia, where exports declined by 34%. Ontario organizations accounted for 56% of Canadian space exports, followed by Quebec and the Atlantic region with each a 13% share of exports. Non-government customers were the most important market segment abroad, accounting for 85% of space export revenues.

The space sector workforce totalled 9,942 space-related FTEs in 2017, of which 43% are classified as HQP (such as engineers, scientists and technicians). The workforce was evenly divided between the upstream and downstream segment organizations. In the upstream segment, 61% of the workforce were HQP, while in the downstream segment, 26% of workforce were HQP. Academic organizations contributed 16% of the total space sector workforce with 1,606 FTEs, of which 59% were HQP.

BERD totalled \$363M in 2017, with 79 organizations undertaking space R&D projects. This represents a 43% increase over 2016 results, with R&D expenditures up by \$109M. Upstream organizations were responsible for the majority of R&D spending, accounting for 56% of total space sector BERD. Space sector organizations reported a total of 203 inventions and 118 patents in 2017. Upstream organizations accounted for 74% of all inventions and 65% of patents.

In 2017, the top 30 Canadian space organizations, which included 4 universities and 18 small and medium-sized enterprises (SMEs), generated 97% of total space revenues and 81% of space employment, a pattern consistent with previous years. They also accounted for 88% of BERD and 65% of patents, but only 32% of inventions.

SMEs accounted for 95% of all Canadian space companies in 2017. Sixty-two percent of Canadian space SMEs were upstream segment companies, and 38% were downstream segment companies. Together, SMEs accounted for 48% of Canadian space sector revenues and 33% of all employees.



Spacewalk training for CSA astronaut David Saint-Jacques

CSA astronaut David Saint-Jacques and his colleagues Nick Hague and Serena Auñón-Chancellor of NASA receive spacewalk training at NASA's Neutral Buoyancy Laboratory (NBL) in Houston. (2017-09-28)

Credit: NASA



Innovative sensor system for the International Space Station will keep astronauts safe

As part of a contract awarded by the Canadian Space Agency (CSA), Neptec Design Group will develop a state-of-the-art vision system for the International Space Station (ISS). This innovative vision system will use a combination of three sensors to monitor the outside of the ISS, keeping the space laboratory inside safe and operational. (2017-09-18)

Credit: CSA

2 Economic Impact Analysis

KEY RESULTS

- In 2017, the space sector contributed **\$2.3B** to Canada's GDP and supported a total of **21,828 jobs**.

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

ECONOMIC IMPACT - GROSS DOMESTIC PRODUCT

In 2017, 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:

- \$1.22B in space sector impacts;
- \$0.59B 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 contributions from other organizations in the economy.

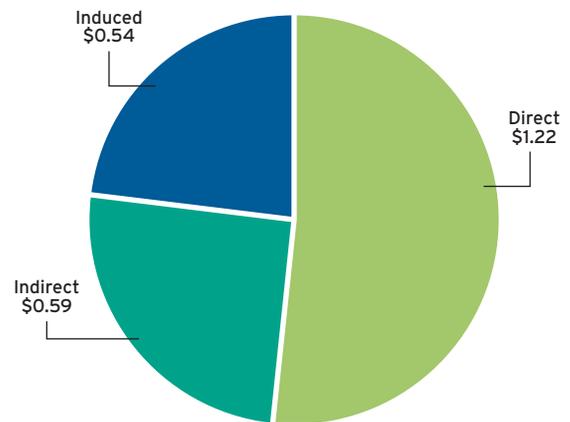
ECONOMIC IMPACT - JOBS SUPPORTED

In 2017, the space sector supported a total of 21,828 jobs in Canada. The total workforce contribution was broken down into the following:

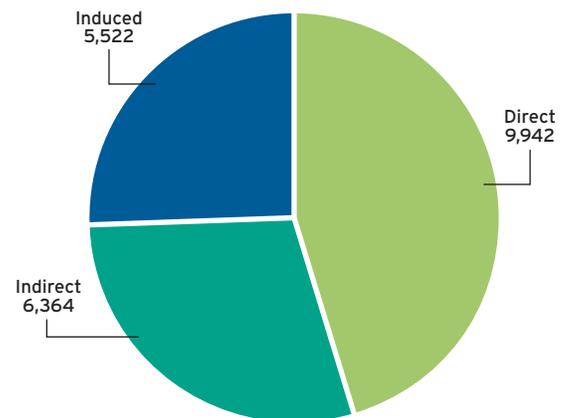
- 9,942 space sector jobs;
- 6,364 supply industry jobs; and
- 5,522 jobs created and supported as a result of consumer spending by associated employees.

The space sector therefore creates jobs in the larger economy with a workforce multiplier of 2.20 (Total Workforce Impact / Space Sector Workforce Impact). In other words, every job in the space sector supports another 1.20 jobs in the economy.

Total GDP Impact: 2017 (in \$B)



Total Workforce Impact: 2017



3 Overall Results

KEY RESULTS

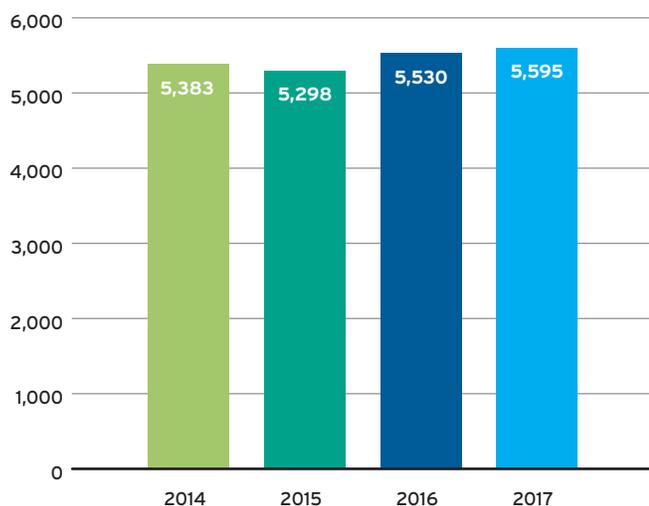
- In 2017, total revenues in the Canadian space sector reached **\$5.6B**.
- The Canadian space workforce remained stable, with **9,942 space-related FTEs**.
- HQP positions experienced **5% growth**, totalling **4,302 FTEs**. HQP represent **43%** of the total Canadian space workforce.
- While Ontario and Quebec are the **two provinces with the highest space revenues**, the Prairies experienced the highest growth.
- Quebec and Ontario account for **77%** of space sector jobs.

TOTAL REVENUES

In 2017, revenues in the Canadian space sector remained stable, totalling \$5.6B, with a 1.2% growth, or a \$65M increase year-over-year. The average annual growth rate of the space sector between 2014 and 2017 was small, at 1.3%.⁴ A detailed analysis of the source of this growth can be found in the section of this report on Revenues by Markets and Customers.

Of note, the findings presented throughout this report are provided at current price (i.e. unadjusted for inflation).

Total Space Revenues: 2014-2017 (in \$M)



Canadarm2 holding Cygnus

Picture of Canadarm2 holding Cygnus, taken by French astronaut Thomas Pesquet during his six-month mission on the International Space Station. (2017-04-22)

Credit: ESA/NASA

⁴ Calculated using Compound Annual Growth Rate (CAGR).



**The CSA at Space Apps 2017:
Getting our feet wet!**

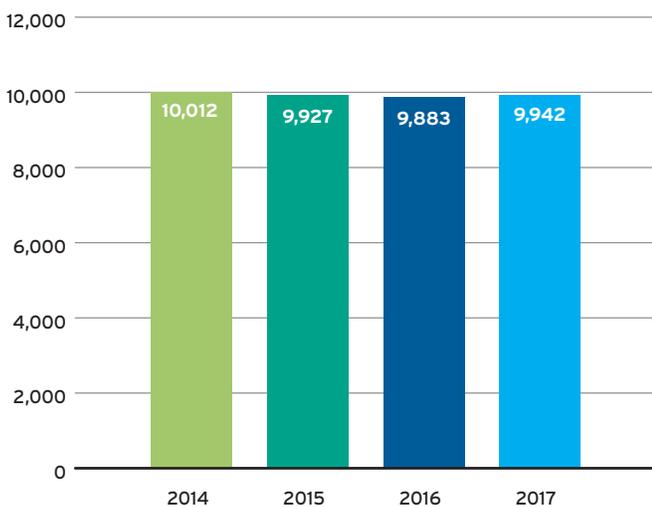
CSA astronaut Jeremy Hansen gives a public talk at Space Apps Waterloo. (2017-04-28)

Credit: CSA

TOTAL WORKFORCE

The Canadian space workforce was stable in 2017, totalling 9,942 FTEs and growing by less than 1%, or 59 FTEs. The space sector workforce is evenly divided between upstream and downstream segment organizations, with 50% of FTEs in each segment. Note that workforce data do not include government employees.

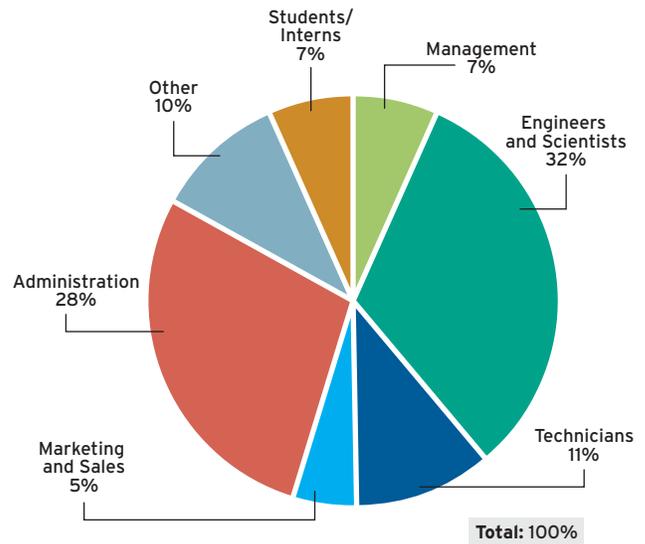
Workforce: 2014-2017



Workforce Groups

In 2017, engineers and scientists comprised the largest category of employment with 3,201 FTEs, representing 32% of the total space workforce. Employees in the administration category made up the second largest group with 2,814 FTEs, accounting for 28% of the workforce. Technicians accounted for 11% of the workforce with 1,102 FTEs. Management, marketing and sales, students, and other employees made up the remainder.

Workforce by Space Employment Category: 2017



Former Canadian Space Agency astronaut Julie Payette appointed Governor General of Canada

In July 2017, it was officially announced that former Canadian astronaut Julie Payette would become Canada's 29th Governor General. Her installation took place on October 2, 2017.

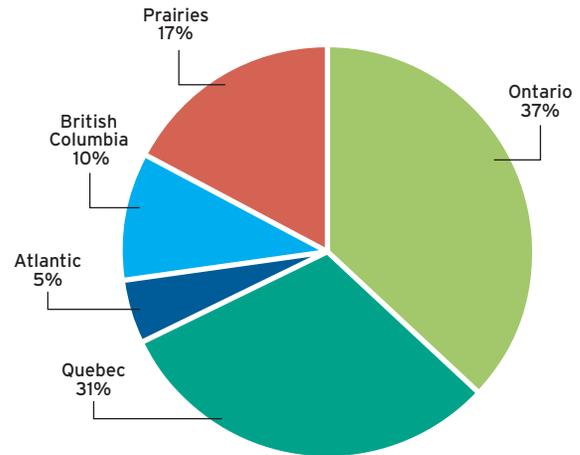
Credit: NASA

Highly Qualified Personnel (HQP)

The HQP measurement tracks the number of engineers, scientists and technicians employed in the space sector. In 2017, HQP positions grew by 5%, settling at 4,302 FTEs. HQP represent 43% of the total Canadian space workforce, but there are significant differences between the upstream and the downstream segments: 61% of the workforce in the upstream segment are HQP, while 26% of the workforce in the downstream segment are HQP.

- 37% of Canada's total space HQP work in **Ontario**, while 38% of Ontario's space workforce are HQP;
- 31% of Canada's total space HQP work in **Quebec**, while 39% of Quebec's space workforce are HQP;
- 17% of Canada's total space HQP work in the **Prairies**, while 73% of the Prairies' space workforce are HQP;
- 10% of Canada's total space HQP work in **B.C.**, while 72% of B.C.'s space workforce are HQP;
- 5% of Canada's total space HQP work in **Atlantic**, Canada while 30% of Atlantic Canada's space workforce are HQP.

Highly Qualified Personnel Space Workforce in Canada 2017



Highly Qualified Personnel: 2017

	Total Workforce	Total HQP	% of HQP Relative to its own Region	% of HQP Relative to National HQP
British Columbia	569	410	72%	10%
Prairies	1,005	732	73%	17%
Ontario	4,269	1,613	38%	37%
Quebec	3,383	1,329	39%	31%
Atlantic	717	219	30%	5%
Total	9,942	4,302		

Space Labour Force Challenges and Needs

A series of new questions on labour force challenges and future skills needs was added to the State of the Canadian Space Sector survey for the first time. In 2017, 49% of Canadian space companies faced difficulties hiring personnel to the extent that positions went unfilled. Companies had the most difficulty finding engineers, scientists and technicians, as well as marketing and sales personnel. The two main reasons highlighted for hiring difficulties were competition from other industrial sectors for the same talent, followed by applicants lacking the skills required for the position.

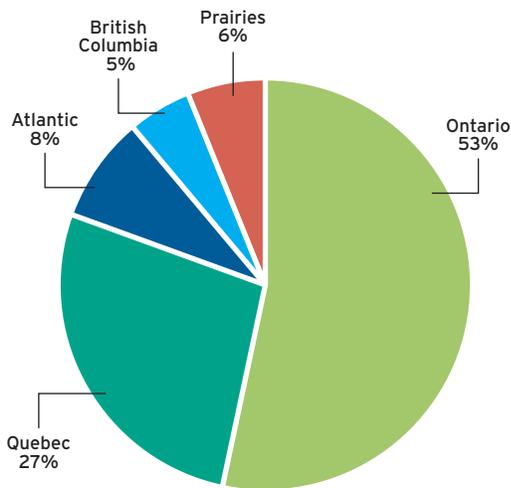
Companies dealing with an employee shortage used three main strategies to deal with the problem: they provided internal training to their employees, outsourced some of the work, and asked existing employees to do overtime.

In the next five years, Canadian space companies will be looking for employees with sought-after skills related to electrical engineering systems, software development, business development and commercialization, mechanical engineering systems, and advanced data analytics.

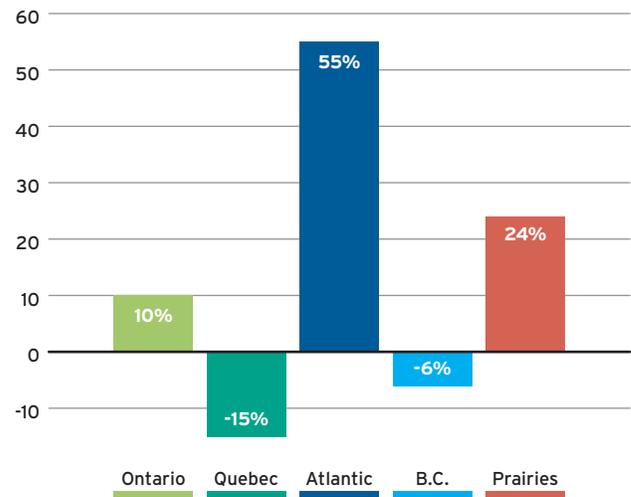
REGIONAL DISTRIBUTION AND TRENDS

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

Regional Proportion of Total Revenues: 2017



Percentage Change of Total Revenues by Region: 2014-2017



Revenues by Region, Domestic vs. Export (in \$)

	2016		2017	
	Export	Domestic	Export	Domestic
British Columbia	200,898,160	186,098,462	132,101,525	158,281,404
Prairies	224,595,383	40,912,268	258,133,111	74,270,140
Ontario	1,065,858,727	1,783,713,772	1,189,394,602	1,783,422,519
Quebec	220,231,098	1,339,474,081	265,626,405	1,261,918,183
Atlantic	273,132,386	195,231,815	274,898,280	197,308,664

Revenues by Region

British Columbia

In 2017, British Columbia had revenues of \$290M, a decline of 25% (\$97M) over 2016 revenues. Domestic revenues declined by 15%, or \$28M, from \$186M in 2016 to \$158M in 2017. Export revenues also declined by 34%, or \$69M, from \$201M to \$132M between 2016 and 2017.

Between 2014 and 2017, B.C.'s total revenues decreased by 6%, from \$309M to \$290M. This decline was driven by a 30% decline in domestic revenues, from \$226M to \$158M. Over the same period, export revenues grew by 60%, from \$83M to \$132M.

B.C. accounts for 5% of Canadian space sector revenues. The number of upstream and downstream segment respondents in B.C. is approximately equal. Upstream segment organizations generated 61% of the province's space revenues, and downstream segment organizations generated 39% of the province's space revenues. B.C. is the only province where the upstream segment generates more revenues than the downstream segment.

Prairies (Alberta, Saskatchewan and Manitoba)

Revenues in the Prairies grew by 25%, or \$67M, over 2017, reaching \$332M. Domestic revenues grew by 82%, or \$33M, from \$41M in 2016 to \$74M in 2017; export revenues increased by 15%, from \$225M in 2016 to \$258M in 2017.

- Alberta revenues increased by 38%, or \$67M, from \$178M to \$245M;
- Saskatchewan revenues declined by 21%, or \$15M, from \$70M to \$55M;
- Manitoba revenues grew by 83%, or \$15M, from \$17M to \$32M.

Between 2014 and 2017, total revenues grew by 24%, from \$268M in 2014 to \$332M in 2017. Although domestic revenues declined by 27%, from \$101M in 2014 to \$74M in 2017, exports grew by 55%, from \$167M to \$258M, over the same period.

The Prairies account for 6% of Canadian space sector revenues. Thirty-three percent of space revenues came from the upstream segment, while 67% came from the downstream segment.

Ontario

Revenues in Ontario grew by 4%, or \$123M, in 2017 and totalled \$3B. Domestic revenues remained stable at \$1.8B while exports grew by 12%, from \$1.1B in 2016 to \$1.2B in 2017.

Total revenues in Ontario increased by 10% between 2014 and 2017. This growth was driven by export revenues, which grew by 30%, from \$913M to \$1.2B. Domestic revenues remained stable at \$1.8B.

Ontario accounts for 53% of Canadian space sector revenues. 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 2%, or \$32M, over last year, settling at \$1.5B in 2017. Domestic revenues decreased by 6%, or \$78M, from \$1.34B in 2016 to \$1.26B in 2017; exports grew by 21%, from \$220M in 2016 to \$266M in 2017.

Between 2014 and 2017, Quebec's total revenues decreased by 15%, from \$1.8B to \$1.5B. This was driven by a 19% decline in domestic revenues, which went from \$1.6B in 2014 to \$1.3B in 2017. Export revenues grew by 12%, from \$238M to \$266M, over the same period.

Quebec accounts for 27% of Canadian space sector revenues. Quebec has almost four times as many upstream segment organizations as downstream segment organizations, while revenues are heavily concentrated in the downstream segment (82%) rather than the upstream (18%).



First RCM satellite passes TVAC test with flying colours!

After four weeks sealed inside the thermal vacuum chamber (TVAC) at the David Florida Laboratory, the first RCM satellite is ready to return to Montreal, where mission preparations will continue. (2017-03-27)

Credit: CSA

Atlantic Canada (New Brunswick, Newfoundland and Nova Scotia)

In 2017, revenues in the Atlantic region increased by 1%, or \$4M, from \$468M in 2016 to \$472M in 2017. Export revenues grew by 1% in 2017, from \$273M in 2016 to \$275M in 2017. Domestic revenues also grew by 1%, or \$2M, from \$195M in 2016 to \$197M in 2017.

- Newfoundland remained stable in 2017, with an increase of 0.5%, settling at \$306M year-over-year.
- Revenues in New Brunswick grew by 2% year-over-year, with revenues reaching \$161M.
- Revenues in Nova Scotia decreased by 14%, totalling \$5M.

Between 2014 and 2017, total revenues in the Atlantic region grew by 55%, or \$168M, which can be attributed to growth in both domestic and export revenues. Domestic revenues grew by 33%, from \$148M in 2014 to \$197M in 2017, while export revenues grew by 76%, from \$156M in 2014 to \$275M in 2017.

The Atlantic region accounts for 8% of Canadian space sector revenues. In Atlantic Canada, there are a few small to medium-sized upstream segment players, which are mainly in academia, 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% (569 FTEs) of Canada’s space workforce, a decline of 9% (-55 employees) over last year.
- **Prairies:** 10% (1,005 FTEs), an increase of 12% (111 employees).
- **Ontario:** 43% (4,269 FTEs), a decline of 3% (-139 employees).
- **Quebec:** 34% (3,383 FTEs), an increase of 4% (128 employees).
- **Atlantic Canada:** 7% (717 FTEs), an increase of 2% (15 employees).

Workforce Group by Region: 2017

	Management	Engineers and Scientists	Technicians	Marketing and Sales	Administration	Other	Students/ Interns	Total	% of Total Workforce
B.C.	57	331	79	27	53	7	15	569	6%
Prairies	93	629	103	17	22	64	77	1,005	10%
Ontario	335	1,124	490	271	1,213	508	329	4,269	43%
Quebec	136	972	358	92	1,397	239	190	3,383	34%
Atlantic	46	147	72	89	129	189	46	717	7%
Total	667	3,201	1,102	497	2,814	1,007	657	9,942	100%

4 Revenues by Markets and Customers

KEY RESULTS

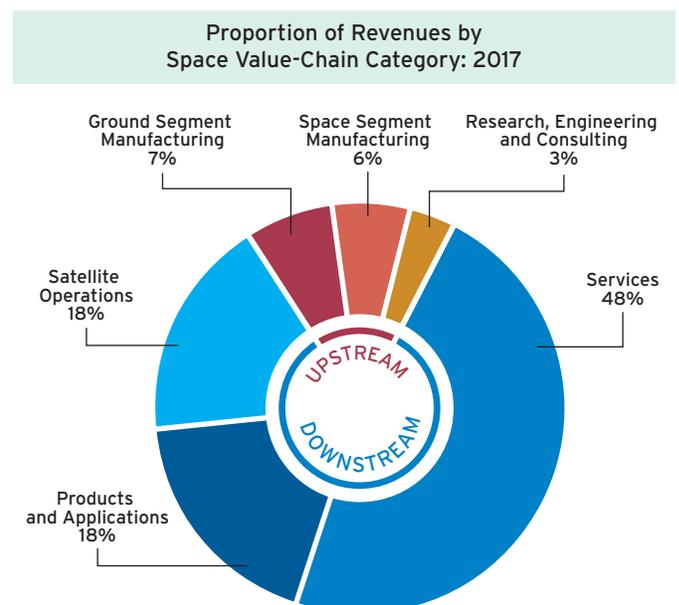
- In 2017, the upstream segment generated roughly **\$0.9B** in revenues, while the downstream segment generated **\$4.7B** in revenues.
- While the Services category accounted for the majority of revenues, growth mostly occurred in the Ground Segment Manufacturing and Products and Applications categories.
- In terms of sectors of activity, **85%** of revenues came from Satellite Communication. However, Navigation experienced the highest growth.
- Canadian space exports increased by **7%**, reaching **\$2.1B**. The U.S. remains the main export destination, accounting for **46%** of space export revenues.
- Overall, **13%** of space revenues were derived from government sources and **87%** from non-government sources.

MARKET SHARE BY VALUE-CHAIN CATEGORY

Space sector revenues can be broken down into value-chain segments and categories 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; Space Segment Manufacturing; and Ground Segment Manufacturing categories – generated \$0.9B in revenues in 2017. The downstream segment – comprised of the Satellite Operations; Products and Applications (e.g. manufacturing of terminals and development of software applications); and Services (e.g. broadcasting) categories – generated \$4.7B in revenues in 2017. A detailed description of the value-chain categorization is provided in Annex C. Revenues in each category can be broken down as follows:

- Research, Engineering and Consulting amounted to \$195M in 2017, a 7% decline (\$14M) from 2016. This category accounts for 3% of total revenues.
- Space Segment Manufacturing amounted to \$346M in 2017, a 33% decline (\$168M) from 2016. It accounts for 6% of total revenues.
- Ground Segment Manufacturing amounted to \$380M in 2017, a 94% growth (\$184M) from 2016. It accounts for 7% of total revenues.

- Satellite Operations amounted to \$980M in 2017, a 5% growth (\$45M) from 2016. It accounts for 18% of total revenues.
- Products and Applications reached \$1B in 2017, a 12% growth (\$114M) from 2016. It accounts for 18% of total revenues.
- Services amounted to \$2.7B in 2017, a 3% decline (\$96M) from 2016. It accounts for 48% of total revenues.



MARKET SHARE BY SECTOR OF ACTIVITY

Revenue growth occurred in every sector of activity in 2017, with the exception of Earth Observation (EO). Trends for the 2014–2017 period are detailed below.

Satellite Communication

In 2017, Satellite Communication generated \$4.7B in revenues, accounting for 85% of total space revenues. The vast majority (90%) of Satellite Communication revenues was derived from activities in the downstream segment, broken down as follows:

- Satellite Operations: \$959M
- Products and Applications (e.g. antennas): \$689M
- Broadcasting Services: \$2.3B
- All other telecommunication services: \$274M

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

- Research, Engineering and Consulting: \$48M
- Space Segment Manufacturing: \$221M
- Ground Segment Manufacturing: \$212M

Satellite Communication revenues grew by 2%, or \$94M, in 2017. Between 2014 and 2017, Satellite Communication revenues experienced a 5% growth, or \$232M, from \$4.5B to \$4.7B.

Earth Observation (EO)

In 2017, EO revenues totalled \$390M, accounting for 7% of total space revenues. The majority of EO revenues was in the upstream segment:

- Research, Engineering and Consulting: \$41M
- Space Segment Manufacturing: \$59M
- Ground Segment Manufacturing: \$162M

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

- Satellite Operations: \$15M
- Products and Applications: \$97M
- Services: \$16M

EO revenues declined by 21%, or \$105M, in 2017. Between 2014 and 2017, EO revenues experienced a decline of 24%, or \$126M, from \$516M to \$390M.

Space Exploration

Space Exploration revenues totalled \$115M in 2017, accounting for 2% of total space revenues. The upstream segment accounted for 97% of Space Exploration revenues, distributed as follows:

- Research, Engineering and Consulting: \$57M
- Space Segment Manufacturing: \$52M
- Ground Segment Manufacturing: \$1.8M

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

- Satellite Operations: \$0.4M
- Products and Applications: \$2.7M
- Services: \$0.9M

Space Exploration revenues grew by 12%, or \$13M, in 2017. Between 2014 and 2017, revenues from Space Exploration grew by 2%, or \$2M, from \$113M to \$115M.

Navigation

Navigation revenues reached \$269M in 2017, which amounted to 5% of total space revenues. In Canada, 99% of space activities related to Navigation are in the downstream segment. Products and Applications, as well as Services, are driven by consumer, business and government end-user demands. Navigation revenues are broken down as follows:

- Satellite Operations: \$4M
- Products and Applications: \$227M
- Services: \$34M

The remainder of activities, which relate to the upstream segment, amounts to roughly \$4M, divided as follows:

- Research, Engineering and Consulting: \$3M
- Ground Segment Manufacturing: \$1M

From 2016 to 2017, revenues grew by 25%, or \$53M. Between 2014 and 2017, revenues from Navigation increased by 42%, or \$79M, from \$190M to \$269M.

Space Science

In 2017, Space Science revenues totalled \$66M, which represents 1% of total space revenues. The majority of Space Science revenues was in the upstream segment:

- Research, Engineering and Consulting: \$44M
- Space Segment Manufacturing: \$5M
- Ground Segment Manufacturing: \$4M

With the remainder in the downstream segment:

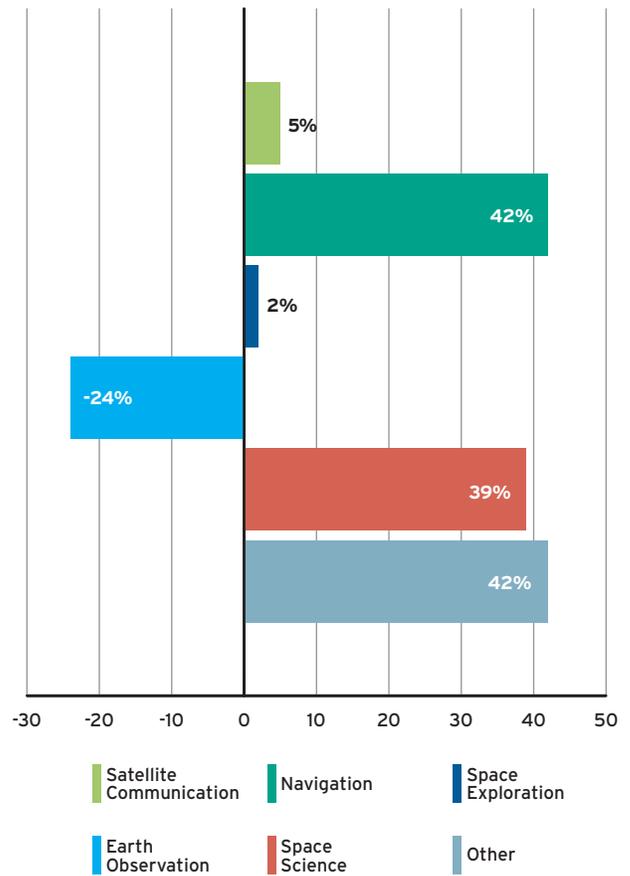
- Satellite Operations: \$1M
- Products and Applications: \$6M
- Services: \$6M

Space Science revenues grew by 8%, or \$5M, in 2017. Between 2014 and 2017, revenues from Space Science increased by 39%, or \$18M, from \$48M to \$66M.

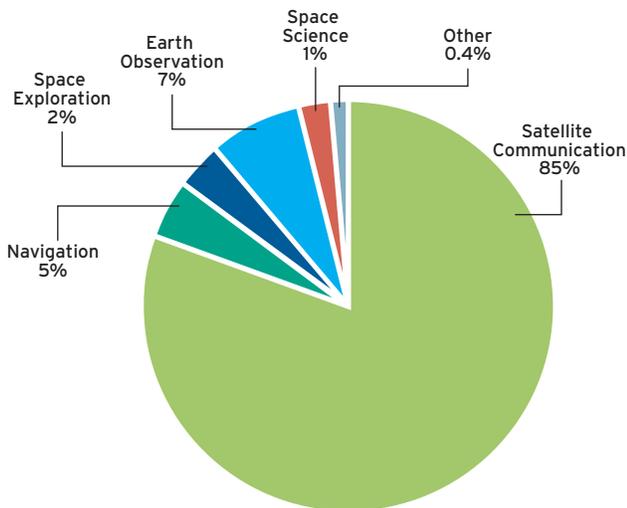
Other

From 2016 to 2017, other revenues grew by 31%, from \$15M to \$20M, which is 0.4% 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 for the previously noted sectors.

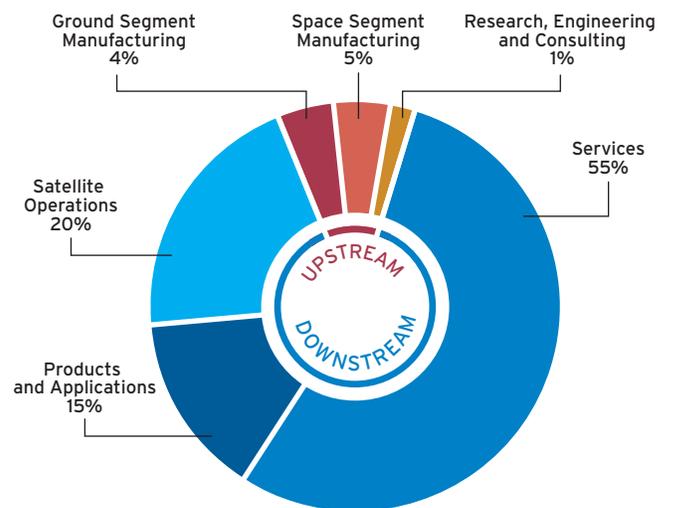
Percentage Change of Revenues by Sector of Activity: 2014-2017



Proportion of Revenues by Sector of Activity: 2017



Breakdown of Satellite Communication Revenues: 2017





Dextre successfully completes the most extensive robotics operation ever conducted on the ISS

For the first two weeks of January 2017, ground controllers and astronauts teamed up with Dextre, the Canadian robotic handyman, to improve the ISS's power system.

Credit: NASA

MARKET SHARE BY CUSTOMER LOCATION

Domestic vs. Export Revenues

In 2017, Canadian space revenues totalled \$5.6B, of which 62% (\$3.5B) was from domestic sources and 38% (\$2.1B) was from exports. Domestic revenues declined by 2%, or \$70M, in 2017; exports grew by 7%, or \$135M.

The average growth rate between 2014 and 2017 was +1.3% for the entire space sector, -3.2% for domestic revenues, and +11% for exports.

When excluding broadcasting, total revenues generated by the Canadian space sector grew from \$2.7B in 2014 to \$3.3B in 2017. With the exclusion of broadcasting, the average growth rate between 2014 and 2017 was +6.3% for the entire space sector, -0.5% for domestic revenues and +11% for exports.

Domestic vs. Export Revenues: 2014-2017 (in \$M)



Domestic vs. Export Revenues: 2014-2017 (in \$)

	Domestic Revenues	Export Revenues
2014	3,826,446,289	1,556,602,010
2015	3,704,150,826	1,594,323,346
2016	3,545,430,399	1,984,715,754
2017	3,475,200,911	2,120,153,923

Export Regions

Export revenues reached \$2.1B in 2017, although not all export markets grew at the same rate.

In 2017, the **U.S.** remained the main destination for Canadian space exports, with 46% of total exports. Revenues derived from exports to the U.S. grew by 7%, or \$66M, from \$918M in 2016 to \$984M in 2017.

Europe remained Canada's second main market for space exports. Canadian exports to **Europe** grew by 9%, or \$42M, from \$470M in 2016 to \$512M in 2017. Europe accounted for 24% of total exports.

Exports to **Asia** grew by 26%, or \$75M, from \$289M in 2016 to \$364M in 2017. Asia accounted for 17% of total exports.

In 2017, exports to **South America** grew by 24%, or \$23M, from \$96M in 2016 to \$119M in 2017. The region accounted for 6% of total exports.

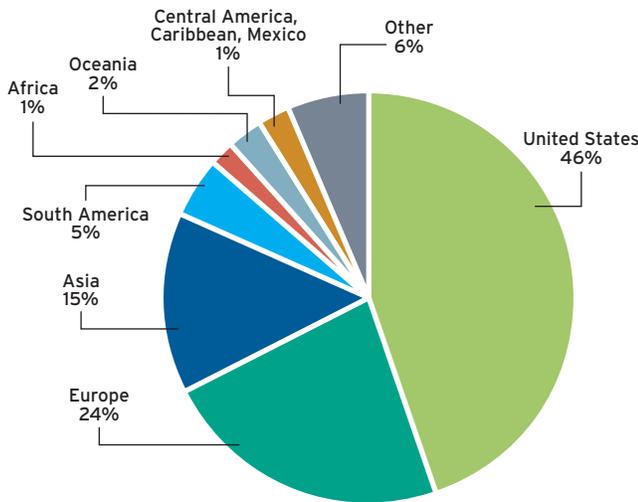
Exports to **Central America, the Caribbean and Mexico** grew by 17%, or \$5M, from \$29M in 2016 to \$34M in 2017. This region accounted for 2% of total export revenues.

Exports to **Oceania** decreased by 43%, or \$15M, from \$34M in 2016 to \$19M in 2017. Oceania accounted for 1% of total export revenues.

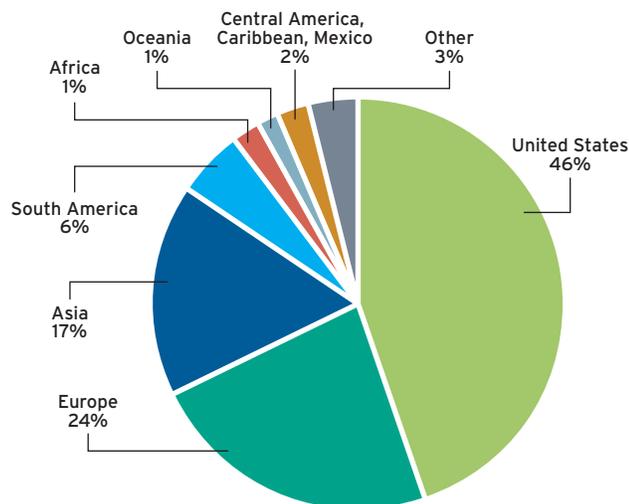
Export revenues from **Africa** increased by 26%, or \$6M, from \$21M in 2016 to \$27M in 2017. Generally speaking, export growth to this region has been uneven; years of strong growth have been followed by declines and vice versa. Africa accounted for 1% of total Canadian space export revenues.

Finally, in 2017, 3% of total exports, or \$61M, was not allocated to a specific region of the world.

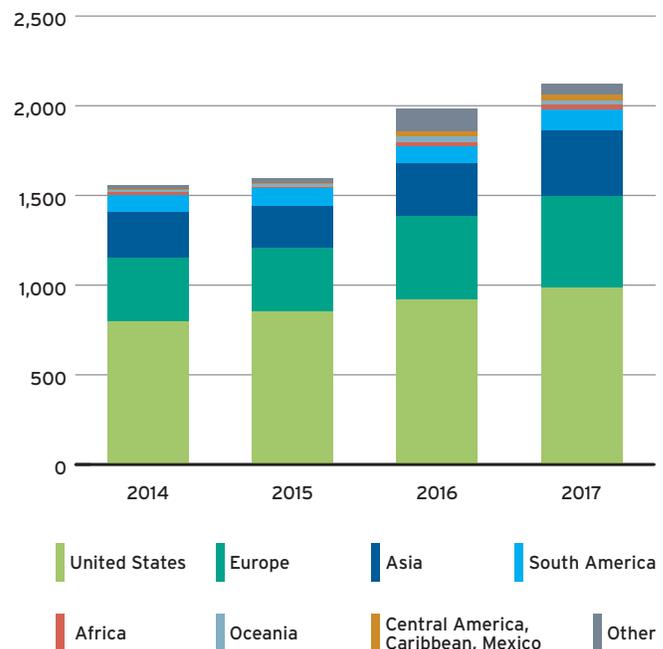
Proportion of Export Revenues: 2016



Proportion of Export Revenues: 2017



Sources of Export Revenues: 2014-2017 (in CAN\$M)



MARKET SHARE BY CUSTOMER TYPE

Customers are 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, 13% of space revenues in 2017 were derived from government customers and 87% 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 49% of revenues from non-government clients in 2017, whereas the downstream segment derived 95% 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 EO sector. In that respect, they face similar drivers and challenges to SMEs in the upstream segment.

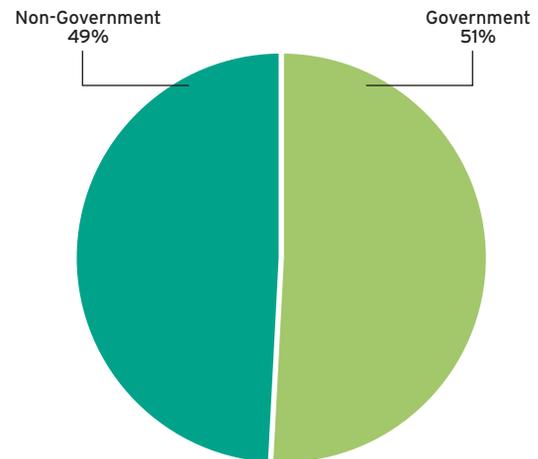


Juno Rover

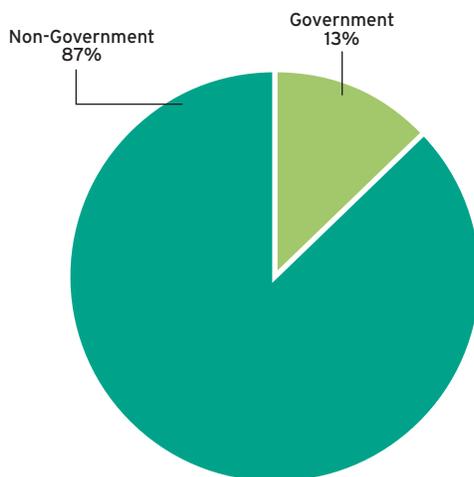
Tests on the CSA analogue terrain with the Juno rover in its configuration for the LEAD mission. (2017-09-28)

Credit: CSA

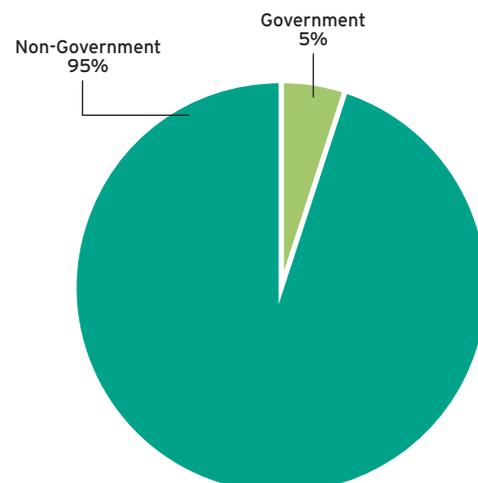
Market Share by Customer Type in the Upstream Segment: 2017



Market Share by Customer Type in the Canadian Space Sector: 2017



Market Share by Customer Type in the Downstream Segment: 2017



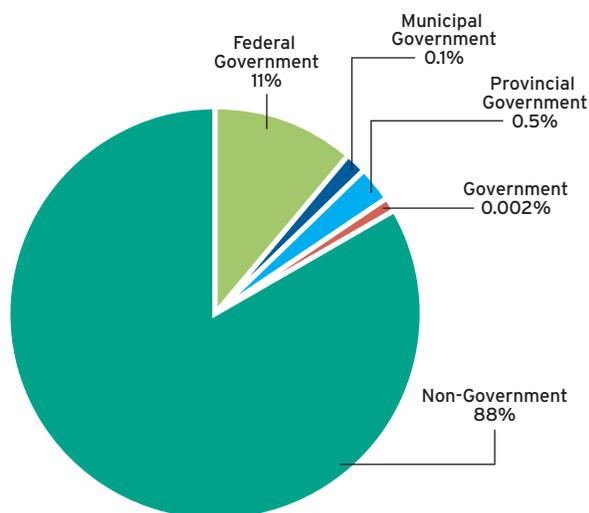
Domestic Customer Breakdown by Type

In 2017, 88% of domestic revenues were from non-government clients. Non-government customers can be individuals, such as subscribers to television and radio broadcasting services. Other non-government customers include businesses, where space-derived information products are integrated into business operations (e.g. Navigation and EO data). A small portion of non-government revenues is tied to financing or sales to non-profit organizations and foundations.

Government customers make up the remaining 12% of the domestic market. Government customers represent the majority of domestic upstream revenue, where they constitute 77% of revenues. Government customers are mainly involved in the Research, Engineering and Consulting category. Non-government revenues constitute the remaining 23%. In the domestic downstream segment, the situation is reversed as government customers account for only 3% of revenues.

The majority of government funding comes from federal sources. The top five sources of federal government revenue reported by space organizations in 2017 were the CSA, Public Services and Procurement Canada (PSPC), the Department of National Defence (DND), the Natural Sciences and Engineering Research Council (NSERC), and Shared Services Canada (SSC).

Proportion of Revenues by Domestic Customer: 2017



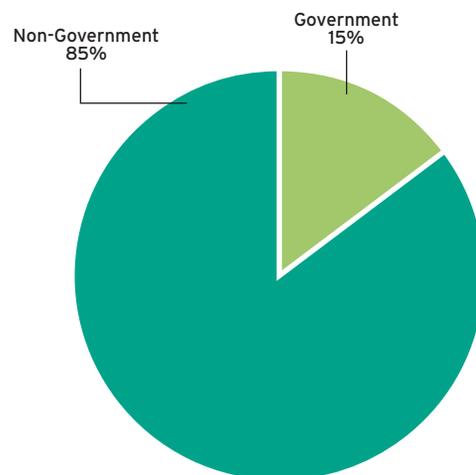
Foreign Customer Breakdown by Type

Non-government customers are the largest market segment abroad, accounting for 85%, or \$1.8B, of export revenues. Government clients make up the remaining 15%, or \$315M, of exports. This is equally true for both the upstream and downstream segments, where non-government revenues account for 68% and 91% of revenues, respectively.

Exports to commercial clients 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 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 EO 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, that 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: 2017



5 Innovation

KEY RESULTS

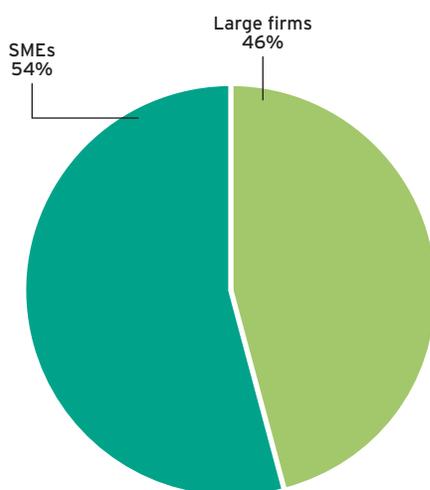
- Business Expenditures on R&D (BERD) expanded to **\$363M** in 2017, a **43%** increase from the previous year.
- R&D intensity for Manufacturing in the Space Sector was **10 times higher** than the average for manufacturing in Canada.
- Canadian space companies derived **\$330M** in revenues through the commercialization of externally funded R&D projects, a **169%** growth from 2016.
- Space sector organizations reported a total of **203 inventions** and **118 patents**.

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

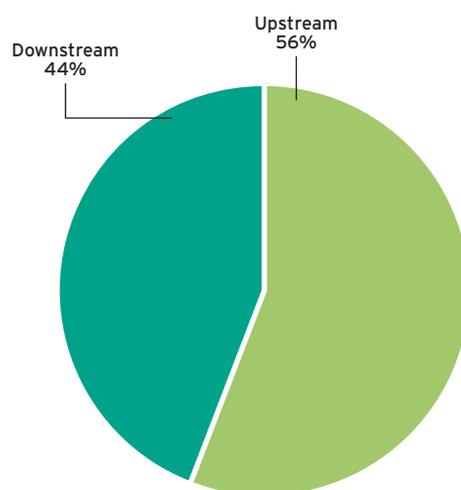
In 2017, there were 79 companies engaged in R&D activities, with BERD spending reaching \$363M. This represents a 43% increase over the \$254M spent on BERD in 2016. Upstream organizations were responsible for 56% of total space sector BERD.

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). Externally funded R&D represented the larger portion of accounting for 53%, or \$194M, of BERD in 2017. Internally company-funded R&D represented 47%, or \$169M, of total BERD.

Proportion of Business Expenditures on R&D by Firm Size: 2017



Proportion of Business Expenditures on R&D by Market Segment: 2017



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 34%. The upstream segment is more R&D intensive than the downstream: upstream R&D intensity is 45%, while downstream R&D intensity is 25%. The R&D intensity for manufacturing in the space sector (which includes both Space Segment Manufacturing and Ground Segment Manufacturing) is 36%, which is 10 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 2017, 44 organizations derived \$330M in revenues through the commercialization of externally funded R&D projects, a 169% growth from 2016 commercialization revenues. The upstream segment accounted for 78% of

commercialization revenues, while the downstream segment accounted for the remaining 22%. Almost all commercialization takes place through companies.

INVENTIONS AND PATENTS (ALL ORGANIZATIONS)

In 2017, 55 organizations reported having made an invention and 35 organizations registered a patent. Between 2016 and 2017, the number of organizations with inventions and patents increased by 22% (from 45 organizations in 2016) and by 52% (from 23 organizations in 2016), respectively. Between 2014 and 2017, the number of organizations with inventions declined by 5% (from 58 to 55), while the number of organizations with patents grew by 21% (from 29 to 35).

A total of 203 inventions and 118 patents were reported. The number of inventions grew by 11%, from 183 in 2016 to 203 in 2017, while the number of patents grew by 53%, from 77 in 2016 to 118 in 2017.

Upstream organizations accounted for the majority of inventions and patents, with 74% of all inventions reported and 65% of patents filed. This is a reflection of the composition of survey respondents, with almost three-quarters of respondents in the upstream segment. In 2017, upstream organizations registered 77 patents and 150 inventions, while downstream organizations registered 41 patents and reported 53 inventions.



Dextre performs first robotic handoff in space

In this image, Dextre is transferring cargo known as STP-H5 (Space Test Program-Houston 5), a suite of 13 experiments, from one robotic hand to another. (2017-02-24)

Credit: CSA

6 Results by Types of Organizations

KEY RESULTS

- Canada's top 30 companies accounted for **97%** of revenues and **81%** of the workforce in 2017.
- **95%** of Canadian space companies are SMEs; they account for **48%** of Canadian space sector revenues and **33%** of all employees.
- Universities and research centre revenues amounted to **\$99M**, representing 1.8% of total revenue. They contributed **16%** of the total space sector workforce with **1,606 FTEs**.

CANADA'S LEADING SPACE ORGANIZATIONS

In 2017, Canada's top 30 space organizations generated 97% of space revenues and 81% of space employment, a pattern consistent with previous years despite changes in the composition and rank of the top 30 space organizations. Canada's top 30 companies account for 88% of BERD and 65% of patents, but only 32% of inventions. Most of the top 30 organizations are companies; however, four academic organizations are also represented. About 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 86% of total space revenues and 58% of employment. Revenue and workforce concentration in the top 10 organizations was similar to 2016, when those organizations accounted for 83% of revenues and 50% of workforce. Canada's top 10 organizations accounted for 68% of BERD, 10% of inventions and 29% of patents. Eight of the top 10 organizations are downstream segment companies.

Large companies, classified as having 500 employees or more, are rare in the space sector. Only 5% of the companies surveyed were classified as large enterprises.

Fifty-six organizations reported space revenues in excess of \$1M during 2017.

SMALL AND MEDIUM-SIZED ENTERPRISES (SMEs)

Ninety-five percent of Canadian space companies are SMEs, and 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: 62% of the SMEs surveyed are upstream segment companies, while 38% are downstream segment companies. Together SMEs accounted for 48% of Canadian space sector revenues and 33% of all employees in 2017.

Space SMEs are highly innovative, corresponding to 54% of all space BERD. Upstream segment space SMEs account for 12% of total BERD, while downstream segment SMEs account for 42% of total BERD in the space sector. SMEs were also responsible for 75% of inventions and 50% of patents in 2017.

Space SMEs are also export-driven, with 77% of their sales reaching customers abroad. The downstream segment accounts for 56% of SMEs' export revenues, while the upstream segment accounts for 21% of SMEs' export revenues.

The SME workforce is highly skilled and specialized, with 50% of its workforce classified as HQP (compared to 34% of the workforce in large firms).

UNIVERSITIES AND RESEARCH CENTRES

Universities and research centre revenues amounted to \$99M in 2017, representing 1.8% of total revenue, with four universities making it into Canada's top 30 space organizations. Universities and research centres received \$95M in domestic funds, mostly from government: \$72M from the federal government, \$13M from provincial governments and \$0.7M from municipal governments. The remainder came from private foundations or companies.

In addition, universities and research centres accessed \$3M 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 \$1.8M. European organizations were the second largest contributor, with funds totalling \$1M (almost half of which came from the European Space Agency). The remaining funding came from other world regions.

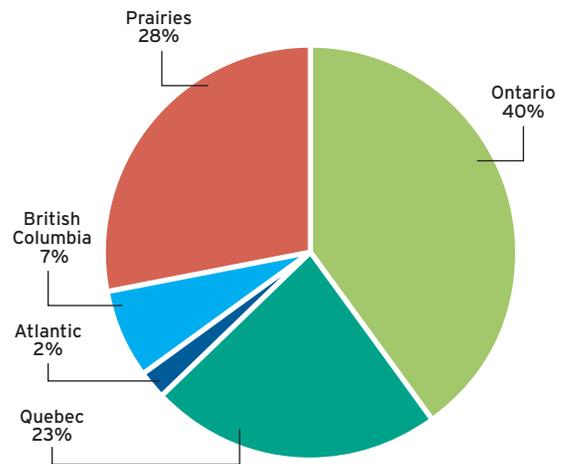
Academic organizations contributed 16% of the total space sector workforce in 2017 with 1,606 FTEs, of which 59% are HQP. An additional 36% of the university and research centre workforce was comprised of students, mostly at the graduate level, who were in receipt of wages or a stipend from their university for work as research assistants, teaching assistants, or other employee-type situations.

Regarding regional distribution, universities and research centres in Ontario captured 40% of space-related funding and 43% of the workforce. Organizations in Quebec accounted for 23% of space-related funding and 24% of the workforce. Universities and research centres in the Prairies accounted for 28% of space-related funding and 24% of the workforce. B.C. captured 7% of space-related funding and 3% of the workforce. Atlantic Canada accounted for 2% of space-related funding and 6% of the workforce.

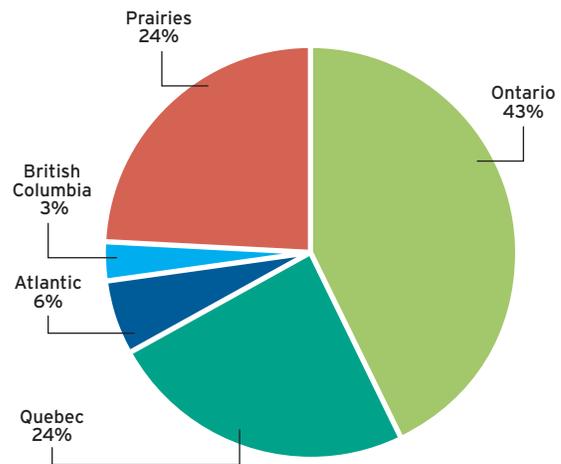
Of the 39 university and research centre respondents, nine reported coming up with inventions in 2017 and seven filed for patents. In total, Canadian universities and research centres generated 27 inventions and filed 15 patents, accounting for 13% of both space patents and inventions.

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-enabled solutions.

Regional Distribution of Space-Related Funding at Universities and Research Centres: 2017



Regional Distribution of Space-Related Workforce at Universities and Research Centres: 2017



7 Conclusion

Overall, the Canadian space sector remained stable in 2017, with revenues of \$5.6B and a workforce of 9,942 FTEs. Export revenues grew for the third year in a row, while domestic revenues continued to decline. The most significant change from previous years is an increase in BERD as well as in the commercialization of projects that were initially funded by government.



Joshua Kutryk and Jenni Sidey-Gibbons's first visit to the CSA as Canadian astronauts

Canadian astronauts Jeremy Hansen, Joshua Kutryk and Jenni Sidey-Gibbons tour the Canadian Space Agency with the Honourable Navdeep Bains, Minister of Innovation, Science and Economic Development, and his family. (2017-07-04)

Credit: CSA

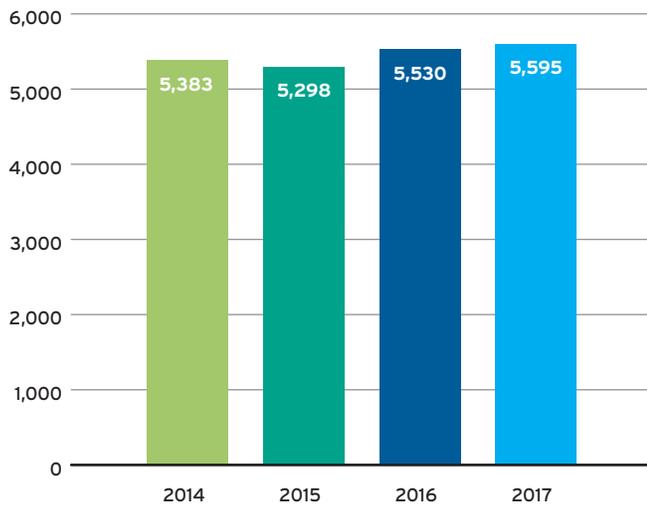


Annexes



A Annex A Economic Trends 2014-2017

Total Space Revenues (in \$M)



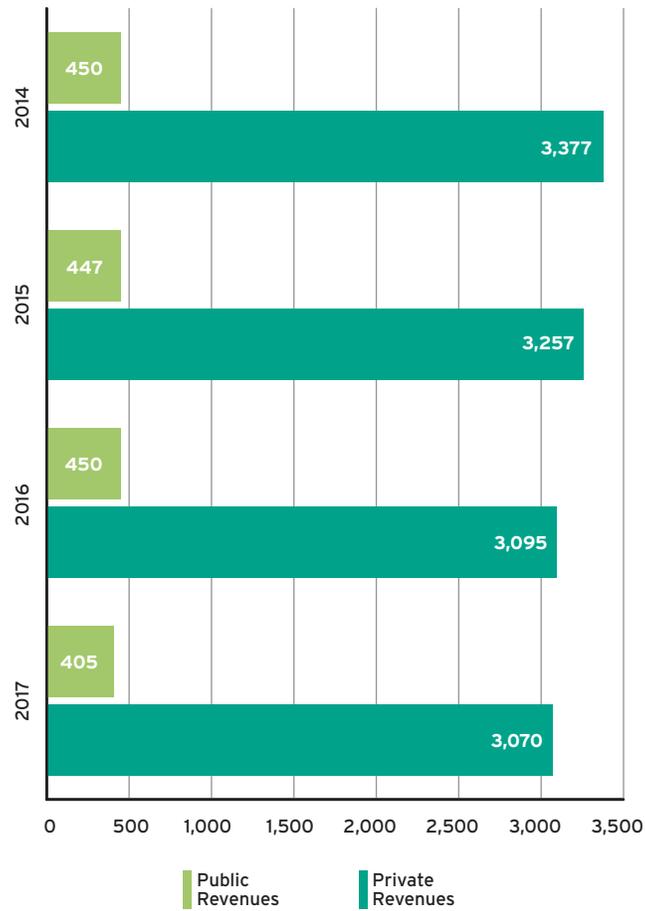
Domestic vs. Export Revenues (in \$M)



Domestic vs. Export Revenues

	Overall (\$)	Domestic (\$)	%	Export (\$)	%	Workforce
2014	5,383,048,299	3,826,446,289	71	1,556,602,010	29	10,012
2015	5,298,474,172	3,704,150,826	70	1,594,323,346	30	9,927
2016	5,530,146,153	3,545,430,399	64	1,984,715,754	36	9,883
2017	5,595,354,834	3,475,200,911	62	2,120,153,923	38	9,942

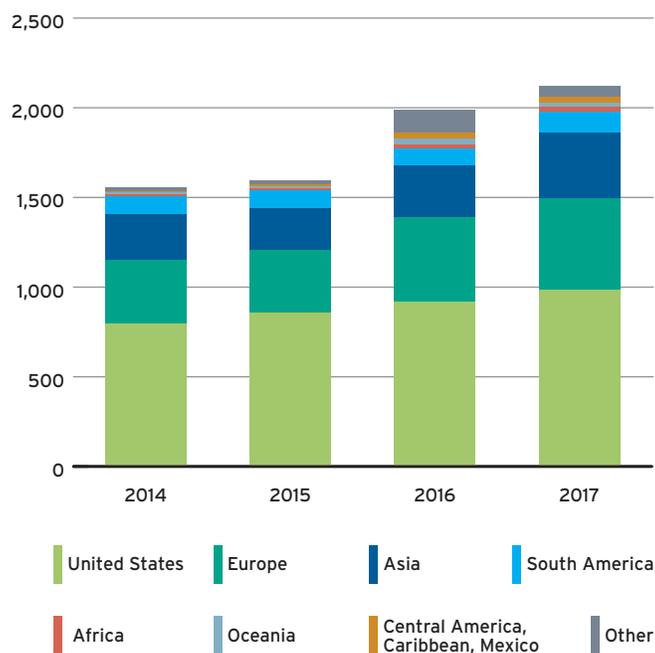
Sources of Domestic Revenues Public vs. Private (in \$M)



Sources of Domestic Revenues Public vs. Private (in \$)

	Public	Private
2014	449,792,184	3,376,654,105
2015	447,164,875	3,256,985,951
2016	450,307,362	3,095,123,037
2017	405,481,021	3,069,719,890

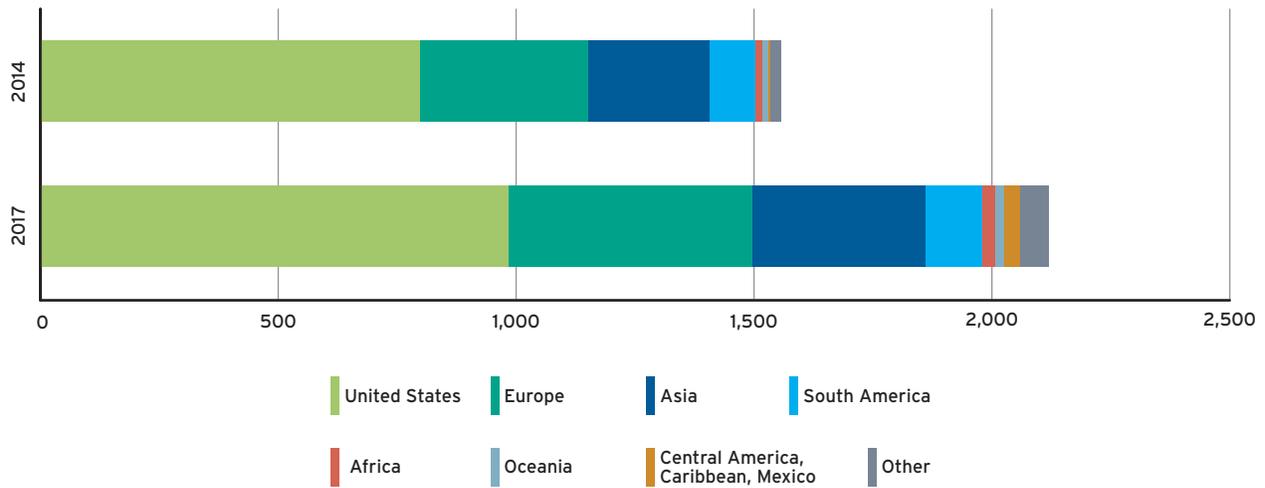
Sources of Export Revenues (in \$M)



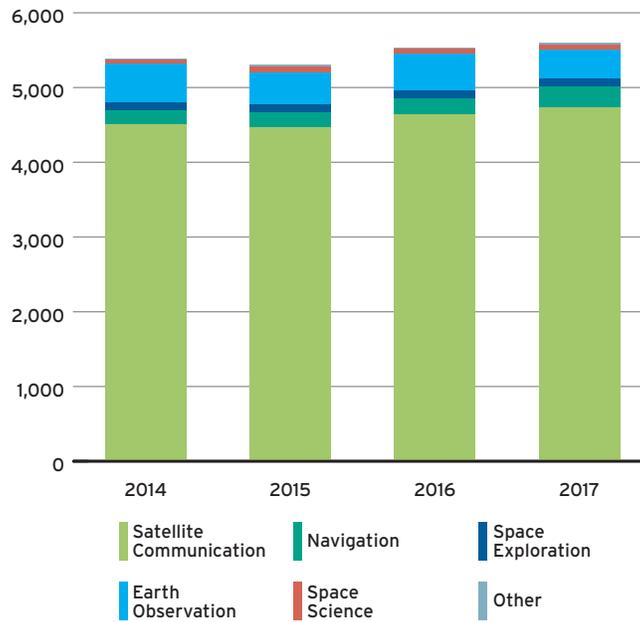
Sources of Export Revenues (in \$)

	2014	2015	2016	2017
United States	796,933,956	854,276,733	917,771,594	984,377,868
Europe	353,667,183	353,577,467	469,630,403	511,604,753
Asia	256,464,215	232,103,945	288,852,552	363,963,814
South America	95,822,808	100,393,238	95,673,005	118,768,200
Africa	14,151,739	8,399,427	21,319,454	26,756,979
Oceania	12,021,875	14,093,353	33,921,646	19,427,205
Central America, Caribbean, Mexico	6,005,134	7,362,703	29,170,340	34,064,675
Other	21,535,100	24,116,480	128,376,761	61,190,428

Sources of Export Revenues (in \$M)



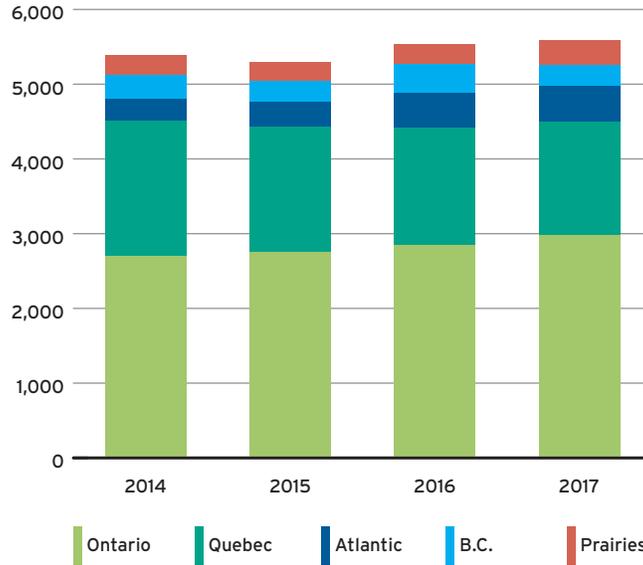
Revenues by Sectors of Activity (in \$M)



Revenues by Sectors of Activity (in \$)

	2014	2015	2016	2017
Satellite Communication	4,503,021,906	4,461,043,078	4,640,903,947	4,735,120,617
Navigation	189,788,695	205,643,650	215,513,917	268,991,704
Space Exploration	112,820,499	111,579,025	101,924,315	114,615,832
Earth Observation	515,574,621	422,510,765	495,309,241	390,365,118
Space Science	47,669,007	70,261,872	61,132,519	66,065,425
Other	14,173,571	27,435,783	15,362,216	20,196,138

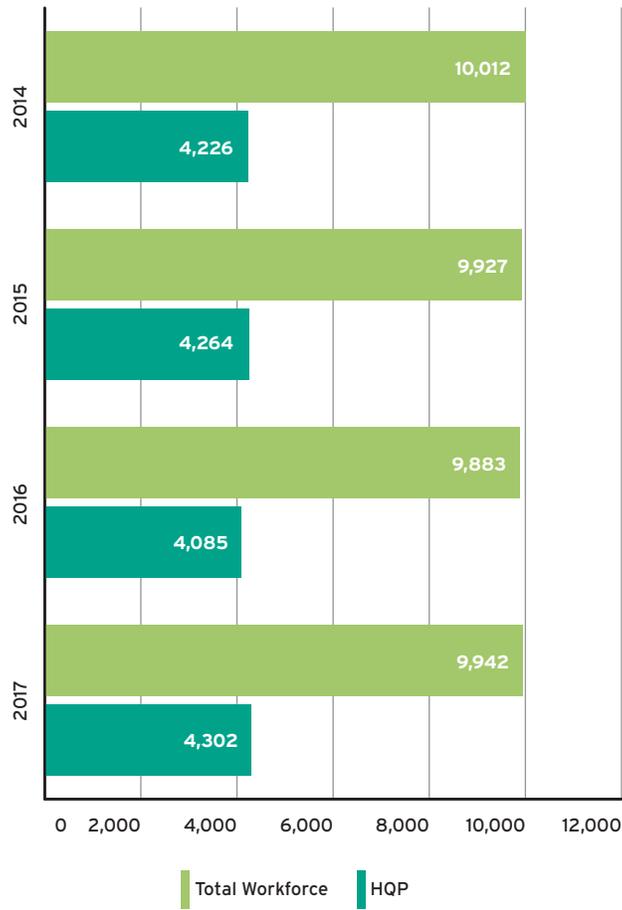
Revenues by Canadian Region (in \$M)



Revenues by Canadian Region (in \$)

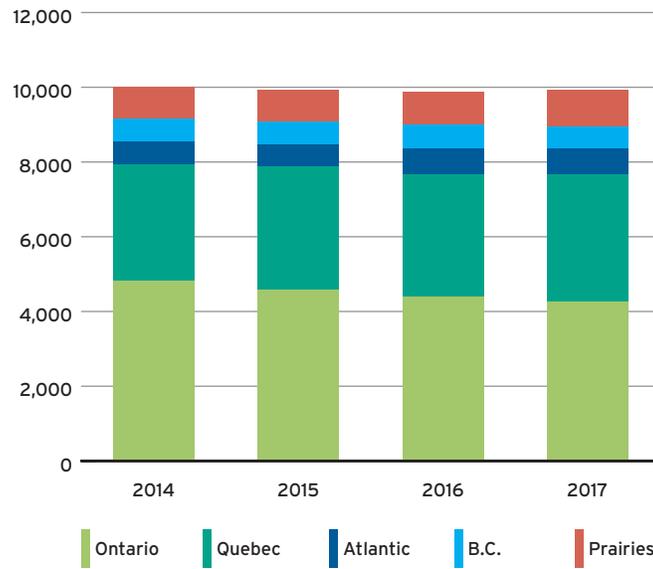
	2014	2015	2016	2017
British Columbia	308,541,040	280,517,113	386,996,622	290,382,929
Prairies	268,047,033	259,162,798	265,507,652	332,403,251
Ontario	2,705,301,452	2,757,233,517	2,849,572,500	2,972,817,122
Quebec	1,796,833,378	1,666,608,951	1,559,705,179	1,527,544,588
Atlantic	304,325,395	334,951,792	468,364,201	472,206,944

Total Workforce vs. HQP



Total Workforce vs. HQP		
	Total Workforce	HQP
2014	10,012	4,226
2015	9,927	4,264
2016	9,883	4,085
2017	9,942	4,302

Workforce by Canadian Region



Workforce by Canadian Region

	2014	2015	2016	2017
British Columbia	614	590	624	569
Prairies	858	867	894	1,005
Ontario	4,820	4,581	4,407	4,269
Quebec	3,126	3,298	3,256	3,383
Atlantic	595	591	702	717
Total	10,012	9,927	9,883	9,942

B 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 2017 questionnaire reported on a fiscal year (generally ending March 31, 2018), with the remainder reporting on a calendar year, from January 1 to December 31, 2017. As in previous years, the questionnaire had a high response rate covering 192 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 publicly 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 will only look back at the past 4 years (2014–2017). 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, weighting 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; Space Segment Manufacturing; Ground Segment Manufacturing; Satellite Operations; Products and Applications; and 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 category of the space sector (collected directly from companies through the questionnaire) are entered into 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.

C 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 Organisation for Economic Co-operation and Development'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 to 2013.

Upstream Segment

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

- **Research, Engineering 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 Segment Manufacturing:** Building and integration of spacecraft, satellites, payloads or any component thereof.
- **Ground Segment 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.
- **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.

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).



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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