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### Reaching beyond

A \$40 billion Canadian space economy by 2040

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CANADA'S SPACE

INNOVATEURS DE L'ESPACE INNOVATORS DU CANADA

This paper was developed in consultation with Space Canada, a national association that represents Canada's space innovators and ecosystem to convey the value of space technology, research, and investment to domestic and international audiences. Space Canada organized round-table discussions with roughly 50 of its members, who generously shared information on their businesses, insights on the state of the sector and its future potential, and ideas about how that potential could be realized.

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## Introduction

Activity in space is expanding at an unprecedented rate. Space is becoming critical to modern economies and societies, national security, and climate action. It is thus a domain of tremendous opportunity for entrepreneurs, investors, and nations. In many respects, Canada is well positioned to take advantage of this opportunity—and, in so doing, strengthen the country's competitiveness, boost its productivity, and help secure its citizens' prosperity in the near and longer terms. But achieving these goals will require a smart, sustained, and well-executed strategy.

Canada has been a spacefaring country since the dawn of the space age. It's often noted, with justifiable pride, that Canada became the world's third country in space when the Alouette I was launched into orbit in September 1962.

Canada continued to be a major player over subsequent decades. Canadarm, which first came into service in 1981, gave the country a prominent role during the US space shuttle era and led to Canada becoming the global leader in space robotics. The groundbreaking RADARSAT-1 satellite, launched in 1995, produced unique images that were in high demand in Canada and around the world.

But times changed. By the turn of the century, spending on Canada's space program had plateaued and its edge in the sector was slipping, even as allies, partners, and real and potential adversaries moved in the opposite direction, placing more emphasis and bigger bets on space. While Canada treated the space race as a brisk walk, many others joined in—and have been running hard.

More recently, that trajectory has started to shift. Focus and funding for Canada's space program have improved, and Canadian space companies—from big, established players to ambitious startups—are full of ideas and energy. However, for the country to harvest the full benefits of space, it will need to forge bold strategies, build on recent momentum, and accelerate its pace. Today's race is as much about economics as it is about novelty, as much about national security as national honour, and as much about the private sector as government.



# The shape of the space economy

Broadly speaking, activity in space can be divided into two categories: exploration and utilization.

**Exploration** is infused with wonder, imagination, and inspiration. It's generally the first thing that comes to mind when thinking of space, whether the image that immediately strikes is of the moon landing, a Mars rover, or some distant galaxy. Contemporary exploration efforts include the Artemis program, a NASA-led initiative that will take astronauts, including Canadian Jeremy Hansen, to the moon and establish a longer-term presence there; the James Webb Space Telescope, a successor to the Hubble telescope, which is providing astonishing images from the deepest reaches of the universe; and European, Chinese, Indian, Japanese, Korean, Israeli, and UAE missions to the moon and, in some cases, asteroids and the sun.

**Utilization,** like exploration, relies on a combination of big vision and expert engineering. However, its orientation is different: While exploration gazes toward the heavens, utilization mostly stares back at Earth, relying on satellites to provide a range of practical services. Every time we use a GPS-based system to find our way to a store or a friend's home, pull up the latest weather forecast, or videoconference with far-flung relatives, friends, and colleagues, we're relying on space-based assets and services.

Straddling exploration and utilization is the International Space Station (ISS), where global collaboration continues despite geopolitical tensions. The multinational ISS crew conducts exploration-related studies on topics such as the effects of a microgravity on bodies, as well as Earth-oriented experiments in fields such as pharmacology, bioengineering, and semiconductors. Before long, private space stations might also join and perhaps even replace the ISS, providing low Earth orbit (LEO) platforms for activities such as space tourism and specialized manufacturing that benefits from microgravity conditions.

In terms of current and potential economic contributions—the topic of this paper—exploration certainly has value. Substantial expenditures on exploration present opportunities for Canadian contractors; moreover, the need to develop new technologies to support exploration can yield innovations that may be applied not only in space but also to myriad terrestrial applications and creative spinoffs.

Still, most of the economic action is in the utilization sector—and that action is growing exponentially. Three key technological advances have led to this surge:

1. The cost of launching satellites has plummeted. This is thanks largely to a 2004 US government policy choice to give the private sector an opportunity to transport crew to and from the ISS. That change in approach, supported by large subsidization, reflected the comparatively mature state of launch technology and jump-started innovation—including the development of reusable components, and ride-sharing arrangements for which multiple payloads are carried on a single rocket. The policy shifts and associated incentivization achieved the intended goals: the number of launches by SpaceX, among the most successful commercial launch providers, as well as by other private companies now far exceeds that by public space agencies, which have instead redirected their efforts to other areas.

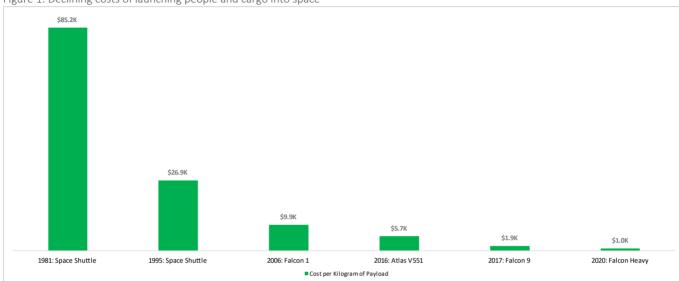
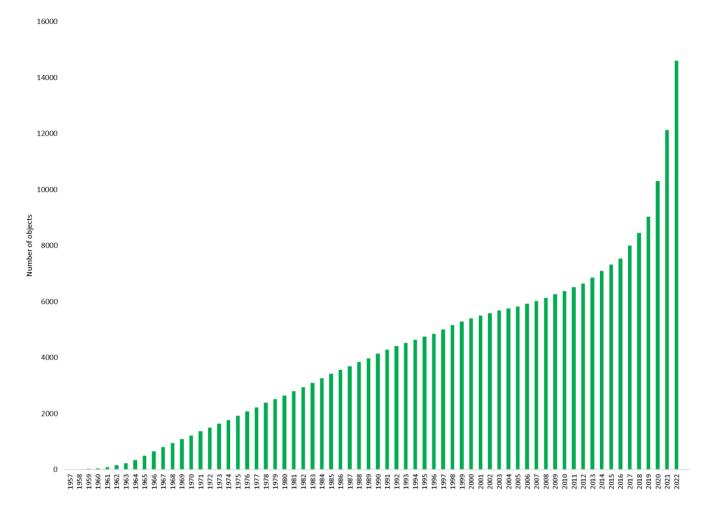


Figure 1: Declining costs of launching people and cargo into space

Source: "Launch costs to low Earth orbit, 1980-2100", Future Timeline.

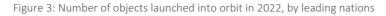
2. Satellite technology has undergone a substantial transformation. A generation ago, satellites were big, costly, bespoke, and complicated. Today, they're often small, inexpensive, relatively standardized, and manufactured using more automation and techniques like 3-D printing. Of course, there also exist other, more sophisticated satellites with broader capabilities that take more time and money to design and build.

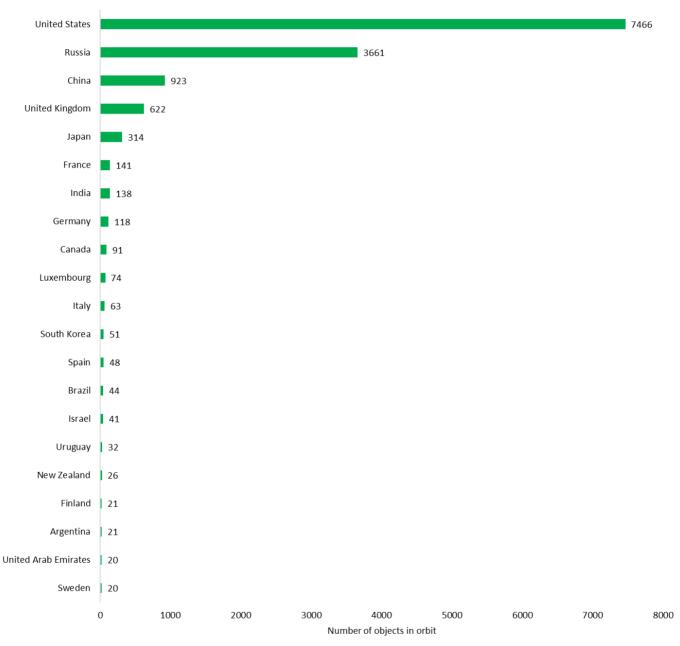
Figure 2: Cumulative number of objects launched into orbit from 1957 to 2022



Note: Objects include satellites, probes, landers, crewed spacecrafts, and space station flight elements launched into Earth orbit or beyond. Source: <a href="https://ourworldindata.org">https://ourworldindata.org</a>.

**3.** Our ability to digest and find practical applications for satellite data has improved dramatically. The huge advances in computing power and analytics, which will be further accelerated by artificial intelligence (AI), have made it possible to extract an extraordinary range of helpful information and insights from data gathered by satellites.





Note: Objects include satellites, probes, landers, crewed spacecrafts, and space station flight elements launched into Earth orbit or beyond. Source: https://ourworldindata.org.



The combined result of these three developments—more satellites providing increasing quantities of data, and increasingly powerful tools to make that data more usable and relevant—has been the massive expansion of space utilization. Currently, the number of satellites in orbit is approximately 11,000, a fivefold increase from just five years ago. It's estimated that, by 2030, there will be up to 100,000 satellites orbiting Earth.<sup>1</sup>

In short, space utilization has entered a boom phase that's likely to persist into and beyond the middle of the century as technologies continue to progress and costs continue to fall. Satellites have become indispensable to modern life, and this sea change means there are significant opportunities to build successful businesses and enhance Canada's competitiveness and prosperity through space-related activity.

<sup>&</sup>lt;sup>1</sup> "October 2023 Issue". National Geographic.



## Areas of opportunity

Canada's opportunities will be greatest where existing and emerging needs intersect with our capacities and comparative advantages.

Given the wide array of potential applications of satellites and the data they collect, and the fact that we're still in the early stages of expansion in this area, it's neither feasible nor advisable to zero in on just one or two areas. Many may hold opportunity for Canadian industry working within an appropriate framework of government policies and support. Significant opportunity areas in the **utilization** segment can be grouped into three categories:

1. Upstream design, manufacture, deployment, and operation of satellites and ground stations. Many companies and countries are deploying or seeking to deploy their own satellites—which translates into opportunities for those who can design, build, and operate them efficiently. Of particular note is the creation of reliable, low latency, worldwide internet connectivity through constellations of satellites in LEO. Such connectivity promises to help bridge the digital divide and attract demand from: individual users, notably those in remote locations; industries like aviation and marine transportation; and government agencies. Canada is poised for success in this endeavour, although there's a great deal of competition: SpaceX's Starlink satellite constellation has already extended internet coverage to



many former dead zones, with OneWeb and Amazon's Kuiper constellations not far behind. That said, for some time, Telesat—Canada's leading satellite operator—has been planning and designing a cutting-edge constellation called Telesat Lightspeed, and has now teamed with the country's leading satellite manufacturer, MDA, which will act as the prime contractor for building the constellation.<sup>2</sup> Compared with its main competitors, Lightspeed will use fewer satellites (initially, about 200)—reducing environmental impacts while aiming to offer equivalent or better performance; additionally, it targets primarily business customers rather than consumers. Lightspeed is expected to attract clients from around the world,

<sup>&</sup>lt;sup>2</sup> "Telesat contracts MDA as prime satellite manufacturer for its advanced Telesat Lightspeed low Earth orbit constellation," Telesat, August 11, 2023.

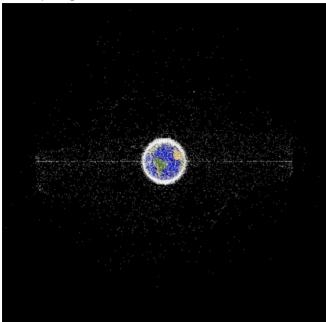
promising to be the largest Canadian space program ever, directly creating many jobs and offering the potential for additional Canadian players to produce components and software.<sup>3</sup>

2. Downstream use of satellite-communication services and Earth observation (EO) data. An almost endless variety of applications and potential for growth exists. Among the most promising areas for downstream use—some of which are already seeing significant activity—are the following:

- Climate-change mitigation and adaptation: Identifying greenhouse-gas emissions such as methane leaks, tracking loss of ice sheets, and monitoring sea levels
- Precision agriculture: Pinpointing where irrigation and/or fertilization are needed and when crops should be harvested
- Forestry management: Monitoring forests to support sustainable logging practices
- Supply-chain efficiency: Providing early signals of emerging rail and port congestion to permit real-time rerouting, schedule adjustments, and enact other mitigation measures
- Fleet and parking management: Allowing operators of trucking fleets and parking facilities to optimize asset use, avoid delays, and reduce emissions
- Insurance: Giving insurers information to enable evidence-based risk assessment and premiums setting
- Disaster response: Facilitating rapid assessment of, and reactions to, wildfires, floods, earthquakes, hurricanes, oil spills, plane crashes, and other natural and human-caused disasters
- Border protection: Safeguarding Canadian sovereignty and detecting unauthorized movements around land and sea borders, including across the Arctic land mass and through the Northwest Passage
- Defence and intelligence: Providing the Canadian military and our allies with secure communication links, as well as with information and insights to help ensure national security, support responses to humanitarian crises, and safeguard the interests of democracies in geopolitical hot spots around the globe

<sup>&</sup>lt;sup>3</sup> "Telesat to receive \$1.44 billion through Government of Canada investment, a major milestone toward completing the financing of Telesat Lightspeed," *Telesat*, August 12, 2021.

Figure 4: Computer-generated images of objects in Earth orbit currently being tracked



Source: https://orbitaldebris.jsc.nasa.gov.

#### 3. Maintenance and protection of satellite infrastructure.

Increasingly crowded orbital zones can lead to dangers similar to those for crowded highways: a greater chance of crashes. This risk is exacerbated by increasing quantities of space junk, mostly from defunct satellites or launch equipment, but also from deliberate experiments to destroy satellites with missiles. One hypothesis, called the Kessler effect, holds that the damage from an accident in space could spread rapidly, with each subsequent collision generating a large number of fragments that, in turn, results in more collisions. Such a chain reaction could shut down space-based services abruptly and for an extended period. Keeping a careful eye on the thousands of satellites and fragments above Earth, enabling clear communication between them, and undertaking active flight operations—all of which may benefit from increasing application of Al—can deconflict orbits and facilitate quick responses if collisions appear likely. Removing debris, in part by employing robotics expertise, can help maintain a cleaner orbital environment. And in-space servicing, assembly, and manufacturing can contribute to more sustainable, longerfunctioning satellites.



Regarding **exploration**, some of the best opportunities are in areas where: a) Canada has significant existing capabilities, and; b) terrestrial as well as space-based applications of innovations can be expected. These could include:

- Robotics: Thanks in large part to Canadarm and Canadarm2, the country is already a leader in this sphere. Canada's commitment to design and build Canadarm3 for the NASA-led Gateway mission—whose aim is to establish a lunar outpost—will further strengthen this position.
- Health: Solutions that keep astronauts healthy—and allow for diagnoses and interventions when issues arise—will be essential with longer and longer missions. Many of these technologies can also be adapted for use in remote locations, including isolated Indigenous and northern communities.
- Food: Canada's strong agricultural sector can help address the need to grow nutritious food for astronauts spending long periods in space, including on the moon and, potentially, on a mission to Mars. Such technologies can also be applied to remote and other communities.
- Mining and energy: Mining technologies adapted for space use will be required to get water and produce fuel to support long-term missions; they may also someday be applied to extract precious metals from asteroids for use on Earth. Canada's mining industry could play a key role in these efforts.

These examples give a sense of the sorts of opportunities that are burgeoning in the space sector. The question isn't whether opportunities will continue to multiply, but rather, how much Canada's economy can benefit from them.



# Economic potential

Experts have yet to settle on a definitive methodology for measuring the space economy, but the Canadian Space Agency (CSA), working in partnership with Statistics Canada, has arrived at credible estimates.

According to the CSA's most recent calculations:

- The Canadian space sector generates \$5.5 billion in revenue annually and contributes \$2.5 billion to the GDP.
- More than 10,000 Canadians are directly employed by the space sector, with another 13,000 jobs supported by spacesector activity.
- Space is one of the country's most R&D-intensive industries.
- Small and medium enterprises (SMEs) account for more than 90% of Canadian space firms and about 30% of employment in the space sector.

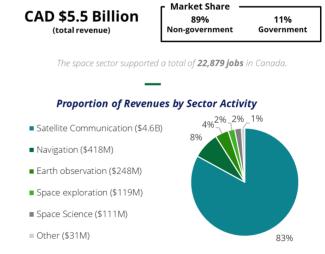
By comparison, the global space economy has been estimated to be worth more than \$600 billion and could exceed \$2 trillion by 2040, given the current growth trajectory. Its compound annual growth rate (CAGR) is currently approximately 7.7%.

As impressive as Canada's space sector may appear, it accounts for only about 1% of today's worldwide space economy—despite the country's economy representing approximately 2% of the global GDP.

So, there's a lot of room to grow. If Canada can create the conditions to capture a share of the worldwide space economy comparable to its share of the general economy, our space sector could be worth \$40 billion by 2040. And because the field is inherently research-driven and has a global impact, its growth could help Canada meet long-standing challenges for innovation, scaling-up, and productivity.

For the sake of Canada's prosperity, "40 by 40" is a goal worth pursuing.

Figure 5: Canadian space industry snapshot (2019)



Space-sector activity can serve **commercial, civil or military purposes,** and refer to activity across the value chain.



## Creating the right conditions

In a realm where success correlates with ingenuity and persistence, industry can contribute to a robust Canadian space economy in diverse ways. What has been called "new space" is a largely private-sector phenomenon fuelled by an entrepreneurial drive for impact and profit, combined with increasing interest from private equity, pension, and sovereign wealth funds.

Creativity, grit, and a readiness to collaborate across firms in this still-emerging, dynamic market are what's needed from those in the space sector. And those outside the sector should be paying increased attention to space-related strategies and a focus on how satellite-based services, information, and insights can improve the efficiency, responsiveness, and reliability of their operations. Like those in the past who lost market share after miscalculating the significance of the burgeoning internet, a failure to act may soon see companies increasingly outmanoeuvred by competitors who are not as slow to respond.

The private sector, however, functions within frameworks established by government. Despite the rise in commercial activity, space remains a domain in which public policies and programs—and the choices governments make on purchasing and delivering their own services—have an outsized effect on the ability of private firms to survive and thrive.

Over the past decade, the national space program got many things right. For example:

- The modernized *Space policy framework*, released in 2014, emphasized commercialization and the role of the private sector.
- The 2019 space strategy, *Exploration, imagination, innovation*, set out ambitious priorities that included connecting all Canadians; supporting and harnessing work on space-related health and food growth, both of which can be adapted to help remote communities; creating a modern regulatory framework to facilitate growth of the commercial space sector; and using space-based data to support innovation.
- The 2022 Earth-observation strategy, *Resourceful, resilient, ready*, stressed the significance of EO data across a wide range of areas—including climate-change mitigation and adaptation—and promised measures such as open access to EO data.

Significant incremental budgetary commitments—a total of \$8.7 billion since 2016, with expenditures anticipated over the coming years and decades—have been made by the Government of Canada through a number of programs and other vehicles. These include the CSA's Space Technology Development Program (STDP); CSA-led initiatives such as the Lunar Exploration Accelerator Program, smartEarth, and the Deep Space Healthcare Challenge; broad-based programs such as the Strategic Innovation Fund; and targeted investments in Telesat Lightspeed. Additionally, the CSA has reinforced Canada's close working relationships with NASA and the European Space Agency, resulting in tangible opportunities for Canadian players as well as intangible but crucial international credibility.

However, in an age when governments and companies around the world are determinedly moving into space, these important steps need to be quickly built upon if Canada is to avoid falling behind, losing business and talent to others, and failing to realize the potential for a national space sector worth \$40 billion by 2040. Canada's future in space is not guaranteed; it will require purposeful and effective public policy.

There are **six interrelated areas** in which the government can act—including moving forward quickly and boldly with announced initiatives—in order to **maximize the odds for a thriving Canadian space sector**:

#### 1. Strengthening governance

Canada's system of government is hard-wired for vertical accountability: Public servants in departments and agencies report up to deputy ministers, who advise and support ministers, who answer to the prime minister and Parliament. This system has generally served Canada and other Westminster-based jurisdictions well, but it has a downside: challenges collaborating across silos on cross-cutting issues.

This hurdle is especially acute for a topic like space, which touches the mandates of multiple governmental departments and agencies, including the CSA; Innovation, Science, and Economic Development Canada; Global Affairs Canada; the Department of National Defence; Transport Canada; Natural Resources Canada; and Environment and Climate Change Canada. Success in space requires cooperation and coordination between and across government organizations that make space-related policies and regulations, allocate funding for space-related research and product development, buy space assets and services, and make significant use of space data. That's why the United States has a National Space Council, and other countries and jurisdictions—from the United Kingdom and Australia to India and Japan—have their own space-related governance arrangements that bring senior decision-makers together.

The Government of Canada should put in place a similar arrangement. The current reliance on ad hoc and project-specific working groups and collaboration between more junior officials can be helpful, but it isn't sufficient. What's needed is ongoing dialogue; a common and coherent set of long-term, strategic priorities; and a coordinated, disciplined execution of strategies. If Canada is to meet the moment in space, its policies and programs must be steered by an integrated, focused, national body—and that will demand leadership from the highest levels.

#### 2. Modernizing the legal framework

The legislative and regulatory framework governing Canada's space activity is in urgent need of modernization. Some instruments, like the Remote Sensing Space Systems Act, have outdated provisions. And for other novel areas—such as launches and in-orbit repair activities—there's a lack of clear rules. These issues can create uncertainty and risk for private-sector players looking to pursue and invest in big ideas, putting them at a disadvantage compared with those in jurisdictions with more fully developed legal regimes.

While the government has had consultations on the establishment of a clear regulatory framework for space, that effort should be accelerated, ultimately yielding comprehensive rules that draw on lessons from other jurisdictions and maximize alignment at the international level. Moreover, given the relatively nascent nature of some space activity, and considering best practices for regulation in general, these rules should be as outcome- and performance-based as possible (rather than excessively prescriptive), contain built-in mechanisms for timely and agile adjustments (avoiding the need for a drawn-out amendment process as conditions quickly evolve), leave room for sandboxes in which novel approaches can be tested and refined, and ensure timely licensing and permitting decisions.

#### 3. Improving funding and financial instruments

As noted previously, there has been an infusion of funding into Canada's space program in the past seven years. And as we enter a period of fiscal tightening, the timing isn't ideal for adding more resources to any government program.

Those considerations, however, must be balanced against both the major near- and long-term contributions the space sector can make to Canadian prosperity and national security. The stark reality is that, even after the recent increases, Canada's space-related spending is dead last among G7 countries when measured as a percentage of total GDP.

A reasonable goal would be to raise funding as a proportion of GDP to match the G7 average while considering how it can be strategically leveraged to simultaneously help Canada meet the NATO defence-spending target of 2% of GDP. Equally important, however, is how funding gets spent—and here, the best approach is not to add yet another mechanism to the plethora that already exist, but rather, to build on the STDP and/or the new Canada Innovation Corporation.

Essential, too, is that funding delivery covers more of the technology readiness level (TRL) continuum (a nine-point scale that goes from basic research to commercialization), moving more forcefully in areas where private money is still hesitant to venture alone. Moreover, to reflect fiscal realities, as well as the complexity and needs of the sector, a revamped funding approach should include a larger tool kit of funding strategies that would entail not just traditional grants and contributions, but also:

- An **equity** option under which government would take a minority stake in some space companies, creating the potential for an eventual return on taxpayer investments
- A **debt** stream, in which loans would be repayable at favourable rates once a firm has achieved a certain revenue threshold
- The partial **backstopping** of private investments by providing **demand guarantees** to help reduce risk and increase the patience of capital
- An **insurance** option, where the government could help insure undertakings the private market may consider too new to fully assess

#### 4. Streamlining procurement

It is axiomatic that public procurement processes must be rigorous enough to protect taxpayer dollars and the integrity of government decision-making. But it's also important to recognize that when it comes to space (though not just space), the economic costs of slow, cumbersome processes and complicated restrictions often outweigh the benefits. A revised space procurement process based on calibrated risk management could include the following:

- Making the "Canadian-ness" of a bid team a material consideration in the assessment of proposals—consistent with practices in the United States, the EU, and other jurisdictions
- Having the government play a larger role—e.g., as the **anchor or an early customer** for Canadian technologies and players; this may add to a firm's credibility and its ability to win deals in other markets
- Updating Canada's **Industrial and Technological Benefits (ITB) Policy** to ensure it has real impacts for high-potential segments of the country's space sector
- Allowing for early and frank conversations between government and industry representatives, with the aims of
  conveying emerging demands, exploring technological options, and ensuring subsequent requests for proposals are
  appropriately tailored to market realities and that they spur innovation
- **Tightening timelines**, from the identification of a need through the review of proposals, the awarding of contracts, and the delivery of a capability—consistent with the fast-moving nature of the sector and its technologies
- Allowing winning bidders to retain and use as much of the intellectual property resulting from the project as is feasible

#### 5. Expanding collaboration

Space technologies and projects involve many complex elements. Collaboration and partnership between firms and/or organizations, which can offer a variety of perspectives, therefore generally translates to richer and more agile innovation.

The responsibility for establishing effective collaboration lies in part with companies and academics; Space Canada, too, is playing a key role in bringing players together and creating networking opportunities. But government can also make an important contribution through a number of measures, including:

- Establishing a virtual platform for companies and researchers to connect—the CSA has already committed to piloting such a platform, **SpaceHub**, so testing, finalization, and release should **proceed as quickly as possible**
- Facilitating collaboration between government scientists and private-sector players
- Making government labs and testing facilities available to early-stage space companies at a nominal cost
- Supporting a **network of incubators** for space startups, which could be modelled on the facilities in Montreal and Downsview Park that serve the aerospace industry, and housed in existing organizations such as MaRS in Toronto and Communitech in Kitchener
- Convening **events** that bring together those from academia, the private sector, and government who are dedicated to space

#### 6. Enhancing the availability of data

One way of turbocharging the development of applications and services that rely on EO data is to make that data easily accessible to Canadian scientists, researchers, and entrepreneurs—and to ensure that, even as data owners are fairly compensated, price points for users aren't prohibitively high. Other jurisdictions have taken major steps in this direction, such as the EU, through its Copernicus program, and the United States, through NASA's Earthdata gateway. The CSA has promised something similar with its **Digital Earth Canada (DEC) initiative**. Like SpaceHub, it's important that this effort move forward **without delay**, and that a DEC portal make **as much data available as possible—in as digestible and usable a form as possible—in real time**.



## Conclusion

The world has woken up to the potential of space. Space-based assets and services are no longer the preserve of a few governments: they are the domain of dozens of nations and thousands and thousands of companies globally.

Strengthening Canada's position in space is a strategic imperative. For the sake of the country's economic competitiveness and productivity—and to help ensure national security and critical services for citizens—Canada needs to bring energy and determination to the new space race. This is not a zero-sum game: International collaboration between governments and businesses will be key to our success. But alongside cooperation, a clear-eyed focus on Canadian interests, a full leveraging of the country's advantages, and a willingness to spend strategically will be essential if Canadians are to fully enjoy the benefits of the space economy.

Space-based activity will be a keystone of the national and global economy over the next century, and Canada's public and private sectors have an opportunity to be major players. Important steps in that direction have already been taken. **Now** is the moment to act—to build on that progress, mobilize our capabilities and resources, and aim for "40 by 40": a \$40 billion national space economy by 2040.

To see the future, we need to look up. To secure it, we need to act.

## **Endnotes**

Figure 1: Declining costs of launching people and cargo into space

Figure 2: Cumulative number of objects launched into orbit from 1957 to 2022

Figure 3: Number of objects launched into orbit in 2022, by leading nations

Figure 4: Computer-generated images of objects in Earth orbit currently being tracked

Figure 5: Canadian space industry snapshot, 2019

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