# RESOURCEFUL
# RESILIENT
# READY

## Canada's Strategy for Satellite Earth Observation

Canada

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## Canada's Strategy for Satellite Earth Observation

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# MESSAGE FROM THE MINISTERS

In 2019, the Government of Canada proudly announced *Exploration, Innovation, Imagination: A New Space Strategy for Canada*[1]. In that document, our Government committed to ensuring Canada's leadership in leveraging satellite data to support scientific excellence, innovation and economic development. With the impacts of climate change becoming more evident every day, innovations in space technologies provide Canadians with reliable and timely information to support science-based decision making, while supporting countless services across the country and driving our economy.

Canada has a long history as a global leader in satellite Earth observation technology, beginning in 1962 when Canada became only the third country to operate a satellite in orbit. We are now laying the groundwork for the continuation of that excellence. As the Minister of Innovation, Science and Industry, in collaboration with the Honourable Steven Guilbeault, Minister of Environment and Climate Change and the Honourable Jonathan Wilkinson, Minister of Natural Resources, we are following up on the commitments made in the Space Strategy by presenting our vision for the future: *Resourceful, Resilient, Ready: Canada's Strategy for Satellite Earth Observation*. Developed in consultation with industry and academia, our new strategy outlines the path to equipping Canada with as many tools as possible to confront climate change and to support Canadians in the 21st century.

Satellites are an integral part of our lives. Many of our everyday decisions, from bringing an umbrella on a walk to deciding if roads are safe to drive, are informed by data provided by satellites passing over our country. National safety and security are also dependent on the unique vantage point of space as increasingly detailed satellite data supports decision making in our communities related to wildfires, floods, and other natural hazards. Satellites help keep Canadians healthy by monitoring air quality in our cities, modelling the movement of disease-spreading species, and forecasting harmful algal blooms in our water. For Canadian industry, the growing demand for environmental and industrial intelligence is bolstering high-tech development. Start-ups and Earth observation firms are using artificial intelligence and advanced data analytics to provide science-based services, from daily crop maps that help agricultural producers feed Canadians to advanced forest growth models that help resource companies provide the products we need for a growing and vibrant population.

In this new strategy, we outline the path forward to capitalize on satellite technology for day-to-day evidence-based decision making and planning. Recent and future investments in new satellite data streams and ground infrastructure will not only help ensure core services continue to deliver for Canadians, but will also see them expand their application into areas such as public health and infrastructure. The strategy highlights our plans to bring together Canada's best scientists to work in data-rich, high-powered analytics environments where better solutions for challenges like climate change and disaster management can be developed and implemented faster. It also recognizes the potential, and the power, of bringing our observations from space down to local communities, especially in Canada's North where the use of satellite information is becoming more important as we work to build resilience to climate change. Finally, the efforts outlined in the strategy provide the foundation to directly support Canada's world-class aerospace and high-tech sectors, fuelling innovation, strengthening the economy and making our industries more competitive.

Our Government remains focused on unlocking the full potential of space technology. Recognizing social, economic, and environmental priorities here on Earth, we remain committed to equipping Canadians to excel in the jobs of the future, to support scientific excellence, to monitor and adapt to climate change, and to advance technology development for the benefit of all humankind.

***The Honourable François-Philippe Champagne***,
Minister of Innovation, Science and Industry

***The Honourable Steven Guilbeault***,
Minister of Environment and Climate Change

***The Honourable Jonathan Wilkinson***,
Minister of Natural Resources Canada

1 Space Strategy for Canada | Canadian Space Agency (asc-csa.gc.ca)

**Satellite Earth observation** (or "satellite EO") is the use of satellites to gather information about Earth's oceans, land, climate, and populated areas. This information helps us protect our environment, monitor infrastructure, ensure Canadian sovereignty, and conduct state-of-the-art science. In today's society, Earth observation data from satellites has become an integral part of our digital economy, benefitting industry, academia, and governments alike; it is critical to a sustainable future.

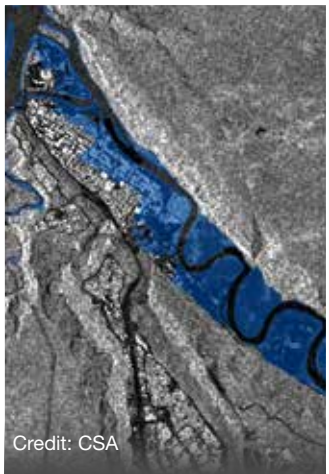
A combination of Canadian synthetic aperture radar and commercial optical satellite images was used to create this map, which shows the extent of flooding in the spring of 2020 in Fort McMurray, Alberta. The Athabasca River's normal extent can be seen in light blue. The dark blue indicates flooding over open land, the pink shows urban flooding, and the green indicates flooded farmland. Satellite EO products like these help local officials respond quickly and inform future planning to reduce flood risk.



Credit: CSA

Credit: NRCan

Credit: Shared Services Canada



Credit: CSA

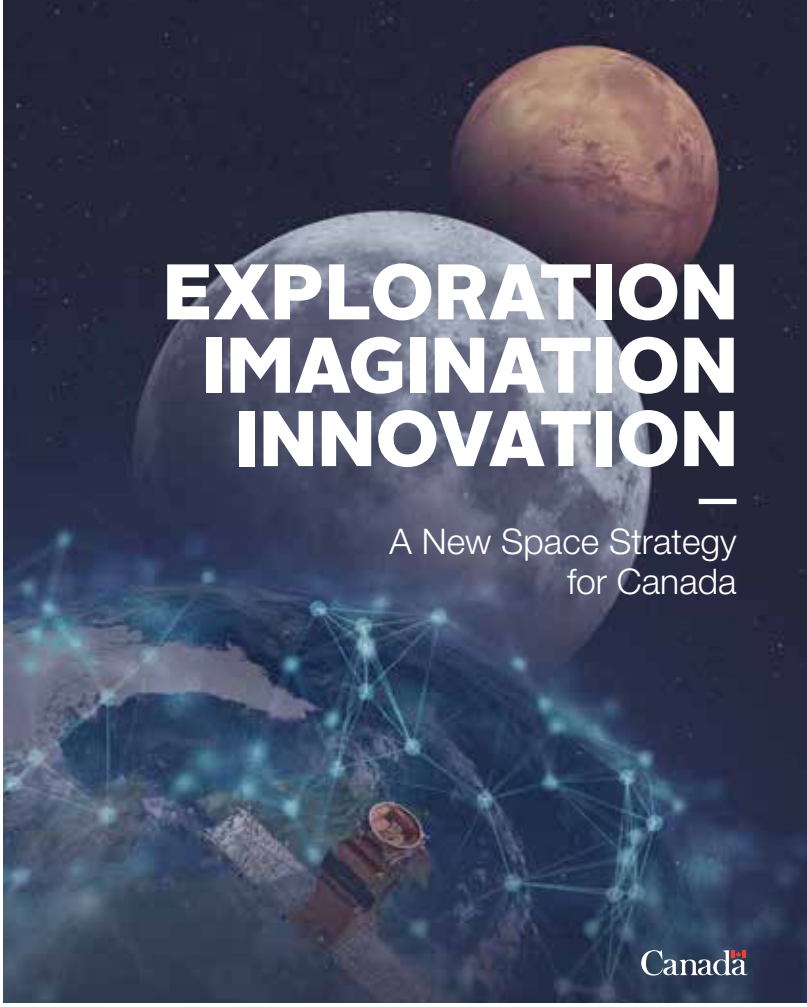
## ABOUT THIS STRATEGY: A BOLD LEAP INTO THE FUTURE

As a country spanning almost 10 million square kilometres, Canada has always faced a unique challenge in collecting the day-to-day information needed to enable our economy and provide critical services to Canadians. Now, more than ever, Canada's vast and changing landscape, including its cities, forests, coasts, and climate, require systematic monitoring and analysis. Weather forecasting, transportation planning, emissions reduction, climate change adaptation, emergency disaster response, public health monitoring, freshwater management, ocean protection, and food production all increasingly rely on rapid and detailed observations of our country.

Thanks to over four decades of science, innovation, and technology development in Canada, many requirements for rapid and detailed information are now met most effectively by satellites orbiting Earth through a practice known as satellite Earth observation (henceforth referred to as "satellite EO"). Investments in satellites, and the systems on the ground that transform their data into new insights, provide innumerable opportunities, economic efficiencies, and societal benefits.

As we emerge from the COVID-19 pandemic and the effects of climate change intensify, satellite data has become a critical asset to ensure Canada's continuing social and economic well-being. Canada has long been a leader in satellite EO, with Government of Canada (GC) innovations in satellite radar and analysis techniques setting the groundwork for broader societal applications and economic activity. However, as the world rapidly changes around us, the time to advance Canada's satellite EO capabilities has come.

Today, revolutionary new applications, from measuring Canada's greenhouse gas emissions in increasing detail to identifying populations vulnerable to diseases and disaster, are emerging across government, industry, and academia. Over the next 15 years, this strategy will guide efforts to generate the skills and economic opportunities needed to take advantage of these abilities. The strategy will also inform the GC's investment in new technologies, such as machine learning, big data analytics, and advanced satellite systems. Ultimately, our objective is to strengthen Canada's digital and traditional economies, enhance government services, and support the scientific community.




Canada's Space Strategy, released in 2019, recognizes satellite EO as a vital part of its objectives to grow the space sector, solve everyday challenges for Canadians, inspire the next generation, and secure Canada's place on the global stage. As Canada's Strategy for Satellite Earth Observation, this document builds on those commitments by elaborating on specific areas to meet the Space Strategy's objectives. Taking an approach that emphasizes domestic and international collaboration, this strategy also supports other GC commitments. This includes enabling action on climate change as outlined in the Pan-Canadian Framework on Clean Growth and Climate Change; creating the jobs of tomorrow as outlined in Canada's Innovation and Skills Plan; ensuring national data sovereignty and fostering a digital data-driven economy upholding Canada's Digital Operations Strategic Plan; and complementing solutions for defence and security challenges as outlined in *Strong, Secure, Engaged: Canada's Defence Policy*.

Informed by the challenges and opportunities of today and inspired by the possibilities of tomorrow, *Resourceful, Resilient, Ready* outlines the GC's new vision for satellite EO. Over the next decade and beyond, this document will guide our actions to realize the full benefits of space technology for a safer and more prosperous Canada. With this strategy, the GC is committing to the investments we need today to build the Canada we dream of tomorrow.

## WHAT WE HEARD

This strategy is the result of a two-year effort by the GC that saw ongoing engagement with the wider satellite EO community. As a part of its vision, the GC is committed to continuing collaboration with private and academic experts, provincial/territorial governments, international partners, and Indigenous communities.

*Resourceful, Resilient, Ready* responds to the views expressed through engagement with Canadian satellite EO stakeholders, and is designed to:

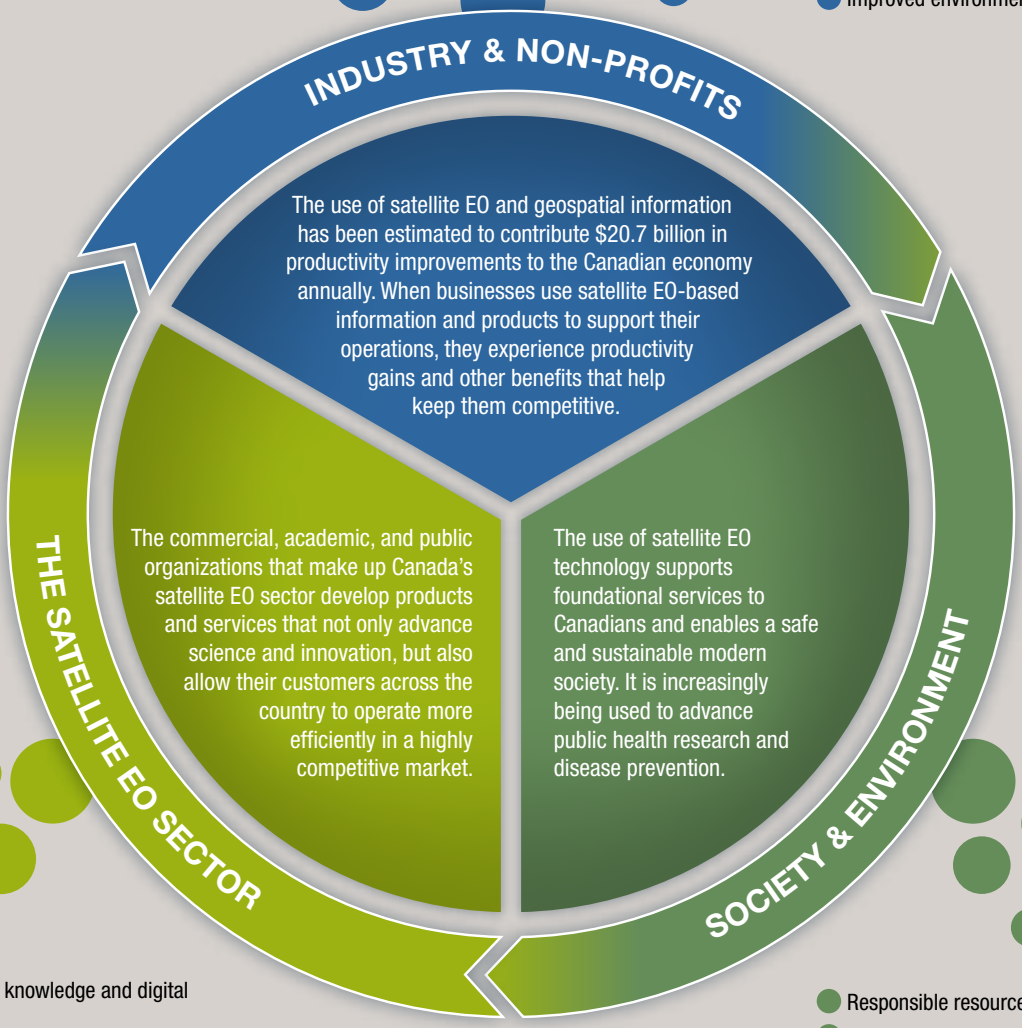
- Enable innovation by increasing the ease of access to open satellite EO data from Canadian and international government satellites;
- Facilitate collaboration between satellite EO stakeholders across the sector, from satellite and antenna manufacturers, to data handlers and product developers;
- Strengthen international cooperation with key partners and expand opportunities for Canadian companies and researchers;
- Create opportunities for the development of innovative business solutions to address priorities of the GC and Canadians; and
- Instill confidence and stability in industry and academia by outlining long-term priorities for the Government, allowing industry to shape their business plans and academia to foster necessary skills.

# THE BENEFITS OF SATELLITE EARTH OBSERVATION

It is difficult to imagine going a single day without access to the satellite EO data we need to understand our planet and how it is changing. Investments in satellite EO technology and capability contribute to building a world-class space sector and enable industry, researchers, and governments to develop and deliver solutions in a wide range of sectors. Satellite EO technology is a critical enabler of the modern economy, and creates countless environmental and social benefits for Canadians.

- Increased productivity and efficiency in operations
- Reduced environmental footprint
- Increased employee health and safety

- Faster and easier regulatory compliance, reporting and certification
- Effective risk assessment and infrastructure monitoring for climate resilience
- Improved environmental and social licence




- Creation of jobs in the knowledge and digital economy
- Growth in number of STEM careers and highly qualified Canadians
- Development of innovative tech applications and skillsets
- Contributions to scientific excellence and discovery
- Enhancement of international reputation
- Development and commercialization of breakthrough technologies

- Responsible resource development
- Clean water
- Healthy Canadians
- Sustainable agriculture and food security
- Security and sovereignty
- Climate change action and resilience
- Reliable infrastructure
- Arctic environmental stewardship

# CANADA'S VISION FOR SATELLITE EARTH OBSERVATION

Through long-term investments in state-of-the-art satellite EO technologies, collaborative partnerships, and skills development, we envision a Canada that is:

**RESOURCEFUL** in using domestic and international satellite data across all economic sectors to increase productivity, drive efficiencies, and ignite innovation.

**RESILIENT** in adapting to our changing climate, from the international to the local scale, with the best science-based evidence for effective decision making.

**READY** to respond to environmental, national security, public safety, and health challenges, with timely information, modern infrastructure, and a next-generation workforce.

## WHOLE-OF-SOCIETY ENGAGEMENT

As we carry out this strategy, the GC is committed to continuing a unified approach for planning and stakeholder interaction through webinars, engagement opportunities, and requests for feedback. Our vision recognizes the need to continue strengthening **whole-of-society collaboration** through a policy of free, open, and accessible data that will enable industry, academia, governments, and Indigenous communities across Canada to benefit from satellite EO. It also acknowledges the vibrant worldwide satellite EO community and the role of **international collaboration** in meeting our own needs while contributing to global issues such as climate change. Canada will continue to participate in global initiatives for **open data and science**, development of data standards, and collaborative missions through international partners and multilateral fora, such as the World Meteorological Organization and the Group on Earth Observations. Ultimately, we envision a lively ecosystem of satellite EO stakeholders interacting to provide services to Canadians, enable scientific breakthroughs, and foster economic activity.

### SATELLITE EO IN ACTION: Supporting Food Security Across Canada

Understanding trends in agricultural production is essential to addressing short- and long-term threats to food security in Canada while maintaining a profitable, competitive, and sustainable agricultural sector, a major driver in Canada's economy. The GC's Canadian Crop Yield Forecaster (CCYF) uses a mix of satellite and climate information to forecast crop yields both during and after the growing season. Information generated by the CCYF is critical to agricultural monitoring, as it affects both economic forecasting and risks to agricultural production, such as those from weather and climate (e.g. drought, flash floods, untimely rains, frost, hail, and storms). At the individual farm level, Canadian companies use satellite EO and advanced analytics to generate online services for customers to pinpoint and better manage unproductive or problematic areas of farmland. Increased use of satellite EO-based technologies within the agricultural sector could produce cost savings to Canadian farmers up to an estimated $1.3 billion over the next decade.

## END-TO-END INTEGRATION AND INNOVATION

The process by which data is collected by satellites and then turned into information to support decisions can be visualized as a value chain (see next page). Each stage of the value chain relies on the others to move data from satellites in orbit to experts on the ground. These experts use the satellite data to create valuable products and services, such as maps, environmental models, monitoring tools, and forecasts. In our vision, investments and activities in each stage of the value chain need to recognize both requirements and opportunities in all other stages: a truly holistic approach. To infuse the satellite EO sector with confidence and security, our collective vision includes end-to-end long-term planning based on input from all stakeholders. This is particularly important given the long development times for new generations of satellite technology. In addition, satellite EO data relies on and is **complementary to ground-based data** from in situ sources, such as weather stations and aerial observations. It is vital that through coordinated information management (IM), satellite EO data be combined, where needed, with the myriad other big data sets that exist today. Further, the GC recognizes its role in being a responsible steward for information concerning the lives of Canadians. In the age of big data, protecting the privacy of Canadians will be achieved through transparent stakeholder engagement and secure digital infrastructure and information technology (IT). As the GC moves toward user-centred services, coordinated efforts in IM/IT will achieve the highest standard of transparent and integrated governance in the digital age.

### SATELLITE EO IN ACTION: Enabling Accurate and Rapid Weather Forecasts

Accurate weather forecasting is vital to helping us go about our daily lives. It also helps in planning business activities and saving lives through early warnings. To enable these benefits, the GC receives millions of observational data points every day from satellites orbiting Earth. This data is processed through complex computer models to provide daily weather information to Canadians. Satellite imagery not only enables an accurate weather forecast, but also allows forecasters to assess aviation hazards, such as low clouds, thunderstorms, hurricanes, and the evolution of dust plumes. More than 90% of the data that goes into weather models is from space, making satellites critical to delivering accurate and timely weather information. However, weather forecasts are not just about planning our days and getting around safely. A study by the World Meteorological Organization found that free and open national weather services in countries like Canada create at least four times their cost in societal and economic benefits.

Satellite image of Hurricanes Irma, Jose, and Katia in the Atlantic Ocean in 2017.

Credit: National Oceanic and Atmospheric Administration (NOAA)/Reuters

# SATELLITE EO VALUE CHAIN - AN END-TO-END SYSTEM

## SECURE & SOURCE

- Design and build Canadian satellites to secure the data we need
- Develop sensors to place onboard international partners' satellite missions
- Source commercial and international data

### DID YOU KNOW?

Canada has a reputation for designing and building satellites that last much longer than expected. For example, RADARSAT-2, which was launched in 2007 and expected to operate until 2014, is still operating in 2022. Today it is orbiting 800 kilometres above the surface of Earth, providing world-class data and reinforcing the economic value of investments in Canadian science, technology, engineering, and mathematics.

## COLLECT & PROCESS

- Download data from satellites to ground stations
- Gather open government data from trusted partners
- Pre-process and archive data so it is discoverable and accessible

### DID YOU KNOW?

Satellite EO data is big data, very big data. Canada's reception stations download 1.8 terabytes of data daily from the RADARSAT Constellation Mission (RCM) alone. That's the equivalent of uploading
1.2 million pictures from your cell phone to social media every day.

## ENABLE ACCESS

- Design and implement shared infrastructure for seamless and remote data access
- Structure large volumes of data so it is analysis-ready
- Release data through easy-to-use portals

### DID YOU KNOW?

Canada's supercomputing capabilities have come a long way. The GC's modern high-performance computers are 70 million times faster at processing information than the first government supercomputers from the mid-1970s.

## COMBINE & TRANSFORM

- Combine satellite EO data with other types of data, including ground observations and socio-economic data
- Develop algorithms and advanced analytic tools to gain new insights from the data
- Harness new insights to build applications and improve existing services

### DID YOU KNOW?

To create Canada's national weather forecast, 14 million different satellite data points are processed through supercomputers every day. These inputs pay off, as the GC's Weather Service receives over 50 million visits per month from Canadians.

## GET MORE FROM OUR DATA

- Coordinate data use in government and facilitate uptake among users in industry and academia
- Develop a highly skilled and inclusive workforce for the future
- Work with users to identify new and ongoing data needs to inform new requirements

### DID YOU KNOW?

A recent review of Canada's academic sector identified that geospatial research using satellite data was by far the largest, and fastest growing, field of space-related research in the country.

# DELIVERING THE VISION: OUR OBJECTIVES

## 1 ENSURE THAT SATELLITE EARTH OBSERVATION DATA IS FREE, OPEN, AND ACCESSIBLE TO MAXIMIZE SCIENCE, INNOVATION, AND ECONOMIC DEVELOPMENT

Satellite data and technologies are transformative, sparking innovation in Canada's space sector and beyond. To ensure that Canada is *Ready* to take advantage of the opportunities in front of us, the GC will:

a. **Enhance access to open data**

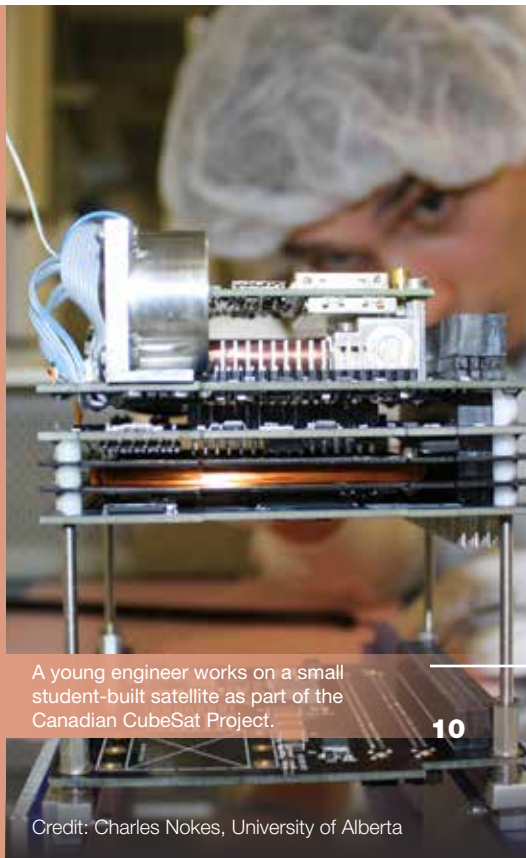
Economic development and efforts to address today's biggest challenges rely on data that is open and freely available. Following international best practices and our commitment to an open and transparent digital government, **the GC will make data from GC satellites, and those of our partners, more open and accessible through a policy of free and open data that is accessible through digital platforms and cloud-hosted Web portals powered by enhanced high-performance computing**. With new tools and data, companies will expand their commercial offerings and market while creating more jobs for Canadians.

b. **Create the conditions for Canada's satellite EO sector to thrive**

The proliferation of benefits from satellite EO relies heavily on the entry and sustainability of firms in the geospatial and environmental intelligence sector. Supporting these firms in the supply chain is an "upstream" of advanced technology and parts manufacturing firms, including factories and distribution centres that provide thousands of jobs across Canada. To support jobs along the entire satellite EO value chain, **Canada will create and enhance programs that reward job creation and innovation while providing early support to cutting-edge start-ups**, such as through the GC's new smartEarth program. Whether meeting GC needs or highlighting private offerings, positioning Canadian firms to be competitive will also be achieved by **streamlining mechanisms for contracting to accelerate innovation and R&D**. **Further, the GC is reviewing Canada's regulatory framework for space activities to ensure they provide timely responses for industry, maintain strategic oversight for national security, and enable commercial growth.**

### SATELLITE EO IN ACTION: Sparking Innovative Canadian Ideas

Since 2000, the GC Space Technology Development Program (STDP) has invested over $186 million to support the creation of nearly 550 technologies, sparking innovation and growth in the Canadian space sector. Over this period, via nearly 50 challenges put out to industry and academia, Canadian companies and researchers have showcased their excellence through new designs and precision instruments that address pressing challenges and advance the reputation of Canadian research and development (R&D). While helping to evolve capabilities for new satellite EO missions that support Canadian priorities, investments from the STDP also open the door for entrepreneurs and researchers across the country to further their careers by generating scientific and commercial solutions to Canada's biggest challenges. Critically, funding at these earliest stages of technology development also helps Canadian start-ups and companies scale up, retain highly qualified personnel, and avoid the challenge of STEM "brain drain."



A young engineer works on a small student-built satellite as part of the Canadian CubeSat Project.

Credit: Charles Nokes, University of Alberta

c. **Foster domestic and international partnerships**

From the Laboratories Canada initiative to our national Technology Superclusters, the GC is well positioned to **convene the brightest satellite EO ideas and people in national hotspots for innovation and scientific discovery**. While the GC hosts significant portions of Earth observation expertise in Canada, knowledge and experience from academia, industry, other levels of government, and Indigenous organizations will play an important role in our future. Through funding opportunities for students and researchers as well as centres of excellence dedicated to satellite EO, Canadians will have access to state-of-the-art facilities to develop new instruments and applications in cross-sectoral partnerships. These partnerships will bring together the best of government, business, and academic innovation. Additionally, **Canada will leverage international partnerships, such as with the European Copernicus program and U.S. partners, and its membership in the Group on Earth Observations and the World Meteorological Organization to increase opportunities for Canadian companies**. Through these partnerships, Canadian companies and academics will be able to access international data sets, build their networks, and improve their competitiveness without needing to leave Canada.

## SATELLITE EO IN ACTION: A Dynamic Sector of Our Economy

Canada's satellite EO sector is vibrant and growing. Most Canadian companies in data transformation and geospatial services are agile small and medium enterprises (SMEs) founded within the past 10 years. At the same time, Canada hosts established world leaders in both satellite manufacturing and data interpretation, rounding out a diverse economic profile for a space sector projected to triple in the coming decade.

- Canadian satellite and ground station manufacturing for Earth observation accounts for $130 million in direct revenues annually. Of note, manufacturing in the satellite EO sector is 13 times more R&D intensive than traditional manufacturing sectors.
- In 2018, 74 Canadian organizations invested $356 million in space research and projects, with significant focus on emerging technologies, such as machine learning and big data analytics.
- Satellite data is vital to the growing geospatial information sector, which contributes $20 billion in economic activity and approximately 20,000 jobs to the Canadian economy each year.

## 2 HARNESS SATELLITE EO TO ADDRESS CLIMATE CHANGE AND ISSUES THAT MATTER TO CANADIANS

Increasingly, satellite EO is helping businesses, communities, and governments become more *Resilient* in the face of climate change. However, keeping pace with change is not enough; Canada needs be ahead of the curve when it comes to generational and global challenges. In pursuit of this, Canada will:

a. **Generate solutions for climate change mitigation and adaptation**

International efforts have recognized that over half of the essential observations needed to understand our changing climate can only be collected by satellites. In alignment with the Pan-Canadian Framework on Clean Growth and Climate Change, Canada is committed to acquiring new satellite data to help mitigate and adapt to climate change. Around the world, countries are investing to support their scientists and to position their economies and populations to thrive in a new climate. **Building on the history of GC innovation in Earth observation techniques and science, we will advance new missions to study issues that matter most to Canadians, such as the Arctic, air quality, water management, and forest fires**. Additionally, the GC will explore new data sets by launching pilot programs for commercial data purchases and testing of pre-commercial offerings that can provide new insights into how our planet is changing.

b. **Measure key environmental and health indicators**

From identifying threats to biodiversity to developing early warning systems for disease outbreak, protecting Canada's environment and ensuring the health of Canadians requires increasingly dynamic information. Today, a fundamental aspect of environmental management and public health monitoring is the need to detect changes rapidly and identify their causes and consequences. Recent work by GC scientists in machine learning and big data analytics has opened up opportunities for detailed and rapid change detection in both natural and built environments, such as reduced air quality in cities, the health of Canada's wetlands, and the movement of invasive species. Satellite EO is also being used to make regulatory compliance and standards certification easier, more cost-effective, and safer through rapid satellite observations. Recognizing the importance of environmental and public health issues, such as pandemic response, **the GC will advance its monitoring and forecasting abilities through investments in big data analytics tools and high-resolution, rapid-revisit satellite imagery**.

A machine learning-derived map of Canada's different types of land cover.

Credit: NRCan

### SATELLITE EO IN ACTION: Mapping Canada's Environment with Machine Learning

It takes 36,000 satellite images to capture all of Canada's 9.985 million square kilometres. Then, it takes an advanced machine learning algorithm to identify and sort the data into the 19 land cover classes our nation has from coast to coast to coast. For this task, high-performance computing is needed to process the 665 billion pixels, and over 100 terabytes of data, to create Canada's National Land Cover map. As the algorithm processes more land cover samples over time, it learns to categorize each pixel even more accurately. Advancements in machine learning, such as this, put otherwise unattainable views of ecosystems, biodiversity and land use change details into the hands of decision makers addressing major issues such as climate change and species conservation.

## 3 STRENGTHEN DELIVERY OF CRITICAL SERVICES TO KEEP CANADIANS HEALTHY, SAFE AND INFORMED

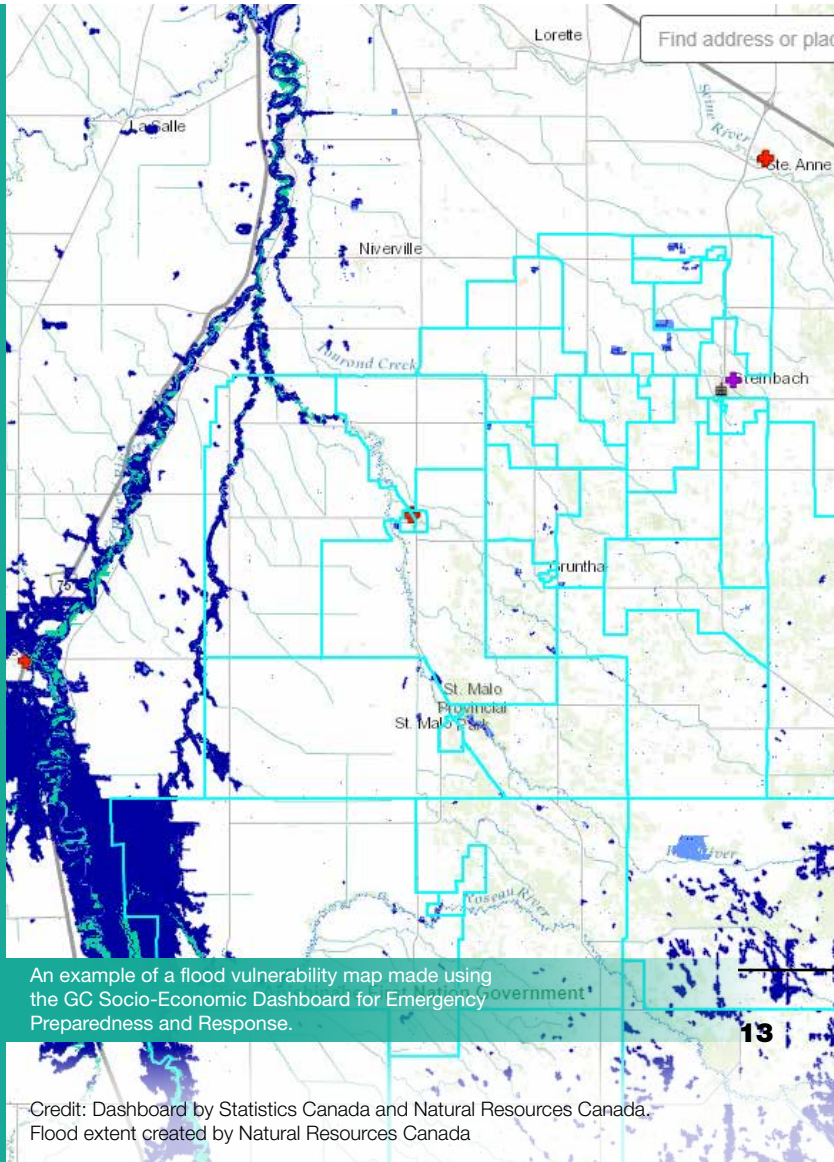
Delivery of more than 60 of the GC's essential services for Canadians relies on satellite data and the Government's wider system of satellite EO infrastructure and expert analysis. Long-term planning is required for the GC to safeguard service continuity and continuously improve its fundamental services to Canadians in a manner that is efficient and *Resourceful*. In pursuit of this, the GC will work with industry, academic, and Indigenous partners to:

a. **Ensure continuity of critical services**

A multitude of government services relies on historical data sets and the uninterrupted flow of quality data each day. Through mission development focused on the long term, the data that underlies many services to Canadians will continue uninterrupted. This will be accomplished by **developing the next generation of government satellites and services through procurement for concepts and R&D from both industry and academia**. Additionally, as Canadian cities and communities grow, more users are seeking benefits from the unique vantage point and capabilities of satellite EO. The GC will work to expand awareness across government at all levels by working collaboratively to invent satellite EO applications for new and emerging users. This enhanced uptake will increase demand and thereby support Canada's growing satellite EO industry. Lastly, in accordance with the GC's Defence Strategy: *Strong, Secure, Engaged*, Canada's civilian satellite investments will be leveraged to complement and provide reinforcement for our current and future national defence systems.

### SATELLITE EO IN ACTION: Identifying Vulnerability and Reducing Risk to Canadians

The GC Socio-Economic Dashboard for Emergency Preparedness and Response provides an easy-to-use online system for provincial/territorial governments and emergency managers to identify populations at risk. During hazard events like floods and wildfires, the dashboard combines information from satellites with geospatial data and socio-economic data from the ground. The result is a detailed data product featuring critical information on transportation and communications infrastructure, hospital capacity, school closures, police and fire services, population characteristics, housing, and health indices. A specific innovation of the tool has been the inclusion of crowdsourced citizen observations (geotagged photos) submitted through an app. The dashboard's information helps emergency managers direct resources, gain new insights on local vulnerabilities, and reduce the economic and human cost of disasters.




An example of a flood vulnerability map made using the GC Socio-Economic Dashboard for Emergency Preparedness and Response.

Credit: Dashboard by Statistics Canada and Natural Resources Canada. Flood extent created by Natural Resources Canada

b. **Modernize Canada's network of critical ground infrastructure**

As the volumes of satellite data grow, increasingly advanced infrastructure is needed on the ground to both collect it and control spacecraft in orbit. **Canada is addressing its data receiving and operations infrastructure by investing in the modernization of a streamlined federal network of ground stations**. This will allow the GC and its partners to downlink more data and communicate more effectively with current and next-generation satellites. At the same time, we are re-affirming our commitment to working with international partners to download vital international data sets. As we move forward, Canadian companies, universities, and international partners will be important partners in leveraging new technologies for data reception and satellite operations. Ultimately, more companies, start-ups, universities, and researchers will have access to this key asset in operating and receiving data from Earth observation satellites.

## SATELLITE EO IN ACTION: Monitoring Our Oceans and Maritime Approaches

Thanks to the three satellites that make up the RADARSAT Constellation Mission (RCM), and their Automatic Identification System (AIS) technology, unregistered foreign ships and illegal fishing boats can no longer move undetected into Canadian waters. The AIS system, coupled with the ability of the RCM to detect ships in all weather conditions, day and night, provides near-real-time maritime surveillance in the Arctic and wide-open ocean areas where other sensors are less effective or unable to operate. This saves time and money by targeting aircraft and boat patrols for national defence and fisheries enforcement, helping Canada exercise sovereignty in the North, restrict illegal fishing, and protect fish stocks and marine habitat from vessels that do not comply with Canadian regulations. The RCM detects oil spills, locates aircraft crash sites at sea, and helps monitor marine protected areas. Combining ocean surface data collected by the RCM with measurements acquired by other sensors, scientists are today creating a four-dimensional model of ocean characteristics to support marine and climate studies, and defence vessel command personnel. In this dual role, Canada's RCM satellites help both understand our ocean environment and strengthen our national security.

## 4 INSPIRE SKILLS AND CAPACITY DEVELOPMENT FOR THE NEXT GENERATION

Realizing the full benefits of satellite EO requires staying ahead of technological developments and demands a highly qualified workforce *Ready* to take the helm of our satellite EO enterprise. To foster a diverse and equitable satellite EO workforce in Canada, the Government will:

a. **Promote satellite EO Education**

Leveraging the investments of today requires encouraging and training youth to be the next generation of experts. **Ongoing and future STEM[1] and BHASE[2] initiatives will work to strengthen skills development and satellite EO literacy by focusing on improved awareness and understanding of the technology's potential, inclusive training and education opportunities, and support for entrepreneurship**. These targeted investments will provide ample opportunities for Canadians to upskill or begin their education in emerging high-tech areas related to satellite EO. Now and in the coming decades, it is also essential to ensure programming which is specifically targeted towards building capacity among high-priority user groups such as Indigenous communities, women and gender minorities, low-income Canadians, and other traditionally marginalized peoples. The future of satellite EO in Canada must be diverse and inclusive, allowing Canadians of all backgrounds to contribute.

b. **Partner with Indigenous and northern communities to deliver locally driven solutions**

Empowering Indigenous and northern communities to create and use applications that support decision making on local issues is of vital importance to the GC. In support of its reconciliation commitments, the Government is committed to open and transparent partnerships with Indigenous communities, where invited, to **co-develop solutions integrated with traditional knowledge that address community-identified needs**. The GC will also continue in existing partnerships to advance innovation in Canada's North, enhance access to STEM careers, and bolster local economies by bringing the benefits of satellite EO technologies directly to northern communities.

1 Science, Technology, Engineering, and Mathematics
2 Business, Humanities, Health, Arts, Social Science, and Education

### SATELLITE EO IN ACTION: Supporting Indigenous Cultural Preservation

Indigenous archaeological sites located in Arctic permafrost are at risk of disturbance and loss as the climate warms and permafrost thaws. Sites along coastlines and river banks are particularly vulnerable. Understanding terrain stability through satellite EO is helping prioritize sites at risk, known only to the Indigenous elders, for salvage. The availability of open high-resolution digital elevation data for the Arctic enables detailed analysis, called "interferometry," using synthetic aperture radar. This process identifies where the ground is sinking due to permafrost thaw, ice wedge melt, slope creep and erosion, and presents results in user-friendly "terrain-at-risk" maps that show centimetre-level changes. Documenting and saving archaeological sites is important for conserving Indigenous cultural heritage, and provides evidence of land occupation that supports land claim and treaty negotiations.

Archaeological team uncovering a tent ring built by the Thule, ancestors of modern-day Inuit peoples.

Credit: Brendan Griebel/Pitquhirnikkut Ilihautiniq

# MOVING FORWARD

Today, Canada's coasts, waters, and cities are changing rapidly as a result of accelerating climate change. Canada's future economic and environmental security depends on our ability to keep up with, understand, and respond quickly to these new realities. With a sustained and collective effort across Canada, through a new paradigm of a coordinated whole-of-society approach and increasing ease of access to open data, the benefits derived from satellite EO can be leveraged to strengthen the economy and address global issues.

The challenges of the 21st century demand that Canada respond with 21st century tools: an integrated free and open satellite EO system capable of putting Canadians in a position to thrive. As other countries invest in their own systems, Canada cannot fall behind in its economic competitiveness or in its service to citizens. As a responsible global actor, Canada also cannot lag behind in its contributions to global science efforts on climate change and other pressing issues.

As entrepreneurs look to start new companies, university departments look to identify necessary skills, and industries look to grow their workforce, long-term strategies such as this are vital in providing stability and confidence. Nonetheless, over the coming 15 years, the GC will continue engaging with experts and users across the country to adapt to changing needs and priorities. This strategy is therefore a strong, yet flexible, commitment to our future.

Between now and 2035, the GC will be guided by the vision and commitments of this document. Over this period, responsible investments, flexible programing, and strategic partnerships will strengthen the Canadian economy, enable GC departments to better meet their mandates, and make Canada truly *Resourceful, Resilient, and Ready*.

Credit: Bristol Aerospace

## SATELLITE EO IN ACTION: The Power of Open Data for Science

Launched on August 12, 2003, SCISAT helps Canadian and international scientists improve our understanding of the depletion of the ozone layer, with a special emphasis on the changes occurring over Canada and in the Arctic. Originally intended to last two years, the satellite remains operational 17 years later, with its mission currently extended through 2024. For more than 15 years the satellite has also been tracking the presence of more than 60 different gases to identify their role in ongoing climate change. The SCISAT mission is an exemplary case of partnership between universities, government, and industry. SCISAT data is free and open to researchers, students, and industry to innovate with and contribute to the advancement of a knowledge economy. As we face significant challenges associated with climate change, we require authoritative data on what it means for Canada. This is possible through open data from missions like SCISAT that allow government and academic researchers to work together and inform policy decisions on mitigating and adapting to climate change.

# ANNEX – FURTHER SATELLITE EO IN ACTION EXAMPLES

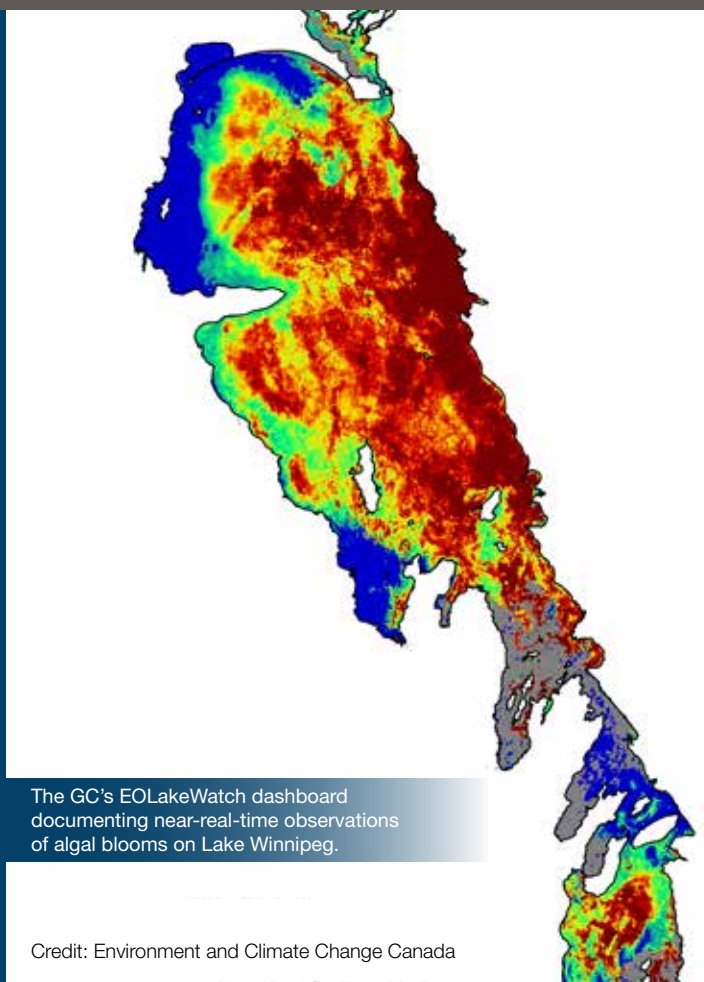
High-altitude balloon prior to launch.
Credit: ECCC-CSA

## SATELLITE EO IN ACTION: Testing New Technology for Monitoring Greenhouse Gases from Space

Canadian industry leads the world in Fourier Transform Spectrometer (FTS) technology and is currently advancing it to better observe atmospheric gases from space. FTS enables satellite imaging of critical gases such as carbon dioxide ($CO_2$) and methane ($CH_4$) that are leading causes of climate change. The technology also supports the surveillance of other important greenhouse gas emissions from sources such as permafrost thaw and forest fires in a warming climate. Canada is targeting application of this new technology as part of future missions, particularly to monitor the Arctic more closely. In preparation, the GC, along with industry and academia, are working together to test prototypes using high-altitude balloons. These high-altitude balloon experiments allow scientists to test how the instrument operates in the cold, low-pressure environment of the stratosphere, a precursor to the instrument one day operating in space.

## SATELLITE EO IN ACTION: Satellite Earth Observations for Lake Water Quality Monitoring

The growth of harmful algal blooms in Canadian lakes has wide-ranging impacts on ecosystem health, drinking water, fisheries, and leisure and recreational activities. Early detection and comprehensive monitoring of algae is fundamental to their management and avoidance. Satellite EO has provided the means to observe blooms with unprecedented frequency and spatial coverage. The GC's EOLakeWatch delivers online satellite-derived products for algal bloom monitoring on select Canadian lakes. For local water management officials and communities, these products go a long way toward addressing existing monitoring gaps, delivering consistent data, identifying areas of specific concern, determining trends, and understanding the causes of algal blooms.



The GC's EOLakeWatch dashboard documenting near-real-time observations of algal blooms on Lake Winnipeg.

Credit: Environment and Climate Change Canada

## SATELLITE EO IN ACTION: Tracking Dangerous Wildfires

Wildfires threaten the safety and well-being of those in their paths, and take a substantial financial toll on the economy each year. Approximately $1 billion is spent annually to combat wildfires in Canada, but the indirect costs – such as losses stemming from damaged infrastructure, evacuations, health impacts, and interruptions to tourism – are significant as well. Most Canadians can recall the 2016 Fort McMurray wildfire as an example of this type of costly devastation; this particular disaster had a total cost of approximately $9 billion. Canadian wildfire managers rely on information from space to be able to track and monitor wildfires, for emergency planning and to adapt to the impacts of climate change on forests. However, current space assets do not provide information during the afternoon and early evening, which is the most critical period of wildfire activity. The GC is currently exploring solutions to develop sensors that will be able to focus specifically on wildfires and their unique characteristics to address this coverage gap.

Satellite-observed forest fires in Canada's Prairies.

Credit: NASA

The speed and coverage of satellite image is invaluable when roads and other infrastructure are washed out during floods.

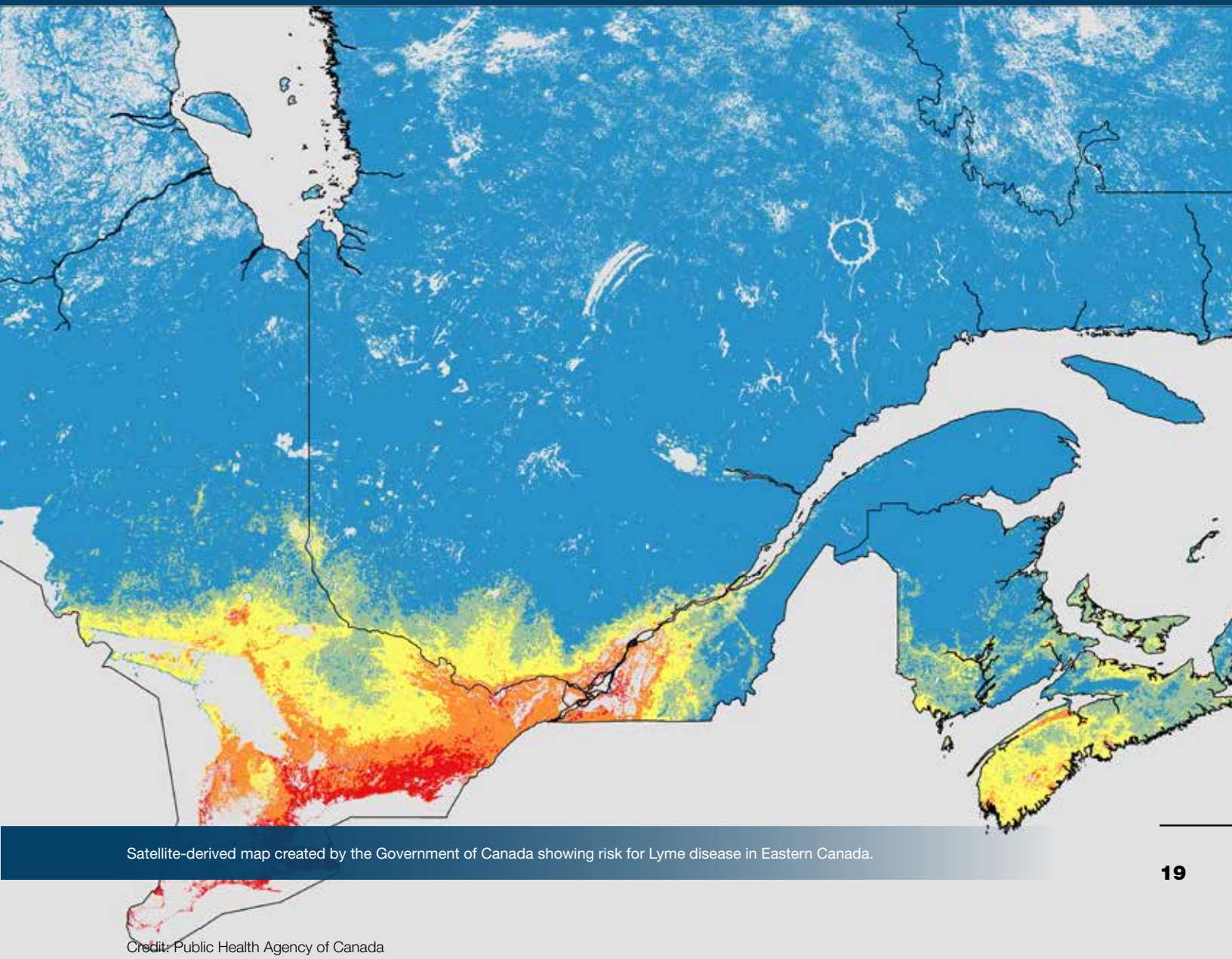
Credit: Transport Canada

## SATELLITE EO IN ACTION: Emergency Response at Home and Abroad

Whether helping to track cyclones in Bangladesh or monitoring fires in Western Canada, satellites help in the face of catastrophe year after year, all over the world via the International Charter "Space and Major Disasters." The Charter was created to provide valuable near-real-time data quickly, and at no charge, to users who need it to respond to major disasters. The agreement represents international collaboration among 17 Charter members operating more than 60 satellites, and has responded to events in 126 countries to date. When the Charter is activated, countries such as Canada prioritize satellite "tasking" to image the affected area as soon as possible so that local officials can quickly provide the requested data to front-line responders. The Charter has been activated nearly 700 times.

## SATELLITE EO IN ACTION:
## Identifying Vulnerability and Monitoring Disease Risk

According to the World Health Organization, 75% of emerging infectious diseases are of animal origin. Of particular concern to Canada is the distribution and quantity of vectors such as ticks and mosquitoes and the diseases they can carry (Lyme disease, West Nile virus). Habitat availability for ticks and mosquitoes is expected to increase with climate change, resulting in northward spread of diseases already present in North America as well as the invasion of exotic vector-borne diseases from subtropical regions. Satellite EO data can provide an early signal on the risk of these infectious diseases by enabling the GC to produce maps that show microclimate and habitat conditions suitable for vectors (e.g. ticks and mosquitoes). When satellite EO data is combined with socio-economic information, the resulting "vulnerability maps" help determine where Canadians are at risk now and in the near future: the fundamental starting point for public health risk management. Throughout the 2020–2021 global pandemic, vulnerability maps were also used to understand the potential for spread of COVID-19, showing satellite EO's valuable role in successful interventions in major public health crises.



Satellite-derived map created by the Government of Canada showing risk for Lyme disease in Eastern Canada.

Credit: Public Health Agency of Canada