GEOSPATIAL PUBLIC POLICY

Global Best Practices for Harnessing the Potential of Satellite Technologies and Applications

Prepared for the Inter-American Development Bank by:
Bartu Kaleagasi, Sean McCarthy, and Peter Beaumont of the Satellite Applications Catapult (UK)

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CATAPULT Satellite Applications

IDB

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INTRODUCTION

Global Context

"Everything that happens, happens somewhere."
– United Nations (2015)

Geospatial technologies and applications have been evolving rapidly over the past decade. This has been driven by the recognition that understanding where people and things are located is central to smart decision making that improves life on Earth in the 21st century. As a result of low-cost launch vehicles, greater access to space, increasing numbers of satellites in orbit, new sensor technologies, machine learning algorithms, advances in cloud computing, higher penetration of satellite-enabled devices, and the emergence of other Earth observation technologies such as drones and high-altitude platforms, the geospatial economy is now expanding into many new geographies and sectors. This has opened up an almost unlimited possibility space for the development of innovative applications that benefit government, business, and society. The global geospatial market was estimated to be around $60 billion in 2021 and is projected to grow by 12.5 percent compound annual growth rate (CAGR) to around $100 billion by 2026.[1] With new services and business models driving the commercialization of this potential, geospatial data has become the next frontier of technological infrastructure to enable better monitoring and insights for a wide range of downstream applications in agriculture, environment, energy, aviation, maritime, transport, health, education, natural resources, finance, and security (see Figure 1).

[1] Markets and Markets – *Geospatial Analytics Market Report* (2021)

Figure 1. **The Next Frontier of Technological Infrastructure**

Source: UK Geospatial Commission[2]

Geospatial data can come from three types of sources: (1) satellite imagery, (2) aerial imagery, and (3) location data, each of which offers different advantages in the complexity, resolution, time, and cost of data acquisition. The combination of two or more of these sources for use in geospatial analytics is referred to as "data fusion." At the global level, a number of institutions have been established to coordinate geospatial policy and support the development of geospatial technologies and applications. These include the United Nations Committee of Experts on Global Geospatial Information Management (UN-GGIM), the Group on Earth Observations (GEO), and SERVIR, a collaboration between NASA, USAID, and leading geospatial organizations in Asia, Africa, and Latin America and the Caribbean (LAC). Recently, UN-GGIM published the UN Geospatial Strategy (2021),[3] which outlines its vision for "effective, efficient and universal use of geospatial information in support of all mandates and operations of the United Nations for a better world as contained in its main pillars: Peace and Security, Human Rights, International Law, Sustainable Development, and Humanitarian Aid." At the national level, most developed countries have established a geospatial body, and some have also recently published a geospatial strategy, including the U.S. Geospatial Data Strategy (2018),[4] the UK

[2] Geospatial Commission – *Unlocking the Power of Location* (2020)
[3] United Nations – *Geospatial Strategy for the United Nations* (2021)
[4] U.S. Department of State - *Geospatial Data Strategy* (2018)

Geospatial Strategy (2020),[5] Canada's Strategy for Satellite Earth Observation (2022),[6] and Singapore Geospatial Master Plan (2018).[7] Many countries have also designed national space strategies, which include the development of Earth observation capabilities.

Space is now recognized as a domain of essential infrastructure for achieving the Sustainable Development Goals (SDGs). As reported by the United Nations, "The importance of the role of Earth observation and geolocation in supporting the achievement of the development goals is recognized by the UN [...] space-based services and technologies are key in understanding climate change and during the full disaster management cycle."[8] This makes it particularly valuable for developing and emerging countries to harness the potential of geospatial technologies, as it could be one of the most effective interventions to drive forward social and economic progress while also meeting global climate targets and safeguarding local ecosystems. Examples of this approach include using geospatial data to improve the management of natural resources and administration of land use (Goal 1: End Poverty), to enable smarter and more connected health services (Goal 3: Ensure Healthy Lives), to support policymakers in monitoring climate change and planning for natural disasters (Goal 13: Combat Climate Change), to improve land monitoring and reduce deforestation from illegal activities (Goal 15: Protect Terrestrial Ecosystems), and to establish global standards for the international sharing of geospatial data and expertise for evidence-based decision making.

From a macrostrategic perspective, space infrastructure is also starting to become recognized as representing critical national infrastructure (CNI), including both upstream and downstream capabilities. This not only emerges through the value of space in providing access to global navigation, communications, and intelligence for international security, but also from its importance in mitigating existential risks which may arise from climate change, global conflict, and space weather. However, the adoption of new technologies in public institutions is a difficult process, and the promotion of new technologies to be developed by the private sector can be equally challenging. Geospatial technologies in particular require a skillset which is significantly more complex than the adoption of traditional digital solutions. This report will explore the role of public policy in promoting the development of geospatial technologies and the adoption of geospatial applications. The objective is to identify global best practices on geospatial policy that can be used to provide recommendations for geospatially developing countries, especially across the LAC region.

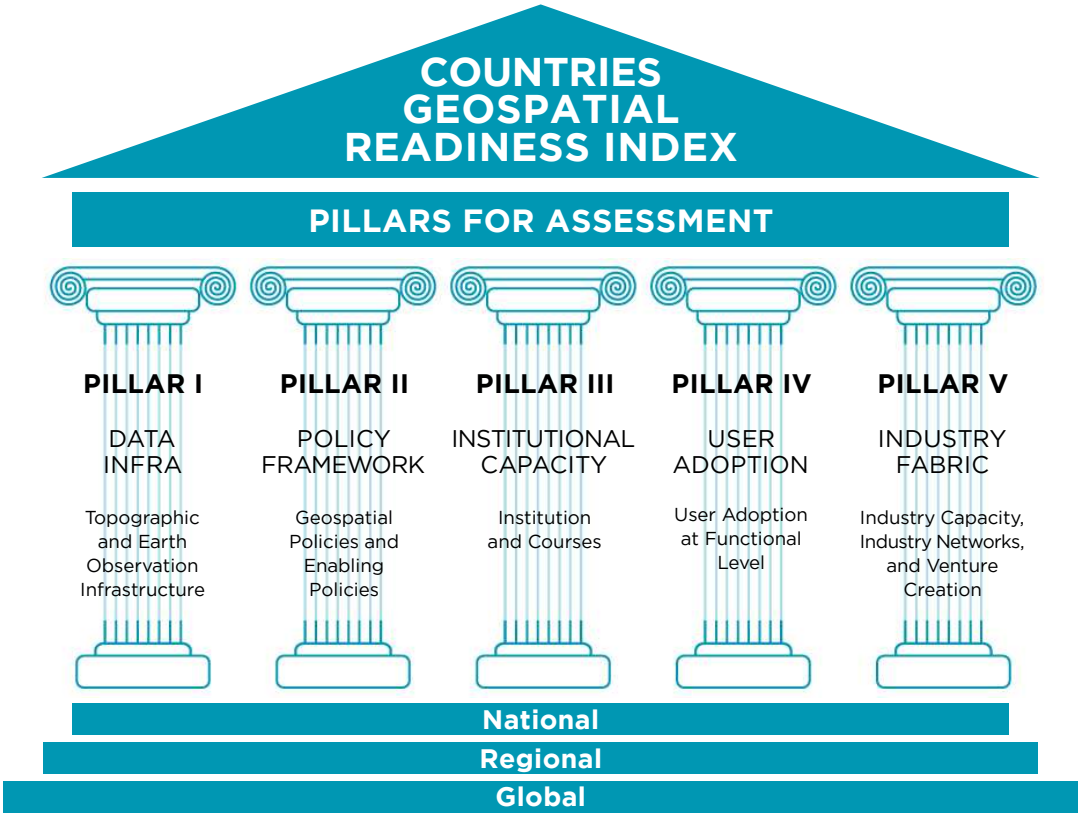
[5] Geospatial Commission – *Unlocking the Power of Location* (2020)

[6] Canadian Space Agency – *Canada's Strategy for Satellite Earth Observation* (2022)

[7] Geospatial Singapore – *Singapore Geospatial Master Plan* (2018)

[8] United Nations – *Space Supporting the Sustainable Development Goals* (2021)

Figure 2. **Pillars to Assess Policy Making**



Source: GeoBuiz (2018)[9]

For the purposes of evaluating case studies and deriving best practices, this report refers to the Countries Geospatial Readiness Index (CGRI) designed by GeoBuiz (Figure 2).[10] The CGRI Assessment Framework considers the following five pillars in ranking countries by their level of development in geospatial technologies and applications: national data infrastructure, policy framework, institutional capacity, user adoption, and industry fabric (Table 1).

[9] GeoBuiz – *Geospatial Industry Outlook and Readiness Index* (2018)
[10] GeoBuiz – *Geospatial Industry Outlook and Readiness Index* (2018)

Table 1. **CGRI Assessment Framework**

Pillars	Subpillars	Factors	Weight
Data infrastructure	Topographic and Earth observation data infrastructure	Stages of NSDI Scale and frequency of update of available thematic layers Open and linked data Earth observation infrastructure and data resolutions	20%
	Positioning infrastructure	Satellite-based positioning systems Satellite-based augmentation systems Ground-based augmentation systems (RTK Base Stations and GCPS)	
	Platforms and portals stage of geospatial technology architecture	Stage of geospatial technology architecture	
	Standards		
Policy framework	Core Geospatial Policy Framework	National geospatial policy Open data policy Space-EO-GNSS policy Drone policy	10%
	Enabling Policies Framework	Science and technology (S&T) and innovation policy Information and communication technology policy + telecom policy Digital/AI/IoT strategy BIM plan/strategy/policy	
Institutional capacity	Knowledge creation	Research courses Post-graduate courses	20%
	Foundational academia	Graduate courses Diploma courses Certificate courses	
User adoption	Mapping or service level		20%
	Asset management/business process modelling		
	Analytics and workflow level		
	System integration level		
	Enterprise level		
Industry fabric	Industry capacity	Existence of industries in different geospatial technology segments	30%
	Industry networks	Industry networks Knowledge networks	
	Innovation promotion	Incubation and accelerator programs	

Source: Geospatial Media and Communications

Key Concepts

This section introduces some of the key concepts involved in geospatial technologies and applications, in non-technical language which has been made accessible to policymakers.

Upstream: Space activities which cover the economic value chain's earlier stages of designing, building, and launching systems into orbit, such as rockets and satellites. This can also include in-orbit activities such as space stations, logistics, and resources.

Downstream: Space activities which cover the economic value chain's later stages of collecting data from orbit, sending it back down to Earth, and analyzing it to develop applications for various industries. These include machine learning and end-user products.

Geospatial data: Data which combines location information (coordinates), attribute information (properties), and often also temporal information (time) about an area on the surface of the Earth. It can be generated in the form of location data from satellite navigation (GNSS) or geospatial imagery from Earth observation (EO).

Satellite navigation (GNSS): The use of satellites, often in geostationary orbit (GEO), to provide location data through time signals, which is transmitted back down to Earth with radio communications. This is also known as global navigation satellite systems (GNSS).

Earth observation (EO): The use of satellites or aerial systems to provide geospatial imagery through remote sensing, which is transmitted back down to Earth with radio or laser communications. Geospatial imagery includes both satellite imagery and aerial imagery.

Satellite imagery: Imagery which is generated through Earth observation by satellites. This can include various types of optical (light wave) and radar (radio wave) imaging, the choice of which depends on the surface being observed and the intended downstream application.

Aerial imagery: Imagery which is generated through Earth observation by drones and other unmanned aerial vehicles (UAVs). This includes similar characteristics to satellite imagery, but with different requirements and capabilities in terms of altitude, resolution, and angle.

Satellite constellation: A group of satellites working together as a system to provide regional or global coverage of the Earth, often also including inter-satellite links. This can generally be positioned in either low Earth orbit (LEO) or medium Earth orbit (MEO).

High-altitude platform (HAP): A type of UAV that operates in the upper atmosphere or stratosphere. It can take the form of fixed-wing drones, high-altitude balloons, or airships (zeppelins). They are also known as high-altitude pseudo-satellites.

Spatial data infrastructure (SDI): A coordinated framework of institutional arrangements, technology standards, and data policies that enable the discovery and use of geospatial data for a wide range of stakeholders. This provides the benefit of standardizing the formats and protocols for both access and interoperability of geospatial data in a country or region.

Geospatial information system (GIS): A system that is designed to capture, store, manage, analyze, and map all types of geospatial data. This provides the architectural foundation for GIS software, which enables users to engage in mapping and analysis of geospatial imagery.

Open-access data: Data that is freely available on a platform that can be accessed by the public to download, modify, and distribute for research or commercial applications.

Analysis-ready data (ARD): Geospatial imagery that has been processed to meet minimum requirements and organized into time-series groups. This allows for immediate analysis with low user effort and interoperability both through time and with other datasets. When stored in a multi-dimensional array format, it is sometimes referred to as a "data cube."

Institutional design: The architectural design of an institution and its mechanisms. This can include the institution's configuration within the public or private sector, as well as its regulatory, economic, decision-making, operational, and accountability systems.

Capacity building: The process of developing and strengthening the skills, resources, and infrastructure that a community needs to perform a given activity. Within the context of geospatial policy, this refers to building capacity to access the imagery, tools, and skills needed to perform geospatial analytics and enable downstream applications.

Innovation ecosystem: The network of startups, companies, venture capital funds, incubation programs, accelerator programs, and public institutions which support and drive technological innovation in an economy. This includes providing access to opportunities for growth, financing, networking, and collaboration, as well as activities such as competitions.

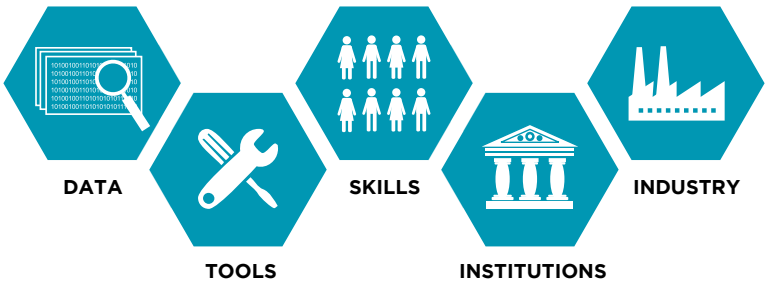
Business incubation: A program which supports entrepreneurs and startups to design their business plan and develop their product or service. This usually includes office space, training sessions, workshops, networking, and introductions to sources of finance.

1. GEOSPATIAL PUBLIC POLICY

1.1. Policy Layers

The types of policies involved in the advancement of geospatial technologies and applications can be categorized as the Five Layers of Geospatial Policy (Figure 3).

Figure 3. **Five Layers of Geospatial Policy**



Source: Satellite Applications Catapult

Data Layer

The first layer of geospatial policy captures the activities involved in creating and enabling access to the "raw material" of the geospatial economy: data. It includes the generation of geospatial data through satellite imagery, aerial imagery, in situ sensors, and geolocation data, as well as the platforms which people need to find and access the right data.

Examples of policy initiatives included in the Data Layer can be found below.

- **Satellite programs:** development and operation of Earth observation satellites
- **Data acquisition programs:** programs for sourcing and licensing of geospatial data
- **Open-access platforms:** platforms for free and public access to geospatial data

Tools Layer

The second layer of geospatial policy captures the activities involved in providing the software that is needed to process and analyze geospatial data for a wide range of downstream applications. This includes tools which empower users to perform geospatial mapping, 2D and 3D modelling, remote monitoring, and resource management.

Examples of policy initiatives included in the Tools Layer can be found below.

- **Geospatial mapping:** software for mapping natural and urban landscapes
- **Geospatial modelling:** software for modelling physical assets and dynamics
- **Geospatial monitoring:** software for monitoring environments and infrastructure

Skills Layer

The third layer of geospatial policy captures the activities involved in educating and training the workforce to use geospatial data and tools. It includes programs for capacity building through education, training, direct support, or knowledge exchange.

Examples of policy initiatives included in the Skills Layer can be found below.

- **Capacity building:** education, training, and resources for geospatial analytics skills
- **Technical GIS support:** specialist or one-off geospatial capacity-building initiatives
- **Knowledge development:** knowledge exchange with government and industry

Institutions Layer

The fourth layer of geospatial policy captures the activities involved in directing institutions to design strategies and coordinate geospatial activities. It includes the establishment of public institutions, geospatial strategy, policy frameworks, and efforts to raise awareness on the importance of geospatial data for government and industry.

Examples of policy initiatives included in the Institutions Layer can be found below.

- **Public institutions:** public agencies, bodies, and centers for geospatial activities
- **Policy frameworks:** policies and mechanisms to build spatial data infrastructure (SDI)
- **Awareness campaigns:** increasing understanding of the value of geospatial data

Industry Layer

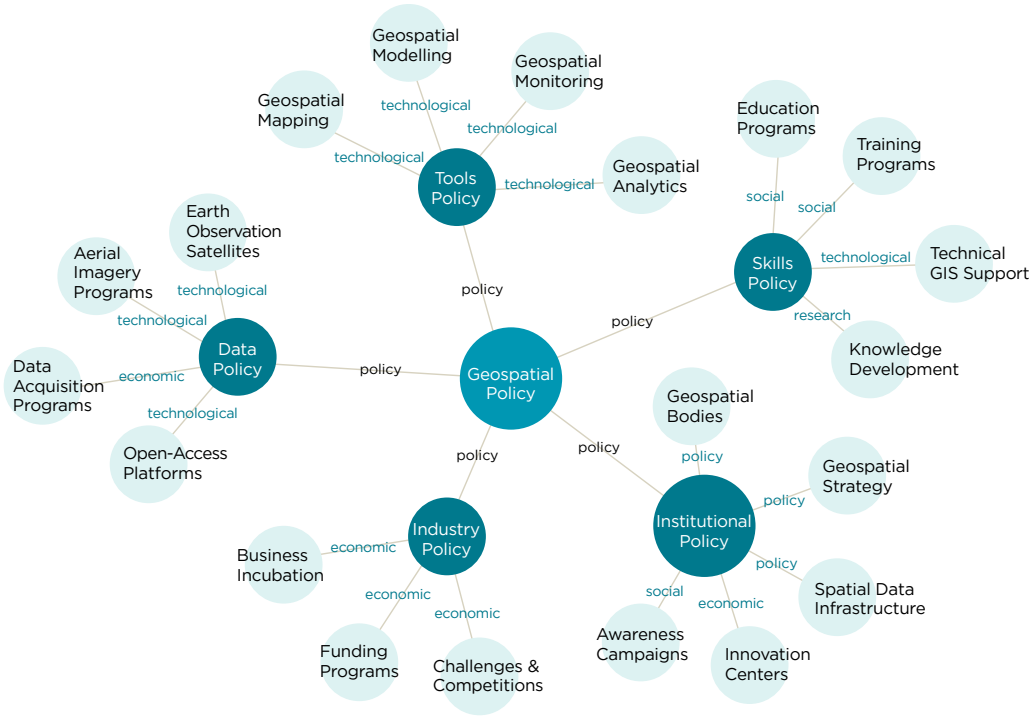
The final layer of geospatial policy captures the activities which are involved in supporting the innovation ecosystem, which drives the future of the geospatial economy. As a result, this includes programs which are designed to support early-stage companies, facilitate access to finance for business development, provide grant funding to commercialization projects, and promote geospatial innovation through challenges and competitions with prizes.

Examples of policy initiatives included in the Industry Layer can be found below.

- **Business incubation:** business support for startups generating or using geospatial data
- **Funding programs:** grant funding for public, academic, or commercial geospatial projects
- **Challenges and competitions:** economic incentives to develop innovative applications

This can also be visualized as a **geospatial policy map** to facilitate strategic decision making (Figure 4).

Figure 4. **Geospatial Policy Map**



Source: Atlas Institution[11]

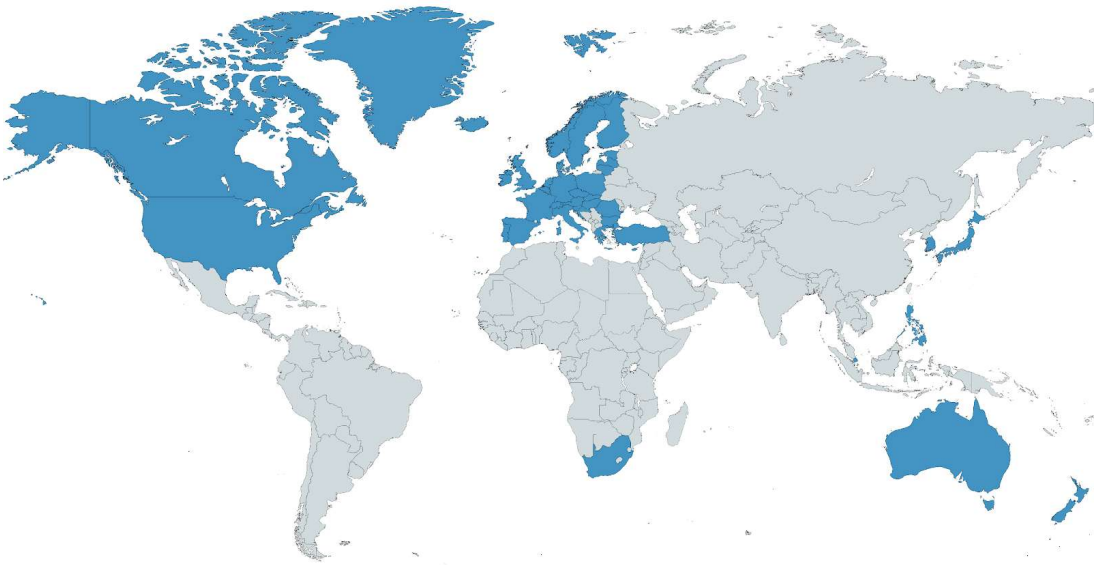
Since geospatial policy involves multiple layers which emerge from a nation's economic, technological, political, and social dimensions, mapping the landscape of possible initiatives can be a highly valuable exercise. This has the benefit of reducing complexity, which helps policymakers to navigate their options, thereby empowering them with more effective strategic foresight and decision making. The interactive visualization displayed above, which was designed by the Atlas Institution, could also be further expanded to include examples of case studies as global best practices, as well as the technologies, institutions, and resources which would be required for the successful implementation of each initiative.

[11] Atlas Institution (2022)

1.2. Country Profiles

This section includes a summary of the countries surveyed during the research phase of this report. For each country, a profile was developed with key data on population, land area, exclusive economic zone area (EEZ), GDP per capita, national space agency, Earth observation satellites, global positioning satellites, national geospatial body, and geospatial readiness levels as classified by the GeoBuiz CGRI framework. Through the geographic and economic context that it provides, this information was then used to support the evaluation of policy initiatives. Figure 5 provides an overview of the countries that were involved in this process.

Figure 5. **Countries Involved in the Process**



Source: Satellite Applications Catapult

In addition, a number of policy initiatives which have been designed to operate at the regional level (e.g., European Space Agency) and international level (e.g., United Nations) were also identified. This trend towards multilateral cooperation is likely to continue increasing over the course of the 21st century as the use of geospatial data becomes more relevant for transnational applications such as economic trade, environmental monitoring, and border security.

1.3. Policy Initiatives

This section includes the complete list of 30 policy initiatives which were identified in the research for this report, ordered alphabetically by each organization's country or region.

- Africa Living Atlas (GeoPortal) | Africa | *website*
- Digital Earth Africa (DE Africa) | Africa | *website*
- Regional Centre for Mapping of Resources for Development (RCMRD) | Africa | *website*
- Digital Earth Australia (DEA) | Australia | *website*
- Murray-Darling Basin Authority (MDBA) | Australia | *website*
- Canada Centre for Mapping and Earth Observation (CCMEO) | Canada | *website*
- Canadian Space Agency smartEarth (CSA) | Canada | *website*
- ESA Business Incubation Centres (BIC) | Europe | *website*
- EU Biodiversity and Protected Areas Management (BIOPAMA) | European Union | *website*
- EU Copernicus Programme | European Union | *website*
- Infrastructure for Spatial Information in Europe (INSPIRE) | European Union | *website*
- Japan International Cooperation Agency (JICA) | Japan | *website*
- Korea Green Growth Trust Fund (KGGTF) | Korea | *website*
- Geodata for Agriculture and Water (G4AW) | Netherlands | *website*
- Netherlands Satellite Data Portal (SDP) | Netherlands | *website*
- Land Information New Zealand (LINZ) | New Zealand | *website*
- Kartverket Open Data Portal | Norway | *website*
- Geoportal Philippines (GeoPH) | Philippines | *website*
- Geospatial Singapore (GeospatialSG) | Singapore | *website*
- Africa Earth Observation Challenge (AEO) | South Africa | *website*
- South African Spatial Data Infrastructure (SASDI) | South Africa | *website*
- Swiss Data Cube (SDC) | Switzerland | *website*
- Göktürk Satellite Programme (TÜBITAK) | Turkey | *website*
- UK Geospatial Commission (GC) | United Kingdom | *website*
- UK Space for Smarter Government (SSGP) | United Kingdom | *website*
- Satellite Applications Catapult (SAC) | United Kingdom | *website*
- International Partnership Programme (IPP) | United Kingdom | *website*
- The Open Data Institute (ODI) | United Kingdom | *website*
- NASA Earth Science Data Systems (ESDS) | United States | *website*
- UN Integrated Geospatial Information Framework (IGIF) | United Nations | *website*

1.4. Policy Evaluation

This section includes a shortlist of the 10 policy initiatives which were identified as the most relevant candidates for global best practices, based on their potential to inform future policy action in LAC countries.[12] Each policy was then evaluated using a matrix to determine a policy rating, allowing for the selection of six case studies for further analysis.

The complete evaluation process can be found in the Appendix of this report. As a result of this evaluation process, the initiatives which scored a policy rating of 8/10 or higher were selected as case studies for further analysis. Although the Space for Smarter Government Programme (SSGP) was not selected, it has been included as part of the Satellite Applications Catapult case study due to the Catapult's role as the implementing organization for SSGP.

Shortlist of policy initiatives:

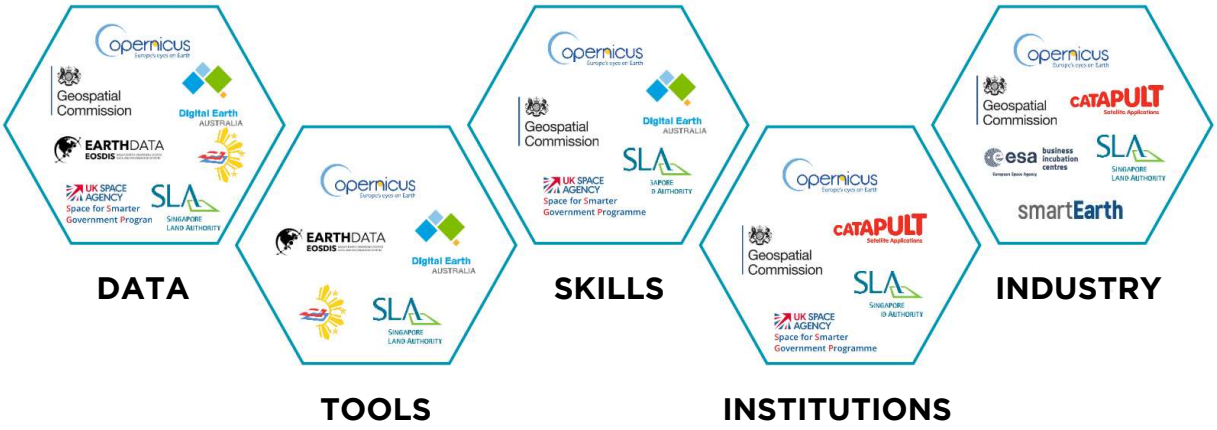
1. Digital Earth Australia
2. EU Copernicus Programme
3. NASA EarthData
4. UK Geospatial Commission
5. UK Space for Smarter Government
6. Geospatial Singapore
7. Geoportal Philippines
8. Satellite Applications Catapult
9. ESA Business Incubation Centres
10. CSA smartEarth

[12] In order to facilitate the selection of initiatives, the authors designed a priority matrix with four types of criteria: **Geography** (considered each policy intervention's relevance to Latin America, the diversity of geographies represented by implementing countries, the diversity of levels of economic development, and geospatial readiness levels), **Earth Observation** (considered each policy intervention's focus on developing public institutions, supporting growth in the innovation ecosystem, or enabling new EO applications which unlock the potential of geospatial technologies), **Intervention Impact** (considered each policy intervention's direct impact as outlined in its objectives, as well as its indirect impact in building future capacity or supporting other countries to implement similar policies), and **SDG Impact** (considered each policy intervention's value in relation to the primary Sustainable Development Goals which are advanced as a result of its impact, including benefits for the environment, economy, and society).

Selection of case studies:

- ✔ Digital Earth Australia
- ✔ EU Copernicus Programme
- ✔ UK Geospatial Commission
- ✔ Geospatial Singapore
- ✔ Satellite Applications Catapult
- ✔ ESA Business Incubation Centres

Figure 6. **Shortlist of Policy Initiatives Categorized into the Five Layers of Geospatial Policy**



Source: Satellite Applications Catapult

2. ANALYSIS OF CASE STUDIES

2.1. Digital Earth Australia

Policy layers: Data, Tools, Skills
Organization: Geoscience Australia
Timeline: 2016 – Present
Budget: ~$7 million per year[13]

Objectives:

Digital Earth Australia is a platform which uses satellite imagery of Australia to provide high-quality analysis-ready data (ARD) and analytics tools. The need for affordable ARD is key to the ongoing use and future growth of geospatial data for both government and industry. By investing in Digital Earth Australia (DEA), the Australian government aims to lower the direct costs associated with accessing and analyzing vast volumes of Earth observation (EO) data, which is provided to the public free of charge.[14]

Activities:

- **Geospatial data products**, which include Earth observation datasets and digital models for coastlines, waterbodies, intertidal elevation, high and low tide composites, surface reflectance, landscape cover, water observations, dynamic land cover for wetlands and mangroves, and bushfire monitoring.
- **Open-access platform** for geospatial data products through the DEA Sandbox, as well as DEA Content Management Interface (CMI), National Computing Infrastructure (NCI), and Amazon Web Services (AWS).
- **Public projects** to develop new geospatial datasets and products for the Australian government.
- **Education and training** activities for capacity building in the use of geospatial data and DEA products.
- **International collaboration** in the *Open Data Cube* (ODC) project for the development of an open-source and freely accessible geospatial data management and analysis software platform.

[13] Geoscience Australia – *CEO statement on Budget 2018-19* (2018)
[14] Digital Earth Australia – *Digital Earth Australia* (2021)

Impact:

As a result of having access to free ARD, Australian businesses will be able to innovate and develop products and services that enable new geospatial applications, improve productivity, and allow them to become more competitive in global markets.[15] The DEA Industry Strategy (2019) includes three areas of focus: (1) data and technology, (2) education and training, and (3) awareness. In addition to the direct impact of its products and projects, it also runs education and training workshops.[16] Internationally, the DEA program also has an impact through its participation in the ODC project, with 9 versions around the world already operational (including in Colombia), 14 in development (in the United Kingdom), and over 30 under review.[17]

Analysis:

Digital Earth Australia is a global leader in the availability of ARD, achieved through implementation of the ODC software platform. Having invested $28 million in DEA on a four-year timeline from 2018 to 2022, the Australian government has fully funded the program to provide high-quality data and analytics tools that support applications such as policymaking, investment decision making, environmental monitoring, and the development of new commercial products and services. Geoscience Australia is currently running an industry consultation through the nonprofit research organization FrontierSI to continue evolving DEA's Industry Strategy and evaluate its impact in various downstream markets. Internationally, DEA's involvement in the development of the ODC platform has an indirect impact by providing the foundations for other such initiatives including *Digital Earth Africa*[18] and the recently announced *Swiss Data Cube*.[19]

Recommendation:

Digital Earth Australia is recommended as a case study on best practices in the development of spatial data infrastructure (SDI) and open-access data platforms. As a result of its success, there have been proposals on developing a Digital Earth Americas program, which would benefit from the existing capabilities and lessons learned from DEA's operations in the last five years. Since it is a relatively low-budget initiative, implementing the ODC platform at a national or regional level in the LAC region and delivering training workshops for capacity building in government and industry would be highly valuable.

[15] FrontierSI – *Digital Earth Australia Industry Consultation* (2021)
[16] FrontierSI – *Digital Earth Australia: Industry Strategy* (2019)
[17] Open Data Cube – *International Data Cube Deployments* (2018)
[18] Digital Earth Africa – *Phase I Summary* (2019)
[19] Swiss Data Cube – *Swiss Data Cube* (2021)

2.2. EU Copernicus Programme

Policy layers: Data, Tools, Skills, Institutions, Industry

Organization: European Commission

Timeline: 1998 – Present

Budget: ~$1 billion per year[20]

Objectives:

The Copernicus Programme is the European Union's Earth observation program in partnership with the European Space Agency. It operates a satellite constellation, collects data from ground-based, airborne, and seaborne systems, and provides geospatial data products for downstream applications. By investing in Copernicus and making its geospatial data free and openly accessible to all users, the European Commission aims to expand the benefits of looking at our planet and its environment to a wide range of stakeholders that develop applications to improve the quality of life of European citizens and beyond.

Activities:

• **Satellite constellation** for Earth observation imagery which is composed of several *Sentinel missions* including Sentinel-1, Sentinel-2, Sentinel-3, Sentinel-4, Sentinel-5P, Sentinel-5, and Sentinel-6.[21]

• **Geospatial data products** which provide *Copernicus Services* in the thematic areas of Atmosphere, Marine, Land, Climate Change, Security, and Emergency. Products include data on atmospheric composition for air quality analysis, solar radiation for renewable energy, ocean currents and sea ice for maritime safety, marine indicators for water quality monitoring, land indicators for vegetation monitoring, land cover and land use for mapping, temperature and ice for climate monitoring, land and sea intelligence for border surveillance, and disaster warning systems for floods (EFAS), forest fires (EFFIS), and droughts (EDO).[22]

[20] smartEarth – *Contributions, grants and contracts awarded* (2020)
[21] Copernicus Programme – *Discover our Satellites* (2021)
[22] Copernicus Programme – *Copernicus Services* (2021)

• **Open-access platform** for its geospatial data and products through the *Copernicus Open Access Hub*, which allows users to access data from all Sentinel missions and APIs to download on a regular basis.[23]
• **Business incubation** funding, which provides €50,000 every year for up to 20 startups that use Copernicus data and services, to be used as an investment for an incubation or accelerator program of their choice.[24]
• **Accelerator program,** which provides up to 50 startups every year with 12 months of coaching, bootcamps, virtual training, networking, and access to investment through the *Copernicus Accelerator*.[25]
• **Competitions** which provide funding and prizes to promote innovation in the use of Earth observation data through the *Copernicus Masters* and partner challenges, open to all types of participants.[26]

Impact:

The Copernicus Programme has been instrumental in providing geospatial data and intelligence to policymakers, researchers, businesses, and citizens. This has enabled a wide range of downstream applications in agriculture, the blue economy, environment, development, energy, natural resources, forestry, health, insurance, disaster management, security, defense, tourism, transport, and urban planning. As estimated in a report on the socioeconomic impact of Copernicus, while the program's costs from 2008 to 2020 were around €7 billion, the benefits to the European economy were estimated to be around €12 billion.[27] Furthermore, in 2015, it was reported that 66 percent of European EO application developers were making use of Copernicus data.

Analysis:

The Copernicus Programme is a global leader in the collection and open-access availability of Earth observation data. Originally inspired from NASA's Landsat program, Copernicus has now developed to include activities across all layers of geospatial policy. This vertical integration model has allowed it to create a global community of EO and support Europe's geospatial innovation ecosystem. Internationally, its data sharing principles are in line with the Group for Earth Observation (GEO), and it has signed Cooperation Agreements with the African Union, Australia, Chile, Colombia, Brazil, India, Serbia, Ukraine, and the United States.[28]

[23] Copernicus Open Access Hub – *Copernicus Open Access Hub* (2021)
[24] Copernicus Incubation – *Programme* (2021)
[25] Copernicus Accelerator – *For Start-Ups* (2021)
[26] Copernicus Masters – *About the Competition* (2021)
[27] European Commission – *Socio-economic impact of Copernicus in the EU* (2016)
[28] Copernicus Programme – *International Cooperation in the area of Data Exchange* (2021)

Recommendation:

Copernicus is recommended as a case study on best practices in the vertical integration of geospatial data, tools, skills, institutions, and industry in LAC countries. However, since it is a high-budget intergovernmental program, this must be adjusted to each country's political and economic context.

2.3. UK Geospatial Commission

Geospatial Commission

Policy layers: Data, Skills, Institutions, Industry

Organization: UK Government

Timeline: 2018 – Present

Budget: ~$55 million per year

Objectives:

The Geospatial Commission is an expert committee established as part of the United Kingdom's Cabinet Office, responsible for promoting the use of geospatial data and coordinating geospatial activities. Its objectives are to (1) set the UK's Geospatial Strategy, including policy and data standards; (2) promote competition and innovation within markets for geospatial data and applications; (3) improve the accessibility, interoperability, and quality of geospatial data; and (4) improve capabilities, skills, and resources to support the growth of geospatial businesses and improve public services. In doing so, the government aims to accelerate the delivery of economic, social, and environmental benefits derived from geospatial data, as well as support international development.

Activities:

• **Geospatial strategy** for 2020 to 2025, developed together with hundreds of institutions, businesses, and individuals through a Call for Evidence in 2018 and published as *Unlocking the Power of Location*.[29]
• **Research reports** to provide technical and policy recommendations for the geospatial industry. Examples include an economic assessment of the geospatial data market, guidance on location data ethics, a report on geospatial data for biodiversity monitoring, and a report on the future of transport and mobility.[30]
• **Data infrastructure** initiatives which include improving public sector access to geospatial data by opening up direct API access through the *Public Sector Geospatial Agreement* (PSGA) in partnership with Ordnance Survey,[31] launching a dynamic purchasing system for geospatial services, and leading the development of a *National Underground Asset Register* (NUAR) to improve construction and urban development.[32]
• **Skills program,** which includes convening an industry skills forum, publishing a report on the demand for geospatial skills in the UK, and providing data science expertise to public sector organizations.
• **Innovation program,** which includes supporting the growth of a geospatial cluster in Scotland and organizing a competition on innovative applications in *Transport Location Data* with Innovate UK.[33]

Impact:

As the United Kingdom's recently established geospatial body, the Geospatial Commission has played a key role in bringing together government and industry stakeholders to design the country's geospatial strategy. This sets out the vision for a national location data framework to support post-COVID-19 economic recovery, help meet net-zero climate targets, and drive the United Kingdom's transition to a world-leading digital nation with a data-driven public sector. Within this strategy, the Geospatial Commission's investments in improving access to geospatial data and promoting innovation in geospatial applications have built the foundations for progress through to 2025.

[29] Geospatial Commission – *National Geospatial Strategy: Call for Evidence* (2018)
[30] Geospatial Commission – *Annual Plan 2021/2022* (2021)
[31] Ordnance Survey – *Public Sector Geospatial Agreement* (2021)
[32] Geospatial Commission – *National Underground Asset Register* (2021)
[33] Geospatial Commission – *Transport Innovation Competition* (2021)

Analysis:

The Geospatial Commission is a promising example of institution building for geospatial policy, with activities that provide benefits across the Data, Skills, and Innovation Layers. As a nexus for the development of the UK's national spatial data infrastructure (NSDI), the Commission's collaborative stakeholder approach to improving the accessibility, interoperability, and quality of geospatial data is likely to be an effective way of empowering the use of Earth observation in the public sector. Internationally, the Commission's main focus is on unlocking the potential of geospatial data to help the UK achieve its net-zero carbon targets, while the COP26 climate conference takes place in Glasgow, as well as its plans to develop an International Geospatial Service.

Recommendation:

The Geospatial Commission is recommended as a case study on best practices in the establishment of a public body to coordinate geospatial activities. Despite having benefits across multiple layers of geospatial policy, it is a medium-budget initiative which would enable LAC countries to design a geospatial strategy with industry stakeholders, build national spatial data infrastructure, launch a geospatial education and training program, and organize competitions to promote innovation.

2.4. Geospatial Singapore

SINGAPORE LAND AUTHORITY

Policy layers: Data, Tools, Skills, Institutions, Industry

Organization: Singapore Land Authority

Timeline: 2018 – Present

Budget: Unknown

Objectives:

Geospatial Singapore is the geospatial program which embodies Singapore's national spatial data infrastructure (NSDI), set up in 2008 and later reconceptualized as Geospatial Singapore in 2018. It is managed by the Singapore Land Authority (SLA) in collaboration with Singapore's Government Technology Agency (GovTech). Its objectives are to achieve (1) Thriving GeoIndustry–Singapore as the geospatial hub of the region with a vibrant enterprise ecosystem; (2) GeoEmpowered People, a workforce that is competent in using geospatial data for increased productivity and better lives; and (3) GeoSmart Government, an effective and trusted public service driven by geospatially enabled processes in policymaking, planning, and operations.

Activities:

- **Geospatial strategy,** which involves developing Singapore's *Geospatial Master Plan* and leading on its implementation through a portfolio of policymaking, data platform, and capacity-building activities.
- **Policies and mechanisms** to enable geospatial data standardization and increase data sharing.
- **Data infrastructure** portals called GeoPlatforms, which include a national map of Singapore with data APIs and government services through *OneMap Singapore*, a digital 3D replica of Singapore built on real-time dynamic data through *Virtual Singapore*, and the development of a geospatial marketplace.[34,35]

[34] OneMap Singapore – *OneMap Singapore* (2021)
[35] Geospatial Singapore – *Virtual Singapore* (2021)

• **Industry center** for geospatial technology and innovation at *GeoWorks*, which brings together government, academia, and industry in Singapore's geospatial ecosystem to build a community. Includes geospatial facilities, collaborative spaces, education and training, innovation challenges, and networking events.
• **Innovation challenges,** which are organized by GeoWorks to match geospatial solution providers with industry users, as well as the *ASEAN Geospatial Challenge* which is directed at students to raise awareness of geospatial data and applications for advancing the UN's Sustainable Development Goals (SDGs).[36]

Impact:

Geospatial Singapore has already had a significant impact on advancing Singapore's geospatial data policy, infrastructure, and industry. For data policy, this includes facilitating collaboration on data-sharing, ISO standardization of datasets across domains, data interoperability for applications such as 3D modelling, a data request mechanism for the public sector, a "geotag by default" policy to mandate the collection of location attributes for government datasets, and over 1,300 data layers shared within government in addition to around 100 thematic data layers shared with the public through its GeoPlatforms. For infrastructure, this includes the availability of OneMap and Virtual Singapore as open-access data platforms for all stakeholders. For industry, this includes the GeoWorks center's capacity building, innovation challenges, and networking, which drive the adoption and co-creation of new geospatial applications for economic growth.[37]

Analysis:

Geospatial Singapore is an emerging example of modern and integrated geospatial policy which includes activities across all five layers, designed within the context of a Smart Nation. Although Singapore is smaller in geography and population than other candidates, it also has fewer resources than most other geospatially developed nations. The successful transition of its NSDI into a geospatial body with an industry center is likely to be a result of its Geospatial Master Plan's comprehensive design, which reflects Singapore's ambitions to remain an economically competitive global city through geospatial technology.

[36] GeoWorks – *ASEAN Geospatial Challenge* (2021)
[37] Geospatial Singapore – *Singapore Geospatial Master Plan* (2018)

Recommendation:

Geospatial Singapore is recommended as a case study on best practices in the modern integration of geospatial data, tools, skills, institutions, and industry. Although this is still an emerging model, it represents a medium-budget alternative to more established policy initiatives like the Copernicus Programme, allowing it to be implemented in less geospatially developed LAC countries.

2.5. Satellite Applications Catapult

CATAPULT
Satellite Applications

Policy layers: Institutions, Industry
Organization: Innovate UK
Timeline: 2013 – Present
Budget: ~$15 million per year

Objectives:

The Satellite Applications Catapult is a nonprofit company that operates as the United Kingdom's center for space technology and innovation. It is one of nine centers in the Catapult Network, funded by Innovate UK and commercial revenues. Its objective is to support the country's space industry by accelerating the growth of satellite applications to capture a 10 percent share of the global space economy by 2030. It aims to achieve this by (1) Energizing the Market – unlocking customer demand by showcasing the value of space-enabled services and opening new markets; (2) Empowering Technology – helping companies to bring their products and services to market by identifying barriers to entry; and (3) Enabling Business – connecting entrepreneurs with the resources they need to grow, opening new routes to market, and attracting investment to United Kingdom–based companies.

Activities:

• **Government projects** in collaboration with Innovate UK, the UK Space Agency (UKSA), the Geospatial Commission, and other relevant institutions. Examples include the *Space for Smarter Government Programme* (SSGP) and *International Partnership Programme* (IPP), both funded by the UKSA.[38,39]

• **Commercial projects,** which include a wide range of research, development, and support for industry clients, such as the *In-Orbit Demonstration* (IOD) program to test and launch new technologies into low Earth orbit.[40] Projects are usually aligned with expertise in the Catapult's value streams – Access to Space, Agriculture, Explore New Markets, Emerging Technologies, Extractive Industries, Geospatial Intelligence, Health and Wellbeing, Intelligent Transport, Sustainable Development, and Ubiquitous Connectivity.

• **Market research** on upstream space technologies, downstream geospatial applications, and future market trends. This includes research for government or commercial projects, as well as institutional research funded by the Catapult's budget such as the *UK Space Capabilities Catalogue* for landscape mapping.[41]

• **Business support,** which includes delivering *Business Sprints* (now Explore and Evolve), establishing the *Space Commercialisation Engine*, and providing support to *ESA BIC UK* and *Seraphim Space Camp*.[42,43]

• **Technical facilities,** which include the *Westcott Innovation Centre* and a range of satellite testing facilities.[44]

• **Co-working spaces,** which include the *Space Enterprise Labs* and other office locations around the United Kingdom.[45]

• **Industry events,** which include forums, workshops, and networking events such as the monthly *Satuccino*.[46]

Impact:

In 2019–2020, the Catapult engaged with 723 organizations, introduced 153 SMEs to the space sector, delivered 45 commercial projects, completed 26 R&D projects, and supported UK businesses to raise over $50 million in that year.[47] Its activities

[38] UK Space Agency – *Space for Smarter Government Programme* (2021)
[39] HM Government – *International Partnership Programme* (2021)
[40] Satellite Applications Catapult – *In-Orbit Demonstration* (2021)
[41] Satellite Applications Catapult – *UK Space Capabilities Catalogue* (2021)
[42] Satellite Applications Catapult – *Business Sprints* (2021)
[43] Satellite Applications Catapult – *Space Commercialisation Engine* (2021)
[44] Satellite Applications Catapult – *Technical Facilities* (2021)
[45] Satellite Applications Catapult – *Space Enterprise Labs* (2021)
[46] Satellite Applications Catapult – *Satuccino* (2021)
[47] Satellite Applications Catapult – *Annual Report 2019-2020* (2020)

enable the commercialization of new geospatial technologies and applications for a wide range of stakeholders in government and industry. Internationally, its participation in programs like the IPP has expanded the benefits of its Earth observation expertise to Colombia, Kenya, and Pacific islands.

Analysis:

The Satellite Applications Catapult is a new and successful model for public–private collaboration to bridge the gap between research and industry. As a nexus for stakeholder engagement and collaboration, it plays an essential role in the UK space ecosystem, with the SDGs at the heart of its mission. The Catapult's ability to engage with and connect policymakers, researchers, businesses, entrepreneurs, incubators, accelerators, and venture capital funds allows it to create value in many dimensions of the space and geospatial economy.

Recommendation:

The Satellite Applications Catapult is recommended as a case study on best practices in institution building for technology and innovation centers. Due to its relatively low budget and ability to generate commercial revenues, this would be a highly effective policy initiative in Latin America and the Caribbean. This could be established within the context of a wider Catapult Network to address other emerging technologies.

2.6. ESA Business Incubation Centres

Policy layers: Industry
Organization: European Space Agency
Timeline: 2003 – Present
Budget: ~$500k per center/year

Objectives:

ESA Business Incubation Centres (BIC) is the European Space Agency's program for space business incubation, which is part of *ESA Space Solutions*. ESA BIC's network includes 22 incubation centers with activities in more than 60 cities across 19 countries – Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Norway, Portugal, Spain, Sweden, Switzerland, the Netherlands, and the United Kingdom.[48] Its objective is to support entrepreneurs in the development of business ideas that use space technology and satellite data to improve life on Earth, thereby also growing Europe's space economy.

Activities:

- **Office space** to provide startups with a collaborative work environment, often on a space campus.
- **Technical support,** which includes up to 40 hours per year of engagement with ESA technical expertise, up to 40 hours of access to laboratory and testing facilities, and workshops with a technical focus.[49]
- **Business support,** which includes workshops and mentoring on business development and growth.
- **Access to finance** in the form of incubation funding from $10,000 to $50,000 and access to regional investors. Support for applying to grant funding opportunities through *ESA Business Applications* which offers a wide range of themes including smart cities, renewable energy, space for infrastructure, digital healthcare, future of

[48] ESA Space Solutions - *Business Incubation* (2021)
[49] UKRI STFC – *ESA Business Incubation Centre United Kingdom* (2021)

aviation, environmental monitoring, virtual reality, and internet of things.

- **Competitions,** which include the *Copernicus Masters* for Earth observation and *Galileo Masters* for geolocation data, with support provided to startups during the application and review process.
- **Networking events** to meet other entrepreneurs, industry partners, customers, and investors.

Impact:

ESA BIC has incubated 1,000+ companies to date, with around 150 new startups joining every year. The network of incubation centers plays an essential role in promoting the value of space for Earth and supporting the European space economy's growth from the early stages of the entrepreneurial journey. In 2019, it was estimated that the program has delivered a 4x return on investment to the European economy. As its alumni community and industry relationships grow, the program has also been able to attract more investment each year, leading to a rise in venture funding for European space companies. Internationally, ESA BIC incubatees have had a significant impact on achieving the SDGs, some of which can be viewed through the *ESA SDG portal*.

Analysis:

ESA BIC is the world's largest space innovation network and a pioneering example of publicly funded business incubation for space technologies and applications. This early-stage focus is particularly important for the geospatial economy, as the "valley of death" in the development of space startups is often more complex to navigate and difficult to survive due to high capital costs, technical expertise, and barriers to market entry. There is also long-term value in creating space innovation clusters, such as ESA BIC UK's location in Harwell Campus to the south of Oxford, which encourages the diffusion of geospatial expertise between academia and industry. Furthermore, the power of associating incubatees with a brand like ESA delivers great benefits to the country's most promising space startups, allowing them to reflect legitimacy when raising funds or securing customers.

Recommendation:

ESA BIC is recommended as a case study on best practices in building a network of space business incubation centers. As the vast majority of space startups either generate or use geospatial data, this represents a major opportunity to promote the geospatial innovation ecosystem in Latin America and the Caribbean with a relatively low-budget initiative. In particular, it is recommended to apply the brand of an existing space or geospatial public institution in order to mirror the benefits of incubatees being associated with ESA.

3. CONCLUSIONS AND RECOMMENDATIONS

3.1. Global Best Practices

As a result of the analysis of case studies, best practices can be derived which represent some of the most effective geospatial policies from around the world. For each policy layer, this will be presented as an overview of policy initiatives along with relevant examples.

Data Layer

1. Satellite programs: The development of an Earth observation satellite constellation can offer significant economic benefits to emerging countries, providing the infrastructure needed to generate their own geospatial data and make it available to businesses and citizens. However, this is not yet recommended for developing countries, as a large amount of resources are required to fund the capital costs and operating expenses of a satellite program. In those cases, alternatives such as data partnership agreements and commercial imagery acquisition can be considered. Examples of Earth observation satellite programs include the *EU Copernicus Programme* and *NASA/USGS Landsat Program*.[50,51]

2. Aerial imagery program: The development of an aerial imagery program can be another valuable source of geospatial data, especially if it involves a framework for the acquisition of commercial drone imagery by the public sector. This can both be more cost-effective and offer a higher resolution of imagery than satellite programs, at the cost of having relatively limited geographic coverage and lower frequency of revisit times. An example of aerial imagery programs includes the *U.S. National Agricultural Imagery Program* (NAIP).[52]

[50] Copernicus Programme – *Infrastructure Overview* (2022)
[51] NASA – *Landsat Overview* (2022)
[52] U.S. Department of Agriculture – *NAIP Imagery* (2022)

3. Open-access data platforms: The establishment of an open-access platform for geospatial data can lower the costs of developing geospatial applications for businesses, as well as increase public interest in the use of geospatial data. This can be sourced from a nation's satellite constellation, aerial imagery program, or commercial acquisition. In particular, the provision of analysis-ready data (ARD), such as through regional implementation of the *Open Data Cube* platform, can significantly lower the barriers to innovation.[53] Examples of open-access data platforms include the *Copernicus Open Access Hub*, *Digital Earth Australia*, *Digital Earth Africa*, and the *Swiss Data Cube*.[54,55,56]

4. Data acquisition programs: The establishment of a data acquisition program can be a powerful alternative for countries which would benefit from access to high-resolution imagery but do not have the resources to develop satellite or aerial imagery programs. This can involve acquisition from commercial providers or other national governments, as well as the development of ground stations which represent the essential space infrastructure to receive imagery and communications directly from satellites in orbit, such as South Africa's new *Space Infrastructure Hub* (SIH) initiative.[57] Examples of data acquisition programs include the *NASA Commercial Smallsat Data Acquisition* (CSDA) program and the *NASA/NGA Commercial Data Access* license agreement.[58,59]

Tools Layer

1. Geospatial analytics platforms: The development of a geospatial data management, processing, and mapping platform can allow a wide range of users to perform analytics on satellite imagery and location data, empowering them to develop custom downstream applications. This could involve a platform which provides the Infrastructure, Platform, and Analytics stages of the Earth observation value chain (Figure 7) for both commercial and public users. Examples of geospatial analytics platforms include *Esri ArcGIS*, *OneMap Singapore*, and the *UN EO Toolkit for Sustainable Cities and Human Settlements*.[60,61,62]

[53] Open Data Cube – *Open Data Cube* (2022)
[54] Copernicus Programme – *Copernicus Open Access Hub* (2022)
[55] Digital Earth Australia – *Digital Earth Australia* (2022)
[56] Digital Earth Africa – *Welcome to Digital Earth Africa* (2022)
[57] ZA Space – *Space Infrastructure Hub* (2022)
[58] NASA – *Commercial Smallsat Data Acquisition Program* (2022)
[59] NASA – *NASA Commercial Archive Data* (2022)
[60] Esri – *ArcGIS Overview* (2022)
[61] OneMap Singapore – *OneMap Singapore* (2022)
[62] EO Toolkit for Sustainable Cities and Human Settlements – *Tools* (2022)

Figure 7. **Examples of Geospatial Analytics Platforms**

Source: Satellite Applications Catapult

2. Geospatial data products: The development of geospatial data products for non-expert downstream users can offer solutions across a wide range of thematic areas. This could involve data products for climate change, maritime, urban infrastructure, humanitarian, and security applications. If integrated into an open-access data platform, this could also be offered as a portfolio of geospatial modelling and analytics products through the data cube model, following Digital Earth Australia. In addition to providing the Analytics and Insight stages of the value chain (see above), this could also cover the Application stage by offering dynamic models and simulations for specific use-cases. Examples of geospatial data products include the *EU Copernicus Services* and *SERVIR-Amazonia Services*.[63,64]

Skills Layer

1. Geospatial education programs: The establishment of a geospatial education program for students and early-career STEM professionals can be an essential step in building the next generation of geospatial analytics skills. This is especially valuable for countries that aim to develop more capacity to harness the potential of satellite imagery and location data, starting at the level of primary and secondary education. Examples of geospatial education programs include the *USGIF Academic Programs*, *Esri UK GeoMentor*, *Singapore MOE-EduGIS*, *ASEAN Geospatial Challenge*, and *Hexagon Education Programs*.[65,66,67,68,69]

2. Geospatial training programs: The establishment of a geospatial training program for both commercial and non-expert public sector individuals can increase the use of geospatial data in a wide range of industries, unlocking significant economic potential and enabling the development of downstream applications in new markets and across government. Examples of geospatial training programs include the EU's *EO4GEO Program*, Africa's *Regional Centre for Mapping of Resources for Development*, and *Esri Academy*.[70,71,72]

[63] EU Copernicus – *Copernicus Services* (2022)
[64] SERVIR-Amazonia – *Service Catalogue* (2022)
[65] USGIF – *Academic Programs* (2022)
[66] Esri UK – *GeoMentor* (2022)
[67] Esri - *Singapore Is Building a Nation of Young Spatial Thinkers* (2020)
[68] GeoWorks Singapore – *ASEAN Geospatial Challenge* (2022)
[69] Hexagon – *Education Programs* (2022)
[70] EO4GEO - *About EO4GEO* (2022)
[71] Regional Centre for Mapping of Resources for Development – *Training* (2022)
[72] Esri – *Esri Academy* (2022)

3. Geospatial capacity building: The operation of a geospatial capacity-building initiative can benefit countries either through the one-way development of local resources and capabilities in geospatial analytics, or through the two-way exchange of knowledge between countries. This could involve an intergovernmental program co-funded by a geospatially developed nation to offer expertise to a geospatially developing nation, or a regional program to stimulate development among a group of countries. Examples of geospatial capacity-building initiatives include *UNOSAT Training Solutions* and the *SERVIR* network of regional knowledge centers across the Americas, Africa, and Asia.[73,74]

Institutions Layer

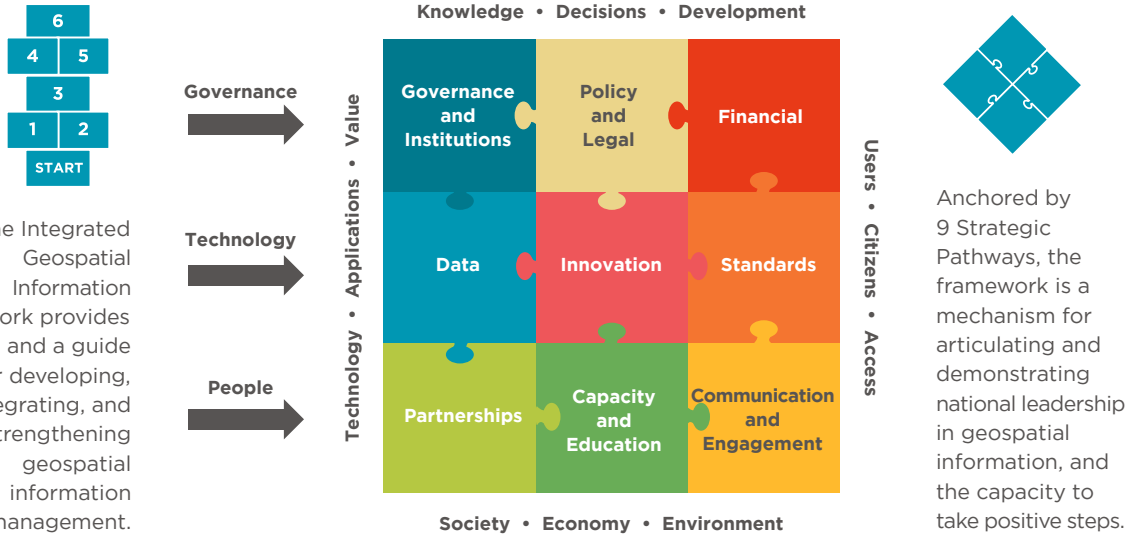
1. Institutional design: The establishment of a dedicated geospatial body that coordinates policy and activities can be an essential foundation to developing the infrastructure, skills, resources, and activities that enable a country to harness the potential of geospatial data and technologies. This could involve a new government agency with its own budget and mandate, or the inclusion of such a body within an existing department. Examples of institutional design include the *Geospatial Commission* and *Geospatial Singapore*.

2. Geospatial strategy: The design of a geospatial strategy which brings together academic, government, and industry perspectives to develop a multi-year plan can be a powerful way to define the vision and capacity-building activities at a global, regional, or national level. This could also involve an agenda on geospatial data ethics, following the model of the American Geographical Society's *Locus Charter*, which can be seen as analogous to ongoing work in AI data ethics.[75] Examples of geospatial strategy include the *UN Geospatial Strategy*, *U.S. Geospatial Data Strategy*, *UK Geospatial Strategy*, *Singapore Geospatial Master Plan*, and *Canada's Strategy for Satellite Earth Observation*.[76,77,78,79,80]

[73] UNITAR – *UNOSAT Training Solutions* (2022)
[74] SERVIR Global – *About Us* (2022)
[75] EthicalGEO – *Locus Charter* (2021)
[76] United Nations – *Geospatial Strategy for the United Nations* (2021)
[77] U.S. Department of State - *Geospatial Data Strategy* (2018)
[78] Geospatial Commission – *Unlocking the Power of Location* (2020)
[79] Geospatial Singapore – *Singapore Geospatial Master Plan* (2018)
[80] Government of Canada – *Canada's Strategy for Satellite Earth Observation* (2022)

3. Spatial data infrastructure: The development of spatial data infrastructure (SDI) at the national or regional level can provide the benefit of standardizing the formats and protocols for both access and interoperability of geospatial data. This could involve a coordinated framework of institutional arrangements, technology standards, and data policies which enable the discovery and use of geospatial data for a wide range of public and commercial stakeholders. Examples of spatial data infrastructure include the *United Nations IGIF* (Figure 8), *EU INSPIRE*, *Arctic SDI*, and *South African SDI*.[81,82,83,84]

Figure 8. **The Integrated Geospatial Information Framework**



Source: UN-GGIM

4. Innovation centers: The establishment of an innovation center can be an effective way to provide an institutional nexus and a physical location for collaboration between academia, industry, and government in the development of geospatial technologies and applications. This could involve a public–private funding model, as well as greater focus on balancing the high-level overview perspective of satellites with engagement from local communities who represent the actual end-users of downstream applications. Examples of innovation centers include the *Satellite Applications Catapult* and *GeoWorks Singapore*.[85,86]

[81] United Nations – *UN-GGIM Integrated Geospatial Information Framework* (2022)
[82] European Commission – *About INSPIRE* (2022)
[83] Arctic SDI – *About Arctic SDI* (2022)
[84] National Geospatial Information – *South African SDI* (2022)
[85] Satellite Applications Catapult – *About Us* (2022)
[86] GeoWorks – *About Us* (2022)

Industry Layer

1. Business incubation centers: The establishment of business incubation centers which provide facilities, workshops, mentoring, and networking opportunities to early-stage geospatial companies can be a highly beneficial and cost-effective initiative to promote innovation and deliver business support. This could be set up as a national business incubation center, or a network of business incubation centers which focus on individual regions within a country. It could also involve an accelerator program for more established companies and activities to stimulate engagement from the venture capital funding ecosystem. Examples of business incubation centers include the *ESA Business Incubation Centres (BIC)*, *U.S. NGA Moonshot Labs*, and *UK Ordnance Survey Geovation*.[87,88,89]

2. Public funding programs: The establishment of a public funding program which provides grant funding for new projects in geospatial technologies and applications can be a simple way to promote innovation without requiring hands-on engagement. This could involve a portfolio of thematic calls which support the potential of geospatial data for addressing sustainable development goals, as well as a technology transfer program which helps companies to acquire and make use of existing intellectual property. Examples of public funding programs include *ESA Business Applications*, the UK Space Agency's *International Partnership Programme (IPP)*, and *smartEarth Canada*.[90,91,92]

3. Challenges and competitions: The organization of challenges and competitions which encourage both new and existing stakeholders to engage in innovation can be a highly effective way of leveraging the "power to incentive prize competitions."[93] This could involve more industry-oriented challenges to promote the development of new technologies and applications, or more public-oriented competitions which foster interest in geospatial skills and spread awareness on the potential of geospatial data. Examples of challenges and competitions include the *NASA Space Apps Challenge*, *Geospatial Commission Transport Innovation Competition*, SANSA's *Africa EO Challenge*, and the XPRIZE Foundation.[94,95,96,97]

[87] ESA Space Solutions - *Business Incubation* (2022)
[88] National Geospatial-Intelligence Agency – *Moonshot Labs* (2022)
[89] Geovation – *We Are Geovation* (2022)
[90] ESA Space Solutions – *ESA Business Applications* (2022)
[91] HM Government – *International Partnership Programme* (2022)
[92] Government of Canada – *About smartEarth* (2020)
[93] Investing in Results – *The Power of Incentive Prize Competitions* (2020)
[94] NASA Space Apps Challenge – *All About Space Apps* (2022)
[95] Geospatial Commission – *Transport Innovation Competition* (2021)
[96] Africa Earth Observation Challenge – *About* (2022)
[97] XPRIZE Foundation (2022)

3.2. Recommendations

As a result of the global best practices identified for the Data, Tools, Skills, Institutions, and Industry Layers of geospatial policy, a set of recommendations can be made for geospatially developing countries across Latin America and the Caribbean. They have been structured into a **Geospatial Policy Roadmap** with eight main recommendations (Figure 9).

Figure 9. **The Geospatial Policy Roadmap**

Source: UN-GGIM

1. Establish a body to coordinate geospatial policy and activities

Estimated Time: Low – 1 to 2 years
Estimated Cost: Low – $1m to $5m per year
A similar model to the White House Fellows or Number 10 Fellows could be applied by creating a Geospatial Fellows program.

2. Design a geospatial strategy together with industry stakeholders

Estimated Time: Low – 1 to 2 years
Estimated Cost: Low – $1m to $5m per year

3. Build a national or regional spatial data infrastructure

Estimated Time: High – 4 to 6 years
Estimated Cost: Low – $1m to $5m per year

4. Establish a geospatial technology and innovation center

Estimated Time: Low – 1 to 2 years
Estimated Cost: Medium – $5m to $10m per year

5. Develop an open-access geospatial data platform

Estimated Time: Medium – 2 to 4 years
Estimated Cost: Medium – $5m to $10m per year
Digital Earth Americas

6. Launch a geospatial education and training program

Estimated Time: Low – 1 to 2 years
Estimated Cost: Low – $1m to $5m per year

7. Invest in business incubation and funding to support startups

Estimated Time: Low – 1 to 2 years
Estimated Cost: Low – $1m to $5m per year

8. Organize challenges and competitions to promote innovation

Estimated Time: Low – 1 to 2 years
Estimated Cost: Low – $1m to $5m per year

For the implementation of these recommendations, it is important to consider the national context of each country when engaging in decision making. While the sequence of policy initiatives above generally represents a flow from more governmental to more commercial activities, any of them can be implemented in parallel. For countries with limited capacity or resources, it is recommended to start with the policy initiatives which have relatively lower cost and time requirements: Geospatial

Strategy, Education and Training, Business Incubation, and Challenges and Competitions. Policymakers are also encouraged to consider a wide range of factors including national priorities (political, economic, social, technological, legal, environmental), institutional capacity of the public sector, economic resources in terms of available budget for government agencies and public funding programs, the nation's military and security configuration along with any restrictions which may arise from it, the existing industry's comparative advantage and innovation ecosystem, and any synergies that there may be with other initiatives or collaborations which are already ongoing.

Where new institutions would typically need to be established for a policy initiative, existing institutions can also be empowered with the budget and mandate to undertake those activities in the short term. For example, a Geospatial Strategy could be designed by the national space or innovation agency, which can be observed in the U.S. Federal Geographic Data Committee's involvement in the *Geospatial Data Act 2018*.[98] Alternatively, certain areas of implementation can be outsourced to third parties such as Google, Amazon, Esri, Carto, Mapbox, Hexagon, Deloitte, Accenture, PwC, Arup, Mott McDonald, Jacobs, Chemonics, and Palladium. This list is not exhaustive; it simply represents companies that have worked with institutions such as NASA, SERVIR, and the UK FCDO in recent years. At the international level, collaboration with the United Nations, SERVIR Global, the Inter-American Development Bank, and the GEO community can also be beneficial to geospatially developing nations. However, the value of building local capacity and intellectual property is important to ensuring a sustainable geospatial industry, which also plays as a factor into decisions over using open-source vs. commercial platforms. Generally, it is recommended that proprietary commercial solutions should be used as a short-term bridge while a country transitions towards developing more local infrastructure and capabilities.

[98] Federal Geographic Committee – *Geospatial Data Act* (2018)

4. APPENDIX:
Policy Evaluation

Digital Earth Australia

Website: https://www.dea.ga.gov.au/

Policy layers: Data, Tools, Skills

Organization: Geoscience Australia

Description: Satellite imagery platform which provides free analysis-ready data for Australian government and industry through the use of Open Data Cube (ODC) software.

Geography: Southern hemisphere, wide variety of climate zones and ecosystems, medium-high geospatial readiness level.

Earth observation: Public institution program, performs geospatial capacity building, enables innovation ecosystem.

Policy impact: Direct impact includes enabling the development of new geospatial products and services, increasing geospatial skills through education and training, and promoting awareness on the value of geospatial data. Indirect impact includes international collaboration to implement ODC software in other countries.

SDG focus: Enables applications which benefit environment, agriculture, government, and emergency management.

Policy rating: **9/10**

EU Copernicus Programme

Website: https://www.copernicus.eu/

Policy layers: Data, Tools, Skills, Institutions, Industry

Organization: European Commission

Description: Earth observation program which operates satellite constellation (Sentinel), open-access data platform (Copernicus Open Access Hub), geospatial services, business incubation, accelerator, and competitions for EU countries.

Geography: Northern hemisphere, continental region with wide variety of climate zones and ecosystems, medium-high geospatial readiness level with several countries ranked top 10 in the world.

Earth observation: Public institution program, operates satellite constellation and provides imagery, performs geospatial capacity building, enables and supports innovation ecosystem.

Policy impact: Direct impact includes generation of geospatial data from Sentinel constellation, enabling the development of new geospatial applications, increasing geospatial skills through education and training, and supporting business development. Indirect impact includes free access to satellite imagery.

SDG focus: Enables applications and provides direct geospatial services for environment, agriculture, government, transport, health, development, emergency management, and security.

Policy rating: **10/10**

NASA EarthData

Website: https://earthdata.nasa.gov/esds

Policy layers: Data, Tools

Organization: NASA

Description: Earth observation program which provides open-access data platform (EOSDIS), analysis toolkits, and acquisition of commercial satellite imagery (CSDA) for geospatial research projects and applications in the United States.

Geography: Northern hemisphere, wide variety of climate zones and ecosystems, highest geospatial readiness level in the world.

Earth observation: Public institution program, provides access to satellite imagery and analysis toolkits, performs commercial data acquisition, enables geospatial research and applications.

Policy impact: Direct impact includes providing access to satellite imagery and tools, enhancing scientific research projects, and enabling new geospatial applications. Indirect impact includes increasing public and industry awareness of Earth observation.

SDG focus: Enables research and applications which benefit environment, agriculture, and emergency management. Provides tools for Earth system science and climate change research.

Policy rating: **7/10**

UK Geospatial Commission

Website:
https://www.gov.uk/government/organisations/geospatial-commission

Policy layers: Data, Skills, Institutions, Industry

Organization: UK Government

Description: Expert committee which defines the UK's Geospatial Strategy and coordinates public sector activities including access to geospatial data, awareness, training, and competitions.

Geography: Northern hemisphere, island nation with temperate climate, medium ecosystem diversity, high proportion of farmland, second highest geospatial readiness level in the world.

Earth observation: New public institution, expands access to geospatial data, promotes public sector adoption, performs geospatial capacity building, supports innovation ecosystem.

Policy impact: Direct impact includes increasing public sector adoption of geospatial data, improving geospatial skills through training, and supporting commercialization. Indirect impact includes providing a roadmap for the geospatial economy's development through technical and policy recommendations within the wider framework of the UK Geospatial Strategy.

SDG focus: Enables the use of geospatial data for applications which benefit environment, agriculture, transport, infrastructure, health, development, emergency management, and security.

Policy rating: **9/10**

UK Space for Smarter Government

UK SPACE AGENCY
Space for Smarter Government Programme

Website:
https://www.gov.uk/government/collections/space-for-smarter-government-programme-ssgp

Policy layers: Data, Skills, Institutions

Organization: UK Space Agency

Description: Strategic program delivered by the UK Space Agency and Satellite Applications Catapult to increase public sector adoption of space data, products, and services. Includes a data procurement initiative, geospatial training, and competitions.

Geography: Northern hemisphere, island nation with temperate climate, medium ecosystem diversity, high proportion of farmland, second highest geospatial readiness level in the world.

Earth observation: Public institution program, expands access to geospatial data, increases public sector adoption, performs geospatial capacity building, supports innovation ecosystem.

Policy impact: Direct impact includes increasing public sector adoption of geospatial data, improving geospatial skills through training, and providing funding opportunities. Indirect impact includes promoting public awareness of space applications.

SDG focus: Promotes the use of geospatial data for applications which benefit environment, agriculture, transport, infrastructure, health, emergency management, and security.

Policy rating: **8/10**

Geospatial Singapore

Website: https://www.sla.gov.sg/geospatial/

Policy layers: Data, Tools, Skills, Institutions, Industry

Organization: Singapore Land Authority

Description: Geospatial program which embodies Singapore's National Spatial Data Infrastructure (NSDI), defines its Geospatial Master Plan, develops geospatial policy, provides geospatial data and platforms (GeoSpace, OneMap, Virtual Singapore), hosts Geospatial Centers for capacity building and community, and organizes innovation competitions (GeoChallenges).

Geography: Equatorial island city-state, tropical climate with rainforest and coastal ecosystems, high geospatial readiness level.

Earth observation: New public institution, builds spatial data infrastructure, expands access to geospatial data, performs geospatial capacity building, supports innovation ecosystem.

Policy impact: Direct impact includes designing geospatial policy, standards, and mechanisms at the national level, improving geospatial skills through education and training, and supporting the innovation ecosystem. Indirect impact includes generating best practices by pioneering a modern approach to geospatial authority and driving forward the future of Singapore's smart economy (GeoIndustry, GeoEmpowered, GeoSmart).

SDG focus: Enables the use of geospatial data for applications which benefit environment, agriculture, transport, infrastructure, health, development, emergency management, and security.

Policy rating: **9/10**

Geoportal Philippines

Website: https://www.geoportal.gov.ph/

Policy layers: Data, Tools

Organization: NAMRIA

Description: Government platform which provides public access to geospatial data and services, promoting the use of standard multiscale basemaps to serve as tools for strategic planning and decision making in the Philippines.

Geography: Equatorial archipelago country, mostly tropical rainforest and oceanic climate with a megadiverse range of ecosystems, medium geospatial readiness level.

Earth observation: Public institution platform, expands access to geospatial data, provides thematic datasets and analysis tools, promotes standardized national approach to GIS.

Policy impact: Direct impact includes expanding access to geospatial data for the public and enabling new geospatial applications. Indirect impact includes building the foundations for standardized GIS by bringing together stakeholders.

SDG focus: Enables the use of geospatial data for applications which benefit environment, agriculture, transport, infrastructure, health, development, and emergency management.

Policy rating: **6/10**

Satellite Applications Catapult

Website: https://sa.catapult.org.uk/

Policy layers: Institutions, Industry

Organization: Innovate UK

Description: Space technology and innovation center which supports UK industry by offering use of technical facilities, performing market research, mapping geospatial capabilities, making policy and technical recommendations, providing business development workshops, and organizing events.

Geography: Northern hemisphere, island nation with temperate climate, medium ecosystem diversity, high proportion of farmland, second highest geospatial readiness level in the world.

Earth observation: Nongovernmental organization, provides market intelligence on geospatial technologies and applications, supports innovation ecosystem, connects industry stakeholders.

Policy impact: Direct impact includes enabling commercialization of new geospatial technologies and applications and supporting business development. Indirect impact includes providing a nexus for stakeholders to network and collaborate on projects.

SDG focus: Supports the development of applications which benefit environment, agriculture, transport, infrastructure, health, education, development, emergency management, and security. Includes sustainable development goals in institutional strategy.

Policy rating: **8/10**

ESA Business Incubation Centres

Website: https://business.esa.int/news/business-incubation-real-powerhouse-for-entrepreneurship

Policy layers: Industry

Organization: European Space Agency

Description: Business incubation program which runs a network of over 60 centers across Europe to support the development of space technologies and applications.

Geography: Northern hemisphere, continental region with wide variety of climate zones and ecosystems, medium-high geospatial readiness level with several countries ranked top 10 in the world.

Earth observation: Public institution program, promotes commercial use of geospatial data, enables development of new geospatial products and services, supports innovation ecosystem.

Policy impact: Direct impact includes enabling commercialization of new geospatial technologies and applications and supporting business development. Indirect impact includes increasing public awareness of space applications and benefits for Earth.

SDG focus: Supports the development of applications which benefit environment, agriculture, transport, infrastructure, health, education, development, emergency management, and security. Includes sustainable development goals in institutional strategy and impact evaluation framework for the ESA BIC program.

Policy rating: **9/10**

CSA smartEarth

Website: https://www.asc-csa.gc.ca/eng/funding-programs/programs/smartearth/

Policy layers: Industry

Organization: Canadian Space Agency

Description: Funding program which provides thematic opportunities for R&D and innovation projects to support the development of Earth observation applications in Canada.

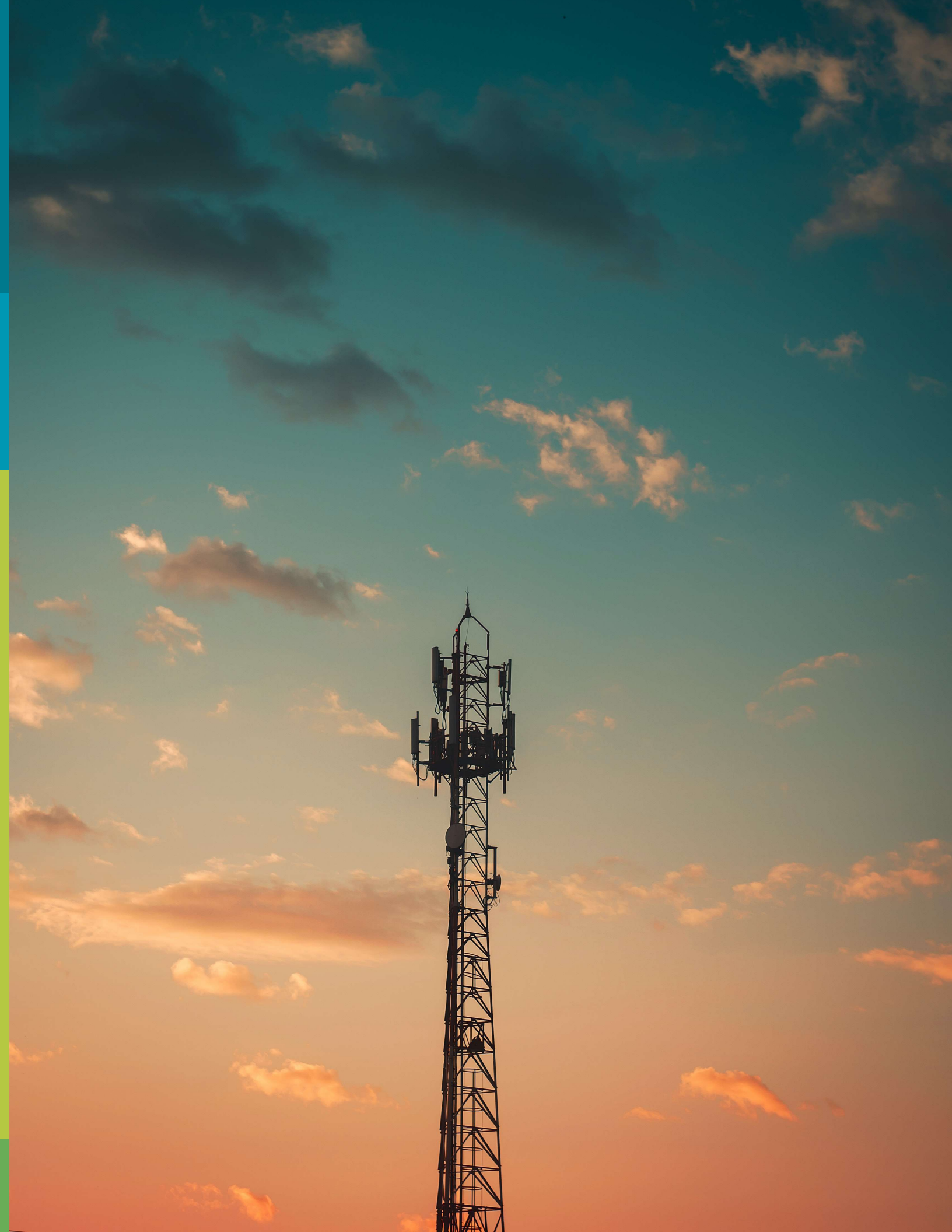
Geography: Northern hemisphere, arctic and coastal climate zones with high forest cover, high geospatial readiness level.

Earth observation: Public institution program, enables the development of new geospatial products and services, supports the innovation ecosystem.

Policy impact: Direct impact includes supporting the commercial feasibility of new geospatial applications. Indirect impact includes raising public awareness on the benefits of space applications to help solve key challenges on Earth.

SDG focus: Supports the development of applications which benefit environment, agriculture, transport, infrastructure, health, and security. Includes thematic funding opportunities for specific environmental challenges such as using satellite data to enhance conservation of the North Atlantic whale (smartWhales).

Policy rating: 7/10

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