[March 2025]

Strategic Pathway 5

Innovation

*This **strategic pathway** recognizes that innovation has the potential to stimulate, trigger and respond to rapid change, advance past outdated technologies and processes, and to bridge the geospatial digital divide. Technology is continually evolving, creating new opportunities for innovation and creativity.*

*The **objective** is to leverage the latest and cost-effective technologies, innovations and process improvements so that governments, businesses, academia, and communities, no matter what their current situation, may advance or leapfrog to modern geospatial information management practices and services.*

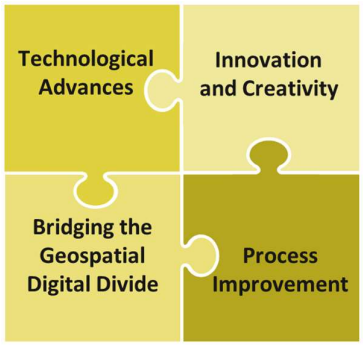
Summary

Digital transformation, emerging technologies, and innovation are both disruptive forces and powerful enablers, reshaping the broader information sector and fundamentally transforming nationally integrated geospatial information management. The volume, speed, diversity, and complexity of geospatial information generation and dissemination are increasing exponentially across sectors. For national governments, this creates a growing expectation that they will leverage new and emerging digital technologies to enhance e-commerce, improve service delivery, strengthen community and user engagement, and drive organizational efficiencies and cost savings.

Ensuring that innovation is embedded throughout the information ecosystem is critical. Innovation has the potential to stimulate and accelerate change, bridge the geospatial digital divide, and maximize the benefits of digital transformation. However, many governments and national geospatial information agencies face institutional barriers—outdated processes, rigid policies, skill gaps, and legacy technologies—that hinder their ability to adopt and benefit from modern, agile solutions.

A key challenge for most countries is how national geospatial information agencies, as central actors in government-led digital transformation, can effectively leverage and drive the adoption of cutting-edge technologies and processes for evidence-based policy development and decision-making. This is why 'Innovation' is a core pillar of the nine strategic pathways of the United Nations Integrated Geospatial Information Framework (UN-IGIF). Innovation encompasses the ability to implement new processes, introduce advanced techniques and technologies, and generate creative solutions that drive meaningful value.

Among the nine strategic pathways, innovation has the potential to be the most transformative—stimulating rapid change, leapfrogging outdated technologies and processes, and bridging the geospatial digital divide. The foundation for fostering innovation and creativity rests on four key elements common to digitally advancing and innovative societies. By embedding innovation into national geospatial information strategies, countries can harness the full potential of digital transformation, ensuring long-term sustainability and impact. The four elements are:



- **Technological Advances** – leveraging new paradigms to produce, share, analyze and deliver information that enriches knowledge-driven economies and societies.
- **Innovation and Creativity –** driving digital transformation by fostering science and technology through strategies, policy and legal frameworks, research and development, innovation hubs that generate new solutions and services.
- **Process Improvement** – enhancing efficiency and productivity by proactively identifying, analyzing, improving and refining existing processes and developing new solutions to achieve efficiencies, operational gains and new products and services.
- **Bridging the Geospatial Digital Divide** – achieved through a combination of technological advancements, data accessibility, supportive policy and legal frameworks, financial commitment, stakeholder engagement, partnerships and capability development.

These elements are underpinned by principles that each country can adopt to promote innovation and creativity. These principles are put into practice through strategic actions that stimulate the use of the latest cost-effective technologies, innovations, creativity and process improvements to deliver and strengthen participation and commitment to achieving the nationally integrated geospatial information management. Tools, such as matrices, examples and checklists, are provided in the appendices to support countries to work through concepts and processes to successfully complete each action. The overall structure for this strategic pathway is illustrated in Figure 5.1.

When implemented, the actions (and their interrelated actions) will enable the achievement of the four elements, which in turn will deliver significant and sustainable national outcomes and benefits. These outcomes include attaining:

- More effective geospatial information management processes, leading to more effective evidenced-based policy-development and decision-making;
- Increased productivity and efficiency achieved through an innovation-driven environments;
- An innovative workforce capable of designing and executing new processes, as well as developing and implementing new products and services; and
- The ability to bridge the geospatial digital divide through an innovation ecosystem that leverages enabling technologies.

Elements of Innovation	Technological Advances	Innovation and Creativity	Process Improvement	Bridging the Geospatial Digital Divide
Guiding Principles	Leadership Trust Digital Connectivity	Digital Literacy Collaboration Enablement	Empowerment Supportive Policies User Centric	
Key Actions for Strengthening Geospatial Information Management	**Geospatial Landscape** Innovation Group Technology Maturity Index Strategic Alignment	**Transformation Roadmap** Modernizing Data Assets Modern Data Creation Methods Enabling Infrastructure	**Operationalizing Innovation** National Innovation System Innovation Programs Innovation Hubs Process Improvement	
	Identifying Innovation Needs Monitoring Trends Technology Needs Assessment	**Planning for Action** Geospatial Digital Transformation Strategy Developing Innovation Culture	**Future Directions** Bridging the Geospatial Digital Divide Integrated System-of-Systems	
Tools to Assist in Completing the Actions	Technology Maturity Index Capability Framework Matrix Geospatial Drivers and Trends ICT Data Inventory	PEST and SWOT Analyses Modernizing Data Assets Modern Data Creation Methods Data Integration Approaches	Data Storage Processes Pillars of an Innovation Program Critical Path Analysis Open SDG Data Hubs	
Interrelated Actions	Governing Body (SP1) Geospatial Information Coordination Unit (SP1) Specialist Working Groups (SP1) Governance Model (SP1)	Geospatial Information Management Strategy (SP1) Country-level Action Plan (SP1) Data Inventory (SP4) Data Gap Analysis (SP4)	Knowledge, Skills and Resources (SP8) Assessment and Analysis (SP8) Stakeholder Identification (SP9)	
Outcomes	Effective geospatial information management processes Increased productivity and efficiency achieved through an innovation-driven environments Innovative workforce capable of designing and implementing new processes, products and services Ability to bridge the geospatial digital divide through an innovation ecosystem			

Figure 5.1: *The overall structure for the Innovation Strategic Pathway – showing the four key elements, guiding principles, actions and interrelated actions, and the tools provided in the Appendices to support and achieve the outcomes.*

5.1 Introduction

The creation, development, diffusion and transfer of new innovations, technologies and associated know-how, are powerful drivers of economic growth and sustainable development.

The 2030 Agenda for Sustainable Development emphasizes the opportunity and potential that the spread of information and communications technology (ICT) and global interconnectedness provides to accelerate human progress, to bridge the digital divide, to develop knowledge and information societies, and scientific and technological innovation.

Within the context of developing countries, the Addis Ababa Action Agenda recognizes that the creation, development and diffusion of new innovations and technologies and associated know-how, including the transfer of technology on mutually agreed terms, are powerful drivers of economic growth and sustainable development. However, the Action Agenda notes with concern the persistent 'digital divide' and the uneven innovative capacity, connectivity and access to technology, including ICTs, within and between countries. There is an urgent need to promote the development and use of ICT infrastructure, as well as capacity-building, particularly in countries in special situations, including rapid universal and affordable access to high-speed Internet.

Promoting and ensuring that innovation is being applied throughout the data ecosystem is critical. Innovation has the potential to have a significant impact on stimulating and embracing rapid change, to bridge the geospatial digital divide and to reap the dividends of digital transformation.

Innovation is the application of knowledge and technology to change, and/or create more effective processes, products and ideas that deliver additional value. Innovation is driven by the need to find solutions to problems; it can be incremental or transformational. As geography is at the heart of every major decision that organizations, businesses and individuals make each day, it can be argued that geospatial information is the most influential data underpinning innovation, creativity and intelligent data systems today.

Technology, and especially geospatial technology, is transforming almost every aspect of our lives - having a major impact on citizens, governments, and all sectors of industry and the economy - at an unprecedented pace and scale. However, all countries are at different stages and levels of development in their integrated geospatial information management journey – including with the many aspects of innovation.

All countries have different starting points depending on their individual circumstances, and what may be deemed as 'innovation' in one country may not be recognized as innovation in another. For this reason, this strategic pathway does not advocate a specific innovation or technology agenda; nor provide a 'future outlook'. The several UN-GGIM reports on 'Future Trends in geospatial information management: the five-to-ten-year vision'[1] (Future Trends Reports) now in its third edition, provides this outlook. Instead, this pathway describes a range of innovative practices that can be applied from different contexts and starting points.

[1] Each edition of the Future Trends in Geospatial Information Management: the five-to-ten-year vision are available here: http://ggim.un.org/future-trends/

While the Future Trends reports[2] provide a global consensus view of the developments and future direction for geospatial information management over the next five to ten years, the 2020 iteration has been produced at this time to specifically complement the UN-IGIF, helping to ensure that the Framework integrates and takes advantage of the latest innovation and trends, and to assist countries in bridging the geospatial digital divide.

As a valuable reference document to this strategic pathway, the Future Trends report cross-references, as an impact assessment, the top trends against the nine strategic pathways of the UN-IGIF. It is notable that while all trends relate in some way to each of the individual pathways, the data and innovation pathways have the majority of direct 'touch points' with the Future Trends reports.

Innovation is creating more convenient, secure and engaging touchpoints between businesses and their customers – providing situational awareness, operational efficiencies and real-time insights. Nearly every aspect of commerce, from point of inspiration to delivery, is being reimagined using geospatial information – geotagging, routing, navigation, marketing, purchasing, delivery, and more.

Emerging technologies – from mobile innovation to Big Data and Artificial Intelligence – are enabling more personalized experiences in new contexts. This is in line with today's consumers, who want more control over their way of life. They don't want to be boxed in; they value choice, and this demand is driving more personalized and more customizable location-based products and services.

Throughout history, this type of disruption not only creates new opportunities but also seismic shifts in consumer behaviour and expectations. The 'online' demographic profile is changing, increasing demands and expectations for high-quality digital experiences. These same 'millennial' customers are also driving innovation, pushing governments to reshape the delivery of integrated data and outcomes. These trends are gaining pace as technology creates new experiences and new experiences create new expectations.

The innovation migration to digital and mobile has created new opportunities for businesses to get closer to their customers. These developments offer significant innovation opportunities but also present challenges - both in terms of policy and in terms of law. Meeting these challenges and ensuring that the potential benefits can be realized by all countries will be important in ensuring that the full value of geospatial information can continue to be realized.

5.2 Context and Rationale

The rapid advancement of technology, digital transformation, and innovation—alongside the exponential growth in data generation—underscored the strategic value of digital geospatial technologies and information for governments today, not only essential for driving economic growth but also for strengthening societal well-being.

We are witnessing an exponential growth in the amount of data being generated and captured. Increases in the volume and variability of data, combined with rapid advances in digital acquisition and information and communication technology (ICT), is changing – presenting opportunities to leverage geospatial information as a transformative tool. This enables governments to better

[2] http://ggim.un.org/documents/DRAFT_Future_Trends_report_3rd_edition.pdf

formulate policies and to respond to national priorities. For example, sensors in autonomous vehicles are able to generate approximately a gigabyte of geospatially enabled data every second; satellites capture imagery of the whole world every day with volumes so large that data can only effectively be used in a cloud environment; and users of social media are creating an increasing amount of geospatially located information – just by sharing a picture or updating a profile or their location.

Technology, digital transformation, innovation, and the corresponding growth in the generation of data has meant that governments now realize the value of digital geospatial technologies and information as key strategic assets that lead to valuable and quantifiable results - growing economies and strengthening the wellbeing of societies around the globe. Yet, reaping the full benefits of the opportunities, afforded through the use of geospatial information and technologies, requires continuous reform and innovation to modernize and support new ways of working, particularly across the public sector (OECD, 2018).

Of the nine strategic pathways in the UN-IGIF, this pathway presents a unique challenge for developing countries—especially the least developed countries. While developed countries have widespread access to emerging data, technologies, and innovations, many developing countries lack the opportunity to engage with these rapidly evolving capabilities. The democratization of ICT, geospatial information, and enabling technologies is not yet equitable; geospatial leadership, knowledge, and innovation remain concentrated in developed economies. While technologies are evolving at a rapid rate, the commensurate capabilities, skills and opportunities in the developing countries are not (Scott and Rajabifard, 2019).

Why is this so? For developing countries, even those with a high-level of awareness and national support, realizing the benefits and efficiencies of digital transformation and innovation, is still out of reach. The reality is that many developing countries are yet to attain effective and sustained access to digital technology and the Internet, and lack the corresponding ICT and computer literacy skills needed to orchestrate meaningful change. For some countries, basic infrastructure challenges such as limited electricity supply, further restrict access to critical geospatial information. Further, there are institutional challenges related to coordination, leadership managing the value chain, fragmented implementation, diffused policy accountability, and then potentially, the lack of skills, tools and mechanisms to properly manage the data supply chain and related technologies (Scott and Rajabifard, 2019).

Importantly, developing countries have a significant opportunity to learn from the experiences of developed countries in their transition to more sustainable and modern methods. Advances in computing power, connectivity, information mobility and data storage capacity, developed over the last few years, are now becoming more widely available to developing countries - but they pose a risk of higher inequality and dislocation of labor and capital (Productivity Commission, 2016).

To ensure that no one is left behind, it is essential to promote the adoption of cutting-edge technologies, processes, and innovations in an inclusive manner. Developed countries have tackled these challenges by reforming regulations, fostering digital start-ups, and investing in workforce development to support labor transitions in the face of technological change. These experiences highlight that technological innovation alone is insufficient—a holistic innovation ecosystem requires

policy interventions, financial investment, and comprehensive education and training programs to create long-term, sustainable impact.

An example of technological leapfrogging is the widespread adoption of mobile phones in developing countries, bypassing the traditional reliance on landline infrastructure. Similarly, developing countries have the opportunity to leapfrog traditional, resource-intensive National Spatial Data Infrastructure (NSDI) implementations by adopting more agile and scalable geospatial technologies. Providing practical guidance on leveraging cost-effective technologies, fostering innovation, and improving processes is at the core of this strategic pathway. The objective is to support countries in cultivating a culture of innovation that drives digital transformation, accelerates national development, and ensures that the benefits of geospatial information management are accessible to all.

5.3 Approach

Innovation involves improving lives and livelihoods by creatively updating thinking, structures and processes by embracing technological and process advancements and concepts.

The 2030 Agenda for Sustainable Development recognises the importance of promoting and fostering scientific and technological innovation in advancing multiple Sustainable Development Goals (SDGs), including to develop policies that support productive activities, decent job creation, entrepreneurship, creativity and innovation to solve sustainable development challenges. Innovation strengthens collaborative industry clusters to stimulate location capabilities and insights, enhancing geospatial capabilities through knowledge networks, encouraging entrepreneurship and building social capital.

Effective innovation requires close collaboration between governments, the private sector, academia, and communities alongside strong investments in higher education and scientific research. At its core, innovation is about improving lives—breaking away from outdated structures and mindsets to embrace new technologies and ideas that drive progress.

In this strategic pathway, the approach for stimulating the use of the latest cost-effective technologies, process improvements and innovations is presented in Figure 5.2. The approach aims to assist governments, no matter their current situation and national circumstances, to leapfrog to state-of-the-art geospatial information management systems and practices. The approach includes four key elements that monitor the geospatial landscape, recognizing that technology and processes are continuously evolving; creating enhanced opportunities for innovation and creativity that enable governments to quickly bridge the geospatial digital divide. These elements (which are able to be considered sequentially) include a heightened awareness of the **technological advances** that are able to support and promote **innovation and creativity** in order to apply and optimize **process improvement** within and across organizations, so that countries are able to **bridge the geospatial digital divide**. These elements are explained in more detail in Section 5.4 below.

Figure 5.2: *The approach to innovation*

The approach includes strategic pathway actions that are recommended as a means to achieve the four key elements. The actions, which are underpinned by guiding principles, provide the step-by-step guidance to implement and achieve the desired outcomes. While most of these actions may be unique to this strategic pathway, there are several interrelated and/or prerequisite actions detailed in other strategic pathways that may also need to be completed. Tools to assist in completing the actions are available in the appendices to the strategic pathway. The approach for Strategic Pathway 5: Innovation is illustrated in Figure 5.2 and explained in the following Sections.

The actual implementation approach of each strategic pathway action will depend on country-specific needs, which may be influenced by country priorities, existing capabilities, resourcing potential, culture and other practicalities. Whatever the implementation approach, each action should reference the guiding principles below (See Section 5.5) as these describe what is important for effective and efficient geospatial information management.

5.4 Elements

5.4.1 Technological Advances

Technological advances, both existing and emerging, represent a key opportunity to bridge the geospatial digital divide and achieve sustainable development outcomes, particularly in developing countries.

Technological advances create new possibilities for economic growth, prosperity, and environmental sustainability. Embracing these technological advancements and addressing fundamental geospatial data challenges, countries can unlock the transformative potential of geospatial information management, ultimately driving sustainable development and bridging the geospatial digital divide. The rapid evolution of technology plays a crucial role in leveraging the potential of the Fourth Industrial Revolution; where individualized production, horizontal integration in collaborative networks and digital integration of supply chains have emerged (Brettel et al, 2014) to create a new way of producing and distributing information products beyond a single enterprise (Lasi et al, 2014). In addition, general purpose technology (communications, energy and transport) is fundamentally changing the way we manage, power and move economic activity across the value chain (Rifkin, 2014).

Geospatial information, embedded within communication technologies, is poised to play an increasingly significant role in driving economic development and sustainability. For instance, the adoption of autonomous transportation systems will transform data acquisition methods through sensors that generate three-dimensional models of the environment. This data will subsequently influence sustainable urban planning and infrastructure development.

Emerging technologies, such as the Internet of Things (IoT), automation, sensors, data analytics, machine learning, deep learning, robotics, and quantum computing, are converging around common themes of data integration, real-time analytics, and knowledge inference. These technologies are delivering real-time, on-demand data from IoT-enabled devices, including vehicle sensors, appliances, satellites, and smartphones. Such innovations are particularly valuable for developing countries, where access to reliable and high-quality data remains a significant challenge. However, for these advances to yield meaningful insights and outcomes, countries must ensure the availability of

trustworthy and accurate data. Effective machine learning, for example, depends on high-quality training datasets, which often require the collection of new and precise information.

5.4.2 Innovation and Creativity

The interplay between innovation and creativity has the power to transform the way governments serve their people.

Innovation lies at the core of digital transformation, driving the generation of new ideas, pioneering approaches, and the continuous enhancing of geospatial information management, services and products. It extends beyond the mere adoption of new technologies, focusing instead on fostering an innovation-driven culture that embraces experimentation, adaptability, and problem-solving. Creativity complements this by inspiring the development of innovative data models, analytical methods, and service delivery mechanisms that maximize the value and usability of geospatial information.

Governments play a pivotal role in enabling and sustaining an environment that fosters innovation and creativity. This involves establishing policies and legal frameworks to support research and development, nurturing public-private partnerships, and cultivating innovation hubs. Strategic investments in science, technology, and higher education form the foundation of a thriving innovation ecosystem. Through collaboration between government, industry, academia, and communicates, countries can promote scientific advancements and digital entrepreneurship, ensuring that geospatial information management evolves to meet emerging challenges and societal needs.

The interplay between innovation and creativity has the power to transform the way governments serve their people. It involves overcoming outdated structures and ways of thinking, while leveraging interdependencies among various technologies (Schwab, 2016). Though governments face challenges such as bureaucratic barriers and the need to develop trust and cultivate a supportive culture, the opportunities for innovation are vast. Strategies like digital transformation initiatives, the establishment of innovation hubs, and the promotion of data as a national asset contribute to this evolution. When governments prioritize opening access to data and fostering a culture of innovation, they not only drive economic growth but also enhance societal well-being, reaping the benefits of a more dynamic and responsive public sector (OECD, 2017).

5.4.3 Process Improvement

Process improvement is a proactive and systematic approach to enhancing efficiency, accuracy, and productivity. It involves identifying, analyzing, and refining workflows, methods, and standards to address bottlenecks, redundancies, and inefficiencies.

Process improvement can be achieved incrementally through small, attainable steps or through bold, transformative measures, ultimately leading to productivity gains, optimized processes, and the development of new products and services. Process improvement applies not only to existing systems but also to the adoption of new developments and technologies. In geospatial information management, process improvement ensures that data is collected, processed, maintained, and delivered in ways that maximize its value for all stakeholders. Key strategies include standardizing data formats, enhancing interoperability protocols, integrating automation and AI-driven analytics, and

fostering collaborative data-sharing mechanisms. Modernizing legal and regulatory frameworks and governance structures is also essential to remove institutional barriers and enable the seamless implementation of innovative solutions.

For successful process improvement, factors such as organizational readiness, leadership, and technological advancements must be considered. Organizational readiness includes adopting a process-oriented mindset, cultivating a culture focused on continuous improvement, and understanding the value delivered to stakeholders (Radnor, 2010). Leaders play a pivotal role by providing visible support, commitment, strong direction, and allocating resources and time for improvements to take place. Success is also dependent on clear communication strategies, appropriate training and development, and the use of external expertise where necessary.

Keeping pace with technological developments is critical to staying current and competitive. Attending conferences, engaging with peers, and seeking advice are effective strategies to remain informed. By continuously evaluating and refining workflows, governments and organizations can increase productivity, reduce costs, and improve service delivery. These efforts not only enhance decision-making and policy formulation but also ensure that process improvement remains a cornerstone of progress and innovation.

5.4.4 Bridging the Geospatial Digital Divide

Bridging the geospatial digital divide is a multi-faceted and inclusive approach. Technological innovation, capability-building initiatives, supportive policies, financial investments, and stakeholder engagement are essential components.

With the current pace of technological advancements, significant disparities persist in geospatial capabilities among countries and regions, particularly between developed and developing. Many developing countries face barriers in accessing and utilizing geospatial information and technologies, restricting their ability to participate fully in the digital economy and leverage location-based insights for sustainable development. Bridging the geospatial digital divide is vital to ensuring that all countries, regardless of their current capabilities, benefit from integrated geospatial information management. By bridging the geospatial digital divide, countries can unlock the full potential of geospatial information, enabling inclusive decision-making, policy formulation, and sustainable development. This effort will ensure that no countries is left behind in the global digital transformation journey, fostering a more equitable and interconnected digital landscape.

This divide is an extension of the broader digital divide, which reflects the disparity between those with access to modern information and communication technologies (ICT) and those without. Key factors contributing to the geospatial digital divide include limited access to computers, ICT, internet connectivity, digital literacy, workforce skills, and financial resources. The rapid evolution of technology in developed countries often widens this gap, as developing countries struggle to keep pace with necessary capabilities, opportunities, and infrastructure (Scott and Rajabifard, 2019).

Addressing the geospatial digital divide requires a multi-faceted and inclusive approach. Technological innovation, capability-building initiatives, supportive policies, financial investments, and stakeholder engagement are essential components, aligning with strategic pathways like those outlined in the UN-IGIF. Governments and international organizations must prioritize expanding digital infrastructure,

promoting accessible data initiatives, and creating collaborative knowledge-sharing platforms. Investments in improving digital literacy, workforce development, and technical training empower national geospatial information agencies and institutions to adopt and apply geospatial technologies effectively. Updating or modernizing legal and regulatory frameworks and fostering partnerships between the public and private sectors can help remove institutional barriers and facilitate innovation.

5.5 Guiding Principles

By adhering to these guiding principles, countries can promote the effective and innovative utilization of geospatial information and associated technologies, thereby enhancing geospatial information management and practices.

There are some specific guiding principles that can be applied by countries to stimulate the creative and innovative use of geospatial information and related technologies, and improve on current data management practices. These principles are mindful of both the potential of ICT as well as the dangers of marginalization of those without reliable access to ICT.

The actual approach to implementing these principles is likely to be different from country to country, and in some countries, approaches may not work in their entirety, as there are different priorities and levels of innovation development maturity and cultural aspects that need to be taken into account. That said, using good ideas and innovative thinking, adopting the following guiding principles is encouraged:

- **Leadership:** Communicate, encourage and foster innovation as a priority through a strong sense of mission and purpose, and with commensurate resources and investment.
- **Trust:** Foster an innovative and creative, experimental and developmental environment built on trust, transparency, responsiveness and freedom of expression.
- **Digital Connectivity**: Ensure organizations and people are able to connect to the Internet, digital infrastructure and networks, as necessary means for the digital transformation, transmission of digital data, and as the foundation for developing and mainstreaming innovative applications across organizations and sectors.
- **Digital Literacy:** Recognize and invest in digital and geospatial literacy, both for the young and the aged, as a basic skill for bridging the geospatial digital divide, fostering greater participation in innovation and creativity by all.
- **Collaboration:** Enable collaboration across and beyond government, between the scientists, technologies, researchers and practitioners, with businesses and civil society. Collaborate with the agency in charge of national innovation initiatives to align, manage, coordinate and communicate on strategic implementations to meet national objectives and priorities.
- **Enablement:** Ensure digital transformation strategies equip all levels of government, all sectors and all people with enabling environment, tools and opportunities to foster innovation and creativity.
- **Empowerment:** Provide space for and foster a culture and environment of experimentation and innovation, shared development and co-located research and development, to embolden innovation and creativity, and scale-up applications.

- **Supportive Policies:** A policy and legal framework that supports experimentation, innovation, creativity and application through polices that promote digital transformation, digital connectivity, and embrace the rapid pace of technological change.
- **User Centric:** Embrace user-centered approaches and application principles to innovate processes, products and services, promote readily accessible, re-purposing and re-use of public domain data and infrastructures.

5.6 Actions

The strategic pathway actions are recommended as a means to achieve the four key elements.

The strategic pathway actions are recommended as a way to achieve the four key elements of innovation. They are a guide to assist countries in their efforts to leverage innovation, technology and process improvement to stimulate and trigger rapid change. Country-specific innovation needs may be influenced by factors such as country priorities, existing capabilities, resources, culture and other practicalities. These will influence approaches for implementing each strategic pathway and their related actions.

For ease of use, particularly to assist countries in the early stages of developing and strengthening their national geospatial information management arrangements, the actions are presented in a sequential step-by-step structure. A road map illustrating this order and where the actions typically occur and are completed, is presented in Figure 5.3. However, it is acknowledged that countries, depending on existing national arrangements, may also wish to start their actions at different steps along the pathway, and in a different sequence. Therefore, a less structured road map is additionally presented in Figure 5.4.

Some actions may have interrelated and/or prerequisite actions that need to be achieved prior to, or in conjunction with, the strategic pathway actions. These interrelated actions are also illustrated in Figures 5.3 and 5.4, are referenced in the text, and detailed under other strategic pathways.

Whatever the implementation approach, each action should take into account the guiding principles in Section 5.5, as these describe drivers for attaining effective and efficient geospatial information management.

The actions for the Innovation Pathway are divided into six categories, which are:

1. Geospatial Landscape
2. Identifying Innovation Needs
3. Transformation Roadmap
4. Planning for Action
5. Operationalizing Innovation
6. Future Directions

The following actions are typically used to address gaps in capability. They serve as a guide to building the necessary capacity to strengthen integrated geospatial information management processes and systems.

Figure 5.3: *The Innovation Strategic Pathway includes several actions and tools designed to assist countries to foster innovation and strengthen participation and commitment to achieving integrated geospatial information management. The actions are divided into six categories and reflect the order with which these actions are typically completed.*

Figure 5.4: *The Innovation Strategic Pathway includes several actions and tools designed to assist countries to foster innovation and strengthen participation and commitment to achieving integrated geospatial information management. The interrelated actions provide key linkages to other strategic pathway actions..*

5.6.1 Innovation Group

The Innovation Group considers technologies and processes that improve the management and application of geospatial information.

Understanding and leveraging the latest cost-effective technologies, innovations and process improvements across the evolving geospatial landscape requires dedicated and ongoing monitoring and review – seeking efficiencies and productivity benefits. This is becoming particularly relevant as national geospatial information agencies transition from traditional data supply models to more modern 'data on demand' and 'knowledge services' approaches.

The Governance Model for integrated geospatial information management (See SP1: Action 1.6.4) should typically include a Specialist Working Group (See SP1: Action 1.6.3), referred to here as the 'Innovation Group' to consider, propose and oversight the implementation of technologies and methods that improve the management, sharing and use of geospatial information across government.

The Innovation Group's ultimate aim is to strategically guide the implementation of information, products, applications and services that provide government, businesses and the general community with better decision-making tools. This includes consideration of modern practices and innovative technologies and methods.

The Innovation Group should report directly to the Geospatial Information Coordination Unit (See SP1: Action 1.6.2) and would typically have the following roles and responsibilities:

- Guide the development of the Geospatial Digital Transformation Strategy (See SP5: Action 5.6.9);
- Monitor and advise on the technology and innovation developments, trends, and future directions for geospatial information management;
- Ensure proposed process improvements and innovation efforts are in line with cross-government priorities, and are delivered in the national interest;
- Direct and monitor ongoing innovation programs and outcomes, and make further recommendations for improvement where necessary;
- Review any policy issues arising from the implementation of new technologies and methods, and make recommendations to the Geospatial Coordination Unit;
- Coordinate initiatives with other Specialist Working Groups (Data, Capacity and Education, Policy and Legal, Financial, etc.) that report directly to the Geospatial Coordination Unit to facilitate consistency, avoid redundant efforts, and manage program interdependencies, such as the need for capacity-building in new technologies;

- Guide the development of new policies, guidelines and reports related to technological innovation and digital transformation, as appropriate; and
- Engage with stakeholders on technology, process improvement and innovation opportunities so that programs are directed towards national priority needs.

The Geospatial Coordination Unit may appoint a senior official, with technology and digital reform expertise, to be responsible for the Geospatial Digital Transformation Strategy. This senior official will typically chair the Innovation Group and report to the Governing Board on the development of the strategy and plan.

Once a Transformation Strategy and plan has been set, cross-functional teams can then be formed to implement the plan. It is a good idea to form teams from across relevant departments and agencies to steer geospatial digitalization projects. This will help ensure that the purpose of the project remains intact from the concept phase, through development, and to the launch.

See Interrelated Actions on Governing Body, Geospatial Information Coordination Unit, Specialist Working Groups, and Governance Model (SP1).

5.6.2 Technology Maturity Index

The Technology Maturity Index can be used as a guide to determine the starting point for the transition to new and innovative methods, processes and technologies.

Before embarking on a pathway of innovation and continual process improvement, the Innovation Group needs to first understand the country's level of maturity of the technology infrastructure to support a national geospatial information management program. The notion is to understand the current situation from a whole of government perspective, as well as the desired situation, in order to develop a roadmap for process improvement and technological innovation.

The Technology Maturity Index for the UN-IGIF can be used as a guide to determine the starting point for the transition to new and innovative methods, processes and technologies. A detailed assessment is not necessary at this stage, as a review of the technologies and methods currently in use will typically be completed at a later stage (See SP5: Action 5.6.5).

The five levels (or stages) of technology maturity are summarized in Figure 5.5 and detailed in Appendix 5.1. It is important to note that maturity levels may differ between organizations, and not all capabilities within a country will equate to a single level. For example, a country may associate with data storage as being at level 2 maturity, while data acquisition may have a maturity level 3.

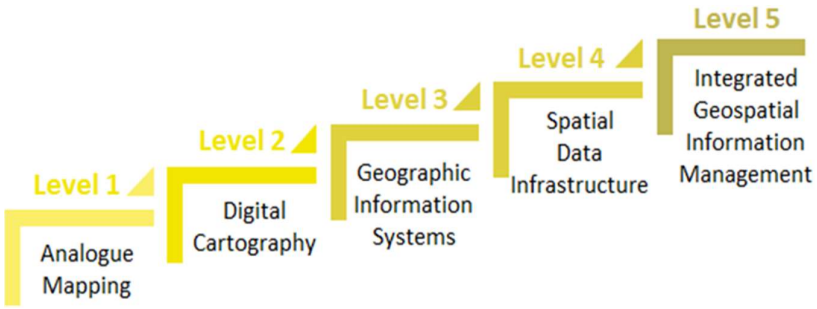


Figure 5.5: *The levels of the technology maturity.*

At this stage, the Maturity Index is used by the Innovation Group to form a consensus on the current deployment of information technology, to stimulate discussion towards a high-level roadmap, and to reach an agreement on the size of the innovation task ahead. The five levels of maturity are (Figure 5.5):

- **Level 1: Analogue Mapping** – Traditional 'manual' cartographic methods are used to prepare paper map products that are used for navigation, planning and visual analysis, and for recording boundaries such as planning schemes, land parcels and census districts etc. Maps and atlases are distributed using analogue methods, such as over the counter sales.
- **Level 2: Digital Cartography** – Maps are produced using computer aided drawing/mapping packages that mimic traditional cartographic methods. For example, data is portrayed and presented according to map scale(s), as opposed to real world representations. Data is typically managed within institutional silos, and data and technology standards are likely to be ad hoc. Digital data files are shared via transportable storage devices, such as CD-ROM.
- **Level 3: Geographic Information Systems (GIS)** – Geographic data is managed within a GIS, typically based on service-oriented architectures and data clearinghouses that support web services and user-oriented functionality (Rajabifard and Binns, 2005), such as the ability to retrieve and consume data directly onto applications. The geographic data is typically characterized by data harmonization through the adoption of national or international (ISO) standards.
- **Level 4: Spatial Data Infrastructures (SDI)** – Geographic data is delivered through an SDI – a data supply model characterized by enabling platforms and services that facilitate the sharing of data to meet specific business goals, strategies, processes, systems and operations, as well as the creation of customized value-added products and services. The SDI employs common interoperable standards that enable information exchange and the delivery of e-services for government, industry and the public. Cloud storage and computing are often used to process and seamlessly analyze vast amounts of data.
- **Level 5: Integrated Geospatial Information Management** – An integrated geospatial information management environment, that enables cross-portfolio data and policy analysis, is achieved by consistently and reliably integrating all types of location-based data (i.e. different geographies) from across different domains of knowledge. Integrated information management involves multiple organizations providing numerous data inputs and advice. This brings versatility and responsiveness to complex decision-making and is the key enabler for knowledge on-demand applications and global semantic networks of query-able Linked Data[3].

The Technology Maturity Index is provided in Appendix 5.1.

[3] Linked Data is structured data, which is interlinked with other data, so it becomes more useful through semantic queries. It builds upon standard Web technologies such as HTTP, RDF and URIs, but rather than using them to serve web pages only for human readers, it extends them to share information in a way that can be read automatically by computers. (Bizer et al, 2009).

5.6.3 Strategic Alignment

The Innovation Group will be a key stakeholder in the development of the Geospatial Information Management Strategy (See SP1: Action 1.6.6). The Working Group advocates process improvements and innovations that are strategically aligned to the priorities of government from an economic, social and environmental perspective. These process improvements and technological innovations will form part of the Geospatial Information Management Strategy.

Geospatial innovation must also align with the country's digital transformation agenda (often referred to as the ICT strategy). There are two reasons why this is important. Firstly, innovation can be directed towards what matters most – this may be reforming land administration and valuation processes, enabling a common operating picture for disaster management, providing transparent governance through the ability to share government data efficiently and effectively, or it could simply be the need to reduce costs by eliminating data duplication. Secondly, by aligning innovation to national priorities, political support and buy-in is generally more likely, and there is greater potential for government investment.

Synergies between a digital transformation agenda (or ICT Strategy) and the Geospatial Information Management Strategy include the need to:

- Facilitate investment in enabling digital infrastructures;
- Stimulate the use of data and technology by the broader community of users as a catalyst for innovation beyond specialist/expert users;
- Improve trust, confidence and security around digital activities;
- Ensure regulatory frameworks are flexible, adaptable and fit-for-purpose;
- Deliver digital government services that are secure, fast and easy to use; and
- Champion an open, free and secure cyberspace.

In contributing to the development of the Geospatial Information Management Strategy and influencing the country's digital transformation agenda, the Innovation Group will need to consider the following strategic alignment questions before embarking on a formal assessment (McKinsey, 2016):

- **Desired Situation:** If we are to strengthen geospatial information management, with no legacy structures or systems to start from, what would our systems look like, and what would be our top priorities?
- **Gaps in Capability:** What is the biggest difference between the vision (i.e. vision in the Geospatial Information Management Strategy) and where we are today with our geospatial information management practices?
- **Enablers:** What geospatial information program capabilities do government need to acquire to make up those differences, and what existing structures and systems would it have to abandon?
- **Current State:** How does government's current digital transformation efforts compare with the changes that are identified above?

- **Priorities:** What new priorities do we need to set for our geospatial digital transformation to bring it into line with the overall vision for improving government business?

By mapping the answers to these questions onto the framework of capabilities and enablers (Figure 5.6), the Innovation Group can set priorities for a powerful and lasting geospatial digital transformation agenda.

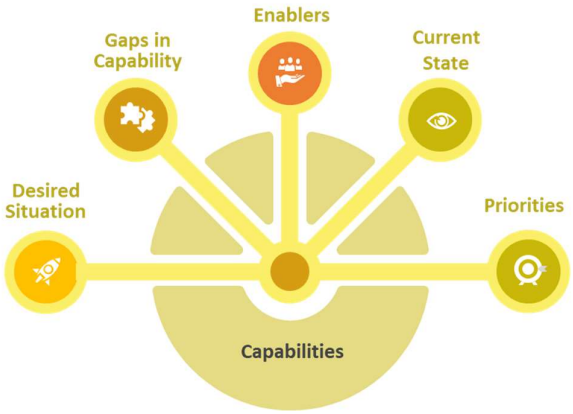


Figure 5.6: *Capability Framework*

An example of a Capability Framework Matrix is provided in Appendix 5.2.

See Interrelated Actions on Geospatial Information Management Strategy (SP1).

5.6.4 Monitoring Trends

It will be valuable to continually review and monitor the drivers, trends, and future directions for geospatial information management; along with the technology and innovation developments.

In defining the Fourth Industrial Revolution, Klaus Schwab, on behalf of the World Economic Forum, noted that all new developments and technologies have one key feature in common; they leverage the pervasive power of digitization and information technology. Many innovations are made possible and are enhanced through digital power. Gene sequencing, for example, could not have happened without progress in computing power and data analytics. Similarly, advanced robots would not exist without artificial intelligence, which itself, largely depends on computing power (Schwab, 2016). These innovations change and embrace all aspects of life and living, including communication, education, employment, industry and its products, and government policies and services. Geospatial and location-based information is increasingly becoming a key part of this pervasive digital world of transformation and innovation trends.

The UN-IGIF recognizes that geospatial information is a critical component of a national infrastructure and knowledge economy that provides a nation's blueprint of what happens where, and the means to integrate a wide variety of government services that contribute to economic growth, national security, sustainable social development, environmental sustainability and national prosperity.

The Future Trends Report has drawn on the global megatrends that convey the broad landscape of technological drivers of the Fourth Industrial Revolution, and analyzed those drivers and trends that are likely to have an impact on the geospatial industry over the coming decade. This high-level analysis shows that despite being driven by technological developments and the availability of new data sources and analytical methods, the geospatial industry is influenced by a much wider set of drivers. It appears certain that a data-driven society will fuel innovation which is central to growth within organisations and countries. Such innovation will be underpinned by developments in the areas of connectivity, sensor networks, data analytics, and cloud computing.

The Innovation Group will need to review and monitor these drivers and trends, along with the commensurate technology and innovation developments, and future directions for geospatial information management. This will inform and assist the Working Group in determining the level of technology maturity (See SP5: Action 5.6.2) strategic alignment (See SP5: Action 5.6.3), and technology needs (See SP5: Action 5.6.5) necessary for a national geospatial information management program.

The Geospatial Drivers and Trends from the Future Trends in Geospatial Information Management: The Five-to-Ten Year Vision (Third Edition) are provided in Appendix 5.3.

5.6.5 Technology Needs Assessment

A Technology Needs Assessment determines where innovation is best directed to close the gaps in what a country desires in terms of their geospatial information management

A Technology Needs Assessment is typically undertaken to determine where innovation is best directed to close the gaps between what a country desires in terms of their geospatial information management capabilities and what they currently have. The assessment process typically includes five detailed steps. These are:

1. **Scoping Exercise** – to define clear goals and objective for the Technology Needs Assessment with respect to the desired future situation, the type of technology and processes to be considered, related studies (such as enabling policy and laws, and skills capacity assessment), and the extent of stakeholder consultations, such as the organizations and individuals.

2. **An Inventory** – to take stock of current technology used for collecting, managing, maintaining and sharing geospatial information. This inventory considers computing hardware (including mobile devices), software and applications (including SaaS and platforms), communication networks (including Internet connectivity and bandwidth), system interoperability, storage systems (including hardware and Cloud), equipment (such as data acquisition, surveying, geodetic, environmental sensors, etc.), data centers as well as any public facing open Internet portals and/or platforms.

   The inventory can be conducted as a high-level review that records government ICT capabilities, or it can be conducted as a 'deep dive' at an organization level – where in addition to

understanding what ICT is available, the inventory is also used as a register to keep track of assets. As a minimum, the deep dive data inventory should record age/version, number and level of usage, as this information can be used to gauge technological innovation capacity.

The technology gap should also be accompanied by a skill gap analysis and relevant national capacity development from academia, research or start-ups (See SP8: Action 8.6.3).

3. **A Policy Review** – to be conducted in conjunction with the Technology Needs Assessment to understand the barriers to innovation. For example, some policies may stifle or explicitly prevent the development and adoption of innovative technologies and methods, such as data protections that restrict access to non-sensitive information, prohibitive data licensing that limits the use of geospatial data, and lack of data and technology standards that impact interoperability.

4. **Data Needs Assessment** – understanding what data is required influences what technologies are needed. For this reason, it is best to conduct a Data Inventory (See SP4: Action 4.6.2) and Data Gap Analysis (See SP4: Action 4.6.4) at the same time as the Technology Needs Assessment.

5. **Risk Assessment** – to understand the risks associated with potentially disruptive technological change. For example, new technologies may have an implication on how governments undertake regulatory functions, while online (digital) services can make services less accessible or usable to a particular demographic. In addition, cultural norms may inhibit technological advancement. For example, some organizations may resist sharing their data, putting ICT projects, which aim to interconnect systems and data, at risk.

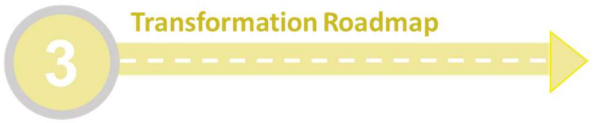
The Technology Needs Assessment will help the Innovation Group to better identify the things that are holding the government back from achieving its geospatial information management goals. Knowing what is working well and what needs to change is crucial to progressing effectively towards geospatial information management strategic goals and making location-based services a success.

Gaps are likely to be identified in a number of areas including data, technology, knowledge, practices and skills, business intelligence, as well as data governance. Often, the best way to identify these needs is through PEST and SWOT Analyses. The PEST Analysis considers the **P**olitical, **E**conomic, **S**ocial, and **T**echnology issues that may have a positive or negative impact on achieving the geospatial goals with external stakeholders. The SWOT Analysis is used to identify **S**trengths, **W**eaknesses, **O**pportunities, and **T**hreats in relation to internal factors; namely the characteristics of government that are an advantage or disadvantage to geospatial information management, those aspects that can be exploited to advantage through UN-IGIF implementation and those realities that are a threat to implementation.

The outcome of the Technology Needs Assessment is typically a report that identifies driving forces for change, what capabilities need to be strengthened and the barriers that are holding back change.

An example of an ICT Data Inventory is provided in Appendix 5.4.
An example of PEST and SWOT Analyses are provided in Appendix 5.5.

See Interrelated Actions on Data Inventory and Data Gap Analysis (SP4);
Inventory of Knowledge, Skills and Resources (SP8)



5.6.6 Modernizing Data Assets

For many countries, even before considering technological innovation, there is often a digital transformation and modernization of data assets required.

For many countries, the journey toward leveraging technological innovation begins with the critical need to digitally transform and modernize their data assets. A key priority is implementing more efficient and effective methods to progressively enhance the accuracy, timeliness, and completeness of the country's geospatial datasets. This transformation is fundamental for enabling informed decision-making, fostering economic growth, and addressing pressing societal needs.

Geospatial data capture, however, presents significant challenges. It is both time-intensive and resource-demanding, requiring substantial investment in technology, expertise, and infrastructure. Despite the best of efforts, geospatial information can quickly become outdated or incomplete due to rapid changes, e.g., urbanization, and evolving societal needs. Gaps in coverage and inaccuracies in geospatial datasets pose serious constraints, potentially disrupting critical business processes. For instance, incomplete data can delay emergency responses, hinder evacuation planning, and negatively impact infrastructure development and resource management.

When addressing geospatial data capture and modernization, countries—particularly developing countries — typically encounter four distinct starting points. These represent unique opportunities to improve data systems and, in some cases, leapfrog directly to modernized methods, bypassing incremental steps. The starting points, as illustrated in Figure 5.7, include:

- Existing Paper-Based Maps: Countries relying primarily on analog, paper-based maps face fundamental challenges but have the potential to transition directly to digital platforms using advanced scanning, georeferencing, and digitization technologies.
- Limited or No Geospatial Datasets: Countries with minimal or no structured geospatial datasets can capitalize on emerging technologies, such as satellite imagery, and UAVs (unmanned aerial vehicles), to establish digital data holdings from scratch.
- Partially Completed Geospatial Datasets: For countries with fragmented or incomplete datasets, integrating existing information with advanced tools like data analytics, cloud computing, and IoT can enhance coherence, consistency, and usability.
- Comprehensive Geospatial Datasets: Countries with well-established geospatial data systems can focus on leveraging automation, real-time data integration, and predictive analytics to maximize efficiency and adaptability.

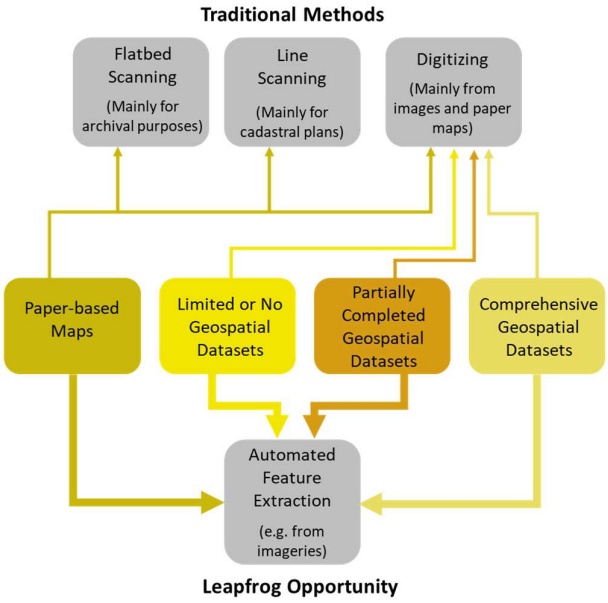


Figure 5.7: *Starting points and leapfrog opportunities for data capture and modernization.*

These opportunities not only highlight the varied starting points for geospatial information modernization but also demonstrate the potential for tailored solutions based on each country's unique context and resources. Leapfrogging technologies and methodologies, especially in developing countries, can help bridge the geospatial digital divide and unlock transformative benefits for sustainable development. Additional details and guidance regarding these starting points and their related opportunities can be found in Appendix 5.6.

Examples of Modernizing Data Assets are provided in Appendix 5.6.

5.6.7 Modern Data Creation Methods

Modern data capture, creation and integration methods are being accelerated and improved through the emergence of new technological tools, innovation, and a greater variety of data sources.

Government policy and decision-makers are increasingly being called upon to use evidence-based research and integrated geospatial information to inform development decisions that will ultimately lead to the achievement of a nation's sustainable development goals.

However, while the objective of 'data analysis' is to enable decision-making, access to the right data is the first crucial step. Countries need access to fundamental and interoperable geospatial data, more rigorous modelling and analysis, and much better data dissemination and management. Linking different data – demographic, statistical, Earth observations, economic, environmental, Big Data, and other societal geospatial data – together with the one thing they have in common - geographic location - is critical.

For many countries, access to accurate and timely data, and associated analytics, remains problematic and undervalued. As a consequence, data-driven decision-making continues to be a major constraint to effective policy setting, and effective monitoring and evaluation of development programs. These

problems are a very real impediment for many developing countries - those most affected by data challenges and need to achieve national development.

Fortunately, modern data capture, creation and integration methods are being accelerated and improved through the emergence of new technological tools, innovation, and a greater variety of data sources. The Future Trends Report highlights a number of these, including the following:

- Earth observation technology such as satellites, high altitude or vehicle-based sensors, which are providing a greater variety and volume of data about the Earth at a higher resolution, greater temporal frequency and at lower costs, than in previous years.
- Continued developments in image recognition and feature extraction, coupled with reduced storage costs, will provide opportunities for faster data capture and creation of geospatial information, and will come closer in quality and usability to that which can be achieved by traditional survey methods.
- The provision of mainstream web service infrastructures, making it easier to create new technology-based products quickly and more cheaply than before and to outsource costs.
- Applications of sensors, robotics, cameras, encryption, cloud computing and other software, and hardware intelligence, are converging to enable new ways for organizations to perceive and capture reality.
- Artificial Intelligence-driven solutions and machine-learning will drive cost efficiency, accuracy and speed in GNSS and positioning, spatial analytics and Earth observation.
- Satellites, unmanned aerial systems (UAS), and sensor technology are being invested in by leading tech giants that are existing providers of sensed imagery and governments.
- The integration of Linked Data and Spatial Data Infrastructures (SDIs) is a promising alternative to overcome issues concerning the discovery, access, exploration and use of spatial data through the Web that impair the full development of SDIs.
- The quality and quantity of crowd-sourced and volunteered geographic information (VGI) location-based content continues to grow. The willingness of 'crowds' to provide data or content for free, which is then monetized by the collectors of the data, continues largely unchallenged.

As countries undertake a Technology Needs Assessment, it is recommended that they reference Future Trends in Geospatial Information Management: The Five-to-Ten Year Vision (Third Edition) to foster innovative and forward-thinking approaches for addressing integrated geospatial information management challenges and closing data gaps. The Technology Needs Assessment serves as a foundation for identifying actions to modernize data acquisition, management, and integration, establish an enabling infrastructure, and support the development of geospatial innovation programs.

Examples of Modern Data Creation Methods are provided in Appendix 5.7; and
Examples of Data Integration Approaches are provided in Appendix 5.8.

5.6.8 Enabling Infrastructure

The potential to capitalize on the true value of geospatial information can be limited because access is generally managed in closed systems of government.

For some countries, the potential to capitalize on the true value of the nation's geospatial information assets can be limited because data storage and access is generally managed in closed systems of government. Storage, access to, and sharing of, data between government agencies remains one of the main challenges on a technical, policy and legal level. While organizations across the government sector often recognize that current processes may be inefficient, there is often no technology available to readily store and share their geospatial data with others.

To resolve data storage issues, many countries are now implementing cloud-based storage systems as modern alternatives, and which provide scalable, cost-effective data storage and computing resources that can be used as and when required. These computing resources are anchored by third-party providers that offer a combination of physical hardware, networks, storage, services and interfaces that are needed to deliver computing as a service. Cloud computing and the internet have transformed the way in which organisations are able to manage data. An increasing amount of data is now being stored in cloud services. There are several advantages, including the opportunity to access, adjust and share information more efficiently, thus increasing economies in data storage.

Internet-based geospatial information data hubs or portals (often referred to as geoportals) are able to provide access to geospatial information from a single location. The geoportal, with its underpinning enabling infrastructure, is an integrated environment where data and products from multiple agencies can be uploaded, discovered, viewed, queried and downloaded. These platforms, which are typically deployed within the framework of the National Spatial Data Infrastructure (NSDI) provide governments with a solid foundation towards transitioning to online citizen-centric whole-of-government services.

There are a number of off-the-shelf systems that provide capabilities to implement a geoportal and enabling Infrastructure, as well as an open-source approach that combines OGC Reference Model architecture and Service Orientated Architecture (SOA) design concepts to provide standards-based integration between GIS and business applications, and data services. A typical conceptual model is shown in Figure 5.8. There are typically six tiers to an enabling infrastructure:

- **User Tier:** Provides access to the data and geospatial services through a geoportal.
- **Application Tier:** Provides the tools to visualize, download and search for geospatial data.
- **Security Tier**: Provides data security and access authentication.
- **Core Services Tier**: Provides the data catalogue and metering services that manage usage and payment services.
- **Integration Tier:** Links the application tier to the virtual data stores.
- **Custodian Tier:** Enables custodians to upload data so that it is available to users.

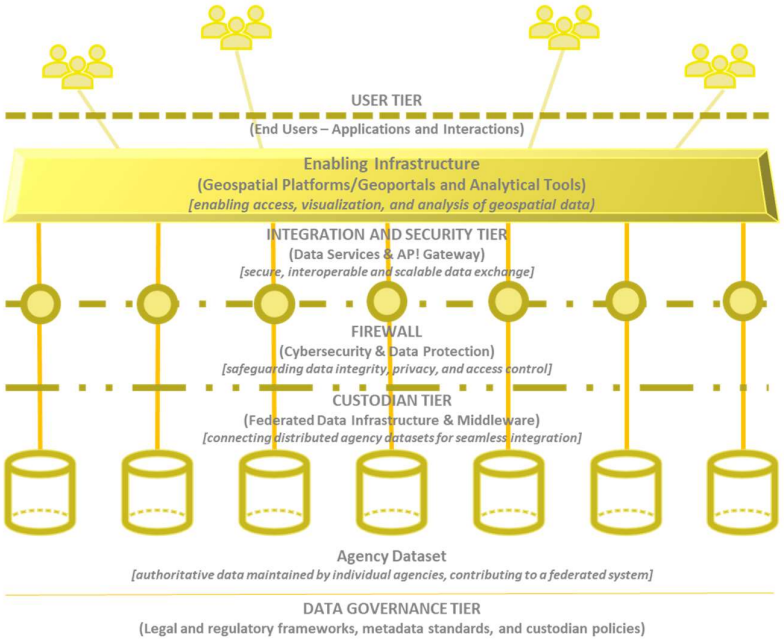


Figure 5.8: *Conceptual view of an enabling geospatial infrastructure.*

A key advantage of adopting a shared infrastructure approach is that agencies can develop interoperable information systems that integrate geospatial data more efficiently and at a lower cost when built on a common foundation. However, enabling infrastructure must go beyond traditional human-machine interaction, where users manually search metadata catalogs or manipulate map views to locate information. Modern geospatial architectures should also support machine-to-machine communication, enabling automated data discovery, access, and integration—essential for advanced applications such as data mining[4], artificial intelligence (AI), and machine learning.

To fully unlock the potential of geospatial information and drive innovation, geoportals and National Spatial Data Infrastructures (NSDIs) must fold into geospatial information and knowledge ecosystems. A geospatial information and knowledge ecosystem is a dynamic network of data, analytics, expertise, and governance frameworks that facilitates seamless integration of real-time geospatial intelligence into decision-making and problem-solving. Such ecosystems leverage advancements in cloud computing, AI, automation, and real-time data streams to support evidence-based policymaking, operational efficiency, and sustainable development.

While the UN-IGIF builds on the foundational progress of NSDIs, it places greater emphasis on data-driven governance, intelligent geospatial services, and collaborative innovation to maximize the societal and economic value of geospatial information in an increasingly digital world.[5]

Examples of Data Storage Processes are provided in Appendix 5.9.

[4] Data mining is the process of examining large databases to discover new patterns and generate new information.

[5] See 'Solving the Puzzle: Understanding the Implementation Guide; and the Future Trends Report.

5.6.9 Geospatial Digital Transformation Strategy

The Geospatial Digital Transformation Strategy is important because Innovation does not occur with one single action, but rather through a series of many coordinated forward-looking steps.

The speed at which innovation occurs represents great opportunities and challenges to those trying to prioritise efforts. However, innovation does not occur with one single action, but rather through a series of many coordinated forward-looking steps. This is why a Geospatial Digital Transformation Strategy is so important. It helps to organize the important steps and keeps all stakeholder on the same path. It also considers the opportunities that digital technology and innovation creates, and sets transformation goals in line with overall government priorities.

A Geospatial Digital Transformation Plan is often a specific plan focusing on technology needs and process improvements. The plan complements the Country-level Action Plan (See SP1: Action 1.6.9) and is strategically aligned to the Geospatial Information Management Strategy (See SP1: Action 1.6.7).

The reason for a Digital Transformation Plan is that technology is cross-cutting, and will have implications as well as benefits across a number of geospatial projects. The Digital Transformation Plan will make it easier to coordinate and visualize activities in terms of system interoperability, economies of scale, capacity needs, policy and regulatory needs, procurement efficiency and monitoring and evaluation. Illustrated in Figure 5.9, considerations include:

- **Interoperability:** How the different project-specific technologies align, particularly with regard to transferring information, as geospatial data supply chains will be technology interdependent and need to be considered holistically from an interoperability viewpoint;
- **Economies of Scale:** Whether one solution can be utilized for all projects e.g. whole of government, cybersecurity, and cloud computing for data storage and information processing etc.;
- **Capacity Needs:** The impact that new technologies will have on human resources and the need for cross-cutting capacity-building programs in a number of skills and areas of innovation e.g. IoT platforms, machine-learning, data security and information classification;
- **Policy and Regulatory Needs:** Where existing policies and laws are enabling innovation and process improvement, so that new/revised policies can be implemented in a way that benefits all digital transformation projects and overcome implementation barriers;
- **Procurement Efficiency:** Whether hardware and software procurement processes can be organized and rolled-out in way that delivers most cost effective and efficient options when requirements are considered holistically;

- **Monitoring and Evaluation:** Whether digital programs are providing the benefits they were meant to provide, and whether those programs should be adjusted to reflect shifts in societal conditions or digital trends; and
- **Communication Strategies:** Whether similar communication approaches can be used across a broader range of projects, particularly if there are common stakeholder groups.

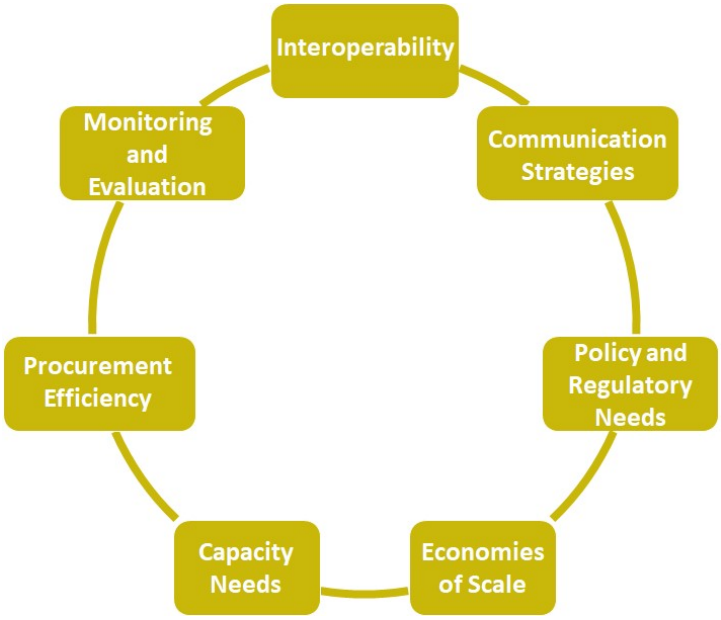


Figure 5.9: *The Geospatial Digital Transformation Strategy and Plan coordinates and visualizes cross-cutting activities.*

See Interrelated Actions on a Country-level Action Plan (SP1); and
Geospatial Information Management Strategy (SP1).

5.6.10 Developing Innovation Culture

Fostering an innovative culture in an organization is as vital as implementing cost-effective technologies, process improvements, and business practices

"Constant change is the new normal" has become a defining characteristic of the digital era, particularly for government organizations operating in the ICT sector, including geospatial information agencies. As digital transformation accelerates and technologies evolve at an unprecedented pace, organizations must not only adopt agile and adaptive approaches but also cultivate a workforce that is equally agile, adaptable, and innovative. After all, “People don’t resist change. They resist being changed.” (Senge, The Fifth Discipline, 1990). It is ultimately the people—not just the organizations—that drive meaningful transformation.

Fostering an innovative culture in an organization is as vital as implementing cost-effective technologies, process improvements, and business practices. Unlike traditional research and development (R&D) models of the past, innovation is not a one-time project or task—it is a continuous and evolving mindset embedded into the organization’s DNA. Establishing such a culture begins with

strong leadership, where a foundation for innovation is deliberately cultivated, guiding the organization toward sustained transformation and relevance.

Effective leadership plays a pivotal role in fostering cultural change and ensuring it takes root in the long term. This requires leaders to actively monitor industry trends, emerging technologies, and shifts within and beyond their sector. Recognizing signals of change—both internally and in the broader market—is essential to anticipating future needs. Organizations must ask: What is our role today, and what must it be in the future to stay relevant? Answering this question clarifies the strategic direction and behaviors needed to achieve long-term goals, shaping the cultural changes required for progress. These considerations align with the 'people' dimension of the Geospatial Digital Transformation Strategy (See SP5: Action 5.6.9), particularly regarding capacity development needs.

An innovation-driven culture empowers organizations to embrace emerging technologies, pursue knowledge, and dismantle barriers to creativity and progress. It fosters an environment where employees are encouraged to align their creative efforts with the organization's objectives, strategic priorities, and commitments to stakeholders. Clear and consistent communication of goals and expectations is essential in reinforcing this alignment.

However, building and sustaining an innovation culture is one of the greatest challenges faced by leaders and managers. Change can be unsettling, and employees may perceive digital or technological advancements as threats to job security. To mitigate these concerns, leaders must frame transformation as an opportunity rather than a disruption—highlighting its potential to enhance roles, improve efficiencies, and unlock new avenues for professional growth. Figure 5.10 provides a conceptual framework for structuring and embedding an innovation culture within an organization.

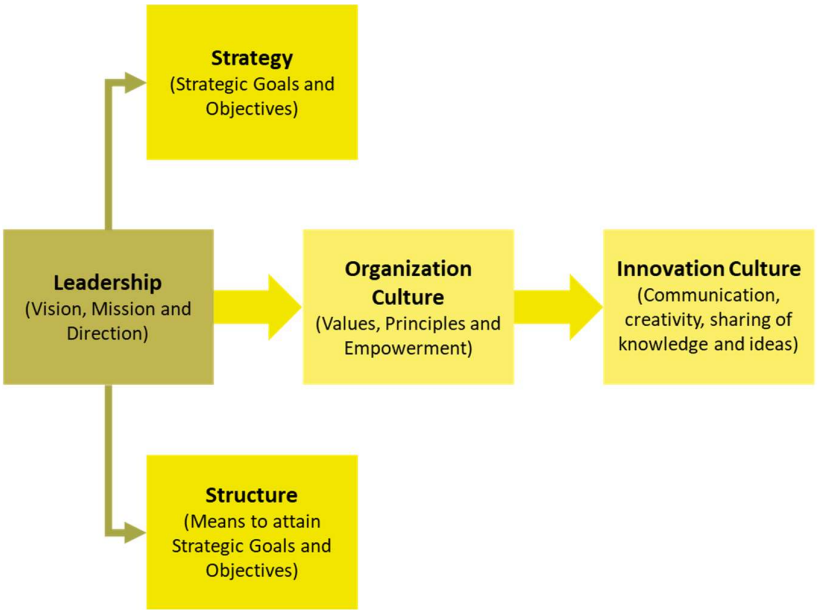


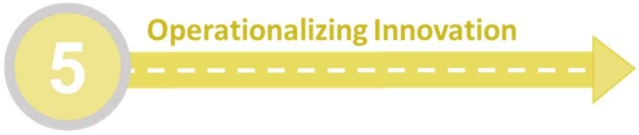
Figure 5.10: *Conceptual approach and structure towards building a culture of innovation in an organization.*

A culture of innovation in geospatial information management is essential for governments and organizations to adapt to emerging technologies, enhance decision-making, and bridge the geospatial

digital divide. This culture is built on several key elements that drive continuous improvement, technological advancement, and data-driven.

- **Leadership:** The central role of organizational leadership and vision in advocating the organizational changes vital to sustain innovation potential;
- **Strategy:** Provides the opportunities through strategic goals and objectives that can influence the path to create and sustain innovation culture;
- **Structure:** Represents the structural characteristics of the organization, methods of assigning responsibilities, the way the organization interacts, and the way staff communicate;
- **Organizational culture**: Source of the principal feature in nurturing culture i.e. the shared values, beliefs and behaviors. The organizational culture works as a mediator and is influenced by the leadership in order to produce a culture of innovation. The emerging culture will determine how creativities are encouraged, how much risks are taken, and to what extend sharing of knowledge and ideas is the norm.
- **Innovation Culture:** This is the outcome of the previous interactions. An innovation culture includes flexibility, oriented visioning, empowering, appreciation of ideas, risk tolerance, communication and collaboration, cultivating external relationships, encouragement, and shared decision-making (See SP8: Action 8.6.4 and SP9: Action 9.6.4).

See Interrelated Actions on Assessment and Analysis (SP8), and Stakeholder Identification (SP9).



5.6.11 National Innovation System

National Innovation Systems are a key driver for economic growth and productivity improvement.

A key component of the innovation process is the flow of technology and information among people, enterprises, businesses and institutions. This flow is referred to as the National Innovation System (OECD, 1997). National Innovation Systems (NIS) are a key driver for economic growth and productivity improvement. They are influenced by, and are able to influence, financial, policy, governance and institutional frameworks. Economic activities are becoming more and more knowledge-intensive, as seen in the growth in high-technology industries and the increasing demand for highly skilled people. The NIS helps to enhance a country's innovative and technological capacity through these processes – and to enhance innovative performance in today's knowledge-based economy.

There are distinct differences between countries when it comes to innovation. Many are yet to achieve a culture of innovation to grow and prosper in competitive global environments. Building this culture requires a system that enables organizations to create a more agile, creative and competitive economy.

Where NIS exist, the approach to innovation is often ad hoc, and narrowly focused on academic research and development. In order to drive sustained economic growth, productivity improvement and innovation, a supportive and incentivized policy framework is required (OECD, 2017). This then has the potential to provide access to investment, subsidies and incentivized programs that support start-ups and larger companies to connect with global value and supply chains.

NIS are typically established at the national level and can be sectoral – focusing on a particular aspect of innovation, such as agriculture and industrial development. These systems typically set the priorities for innovation programs established at a sub-national, organizational and/or community level (See SP5: Action 5.6.12).

Elements of a NIS generally encompass infrastructure and knowledge, collaboration, education and skills, funding, regulation and policy, and culture. These are all equally important elements, and when considered together in a systematic and joined-up manner, they can address a country's long-term strategy in business innovation, and in collaboration between government, researchers and industry. As an example, the Australian Innovation System is illustrated in Figure 5.11. This innovation system can be adapted to suit a county's innovation culture where geospatial innovation is central to its core. Objectives are to:

- Support high-quality research that addresses national geospatial challenges and opens up new opportunities;
- Build a strong base of skilled researchers to support the national geospatial research effort in both the public and private sectors;
- Foster geospatial-related industries of the future, securing value from the commercialization of research and development;
- Enable more effective dissemination of new technologies, processes, and ideas;
- Increase innovation across the economy, with a particular focus on small and medium-sized enterprises;
- Encourage a culture of collaboration within the research sector and between researchers and industry;
- Assist researchers and businesses to be involved in more international collaborations on research and development; and
- Encourage the public and community sectors to work with others in the innovation system to improve policy development and service delivery.

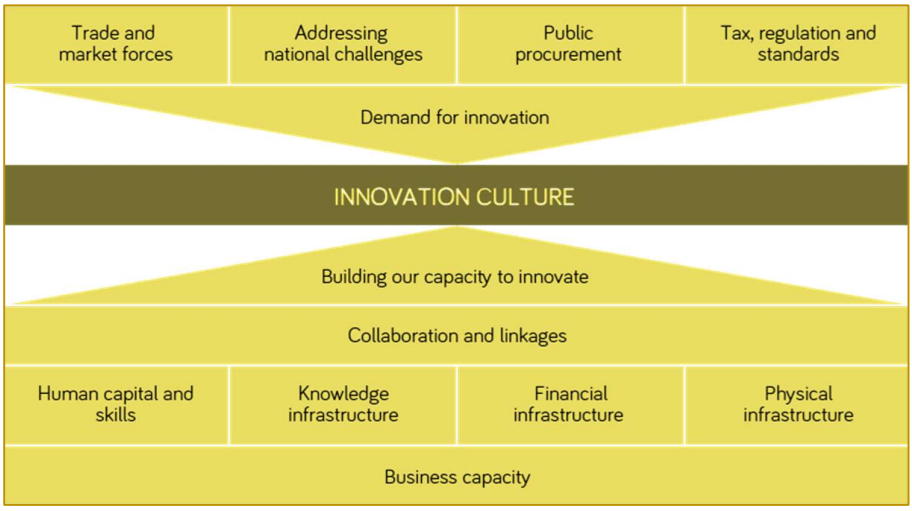


Figure 5.11: *Australia's Innovation System (BCA, 2014)*

5.6.12 Innovation Programs

Innovation programs are a subset of a National Innovation System - used to take up new ideas or new ways of doing business and make them viable.

Innovation programs are a subset of a National Innovation System. The objective of an innovation program is to take new ideas or new ways of doing business and make them viable. Innovative change may be simple, incremental ideas that can be implemented immediately; or visionary ideas requiring research to ascertain their viability and long-term development.

Innovation programs are typically adopted to capture and fund new ideas; build research and development capacity and support an innovation culture across government and within organizations. Many governments have supported innovation programs within and across organizations to build their knowledge economy. There have been various degrees of success. The challenge has been to develop innovation programs that maintain the initial impetus for new ideas, methods, products and services, and enable success to continue in a repeatable and sustainable way.

Innovation programs are an investment in the future, and therefore require a long-term view to realize all of the benefits. Innovation programs that have achieved success are those that recognize innovation is a mindset that needs to be embedded within and across organizations. This means providing avenues for all staff to be involved in the innovation program – the notion being the greater the momentum, the higher the chance of success. Timeliness is a major factor. Innovation cannot become a part of an organizational culture if the lag between idea and production is too great.

Innovation programs typically include five pillars – innovation management, innovation infrastructure, the internal innovation community, open innovation community and monitoring and evaluation. These five pillars are elaborated in Appendix 5.8.

An example of the Pillars of an Innovation Program is provided in Appendix 5.10.

5.6.13 Innovation Hubs

Geospatial innovation and entrepreneurship is being driven by the creation of innovation hubs and programs aiming to support new and emerging start-ups in the geospatial sector.

There are a growing number of success stories that demonstrate how countries can stimulate innovation and creativity – transforming the way work is done to generate economic growth and societal well-being. One such approach towards digital transformation strategies are innovation hubs. Geospatial innovation hubs and incubation centres are not a new concept but have seen a surge in interest in recent years. Sponsored by national geospatial agencies, geospatial innovation and entrepreneurship is being driven by the creation of innovation hubs and programs[6] aiming to support new and emerging start-ups in the geospatial sector.

These innovation hubs are being established through seed funding, capacity development, public private partnerships, learning programs, and mentoring opportunities. Importantly, they leverage access to national geospatial datasets to solve real-world challenges. These programs are targeted at both early-stage start-up companies and seasoned corporations that are looking to adopt geospatial technologies, processes, specifications and data to solve problems and build new applications. They create solutions and jobs, support national prosperity and bring together multiple disciplines from the private sector, academia and government agencies to drive geospatial innovation and data use.

More recently, private sector organisations have started to embrace the notion of innovation programs (See SP5: Action 5.6.12) providing tech-startups with access to industry-expertise in business management, marketing, product development, as well as mentorship.

Technology and innovation hubs are becoming part of enterprise innovation strategies, helping to self-disrupt the geospatial industry and ensure its continual evolution. To keep pace with the ever-increasing user expectations and technological advances, an increase in the number of geospatial innovation incubators is expected; run both by national geospatial agencies and private sector organisations.

This strategy is also being realized through the establishment of the United Nations Global Geospatial Knowledge and Innovation Centre in Deqing, China[7]as a collaborative knowledge, technology and innovation hub for bringing contemporary methods in geospatial information together. The objective of the Centre is to strengthen and advance national geospatial information management, systems and capacities in countries. The Centre's overarching goal will be to work towards the ambitions of implementation of the UN-IGIF set by countries, to develop capacity, promote and support the required innovation, leadership, coordination and standards to develop, strengthen, integrate and deliver national geospatial information policy, data, systems, tools, services and capabilities.

[6] National government examples include Geovation Hub in the United Kingdom: https://geovation.uk/; GeoHive in Ireland: https://geohive.ie/index.html; and GeoWorks in Singapore: https://geoworks.sg/.
[7] http://ggim.un.org/meetings/GGIM-committee/9th-Session/documents/E-C.20-2020-4-Add_1_Strengthening_Geospatial_Information_Report_31July2019.pdf

5.6.14 Process Improvement

Process improvement is the proactive task of identifying, analyzing and improving existing business processes, methods, and standards of quality.

When implementing continuous process improvement in government, one of the key factors to consider is organisational readiness – elements such as having a process view, developing a culture focused on improvement, and an understanding of the customer (including the public) and the 'value' within the organisation (Radnor, 2010). The key success factor is strong leadership and visible support from management. Other success factors include an effective communication strategy, appropriate training and development, providing resources and time for the improvements to take place and using external expertise and support. Importantly, process improvement should be viewed and understood as a philosophy – more than just a policy and a set of tools.

Further, and in a similar vein, managers will need to view their organizations as a system and not a series of functional processes or activities. This means supporting a structure which is 'value facing' rather than 'management facing'. This may mean understanding processes not just across functional but organizational boundaries. This will bring about a better understanding of variety and variability of demand so that resources and capacity can be designed to respond around different types of 'customer' groups and demands.

By focusing on value, process and variation through viewing the organization as a system and understanding the data, it is possible to achieve impact in terms of improved time, cost savings, service quality as well as employee morale and satisfaction – all which support in achieving the requirements of the efficiency agenda. However, public sector leaders and managers need to fully understand what this means, commit and support it and not merely view it as another policy. They must view it not as a set of tools but as part of an organizational strategy which can include rapid successes (which help in justifying its use particularly in a changing political environment) that fundamentally consists of a shift in culture, thinking and structure.

Critical path innovation is one way to progressively work towards process improvement. The process is to critically analyze existing, and often complex, geospatial information management workflows and procedures. This analysis is important for uncovering inefficiencies and barriers. Critical path innovation is not necessarily about being radical. In many cases, small incremental process improvement steps can be taken early to streamline data access. When connected, these steps will lead to improved business intelligence capabilities. Small innovative process improvements are often more effective than one large project, particularly given financial constraints and difficulties associated with overcoming cultural barriers to change.

Examples of the Critical Path Analysis process are provided in Appendix 5.11.

5.6.15 Bridging the Geospatial Digital Divide

Although innovation and creativity have potential to significantly impact on, stimulate and embrace rapid change, and bridge the geospatial digital divide in developing countries, there is a general lack of capacity ***to do so.***

An aspiration of the UN-IGIF, and captured in its mission, is to assist developing countries to stimulate action towards bridging the geospatial digital divide. This is a major goal. However, a number of impediments beyond the control of national geospatial information agencies in many countries, ensure that some solutions will remain complex and difficult in their implementation.

At a basic level, addressing the gaps of the digital divide is a complex process that requires action on multiple fronts, including equitable access to computers, the Internet and other ICT resources; the opportunities to develop and adopt the knowledge and skills to increase computer literacy; and the value of inclusive understanding and use of the content, technology and uptake of digital continues to limit the ability for some developing countries to capitalize on many of the even basic geospatial capabilities that are heavily dependent on wireless and broadband Internet applications as the backbone of the digital ecosystem.

Additionally, the dynamic nature of technology change and innovation is difficult for developing countries to keep pace with. Although innovation and creativity have the potential to have a significant impact on stimulating and embracing rapid change, leapfrogging[8], and to bridge the geospatial digital divide in developing countries, there is a general lack of capacity to do so without considerable industry and financial support, including in the establishment of geospatial technology centres of excellence and innovation networks.

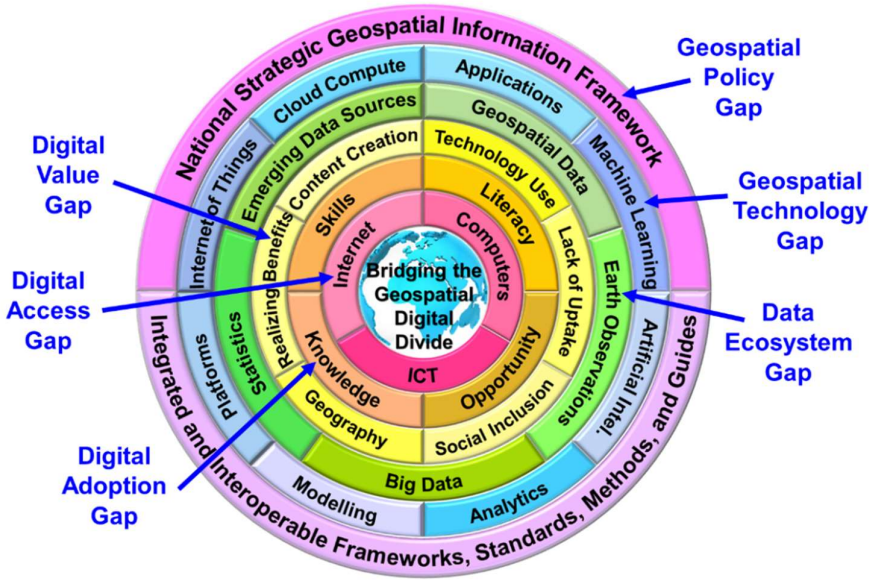
The digital divide not only limits the exploitation of data itself. When viewed through a geospatial lens, the digital divide extends to, and is compounded by, the gaps in the geospatial digital divide. Breaking the six 'gaps' in Figure 5.12 down to the most basic levels, there are several fundamental impediments that are persistent and must be overcome to bridge the geospatial digital divide (Scott and Rajabifard, 2019). These include:

- **Digital Access:** Is core to bridging the digital divide and geospatial digital divide. Bringing people online in the first instance is both the greatest challenge and success. Many developing countries are in a special situation. Having access to reliable electricity and the Internet are the greatest impediments. Without these basic commodities, access to ICT, computers and technology becomes irrelevant;
- **Digital Adoption:** While stemming from lack of skills, literacy and knowledge, it is lack of 'opportunity' to participate in the information society that is the greatest impediment.

[8] Leapfrogging generally refers to the adoption of advanced or state-of-the-art technology in developing countries in an application area where immediate prior technology has not yet been adopted.

Bringing people online will increase skills and literacy at a rapid rate, particularly with the younger generations;

- **Digital Value:** Inclusion (or exclusion), demographics (gender, race, ethnicity, age, education, social status) and geography (urban versus rural) are the main impediments, are almost entirely socio-economic in nature, and require medium to long-term strategies to be implemented by governments to overcome them. The solutions to these problems reside outside of the realm of technology, but are critical for innovation;
- **Data Ecosystem:** The impediment is lack of data. More geospatial data, including fundamental data, information and resources need to be created, accessible, sharable and online. Countries should be able to access and derive national benefits from this wealth of data – but this is not the case. Nor are they leveraging value from data contributors from local and regional governments, private companies, academia, civil society, and citizens including crowdsourced and volunteer geographic information;
- **Geospatial Technology:** The enabling, and increasingly growing, technology innovations and digital transformation is growing every day. The impediment is access and literacy to use it. Harnessing and using technology, and with the appropriate skills and bandwidth (including high-end or low-end options), is the challenge. While technology opportunities remain unevenly distributed, they are solvable, and industry is leading in this area. Further, leapfrogging with technology provides new opportunities; and
- **Geospatial Policy:** The lack of integrated and interoperable frameworks and guides has been the major impediment until now, but can be rectified through the UN-IGIF. The leadership and role of government and institutions as facilitators, is critical to ensuing that no one is left behind, and should not be underestimated.



- ***Figure 5.12:*** *The gaps of the geospatial digital divide (Scott and Rajabifard, 2019).*

Many developing countries face similar digital divide and geospatial digital divide challenges, yet are addressing and prioritising them slightly differently, depending on context and national priorities. There is no doubt that the combined momentum of the 2030 Agenda and digital transformation, including the Fourth Industrial Revolution, is having an impact, building digital capacities as an accelerator for SDG implementation. But there are still concerns that they are not yet inclusive enough and that (growing) disparities still exist. Unlocking the potential of creative innovation and digital technology offers opportunities to increase the effectiveness, efficiency and coverage of development, but national policy, laws and regulation will need to provide better direction and an enabling environment for innovation and technological progress.

5.6.16 Integrated System-of-Systems

The adoption of a system-of-systems approach, built on reliable, secure, and scalable platforms and data hubs, is essential for countries to effectively address national priorities and monitor and report on the Sustainable Development Goals (SDGs).

As highlighted in this strategic pathway and reinforced throughout the UN-IGIF, technology and innovation trends are shifting away from fragmented, siloed data storage and management toward an integrated, 'federated' system-of-systems approach[9]. A system-of-systems refers to a network of independent yet interconnected systems that function together as part of a larger, more complex framework. Each system consists of interrelated and interdependent components—such as data, software, algorithms, analytics, tools, and services—that interact to create a unified geospatial ecosystem. Geospatial Information Systems (GIS) themselves exemplify this concept, integrating diverse elements to deliver location intelligence and spatial analytics.

Implementing a system-of-systems approach enables governments to leapfrog legacy geospatial technologies and rigid infrastructures by adopting more agile, flexible, and cloud-enabled solutions. These solutions harness geospatial web services, artificial intelligence (AI), advanced analytics, the semantic web, and scalable cloud computing to enhance data accessibility, interoperability, and decision-making.

A prime example of this federated approach is the establishment of SDG Data Hubs, which form a scalable global network of interoperable, country-led platforms that connect to the global Open SDG Data Hub. These hubs allow countries to collect, store, access, analyze, and share actionable SDG data across global, national, and sub-national levels within a secure and scalable environment.

The overarching strategy is to develop an open, standards-based, and federated system that integrates geospatial and statistical data into an interoperable, real-time knowledge framework. Leveraging web and GIS technologies, this system enables data analysis, collaboration, stakeholder engagement, and transparent communication—empowering policymakers with evidence-based insights for sustainable development.

[9] Federating data or creating a federated information infrastructure involves linking and integrating decentralized data sources while maintaining their independence. This approach allows diverse systems or organizations to share and access data collaboratively, ensuring interoperability, consistency, and security without centralizing the data itself. It fosters a cohesive framework for leveraging distributed information efficiently

As the Fourth Industrial Revolution advances, the demand for on-demand geospatial knowledge within society and the digital economy is rapidly increasing. This evolution is driving the transition toward a Geospatial Information and Knowledge Ecosystem (GIKE)—a framework that integrates geospatial technologies, analytics, automation, and visualization into decision-making environments. An ecosystem thinking represents a paradigm shift—moving geospatial capabilities beyond traditional mapping applications to become a core enabler of the wider digital knowledge ecosystem. This shift positions geospatial data as a foundational layer in supporting human and machine-driven decision-making, automation, and artificial intelligence.

The UN-IGIF is intended to usher in a new paradigm or a paradigm shift, connecting geospatial information with digital transformation, ensuring that location-based knowledge remains essential for data-driven governance, innovation, and sustainable development.

An example of Open SDG Data Hubs is provided in Appendix 5.12.

5.7 Deliverables

The list of deliverables below are the outcomes typically created as a result of completing the actions in this strategic pathway. They are key success indicators in realizing an Integrated Geospatial Information Framework. Examples include:

- Innovation Group
- Technology Maturity Matrix
- Strategic Alignment Study
- Monitoring Trends and Technology Needs
- Modernizing Data Assets and Data Creation Methods
- Enabling Infrastructure
- Geospatial Digital Transformation Strategy
- Building an Innovation Culture
- Innovation System and Program
- Innovation Hubs
- Process Improvement
- Bridging the Geospatial Digital Divide
- Integrated Systems-of-Systems

5.8 Outcomes

The following outcomes result from stimulating the use of the latest cost-effective technologies, innovations and process improvements:

- More effective geospatial information management processes, leading to more effective evidenced-based policy-development and decision-making;
- Increased productivity and efficiency achieved through an innovation-driven environments;
- An innovative workforce capable of designing and executing new processes, as well as developing and implementing new products and services; and
- The ability to bridge the geospatial digital divide through an innovation ecosystem that leverages enabling technologies.

5.9 Resources

As part of the work programme of UN-GGIM, various initiatives and activities are undertaken by its Subcommittee, Expert Groups, and Working Groups under the Committee of Experts. These efforts involve multi-stakeholder collaboration to ensure inclusive and participatory outcomes and outputs. This approach has enabled the development of numerous resource documents and publications that serve as valuable tools for addressing the challenges associated with implementing innovation programs, particularly in developing countries.

This includes specifically the work and contributions of the following reports:

- Future Trends in Geospatial Information Management: The five-to-ten-year vision. Third Edition;[10]
- The value of Integrated Geospatial and Building Information Modelling (BIM) solutions to advance the United Nations Sustainable Development Goals (Agenda 2030) with specific focus on resilient infrastructure;[11] and
- Advancing Role of Geospatial Knowledge Infrastructure in World Economy, Society and Environment: A Discussion Paper.[12]

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