

A Geodesy and Positioning Thematic Layer - Identifying tools to connect the GGRF and IGIF

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SUMMARY

Effective and sustainable modernization of a nation’s geodetic framework relies on the ability of the relevant organizations and other stakeholders to communicate, integrate, and align both their strategic objectives and operational planning with the United Nations Committee of Experts on Global Geospatial Information Management (UN GGIM) Sub-Committee on Geodesy’s (SCoG) roadmap for a Global Geodetic Reference Frame (GGRF) for Sustainable Development. In addition, to implement geodetic modernization initiatives through multiple government agencies, a holistic country action plan (CAP) for geospatial information management must incorporate pertinent geodetic outcomes and outputs. Presently, the CAP framework and principles used by nations is the UN GGIM Integrated Geospatial Information Framework (IGIF).

From engagement with geospatial and survey communities across emerging nations in the Asia Pacific region, it is evident more assistance and coordination is necessary to articulate, integrate and connect geodetic organizational strategies with the requirements of the GGRF roadmap; the strategic pathways of the IGIF; and resourcing for a meaningful and relevant multi-faceted CAP. One of the supporting mechanisms for such planning or preparation, which representatives of the International Federation of Surveyors (FIG) Asia Pacific Capacity Development Network (AP CDN) and the UN SCoG Education, Training and Capacity Building (ETCB) working group are considering, is a policy framework and guide for a “Geodetic and Positioning Thematic Layer” (GPTL). Essentially, this “thematic layer”, in terms of the GGRF and IGIF, aims to provide a comprehensive understanding of, and a toolbox for, the “why, what, how, and who” of geodesy and positioning.

This discussion paper will provide background and insights for a GPTL dedicated to recognizing, and aligning the geodetic capacity development needs with broader geospatial information management issues and applications. The paper will also outline a rigorous, participatory, and inclusive consultation process for the design and development of a thematic layer. Furthermore, as the intention of the authors is to prepare a forthcoming “white paper” that will concisely describe the issues of a GPTL and initiatives for an appropriate guide and/or policy framework, this paper will seek feedback on: the potential scientific, social, environmental and political benefits of modernizing geodetic infrastructure and systems; the

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challenges associated with the GGRF roadmap; leveraging the geodesy-relevant elements of each IGIF strategic pathway; the importance of collaborative efforts; and the capacity development needs and resources in relation to governance, technology and people.

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1. INTRODUCTION

The need to know our location on Earth down to the smallest possible measurement may only be satisfied by international collaborations in geodesy. Currently, no country has the capacity, be it physical, infrastructural, analytical, or financial, to make or sustain such precise measurements on its own. Because of this, members of the international geodetic community leverage limited national or regional assets to optimize current geodetic knowledge and capability through international collaborations and stakeholder non-governmental organizations.

The challenge for the geodetic community is to work towards a solution for the “problem” as identified in the General Assembly resolution 69/266, *A Global Geodetic Reference Frame for Sustainable Development*, which according to the 2015 UN press release, “outlines the value of ground-based observations and remote satellite sensing when tracking changes in populations, ice caps, oceans and the atmosphere over time. Such geospatial measurements can support sustainable development policymaking, climate change monitoring and natural disaster management, and also have a wide range of applications for transport, agriculture and construction.” Progress toward the UN General Assembly Resolution and implementation of the subsequent UN GGIM Subcommittee on Geodesy (SCoG) roadmap for a sustainable GGRF by UN member states has seen varying degrees of success, and subsequently, mixed outcomes in parts of Asia and in the Pacific Islands Countries and Territories (PICTs).

Global geodesy is dependent on findable, usable, and inter-operable contributions from nations all around the globe, since no single country can maintain the Global Geodetic Reference Frame alone. As the global demands for precise geodetic information increase, there is a very real threat to the long-term sustainability of geodetic infrastructure. To address this, GSOs should seek to align public-service geodetic initiatives (such as the UN GGRF) with widely recognized policy frameworks such as the IGIF and UN SDGs, as a means to equip the members of the global geodetic community with the best possible tools to help themselves, and to share with each other.

In this paper, the potential benefit of standardized organizational and administrative management tools or pathways for addressing the challenges and streamlining the adaptation of the GGRF within the context and common vocabulary of the UN GGIM IGIF will be explored. This paper will also offer preliminary discussion points based on experiences, a global survey, and the incorporation of information obtained through several years of active engagement with representatives from various countries in Asia and the Pacific region that served as pilot countries in implementing the IGIF in the Asia-Pacific region through country-level action plans. The results of a globally-distributed survey of reference frame education, training, and capacity building (ETCB) needs, summarized in Keenan et al and carried out to address one of the operational recommendations of the GGRF Roadmap Implementation Plan, have provided an initial glimpse at community needs and gaps, as well as the potential underlying ETCB causes of GGRF vulnerability. This analysis also includes outcomes from ETCB working group engagement with geospatial information management stakeholders from geodetic survey organizations (GSOs), professional member associations (including the

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International Federation of Surveyors and its Asia-Pacific Capacity Development Network as well as the International Association of Geodesy), in addition to national mapping and space agencies, geodetic commissions, research organizations, and universities.

Ultimately, the major output of this paper is to instigate open discussion amongst interested groups on the design, and development of a Geodesy and Positioning Thematic Layer (GPTL), a suite of tools based on IGIF-standardized principles, organizational templates, and vocabulary, in a process that is participatory and inclusive. It is the intention that this paper facilitates and stimulates conversations amongst the geodetic community and its stakeholders to develop a comprehensive roadmap and toolbox for implementing the IGIF within the geodetic sector and its associated positioning applications. The authors aim to initiate this engagement from the perspective of education, training, and capacity building (ETCB), (noting that this is one of five major principles and thematic areas within the UN GGIM SCoG) in its capacity to develop and strengthen geodetic capacity and capability as a critical component of a GGRF for sustainable development.

2. SYNOPSIS OF GEODESY CAPACITY AND CAPABILITY CHALLENGES AND NEEDS

A Geodesy and Positioning Thematic Layer (GPTL), developed as a suite of tools and resources based upon the standardized vocabulary, classifications, and templates of the IGIF, is built upon the imperative to identify the primary capacity and capability challenges being experienced by countries and organizations, to synergize them with the IGIF, and bridge any gaps in guidance or standardization unique to geodesy and its broader applications. When analyzing the information gathered at relevant forums and meetings as early as 2013, as well as the 2018 reference frame competency survey results, numerous ETCB causes contributing to the degradation of usable public geodetic infrastructure could be grouped in two overarching threats to the GGRF: 1) existing ETCB resources are insufficient, and 2) existing ETCB resources cannot be found or accessed. In this analysis, it is proposed that both of the aforementioned threats may be attenuated by one leverage point: standardization of terminology, classification, templates/organization of resources.

Utilizing internationally recognized and accepted frameworks for collaborating with international partners and non-government organizations (NGOs) may enable members of the international geodetic community to utilize and optimize limited national or regional assets, as the standardization of both vocabulary and templates enables people and organizations of varying reference frame competency and familiarity to identify, understand, and use diverse geodetic resources to address the pressing problems in their country or region. Ideally, a GPTL will be a geodetic complement to the IGIF focus “on geospatial information that is integrated with any other meaningful data to solve societal and environmental problems.” In this, a GPTL may support the IGIF intention to “act as a catalyst for economic growth and opportunity” contributing essential geodetic variables to “improved decision-making for national development priorities and the Sustainable Development Goals.”

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One such problem that may benefit from a GPTL is assisting many GSOs seeking to modernize their geospatial reference system (GRS) or geodetic datum, along with the associated infrastructure and systems, and in doing so, align their strategies and pathways to the UN General Assembly Resolution A/RES/69/266, Road Map for the GGRF, and Road Map for the GGRF for Sustainable Development Implementation Plan using a common vocabulary and organizational templates.

Presently, many GSOs already organize and concentrate agency efforts (personnel and operational resources) on initiatives associated with implementing the five GGRF key areas of action:

- **Governance** – In the context of a GSO, this takes the form of a framework that supports responsible and transparent administration / management of the organization; in particular its finances, resourcing, infrastructure, systems, as well as accountability, and conduct of the people.
- **Infrastructure** – In both scientific and applied geodesy, homogeneous distribution of modernized geodetic infrastructure that utilizes or provides access to an accurate positioning frame and location information.
- **Policies, Standards and Conventions** – Within a GSO, this includes codes of practices, guidelines; and especially statements, agreements, licenses in relation to exchanging and sharing geodetic data.
- **Education Training and Capacity Building** - identifying fit for purpose and appropriate geodetic capability, skills and educational programs, which can be accessible, shared and updated.
- **Communications and Outreach** - programs to enable geodesy (reference frames) and its “deliverables” to be more visible and understandable to society, which also advocate the value proposition to the community.

There is an alignment or synergies between the GGRF key areas of action and the IGIF, as demonstrated in the Table 1. Please note the IGIF, as well as GPTL themes will be discussed in more detail in Section 3.

	IGIF Strategic Pathway	GGRF Road Map Equivalent
Governance	Governance and Institutions	Governance
	Policy and Legal	Policies, Standards and Conventions
	Financial	Governance
Technology	Data	Policies, Standards and Conventions
	Innovation	Education, Training and Capacity Building
	Standards	Policies, Standards and Conventions

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People	Partnerships	Governance; Outreach and Communication
	Capacity and Education	Education, Training and Capacity Building
	Communication and Engagement	Outreach and Communication

Table 1: IGIF Strategic Pathway alignment with GGRF Road Map equivalent theme

In the case of GSOs in the Pacific Island countries and territories (PICTs), and numerous developing countries in the Asia-Pacific region, planning, executing, and realizing programs affiliated with these GGRF foundations has been, and continues to be, challenging. The associated challenges confronting GSOs were evaluated, in Keenan et al (2020) from a technical competency perspective, and Sarib (2020) from a capacity development perspective. For clarity and connection to the IGIF, the geodetic capacity and capability issues from both papers have been subsequently classified into the three IGIF main areas of influence – governance, technology, and people.

2.1 Governance-related Geodetic Capacity and Capability Needs

- Ensuring geodetic capacity and capability strategies, plans and policies are linked to technical improvements, as well as other significant agency or national “drivers” including environmental, economic, social and political.
- Developing geodetic capacity and capability evaluation systems to consistently and transparently demonstrate that individual, organisational, or national objectives have been achieved; and that this achievement is measured not only via technical performance indicators, but also economic, social and political measures.
- Incorporating geodetic capacity and capability programs and arrangements as part of an ongoing organizational action agenda and strategy so as to justify resourcing.
- Developing more relevant strategies and policies to reflect the potential benefits of geodesy, the why, what and how of geodesy, and the interaction of geodesy with other sectors / disciplines on capacity and capability matters.
- Improving the awareness, requirements and understanding of the resourcing programs / opportunities from “donor” or sponsor agencies. This also includes knowing who to contact, how to apply for support, and what to submit / provide.
- Ensuring clear pathways, structures and roadmaps to facilitate geodetic capacity and capability collaboration and engagement that are included within an organisation, between organisations in a nation, and with regional organisations.
- Ensuring maintenance and compliance with relevant legislation, regulation and policy.

2.2 Technology-related Geodetic Capacity and Capability Needs

- Providing frameworks and agreements to facilitate the sharing of geodetic datasets for disaster risk management, such as for early warning systems, and the measurement of

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the effects of natural phenomena such as tsunamis, earthquakes, plate tectonics, storm and flooding events, and volcanic activity.

- Ensuring geodetic capacity and capability for building and maintaining or modernising geodetic (and geospatial) infrastructures and systems for earth measurement and monitoring.
- Modernising geodetic infrastructure to support land administration systems to ensure indefeasibility of registration of rights, restrictions and responsibilities.
- Ensuring foundation (fundamental) positioning data has integrity - accurate, current, geo-referenced, and facilitates integration and interoperability in a modern information system.
- Administering and visualising geospatial information in 3 dimensions (with a temporal component) and in a digital environment.
- Using and maximising the internet, “cloud”, mobile devices, web-based services or data portals, crowd sourcing, and web services to deliver geodetic, geospatial, surveying and mapping services.
- Having access to reliable digital communications.
- Developing digital frameworks / mechanisms to access, learn and share relevant theory and practical experience with respect to core competencies from a variety of sources. Ideally a knowledge database, portal or a repository for geodetic capacity and capability tools and information, discussions – templates, presentations, papers, etc.
- Developing frameworks / mechanisms to utilise and support “providers, trainers, educators, experts, and specialists” to deliver geodetic capacity and capability.
- Ensuring relevant standards, and practices (incl. professional / ethical conduct) are maintained or complied with.

2.3 People-related Geodetic Capacity and Capability Needs

- Undertaking a national or regional analysis of geodetic capacity and capability to identify - knowledge “gaps” between member countries and the provision of core competencies¹ – who, how, where and quality / suitability.
- Effectively discovering, understanding existing organizational geodetic capacity and capability; and prioritising the training and competency needs for the future.
- Ensuring findable and accessible geodetic capacity and capability frameworks / mechanisms for – training, exchanging knowledge / learnings; recognising and assessing qualifications, sharing resources, accessing educational / academic institutions.
- Having the geodetic capacity and capability advocate (and tangible material) and enable decision makers to recognise geodesy’s value or importance and contribution to an organisation (and the nation).
- Ensuring leaders have the necessary skillsets to influence, inspire and motivate others to achieve both organizational and personal geodetic capacity and capability objectives.

¹ Refer to Appendix A – for the UN SCoG ETCB Geodetic Core Competency Matrix.

- Having leaders secure the political (and community) will, support, and commitment; and having the ability to maintain momentum.
- Ensuring leaders and organisations are able to manage and implementing change.
- Provision of a system and / or strategies to assist and encourage existing agencies (and countries) with geodetic capacity and capability to provide more support and be more involved in “core competency” education / training.
- Provision of a geodetic capacity and capability that leads to outsourcing, especially when there is a desire to immediately establish a geodetic datum or reference frame rather than learn how to do it; this erodes the ability to be sustainable.
- Improving the understanding of the purpose, strategy, approach, and requirements to accessing (or even becoming) a geodetic data repository or analysis centre.

2.4 Major Impediments to Implementing the GGRF in the context of the IGIF

Considering the above, and also recognizing that geodetic capacity and capability challenges are not all-encompassing, in that they do not articulate the set of issues unique to each GSO or country, the analysis of the geodetic capacity and capability (and GGRF) challenges or overarching problems can be summarized as:

- **Governance** of public-service geodetic initiatives must be aligned by standardized and recognized policy frameworks and vocabularies that ensure the consistent and transparent inclusion of geodesy and positioning in relevant geospatial strategies, regulations, and legislation.
- **Technology**, including geodetic infrastructure and supporting communities of practice, must be diversely distributed, understood, and maintained around the world to maximize the potential social benefit of geodesy.
- **People** must be trained to maintain, analyze, process, and distribute interoperable geodetic positioning data needed to satisfy scientific observation requirements.

3. A GEODETIC AND POSITIONING THEMATIC LAYER (GPTL) IN SUPPORT OF IGIF COUNTRY - LEVEL ACTION PLANNING

The previous section outlined and summarized the geodetic capacity and capability challenges experienced by countries, and their GSOs, in relation to implementing the GGRF Road Map. Considering this analysis as the main drivers for developing a GPTL, it is necessary to also explore the why, what and how a GPTL can serve as a tool to assist GSOs to achieve organizational, country, and regional objectives under the auspices of both the IGIF and the GGRF. It also needs to be acknowledged that as reference frames (geodetic datums) become a more critical component of contemporary geospatial information systems, it can no longer be overlooked and “taken for granted” in strategic and operational resourcing; thus it is imperative that geodesy and geodetic needs are clearly articulated in the context and structure of the IGIF.

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3.1 Background

The IGIF Overarching Strategic Framework and Implementation guide serves as a roadmap to help governments draft Country-level Action Plans (CAPs) to develop, access, and use geospatial information to make effective policies and more accurately direct aid and development resources. For less-developed countries, it may serve as a tool to reducing and possibly bridging the digital and technical divide with their more prosperous neighbors, meeting community expectations, securing socio-economic prosperity, and providing justification or rationale for development partner funding of geospatial initiatives or projects.

In developed countries, the IGIF is also recognized by geospatial survey organizations and national mapping agencies, as a mechanism to monitor and evaluate the status or condition of their national geospatial data framework in as it contributes to the UN Sustainable Development Goals (SDGs), the Sendai Framework for Disaster Risk Reduction (Sendai Framework) or country-level development activities, by assessing their organization’s performance with the nine strategic pathways, and then bench marking results with or against other similar agencies from different countries. Likewise, the IGIF could also be used in the same way to monitor and measure the effectiveness of GSOs with respect to the GGRF, and other agencies. The main difference however between the approaches would be the requirement to establish thematic layers that were more specific to the geodesy and positioning.

Briefly, from an emerging geospatial economy and developing country point of view, the IGIF is often regarded as a “reference and implementation guide” that will enhance and manage national geospatial information administrative arrangements, as well as infrastructure and resources, through a structured approach. The IGIF’s strategic messages, or policy statements, along with suggested development pathways are formed into three parts:

- **Part 1** is an Overarching Strategic Framework and the “why”;
- **Part 2** is an Implementation Guide and the “what”; and
- **Part 3** is a Country- level / specific Action Plan and the “how, when and who”. Refer to Diagram 2.



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Diagram 2: Why, what, how, when and who of the IGIF (Image courtesy of UN GGIM)

The IGIF Implementation Guide, released for consultation in early 2020, provides nine strategic pathways within the three aforementioned main area of influence (governance, technology, people). These nine strategic pathways attempt to maximize the innovative and integrative nature of geospatial information by making it available and accessible to governments, community, businesses, academia, and civil societies to innovate, co-create and develop new products, services, and applications that deliver new knowledge for evidence-based policy and decision-making. In this case, a GPTL would provide an access point to important geodesy-specific resources both within the geospatial context of the IGIF as well as addressing any needs unique to geodesy. Refer to Diagram 3.

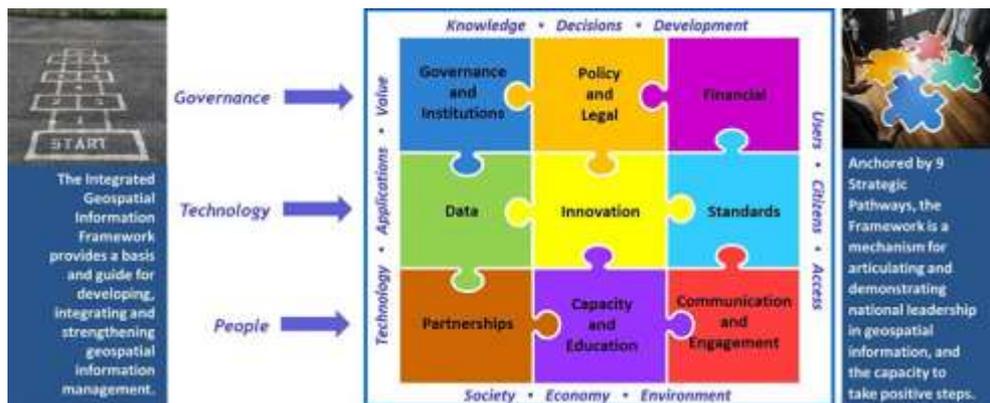


Diagram 3: Nine “integrated” strategic pathways and combined outcomes (Image courtesy of UN GGIM)

3.2 Incorporating Feedback and Consultation from GSOs and Country-level Action Planning from Pilot Countries

Several UN Member States have participated in IGIF Country-level Action Plan pilot countries, including two countries in the Asia-Pacific: Fiji and Tonga. In addition to this, other GSOs have already started preliminary development of Country-level Action Plans. As such, the geodetic community has noted numerous potential benefits of implementing parts of the IGIF into various GGRF-relevant policy instruments and organizational planning. The geodetic community also sought to better understand how international collaborative efforts, through the UN, as well as via non-governmental organizations and professional associations (Such as FIG and IAG), may arrive at effective policy and implementation plans that guide development efforts in a standardized, comprehensible, and interoperable manner.

To further support the concept of a GPTL, various representatives from PICT GSOs were consulted on their recent experiences with forming Country-level Action Plans. From preliminary feedback, there is anecdotal evidence that suggests a GPTL, with associated policy statements, principles and explanatory guides, would have greatly facilitated their GSO strategy, operational planning, fiscal management, monitoring and accountability framework,

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capacity and capability programs, and furthermore assist with the preparation of a consolidated geospatial information management Country-level Action Plan.

A notable concern is indirectly reflected in comments made by some GSOs from developing countries, who advised that the level of the language and quantity of IGIF documentation and modules can be overwhelming or beyond their capabilities to administer, and thus lose its effectiveness and influence. They also stated that a guide which articulated the how the GGRF can be effectively implemented in terms of Part 1, 2 and 3 of the IGIF would be very useful. Nevertheless, a GPTL, and associated documents, along with improved collaboration between countries should alleviate these issues. Section 4 of this paper discusses possible content of a GPTL.

Applying the IGIF, in terms of supporting geodesy, has the potential to help the geodetic and geospatial community to better identify IGIF elements with the science of geodesy, and to also reinforce the utilization of international collaborative efforts. Through both the United Nations as well as non-governmental organizations and professional societies, such as FIG and IAG, organizations approaching the IGIF via a GPTL should have more awareness and comprehension of the relevance of the IGIF, and with enhanced ability break down the strategic pathways into terms that their agency and decision makers are familiar with. It may also enable all stakeholders involved to understand the importance of geodesy to geospatial information management, and accommodate each other's needs, share resources, and arrive at a strategies and policies that guide geodetic capacity and capability development efforts (both nationally and regionally) in a standardized, comprehensible, and interoperable manner.

Continuing the notion of organizing current and future geodetic capacity and capability development, resources and educational opportunities via thematic layer (or toolbox), that serves as a specialized accessibility supplement to the IGIF, may play an important advocacy role to ensure geodetic infrastructure and capacity development is included in a country's overall geospatial information management plan. Furthermore, alignment with the IGIF and GGRF gives the brand recognition, visibility, and prestige associated with the UN to those wishing to secure domestic and regional political support for geodetic infrastructure development.

3.3 Utilizing a GPTL to ensure sufficient and sustainable inclusion of geodesy in IGIF Country-level Action Plans

Broadly speaking, geodetic organizations are encouraged to align or harmonize their organizational plans with the vocabulary and template of the IGIF, in order to ensure sufficient and appropriate representation of geodesy in IGIF Country-level Action Plans. Furthermore, these plans should also note the value of aligning with the GGRF Road Map and Road Map Implementation Plan. A well-designed GPTL will ensure that all relevant GGRF documents, plans, and other information are made findable and accessible to geodetic stakeholders, and facilitate interoperability of geodetic capacity and capability resources as well as infrastructure.

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In the case of a GSO, aligning existing plan and policies within an IGIF Country-level Action plan and the GGRF Road Map Implementation Plan to ensure the development and maintenance of a national GRS /geodetic datum is ongoing, geodetic information is findable, accessible interoperable and re-useable (FAIR), and their effective geodetic policies are in place to ensure more direct aid and resourcing is appropriately allocated. For some GSOs, the IGIF will also provide important guidance for optimal and exhaustive Country-level Action Plan development, leading to concrete recommendations on establishing national geodetic or geospatial infrastructure / systems, improving geodetic capabilities, and tangible outcomes for the GSO as well as its stakeholders. Also, with structured and harmonized organizational planning, GSOs are empowered with opportunities to partner with traditional and non-traditional geospatial groups emanating from NGOs, commercial entities, academic institutions, and scientific agencies who have access to relevant data, technology, and knowledge.

As previously mentioned, the IGIF Implementation Guide contains strategies and tools in nine strategic pathways. However, prior to the introduction of the IGIF, several GSOs from the Pacific Islands Countries and Territories (PICTs), including those who have or are currently participating as Country-level Action Plan Pilot Countries, recognized the potential benefits of operationalizing parts of the IGIF in various agency strategies, policy statements, and commenced country action planning to advance the modernization of their geodetic datum, national mapping, land information systems, and to also leverage international collaborative efforts. The projects undertaken focused on developing GNSS CORS infrastructure and systems, acquisition of geodetic equipment and unmanned aerial vehicles, and building specific geodetic and surveying capabilities within the GSO; all of which were part of broader nation building objectives, such as to manage the impacts of sea level rise or natural disasters. Refer to the article “Pushing Boundaries in Geodetic Modernisation” in the February/March 2021 issue of Position: The Australasian Magazine of Surveying, Mapping, and Geo-Information for more detail on case studies from Fiji, Tonga, and Tuvalu.

4. A GPTL IN SUPPORT OF THE GGRF

4.1 What does a GPTL look like with respect to IGIF Strategic Pathways?

As previously mentioned, and in summary, the overarching GGRF policy problems are:

- To maximize the potential social benefit of geodesy, infrastructure must be diversely distributed and maintained around the world.
- People must be trained to analyze, process, and distribute geodetic positioning data needed to satisfy scientific observation requirements.

In terms of capacity development, the policy problem contributing to the aforementioned issues is that usability of public geodetic infrastructure is at risk of degradation (partially) due to inadequate capacity development. A solution to this is the development of a GPTL.

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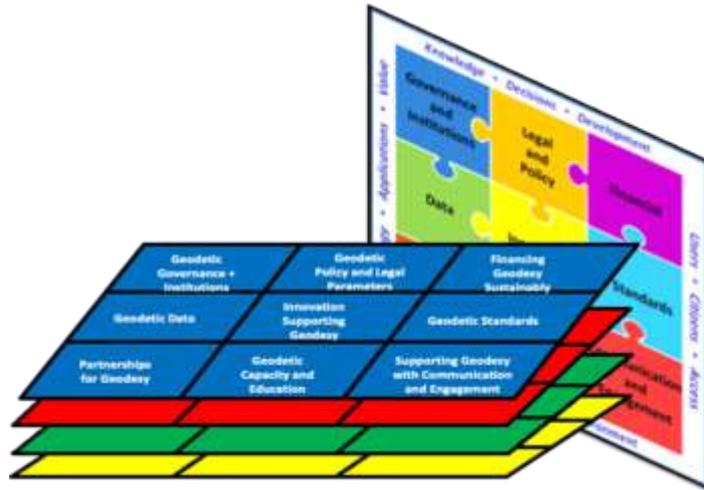


Diagram 4: GPTL in terms of the IGIF Implementation Plan Strategic Pathways

The GPTL could take the form of a companion document and align with the IGIF Implementation Plan Strategic Pathways (refer to Diagram 4 for a pictorial representation). In other words, the GPTL may identify geodesy-specific approaches, terms, and resources to support and complement each of the Strategic Pathways. For example:

- Strategic Pathway-G1: Geodetic Governance and Institutions
- Strategic Pathway-G2: Geodetic Policy and Legal Parameters
- Strategic Pathway-G3: Financing Geodesy Sustainable
- Strategic Pathway-G4: Geodetic Data
- Strategic Pathway-G5: Innovation Supporting Geodesy
- Strategic Pathway-G6: Geodetic Standards
- Strategic Pathway-G7: Partnerships for Geodesy
- Strategic Pathway-G8: Geodetic Capacity and Education
- Strategic Pathway-G9: Supporting Geodesy with Communication and Engagement for this purpose

To determine, and to ensure the geodetic content of a GPTL, and associated frameworks (or documents) are relevant, effective, and aligned with geospatial information management concepts, the purpose or objectives of a GPTL must be clearly articulated. For example, the outputs or outcomes of the GPTL could include:

- Enable GSOs to align and the implement the GGRF Road Map as part of an IGIF Country-level Action Plan.
- Support GSOs to measure and monitor the achievement of the UN SDGs or DRR through the science of geodesy.
- Development of comprehensive CAPs and relevant organizational plans to achieve the GSOs objectives, as well as the GGRF vision, mission and action agenda.
- Provide strategic and pragmatic guidance towards the preparation and implementation of Country Action and GSO planning, in particular what is more relevant or important or critical to a GSO and why.

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- Advocate continuous strengthening of the five GGRF principles and action agenda.
- Enhance collaboration and partnerships at the local, national and regional level.
- Identify (through common vocabulary and standardized terminology), and align (through internationally accepted organizational templates and outlines) the geodetic capacity and capability development needs with broader geospatial uses and applications of the IGIF.
- Countries and decision maker are fully informed about the role of geodesy and its relationship with other sectors.
- Geodesy and positioning stakeholders, including GSOs and leaders to, recognize the importance of, and understand the **why, what, and how** of geodesy in relation to the social, environmental and political needs of a country.
- Foster GSOs to construct or transform their existing geodetic framework to align with a unified modernized model
- Assist with the remove existing GSO silos, culture and paradigms.
- A common / standardized framework to determine the foundations / basis of a “needs analysis” that will also identify a GSOs strengths, weaknesses, opportunities, and threats.
- Enable donor agencies and supporting organizations to appraise resourcing requests and assistance in a consistent manner.

The GPTL framework and document(s) would also identify cross-cutting geodetic issues in the context of the IGIF three areas of influence – governance, technology and people. Successful articulation of these will further advocate the critical role of the GGRF using discrete and interoperable capacity resources. It would also emphasize and fill gaps in geodesy-specific guidance, and provide geodesy-specific examples of relevant and current policy statements, explanatory guides, and other lessons learned from the global geodesy community; in particular to those pertaining to the five GGRF key areas of implementation or action. The additional benefit of developing and utilizing the GPTL, is the opportunity to unify descriptive vocabulary within the diverse global geodesy community, and establish a clear and transparent organizational system for geodetic capacity resources, that will minimize the duplication of effort, and also foster a culture of sharing and organizational collaboration.

4.2 Governance

As the global demands for precise geodetic information (in near real time) increase, there is a very real threat to the long-term sustainability of geodetic infrastructure that underpins most positioning or location based services. By aligning governance of GSO policy and initiatives to country-level development activities; as well as recognized UN mandates, resolutions or policy frameworks such as the IGIF, SDGs, and the Sendai Framework, a GPTL IGIF “toolbox” should serve to equip the members of the geospatial community with the mechanisms to help domestic geodetic survey improvement (modernization), and to share capacity and capability with each other.

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The IGIF recognizes that effective governance is “essential to achieving integrated geospatial information management.” This is further recognized within the SCoG, as its Governance Working Group seeks to identify and fill current gaps in appropriate governance arrangements in support of the GGRF, routinely developing position papers to serve as an aspirational tool for engaging commitment from UN Member States.

Within a broader policy analysis context, using the IGIF in GGRF governance can be considered a “normative frame” in that it aligns or links individual, organisational, and national geodetic capacity and capability plans to regional and global “initiatives” or “issues” that are described in a common vocabulary, and presented in an intuitive and familiar organizational template. Considering the potential benefit of an internationally usable and understandable GPTL, appropriate governance will be essential.

4.3 Technology

A critical component of geodetic infrastructure is the information technology, related platforms, digital communications and systems that lays the foundation for the GGRF. The IGIF notes that “technology influences geospatial location data, innovations, and the required standards that respond to continually evolving needs, demands, and uses.”

IGIF Strategic Pathway 6: Standards (SP 6) notes the enabling power of technology and data interoperability, in addition to applying standards to improve discovery, sharing, and use of geospatial information. SP 6 calls for deconstruction of information and technology silos – particularly those that result in delays in costs in expanding or adapting data and tools to work with other resources, software, and organizations; or those that restrict cross-government data sharing and integration. It also suggests establishing Communities of Practice to accelerate the benefits of standards and operability by sharing and leveraging proven, standards-based good practices between otherwise unconnected entities; cooperatively addressing issues of common importance.

When considering how SP 6 may guide development of geodetic capacity and capability within a GPTL, authors are encouraged to note how SP 6 calls for communal enabling of knowledge discovery and inferencing between systems (and by extension, people and governments) using unambiguous definitions – an established, standardized vocabulary that facilitates understanding across languages, cultures, and capacity levels. Building on the governance challenges and actions addressed above, a GPTL would include geodetic capacity and capability resources as they apply to the effective and sustained use of geodetic infrastructure, as it supports positioning applications.

4.4 People

Ultimately, it is people who build, implement, use, and benefit from a sustainable GGRF or modernised GRS. As stated in the IGIF, “the people aspect is arguably the most important component, as it is the people who are the Framework enablers – performing all tasks needed for a successful IGIF – often through partnerships and in collaboration with others. Having

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the necessary skills and knowledge is crucial to success, requiring capacity and education programs, and ongoing communication and engagement.” In short, sustained human capacity and capability is the critical element that will build, maintain, and enable use of the GGRF, and furthermore bind the geospatial information elements, of governance and technology.

When considering the development of a GPTL, the “people” element, especially in the context described in Strategic Pathway 8: Capacity and Education (SP 8), has been at the forefront of this paper’s analysis and discussion. Considering the technologically-rooted recommendations for communities of practice and standards-based knowledge transfer discussed in SP 6, the following proposed actions, in alignment within the template of SP 8 as well as interrelated and prerequisite actions in other Strategic Pathways, are recommended. Considering both SP 6 and SP 8 helps ensure a GPTL that empowers people, organizations, and regions to effectively include geodesy in IGIF CAPs, as well as to ensure interoperability and comprehension of associated processes, templates, and tools that are developed by organizations and governments around the world.

5. NEXT STEPS FOR DEVELOPING A GPTL

The implementation steps to developing a geodetic and positioning thematic layer outline the essential tasks to be done, and may be summarized as follows:

1. Identify where the IGIF already addresses the role of geodesy in geospatial information management; and evaluate its’ effectiveness, namely what and how elements can be improved.
2. Identify “stakeholder” areas that may not specifically address geodesy, but are clearly relevant to current geodetic projects, efforts, and concerns.
3. Research and summarize, in terms of geospatial information management, why large scale national and international development projects fail to deliver their intended outcomes.
4. Collect lessons learned and best practices from colleagues who have provided assistance with and participated in the Part 3: Country Action Plan first-round development.
5. Scan the environment and reference key documents (includes non UN GGIM material) supporting the development of the Global Geodetic Reference Frame (GGRF) within the nine strategic pathways and their respective templates.
6. Identify opportunities to use IGIF to facilitate both qualitative and quantitative tracking progress of countries' ability to meet targets of the UN Sustainable Development Goals, the Sendai Framework for Disaster Risk Reduction, the Paris Agreement, and others.

Once these steps are completed, responsible stakeholders (individuals and groups) should be identified for each step, and required capabilities (structure, resources, motivation) of each contributing stakeholder should be inventoried.

In future efforts, clear principles of policy development should be introduced, including policy elements such as the strategic triangle, theory of change, and Ishikawa (also known as fishbone) diagramming. Strategic elements should be aligned with the three IGIF areas of influence, as well as existing geodetic policy analysis.

5.1 Community Consultation and Inclusion of Feedback

Looking forward, it is a combination of leadership, coordination, and passion that will inspire the big ideas and subsequent implementation to link geospatial information with national development strategies as they serve the needs of their people. In the past two years, members of the ETCB working group have made an active commitment to engage with colleagues in small island developing states, whose collaborative efforts in geospatial information management continue to inform and inspire.

Next steps to developing an IGIF thematic layer to serve global geodesy needs will need to be rigorous, consultative, and inclusive. Discussion, design, and development of this thematic layer will rely heavily upon feedback and lessons learned from colleagues who have already participated in IGIF Country Action Plan development, as it will provide important practical examples for other countries looking to utilize this framework for both communication and collaboration as well as seeking funding for geodetic infrastructure, capacity development, and beyond.

5.2 GSO Actions – Moving Forward

The endorsement of GPTL by the geodetic community, is anticipated to be a 6-12 month process, thus for GSOs who are contemplating the development of an organization strategy or utilizing the IGIF for geospatial or geodetic modernization, it is recommended GSO's consider the following –

- Undertake an evaluation of its business operations and a “needs” analysis, to (a) analysis and critical assess the strengths, weaknesses, opportunities and threats, and (b) identify and understand the internal and external factors or key issues affecting national geodesy. The analysis will also assist with country-level action or operational planning, as well as forming answers to the “why, what, how, and who” for a geodetic and positioning tool box.
- Develop or maintain partnerships and collaboration with likeminded geospatial and geodetic organizations, scientific or professional societies to share knowledge, experiences, resources and information.
- Participate in, engage and/or support regional / global geodetic capacity and capability development initiatives that (a) improve geodetic competency or bridge identified gaps; and (b) establish geodetic governance, technical and people frameworks, mechanisms, policies, standards, and practices.

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APPENDIX A - UN SCoG ETCB GEODETIC CORE COMPETENCY MATRIX

Level	Competency Requirements	Training provided by	
1	<p>Basic understanding of:</p> <ul style="list-style-type: none"> GNSS Reference frames, including geoid models, vertical and horizontal datums 	<ul style="list-style-type: none"> Educational institutions – universities and polytechnic institutes Government mapping agency Private companies 	Countries that might have one CORs and maintain a traditional geodetic network of reference marks – e.g. small Pacific Island Nations?
2	<p>The above plus knowledge of:</p> <ul style="list-style-type: none"> Constructing, building and running a small CORs network GNSS processing using standard software - e.g. Trimble, Compass Solution (ComNav), LGO(Leica),.... Least squares processing and provision of datum access Geoids models, precision, determinations and basic implementation Implementation of a vertical datum including use of geoid models 	<ul style="list-style-type: none"> Educational institutions – universities and polytechs UN-GGIM Geodesy Capacity Group FIG Government mapping agency Private companies 	Countries with small CORs network and those who adopt global Reference frames for their nation reference frames – e.g. Fiji?
3	<p>The above plus high knowledge of:</p> <ul style="list-style-type: none"> Implementing and running large CORs networks High end GNSS processing and datum access Geoid model computation and implementation into a vertical datums Monitoring earth dynamics and including in datum realization Geodetic database management 	<ul style="list-style-type: none"> Specialized courses – e.g. geoid school UN-GGIM Geodesy Capacity Group IAG and FIG Government mapping agency Private companies 	Countries with a more extensive CORS and developing their own specialized national and vertical datum – e.g. New Zealand and Sweden?

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4	<p>The above plus expert knowledge of:</p> <ul style="list-style-type: none"> • Reference frame determination and computation • High end GNSS analysis and processing • SLR including analysis and processing • VLBI including analysis and processing • Gravity collection, processing and geoid determination • Analysis centre – combining various geodetic techniques to determine reference frame parameters • Use of other potential geodetic techniques – e.g. DORIS and InSAR 	<ul style="list-style-type: none"> • IAG • Specialist training courses run by NASA/JPL – e.g. on VLBI or SLR • Private companies • Specialized software training courses – e.g. Bernese 	<p>Countries engaged in Global Reference frame determination and Geodesy Science - e.g. US, Australia and Germany?</p>
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