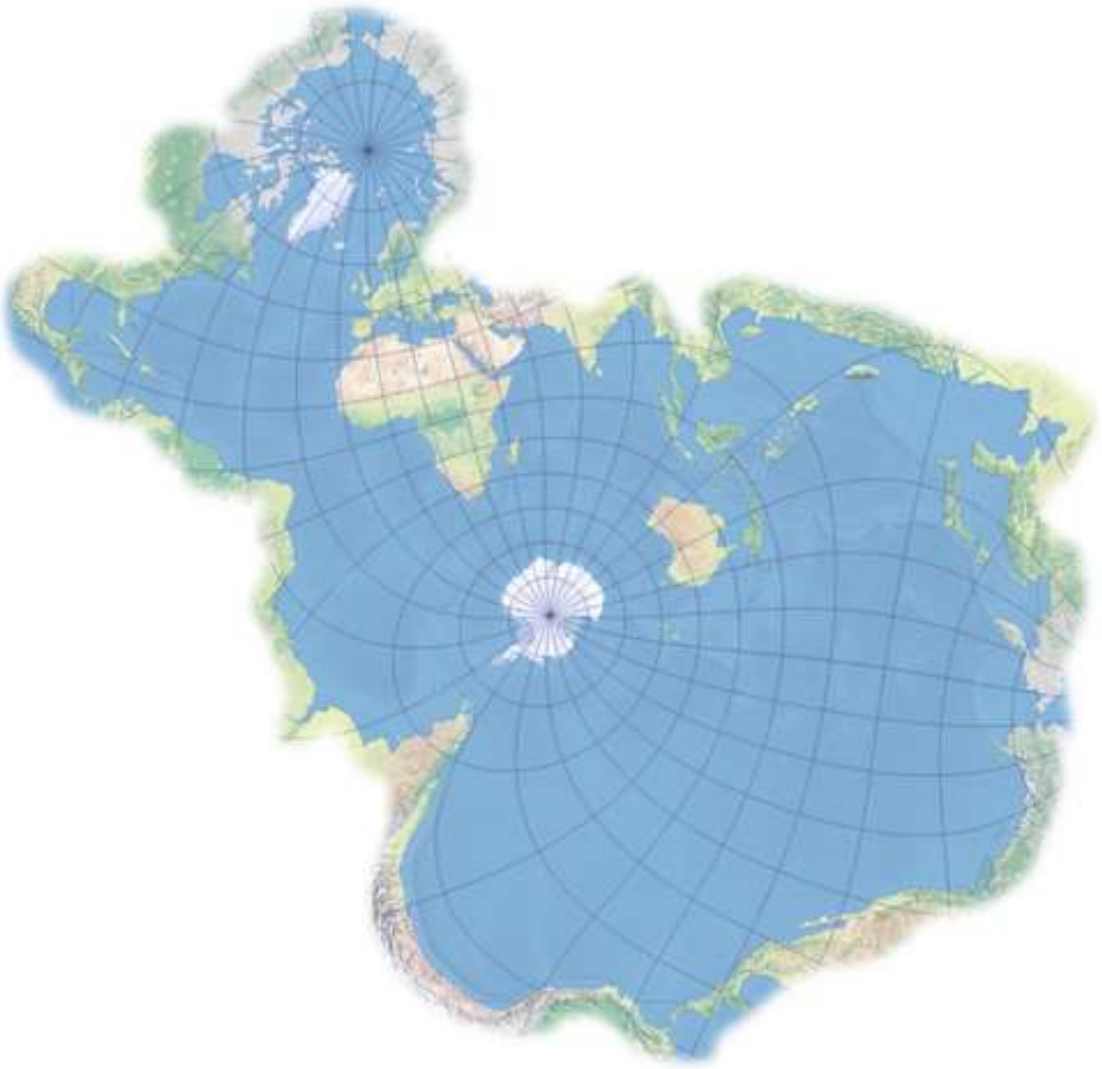


UN-IGIF-Hydro

Operational Framework for Integrated Marine Geospatial Information Management

Part Two – The Strategic Pathways

A note on the cover image
The cover image shows the "Spillhaus Projection." Athelstan F. Spilhaus, a South African-American geophysicist and oceanographer, authored this projection circa 1942. The projection defines a world ocean map that intersects the oceans as little as possible, showing the globe with the oceans as the main focus. This image portrays the aim of this guide, a "water -centric" and integrated view of the world, and reflects the UN-IGIF's integrated philosophy.

Table of Contents

Introduction to Part Two

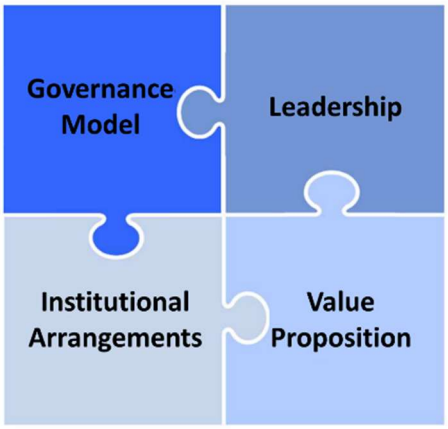
Part One of the Operational Framework is a high-level introduction that describes the "why" of the UN-IGIF-Hydro. It provides supporting background, context and an initial presentation of the value proposition for an UN-IGIF-Hydro implementation. Focusing on the United Nations Working Group on Marine Geospatial Information recommendations and the UN-IGIF's nine strategic pathways, Part Two presents the "how" of UN-IGIF implementation for that part of the Earth covered by water, which is approximately seventy percent of the surface of the Earth.

In this Part Two, the UN-IGIF Strategic Pathways (SPs) are presented with examples of good practices, detailed guidance and examples for those implementing UN-IGIF in the hydro environment.

1. Governance and Institutions (Strategic Pathway 1)

This section describes unique characteristics of the hydro environment and how they relate to the UN-IGIF sections in SP 1 - Governance and Institutions. UN-IGIF implementers should focus on institutional arrangements, the layout of the geospatial agencies making up total custodianship across the entire infrastructure, and value propositions specific to the hydro environment.

1.1 Leadership and Institutional Arrangements



Ensuring that 'wet-side' interests are included in the national geospatial leadership board is imperative to the success of advancing an integrated program. Overall, governance of the geospatial infrastructure sets out a framework against which specific policies, norms, and guidance are put in place. These (discussed in more detail in Section 5) implement the overall Governance Framework. The Governance Framework should, in our context, set out and balance all priorities, and core objectives that include implementation of specific international conventions.

The Governance Framework, from the 'water' or hydro perspective, has to balance the state's political requirements, internationally and regionally, together with domestic priorities and user needs. It also must provide the basis on which Water interests are coordinated using the institutional arrangements that are in place. Reconciling terrestrial interests should be driven from the central Governance model to avoid a slide into conflicting and inefficient silos. Within the 'water' or hydro environment there may be ample opportunity to reuse existing governance models developed internationally by, for example, the International Hydrographic Organization (IHO) and International Maritime Organization (IMO). The Governance model is where the core integrative approach of the UN-IGIF is defined and then implemented via the institutional arrangements that are put in place.

Geospatial data plays a key role in the expression of regulatory and planning processes. From the Water perspective, leadership of the national geospatial strategy will drive a transformational

approach that is able to harmonize the domains and requirements of Land and Sea, of Terrestrial and Inland Waters and other areas where Water plays a part.

> **"Institutional arrangements"** - "Formal and informal cooperation structures that supports and links public and private institutions and or organizations, and which are used to establish the legal, organizational and productive frameworks to allow for sustainable management of geospatial information, inclusive of its creation, updating and dissemination, thereby providing an authoritative, reliable and sustainable geospatial information base for all users." - UN-IGIF SP1 - Governance and Institutions

The allocation of responsibilities to a number of institutions is a key determinant of the outputs of the infrastructure. Often, and historically, these lines of division between institutions responsible for data are drawn between functional areas of the state or the domains which they cover.

As is seen in SP6 and SP4, there is a substantial difference in different domains and this is often reflected in the way the geospatial institutional arrangements are aligned. In institutional arrangements for geospatial data, an institution may be "responsible" for data – i.e., it is authoritative for that particular domain, (in SP4 terms – custodianship) and this allocation of custodianship is often delineated across domain boundaries. The UN-IGIF SP1 describes this observation:

> "Within countries, there are often a number of national institutions responsible for the management of geographic information, depending on their needs and/or mission. The division of roles and responsibilities is usually domain-specific where urban, transport, rural, forestry, environment, cadastral, topographic, statistical mapping and remote sensing is conducted by different organizations and institutions. There are typically very limited policies or agreements in place to mandate and encourage the required coordination and data exchange, and often no underlying organizational culture of sharing information."

The UN-GGIM report on Future Trends in Geospatial Management [REF], also noted:

> "The marine element of established NSDI is often less well developed and the overall need for better integration of marine data is becoming more apparent. As a component framework within a NSDI, national hydrographic offices are mostly separate entities with somewhat loose connections to the NMGAs. Integrating marine-based charting and land-based mapping as one continuous surface continues to be a constraint; for this to be achieved, new tools, new data collection methods, data specification standardisation, and improved data management will be required."

The following diagram shows some examples of how this might manifest itself in a geospatial infrastructure where the physical domain is split between "Land Agencies" and "Marine Agencies". Other institutions responsible for stakeholder groups such as civil mapping, defence, legislative and other responsibilities may have a domain covering the entire physical domain and are charged with data integration. This traditional approach is seen in many states.

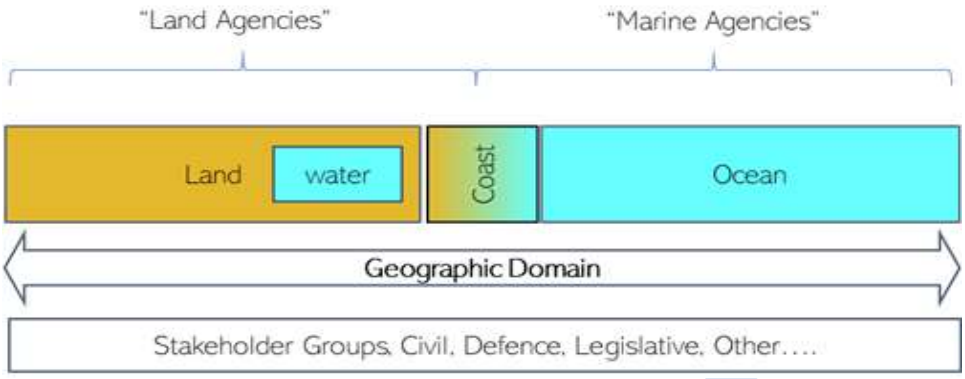


Figure 1: Potential Institutional Arrangements in the Water Domain

The diagram illustrates the two main degrees of freedom in the institutional arrangements within an administration in respect of the 'water' or hydro environment delimited by "end users" and the physical domain. Examples of institutions could be:

- A civil land mapping agency responsible for terrestrial mapping including internal waters and waterways as well as a proportion of the coastal domain. E.g., LINZ or Ordnance Survey
- A defence organisation producing terrestrial mapping for the defence domain.
- A hydrographic office which produces charts for both civil and defence use covering Oceans and Seas as well as coastal waters. E.g. UKHO[3]
- Legislative bodies responsible for legal instruments covering law of the sea and the United Nations Convention on the Law of the Sea (UNCLOS), as well as legislative management for land rights and cadastre
- Other levels of government, agencies, and groups (e.g., research and development, scientific, oceanographic, statistical)

Fundamentally all infrastructures can be represented in this way: Their function against the spatial domain they are "responsible for."

The 'water' or hydro environment has a fundamentally different nature and requirements.

There could also be, for instance, agencies responsible for "marine" engineering and infrastructure including coastal protection, ports and harbours.

This is rarely a complete picture, institutional arrangements when considered in their entirety represent a complex network of interactions between primary institutions, users and intermediaries.

The UN-IGIF does not promote a single, optimal assignment of individual functions to institutions. Under UN-IGIF these are defined by the implementer using the guiding principles to define a management strategy. The UN-IGIF approach therefore favours a single integrative approach which may challenge existing structures and redefine existing arrangements.

In any implementation there are always:

i) Boundaries between functional areas and their domains of responsibility which must be defined and managed.
ii) Responsibilities and custodianship which may not be shared, such as the fulfillment of international obligations like Safety of Life at Sea (SOLAS) and UNCLOS, balanced with domestic and regional obligations.

There are "correct" ways to arrange institutions.

This arrangement issue is often very noticeable in the 'water' or hydro domain. For example, in many countries around the world, nautical charting and ocean mapping are controlled by navies or uniformed services who may have little or no contact with national mapping or geospatial agencies. This can be problematic for several reasons. Primarily, it creates a divide between land mapping agencies who are almost always civilian and are often responsible for non-navigable waters and their management. This difficulty is often concentrated and most apparent in the coastal zone where agreement on shoreline and boundaries can be a challenge. Since shoreline forms the basis for maritime boundaries, this has the potential for follow-on negative impacts when establishing ocean resource planning and regulations, including fishery management and oil/mineral exploration.

Share experiences and use best practices.

Another challenge with regard to military custodianship of marine data is that of restricted availability. Many view marine information as a national security asset and limit distribution to what is included on nautical charts. This may not be in line with what land mapping agencies make publicly available and severely inhibit the return on public investments. Often, scientific and oceanographic applications and broader uses for Marine Spatial Planning (MSP) rely on seamless datasets spanning land and water; divisions at fundamental organizational levels are difficult to overcome. The military/classified nature of some data and the specialized nature of other geospatial data types means some cross-institutional responsibilities and restrictions are inevitable. This places a requirement, driven from the Governance model, to ensure interoperability, reuse and harmonization.

Availability is critical to realizing the full value of data in any geospatial domain. Whether control of geospatial information in the 'water' or hydro environment is located within the military or not, it is important to ensure the UN-IGIF Geospatial Coordination Unit [UN-IGIF SP1, 1.6.2] establishes a structure where institutions follow the guidance of, and participate in, a national geospatial leadership board. Under UN-IGIF, this drives requirements for data sharing, standards adoption and interoperability.

Similarly, many administrations separate responsibilities between the terrestrial and marine domains at a fundamental institutional level. This risks incompatibilities within data and inconsistencies that may be felt at the boundaries of responsibilities, most often in the coastal zone where differences of datum, data collection, purpose and usage need attention to ensure consistent and integrated data is the product of the infrastructure.

Often a large degree of institutional fragmentation is visible when the entire 'water' or hydro environment is considered, including rivers and waterways management, MSP, fishing limits and management of natural resources. Such fragmentation along functional lines has the result of fragmenting data and increasing the requirements for interoperability across the SDI dramatically.

Key, therefore, to defining institutions and charging them with custodianship is the Governance, policy and structure which provides sound, rigorous interfaces between the domains and enables common standards (SP6) covering data (SP4) produced and used throughout the infrastructure. Addressing the boundaries between the land and 'water' or hydro environments can produce an integrated management and production of data and specific key technical areas contribute to this goal. Integrated vertical datums, harmonized scale considerations, interoperable domain content models and adoption of open standards can contribute to a harmonized coastal zone but organizational drivers must act in tandem with the technical aspects to achieve a long term sustainable integrated model spanning the domains.

The Governance Model is key to balancing different needs and defining an optimum structure.

As will be seen many times in this Guide, these dividing lines of responsibility, whether geographic, political, cartographic, administrative, or semantic, require attention to detail and will benefit the most from the UN-IGIF approach. The Governance Model should be specific enough to determine the responsibility, and establish Custodianship, of data within the administration. Institutional responsibilities could be defined, for example, in reference to vertical tidal datums or zones defined in core legislation, the key artefact being the state's baseline.

For some a single geospatial agency, for others a demarcated structure.

Diverging management principles within Marine institutions from that of the national policy set for land information can substantially reduce the return on investment for the public. The Governance model must drive reconciliation of these principles in its institutions to achieve maximum benefit for the public.

Administrations with their own local hierarchies (state/federal) often present another axis of complexity with relationships and responsibilities to be defined. In general, international obligations (more common in the marine domain than terrestrial) are normally dealt with from a federal level while more domestic issues such as planning/zoning and licencing are normally dealt with by sub-national authorities, so interoperability, redundancy, and data-sharing need to be established along with a way of resolving issues should they arise.

1.2 The Governance Model

The UN-IGIF Governance Model under SP1 provides a methodology for developing a coherent picture of how the institutional arrangements meet the needs of the country through the geospatial infrastructure. The primary paradigm shift of recent decades is to view geospatial data as the product of a single state function: an integrated agency, with defined custodians responsible for individual domains equipped with a presumption of reuse and interoperability. Geospatial data, though, seldom resides within a single institution and, as described in this section, this is a particularly acute issue in consideration of the 'water' or hydro environment for many reasons. For the Water element to be fully incorporated in the Governance model several factors should be considered (in addition to those specified in SP1-1.6.4):

- Demonstrating how international obligations are met
- How international relations are supported by geospatial agencies
- How domestic requirements are harmonised with international obligations and foreign affairs policy

From a 'water' or hydro perspective, the following suggested questions assess, critically, how integrated the representation of Water is, in all its forms, within a pre-existing infrastructure:

i) Is there a coherent picture of the "coastal zone"? Are responsibilities and interfaces clearly defined?
ii) Are maritime zones defined in legislation and given due publicity in accordance with international conventions and commitments under domestic legislation? Is adequate, documented geospatial data in the public domain?
iii) Rivers and Inland Waters – does land mapping reconcile with regulated navigational charts?
iv) Does an accurate and comprehensive tidal model cover the extents of all zones?
v) Is it possible to capture the reuse of data between, for example, terrestrial and marine institutions, defence and civil institutions, legislative and mapping institutions, mapping and scientific institutions? Do all institutions enable reuse of data for stakeholders?

1.3 Testing the Outputs

As with most UN-IGIF SPs, there are no fixed outputs from the process against which an implementation can be tested. These should be defined as the implementer goes through the SP1 actions. Some example outputs listed in the SP1 implementation guide are:

- A Governing Board, such as a Steering Committee and agreed Steering Committee Charter;
- A Geospatial Coordination Unit appropriately staffed and with delegated powers, roles and responsibilities, and funding and computing resources;
- Fully functioning Specialist Working Groups (or subcommittees) with specific Terms of Reference;
- Geospatial Information Management Strategy;
- Change Strategy:
  - Data Inventory and Gap Analysis
  - Institution Culture Assessment and Gap Analysis
  - Data Acquisition and Supply Chain Assessment
  - Technology Assessment and Gap Analysis
  - Policy and Legal and Review and Gap Analysis
  - Capacity Assessment and Gap Analysis
- Detailed Country-level Action Plan including a schedule of actions;
- Monitoring and Evaluation Framework and Success Indicators for effective multi-stakeholder monitoring of actions under the Action Plan Road Map.
- Geospatial Value Proposition and Socio-economic Value Assessment.

[Source SP1 1.7]

The template suggests some 'water' or hydro environment specific tests to ensure a truly integrative approach has been taken in the application of the UN-IGIF:

i) Does the Governing Board and Coordination Unit represent the interests of the entire spatial domain of the geospatial environment, including land, the outer limits of UNCLOS

zones (territorial seas, boundaries, exclusive economic zones (EEZ), etc.) and all defined internal waters, rivers and wetlands?

ii) Do the Specialist Working Groups have roles and responsibilities similarly integrated between:
   a) International and Domestic requirements
   b) Land, Sea and Internal Waters
   c) The scientific, mapping and planning/legislative communities

iii) Do the institutional arrangements reinforce an integrative, custodianship arrangement and working approach and discourage the development of domain-specific silos?

iv) Do the Value Propositions encompass and communicate the value of geospatial data in the 'water' or hydro environment and its contribution to the Value proposition of the geospatial infrastructure as whole?

v) Do the institutional arrangements enable a long-term sustainable production of data which is integrated between the Land and 'water' or hydro environments through sound technical architectures and Policy and Legal structures?

2. Policy and Legal (Strategic Pathway 2)

This section focuses on the legal frameworks that drive the geospatial framework creation and address those characteristics, specific to the hydro environment, which should be considered within an UN-IGIF implementation program.

Key observations within the 'water' or hydro domain demonstrate that legal and policy frameworks and their defining geospatial data are co-dependent. On the one hand, it is impossible to build legal and policy frameworks without placing an integrated dataset at their source and the creation of geospatial data is impossible without a legal and policy framework supporting their collection and reuse. The relationship between the law of the sea and cartography is strong, however still undervalued, and the aim of an effective geospatial information framework should be filling this gap.

As outlined in UN-IGIF SP1, UN-IGIF implementation should recognize the importance of delimiting geospatial infrastructure boundaries among its priorities. A fundamental difference between terrestrial and maritime boundaries is the nature of the space on which they are drawn and the length and modalities of the relevant processes for their definition. The development of the international legal framework surrounding the definition of maritime boundaries has become a specialized discipline, through decades of States practice, codification of rules and the case law of international courts and tribunals. Significant technical skills in hydrography and marine charting have been – and still are – required to shape these foundations. In such a context, the UN-IGIF Governing Board (SP1) and Geospatial Coordination Unit (SP1) are entrusted with ensuring that an integrated approach is taken with respect to the collection and use of data and the building of legal frameworks.

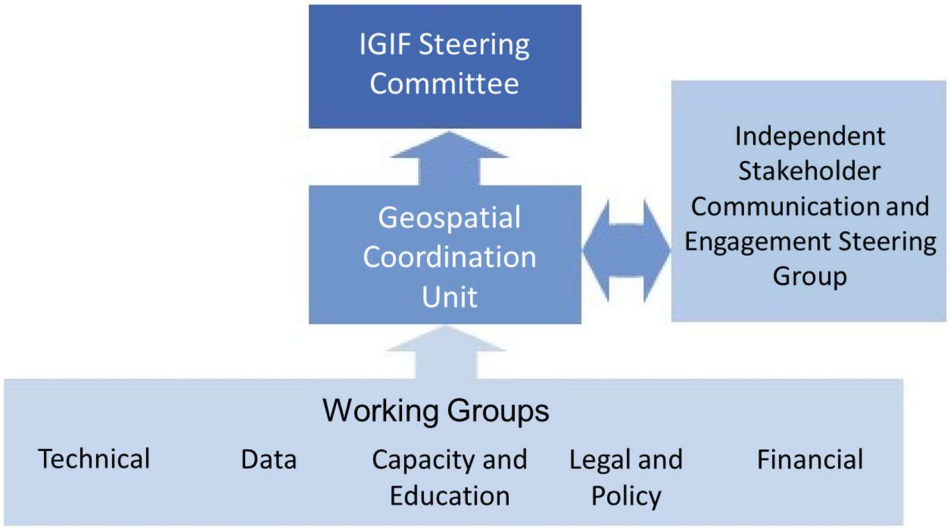


Figure 2: TITLE TBC

As stated in the UN-IGIF overview, the emphasis should be on a "multi-thematic" approach where different uses and stakeholders are addressed simultaneously. Within this context (the above diagram is taken from SP1), the UN-IGIF process should ensure that:

- The country level Action Plan details how international legal instruments concerning the marine spatial domain and its representation on charts are implemented. This stage mainly includes consideration of the SOLAS Convention (in particular, Chapter 5, Regulation 9, "Hydrographic services", in relation to mapping) and the UNCLOS (in relation to those obligations concerning the establishment, deposit and publicity of charts or lists of coordinates – specifying the geodetic datum – of fundamental maritime zones). Obligations deriving from these instruments require specific actions at policy level to enable implementation of the relevant actions and define custodianship, management and updating of data.
- Where spatial data is required to support further regional obligations by zoning or delimitation, then these are defined as spatial data under a suitable custodianship and could be recorded and represented in an integrated cadastre..
- Where a national Marine Spatial Planning framework is required, it is built on the fundamental marine zones as defined in the UNCLOS.
- Inland Water and its relation to oceans and seas should be approached in an integrated manner. This may require the establishment of an Integrated Coastal Zone framework.
- Critical to an effective geospatial infrastructure is a harmonised, sustainable management and model of all such data, ensuring that it is fit for purpose, both legally and geo-politically.

The UN-IGIF implementation should ensure maintenance of a network of interoperable agencies, effective institutional arrangements mandated with the production of

reusable data that meet the relevant needs, enabling the benefits detailed in the value proposition and implementing the provisions of the Governance Model.

One of the main purposes of a geospatial infrastructure in the maritime domain lies in supporting the implementation of international conventions. As stated above, SOLAS and UNCLOS are the two main conventions, but others exist that have significant geospatial components and require consideration in national legislation and governance structures. Instances are to be found in the International Convention for the Prevention of Pollution from Ships (MARPOL) regulations, in further instruments adopted under the auspices of the IMO including spatial and navigational measures, as well as in international, regional and sub-regional legal frameworks to be implemented through area-based management tools. Additionally, more specific obligations, deriving from international legal instruments and involving the analysis, definition and use of spatial data collected from the marine domain, may be recalled and detailed in bilateral agreements between neighboring coastal States – typically, in a delimitation process. These can also govern:

Supporting international obligations, regional and domestic obligations with geospatial data

i) Prospection, exploration and exploitation of marine natural resources
ii) Trade and commercial development
iii) Environmental protection and management (pollution prevention)
iv) Responses in case of emergency
v) Fishing limits and controls
vi) Search and rescue
vii) Scientific Research
viii) Maritime limits and boundaries
ix) Tourism and recreation
x) Blue sustainable growth
xi) Marine protected areas (MPAs) and other effective area-based conservation measures (OECMs)

2.1 Legal Framework

An integrated geospatial information framework should support the implementation of a legal framework with unambiguous, fully populated and non-duplicated data, representing the precise geographical scope of each relevant agreement, convention and domestic legislation.

If the relevant legal instrument is defined appropriately, with an integrated approach, it will duly take into account – although without necessarily encompassing them all in the same text – inland waterways regulations (including prevention of land-based marine pollution), restrictions on trade and commercial development, domestic pollution coastal zone legislation, maritime space, blue sustainable economy, ecotourism.

The goal of compliance with obligations deriving from international conventions with scopes of application geographically defined, therefore, is a big determinant in the production of geospatial data. However, the challenge is the reuse of such data and the production of them in an

interoperable way that also serves domestic requirements and needs. This section further details some of the legal aspects to be considered when representing the hydro environment in the UN-IGIF context, with a view to assisting in placing such a process within an emerging integrated framework between law and geospatial data collection, representation and management.

2.2 International Conventions

Among the international conventions relevant to the UN-IGIF process, SOLAS and rules and regulations concerning the safety of navigation actually dominate the discourse in terms of concrete actions to be undertaken by technical experts and ongoing activities required, such as timely updates of charts and compliance with standardization efforts at the international level. However, UNCLOS has potentially far greater significance, both because of its nature as the global reference treaty for what concerns the marine spatial domain and because of its role in regulating relationships among neighboring States in terms of spatial delimitations. Other instruments should be included, such as MARPOL, IMO resolutions, and the regional instruments and arrangements that exist across multiple sectors (pollution prevention; fisheries regulation, management and control; maritime spatial planning; environmental protection; integrated coastal zone management; etc.).

Production of marine charts discharge a state's SOLAS obligations. These datasets have value broader than marine navigation though.

From the UN-IGIF point of view, the challenge is securing coherence between the production of such marine geospatial data alongside the reuse of data to comply with domestic requirements. The UN-IGIF process emphasizes the interoperability of such data and the need to comply with legal obligations by producing geospatial information frameworks in a coordinated fashion through balanced institutional arrangements.

Navigation and SOLAS

SOLAS is the main international convention driving the production of geospatial data in the hydro environment. It is primarily concerned with the marine domain, i.e. the production and maintenance of geospatial data in the form of nautical charts for the purpose of ensuring the safety of (primarily commercial) marine shipping[6].

For many years, nautical charts have been viewed as cartographic paper artefacts undertaken to satisfy the requirements of the SOLAS Convention. However, these instruments undoubtedly represent also geospatial datasets. The International Hydrographic Organization (IHO) provides the framework and the organization for the establishment and production of nautical charts. Its activities have included the identification of the necessary practical means, including standards, capacity building support and technology resources. These are explored in more detail in Section XX. Cooperation and innovation are two essential complementary aspects of chart production. Full use should be made of the resources available at the global level to enhance these goals.

The SOLAS Convention requires the carrying of nautical charts on commercial vessels and presupposes the existence of a state infrastructure to support this.

The relevant definition can be found in SOLAS, Chapter 5, Regulation 2:

> *2.2 Nautical chart or nautical publication is a special-purpose map or book, or a specially compiled database from which such a map or book is derived, that is issued officially by or on the authority of a Government, authorized Hydrographic Office or other relevant government institution and is designed to meet the requirements of marine navigation.*

The mandatory carriage of charts is provided in Regulation 19:

> *19.2.1 All ships irrespective of size shall have:*
>
> *19.2.1.4 nautical charts and nautical publications to plan and display the ship's route for the intended voyage and to plot and monitor positions throughout the voyage. An electronic chart display and information system (ECDIS) is also accepted as meeting the chart carriage requirements of this subparagraph. Ships to which paragraph [2.10] applies shall comply with the carriage requirements for ECDIS detailed therein;*

The relevant updating obligation is envisaged in Regulation 27:

> *Nautical charts and nautical publications, such as sailing directions, lists of lights, notices to mariners, tide tables and all other nautical publications necessary for the intended voyage, shall be adequate and up to date.*

These three regulations in the SOLAS Convention provide the underpinning framework for the functioning of hydrographic services and offices worldwide. They are often enshrined in one form or another in the domestic legislation of SOLAS States parties, with specific emphasis given to their legal implications.

There is, therefore, an intrinsic legal liability in the production of nautical charts and publications, which is often undervalued by the legal instruments themselves. Such underestimation contradicts the evident relationship between the function of charting and the legal implications of actions or occurrences that are regulated or measured, respectively, within geospatial frameworks. For instance, one of the defining aspects of marine transportation is the amount of liability involved. The environmental and financial consequences of maritime accidents are often far larger compared to the terrestrial ones. Navigational information issued by the State carries an enormous liability, should an incident arise through error or omission. This liability is borne by the State and, where appropriate, by the actual producers of nautical charts. The "liability question" is, thus, a major determinant of the scale and nature of the operations required by a producing State and should represent an important consideration both in the Governance structure (SP1) and in the Policy and Legal structure (SP2).

Establishment of Limits and Boundaries

The implementation of UNCLOS with respect to the establishment of maritime limits and boundaries is pursued by State legislation necessarily through legal instruments that include geospatial references.

Although limits and boundaries are likely to be pre-existing, their use must be integrated and sustainable.

Limits are likely to encompass already all the potential maritime zones envisaged in the UNCLOS (including exclusive economic zones and outer continental shelves), and boundaries are likely to be already settled, in the context of infrastructures with a long history of legislation and international relations. The UN-IGIF approach would be to consider such existing legislation and treaties and their supporting policies and processes as elements of the broader framework of the integrated geospatial infrastructure. UN-IGIF emphasizes the definition of a sustainable approach that guarantees long term reuse of such data through interoperability.

Some examples of elements to be defined are the following:

- Establishing processes and organisational structures to support the acquisition and compilation of data for the definition of a baseline and its component parts
- Defining maritime limits and boundaries
- Supporting national legislative processes
- Depositing standardized data as part of statutory policies at national level and depository obligations under the UNCLOS with the UN Division for Ocean Affairs and the Law of the Sea (DOALOS)

The geospatial nature of the UNCLOS provisions is undeniable. This presents challenges in any national infrastructure as it requires the combination of advanced skills in both the legislative and geospatial domains, as well as demonstrates the need to integrate pre-existing (often historical) data into contemporary systems. By providing the legal framework for all maritime activities, UNCLOS eventually requires the establishment of geospatial datasets and sustainable management processes of geospatial data. Legal and policy frameworks should promote this element as a central component of the UN-IGIF in the hydro environment.

2.3 Other Primary Policy and Legal Considerations

In addition to securing compliance with obligations deriving from international conventions, the infrastructure should bridge global standards and domestic requirements and provide a comprehensive framework for meeting the objectives of the UN-IGIF and SDGs. As noted earlier, the tensions between domestic and international and cross-sectoral competences need to be addressed in a holistic manner. Few agencies serve only a single purpose, and data are required to meet many international and regional commitments. UN-GGIM, therefore, as a geostatistical framework, relies heavily on data to demonstrate legal compliance and technical coherence with international conventions, regional and sub-regional agreements and arrangements and domestic legal and policy initiatives.

2.4 Non-Navigation Considerations

Broader uses of the same data within an integrated infrastructure can be enabled by technological and organizational means. A comprehensive policy and legal framework with full consideration of the variety of uses of the hydro environment should ensure that the relevant data are not produced for a single purpose only.

A considerable amount of data is produced to satisfy navigation-based uses. A reuse of these data should be envisaged that encompass other uses. An UN-IGIF implementation needs assessment should identify a need for “strong influence” (in UN-IGIF terminology) in assuring reuse of data in the hydro environment outside the navigational use case.

Similarly, there is a need for strong influence when defining policy and legal structures aimed at ensuring that data are made available for the purposes of scientific research and education. UN-IGIF places great emphasis on these elements and again, the production of data is often focused solely on navigation needs and does not take a balanced approach across multiple stakeholders and multiple sectors.

Scientific research often requires data from across boundaries; therefore, standardization and interoperability are required to ensure that data are fit for such reuse by the scientific community. Adoption of international standards can be crucial to ensure interoperability between different national stakeholders. Scientific research is critically dependent on data that spans boundaries, and the marine domain, due to its fluid nature, is acutely sensitive to these dynamics.

2.5 Data Protection, Licencing and Sharing

The fundamental nature of maritime mapping, and the high cost of its acquisition, gives it a substantial value. The “official” view of the marine domain can attract value from outside the navigation community. Seamless integration with terrestrial data can also increase such value for ancillary purposes. Similarly, other institutions can often hold data which has “value” across many different sectors. Most institutions create by-products alongside their primary responsibilities which have value elsewhere. The value of such datasets can sometimes outweigh the value of the processed, finished product.

The aim, in the ‘water’ or hydro environment, therefore, is to ensure that the significant value of data gathered is realized within the policy and legal framework. Any policy or legal framework should define a sustainable business model for its institutions as well as guidance for how, and to what extent, data in the national infrastructure can be licensed, shared, and used.

The most common example is navigational charting, as a primary output of the geospatial infrastructure which can be monetized and can provide a sustainable commercial basis (at least in part) for the infrastructure’s operations.

The decision and adoption of a business model should be predicated on a broad picture of the value proposition for the country as a whole. Monetizing any data restricts potentially its supply to those who are able and willing to pay. This should be balanced against the income generated (which can sustain many infrastructures). This consideration exists across all domains – but in the ‘water’ or hydro environment the situation is more acute because of:

i) The highly regulated and authoritative nature of marine chart data and the sustainable direct revenue stream it can enable.
ii) The high cost of acquisition and processing of marine data.

Commercial distribution often leads to requirements for data protection. In the context of the hydro environment, where data is released for navigation purposes the implicit risk and extremely high impact of it is an important consideration. Legal liability for navigational data is generally borne by the state and this can affect the cost of its acquisition and processing significantly. The safety critical nature of the marine transport domain (both in marine areas and inland waters and navigable waterways) enhances the need for data integrity. A range of technologies and standards can be implemented in this respect. How data integrity is assured for data custodians and their users is therefore a high priority.

2.6 Outcomes

The UN-IGIF presents a set of outcomes for Legal and Policy implementation as follows:

- Sound and enabling policy and legal environment that maximises the utility of geospatial information and safeguards a jurisdiction or entity's interest.
- Effective and secure management, sharing, integration and application of geospatial information.
- A policy and legal framework that evolves over time, responds to societal progress and technological developments and keeps pace with fast changing economic, societal and personal landscapes.
- Clarity in responsibilities and mandates, strengthening governance and accountability in geospatial information management.

The following suggestions are made for outcomes from the Policy and Legal strategic pathway for the 'water' or hydro environment. These complement those set out by the UN-IGIF.

- The concept of authoritative and custodianship, legally and organisationally, defining the Custodians for the foundational data making up the elements of the 'water' or hydro environment.
- How legal responsibility is devolved into the participating institutions in respect of custodianship.
- Clear Policy and Legal framework covering custodianship and production of data for international conventions, and support for domestic legislative and planning purposes. This should also satisfy national requirements with Water equally represented alongside any terrestrial framework.
- A commercial framework for data licensing which balances the utility of free and open release with the need to provide a sustainable business model for all institutions.
- A rigorous assessment of legal liability, with particular reference to marine and inland navigation.
- How to implement mandatory elements of the internal infrastructure for interoperability, and the use of consensus based, open and free standards.
- A viable, sustainable resource framework for the institutions in the infrastructure including a business model.
- How the institutional arrangements are implemented. Key regions specific to the 'water' or hydro environment such as the coastal zone should have well defined responsibilities for interoperability and data sharing.

3. Financial (Strategic Pathway 3)

This strategic pathway establishes the business model, develops financial partnerships, and identifies the investment needs and means of financing for delivering integrated geospatial information management, as well as recognizing the milestones that will achieve and maintain momentum, and realize benefits.

While the core concepts of the Financial Strategic Pathway are the same as those within the broader UN- IGIF, the implementation guidance provided within UN-IGIF-Hydro are intended to highlight and address considerations specifically focused on marine geospatial information.

Financial governance, planning, management, and investment are required to achieve sustainable integrated geospatial information management. Investment will typically be realized when governments can see evidence that geospatial information will deliver social, environmental, and economic benefits nationally, and there is a corresponding and credible financial plan to realize these targeted benefits.

It is important to realize that these benefits may not be realized in a manner with a clear financial Return-on-Investment. Some investments may provide less direct economic benefit but instead primarily provide benefits to society or the environment, such as supporting marine protected areas. Other investments may support opportunities where the benefits realization may not be easily quantifiable – and if quantifiable, perhaps not fully known for many years to come, for areas such as climate change. Member States may consult the UN-IGIF-Hydro Value Propositions to further consider the value of investment in a variety of use cases.

Member States should establish a business model (preferably one that is documented and agreed upon at the highest appropriate level) that is compatible with their country or organization's fiscal policy; identify opportunities for aligning marine geospatial data use cases with national objectives, partnerships, and potential benefit; determine the business case for why investment is needed now, how much is needed, funding sources, and economic return; and a method to evaluate, monitor, or measure benefits realized through the investment.

The approach to the Financial SP consists of four elements, each with its own set of guiding principles, key actions for strengthening geospatial information management, tools to assist in completing the actions, interrelated actions, and outcomes. Additional information on the approach and on each of its components is contained on pages 4-32 of the UN-IGIF SP 3 (Financial) document.

Implementing the aforementioned approach will in turn deliver needed and sustainable national outcomes and benefits for a country, including:

- An investment plan that includes current funding sources, obligations, and estimates for future years;
- New funding initiatives identified to meet the priorities for integrated geospatial information management;

- A financial accounting of costs associated with all aspects of a national integrated geospatial information program;
- The socio-economic value of geospatial information that is well defined and aligns with the financial plan to realize benefits, quantified to the most appropriate quantifiable value.

While the UN-IGIF and UN-IGIF-Hydro serve as bases and guides for developing, integrating, and strengthening marine geospatial information management, there is substantial flexibility within the approach. Each individual country's governance, plans, policies, and value outlooks can and likely will lead to different implementations through the Financial SP.

The UN-IGIF-Hydro recognizes components of the approach to the Financial SP which may be of particular importance, if not inherently unique, to the marine geospatial domain. Emphasis on aspects of the marine geospatial domain which differ from that of the land and other domains is recommended, such as the following:

Business Model

Some Member States will choose to give information away for free to allow for maximum equitable access to their data; some Member States will decide to charge for their data; and while it is not recommended, some Member States will allow very limited access to their data. Governments and organizations following each of these business models exist within the marine geospatial domain, though they are present in the broader geospatial domain as well. These business models, and others, are further detailed within the UN-IGIF SP 3 (Financial) document.

Opportunities

The marine geospatial domain offers a unique set of investment opportunities, and challenges, in comparison to terrestrial geospatial data. Ocean-related geophysical processes do not start or end at the edge of territorial boundaries or EEZs, and a significant portion of the ocean lies beyond the limits of national jurisdiction.

Opportunities in the marine geospatial domain include the realm of ocean and marine science, sonar data collection, ocean bathymetry, and the blue economy. Given the span of the ocean and its processes, regional and international partnership is beneficial in finding the opportunity to join investment with capability for the benefit of all involved.

Investment

Discovering opportunities to recuperate investments into marine geospatial information programs can be a challenge, but opportunities do exist for Member States to consider within the context of their national objectives. A practical manner to address this challenge could be identifying opportunities specifically aligned with maritime geospatial information programs supporting national goals, international treaties, contracts, and partnerships.

One common national objective is the production and distribution of nautical charts (in digital or paper format) to fulfill obligations under the Convention for the Safety of Life at Sea (SOLAS). The sale of these nautical charts, and the products and services derived from them, provides one method to recuperate funds invested into the collection and processing of data and the dissemination of products and services. Some countries may opt to join a Regional Electronic

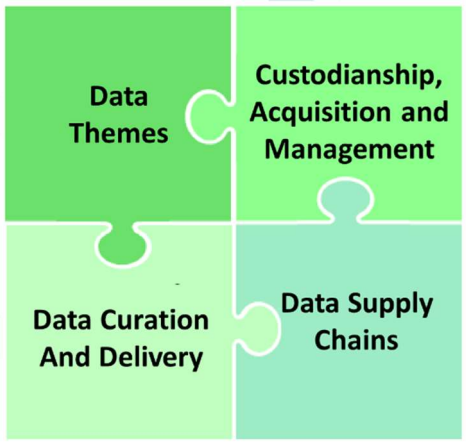
Navigational Chart (ENC) Coordination Center (RENC) which will assist its Member States in managing the distribution chain (from the Hydrographic Office, to the Value Added Reseller, to the mariner), assist with quality assurance, and return regular distribution of payment from the sales of charts and other products.

Benefits Realization

In most cases, marine geospatial data can provide positive benefit to at least one (if not many) of the UN Sustainable Development Goals locally, regionally and potentially globally. These benefits may not be strictly financial, and the realization of some benefits may be clear while others remain more difficult to define and to measure. Particularly, if dealing with the ocean and its far-reaching impacts, the measure of benefit financially, socially, and economically may be better viewed through a wider lens.

4. Data (Strategic Pathway 4)

Data is, of course, one of the central elements of the UN-IGIF approach, forming the essential subject matter of the UN-IGIF process. Data must always co-exist with its defining governance and institutional framework (SP1), legal and policy elements (SP2), and other aspects of the UN-IGIF. Within the 'water' or hydro environment the co-dependence of data assets with their defining environments is common. There are many defining characteristics specific to the 'water' or hydro environment which are explored further within this section.



From the hydrographic side these include the requirement to implement data to support international conventions such as SOLAS for the production of standards conformant hydrographic charts, and data to support legislative and planning processes. This section also looks at how Water is approached domestically, both for oceans, seas, and inland waterways and watercourses. A well-coordinated geospatial programme will establish an integrated infrastructure and there is always a need within the UN-IGIF for an integrative approach. This section looks at how this domain can be implemented using the UN-IGIF methodology and the guidance provided in SP4. This focuses on how data representing the Water elements can be considered in emerging infrastructures and how interfaces between institutional arrangements can be established to enhance reusability within different custodianship models.

The key to an integrative approach is a balance between the custodianship implemented by the institutional arrangements and the interoperability demanded by the different stakeholders. The 'water' or hydro environment within a national geospatial infrastructure is no different in this regard. Whatever the institutional arrangements implemented, the integrative approach should measure and develop reuse between institutions, partners and innovators in pursuit of the SDGs.

4.1 Data in the 'water' or hydro environment

Because the Water and Terrestrial domains are fundamentally different there is often a focus on their defining models and the difference between them. A model is a description of the underlying structure of its content and the relationships of its component parts. Models represent a core part

of the technical element of data and are an abstract description of a domain in standardized form. There is a strong link between the development of models and standards associated within them and interoperability is founded on compatible models and their characteristics.

- Within the 'water' or hydro environment, the characteristics observed in other SPs in this guide are strongly evident:
- Within the Hydrographic domain there is a common model for the representation of data focused on the production of hydrographic charts. This is an inherently international model in focus and scope and requires a knowledge of the conventions they are designed to implement.

Domestic modeling dominates modeling of the 'water' or hydro environment for internal waters, rivers, and watercourses. Often these are integrated with models designed for land mapping, planning, and other functional areas of the infrastructure. There is therefore a need for interoperability between international and domestic models.

The Key to integrating the diverse nature of Land and Sea is through models which describe their structure.

The core challenge, crucial for an integrative approach, is to develop and implement under the UN-IGIF, content models which fulfill a requirement for interoperability. This is described further in section 6.8.

A focus on this is vital in the geospatial strategy (SP1) and actions of key stakeholders (SP9) UN-IGIF components. In order to break down this challenge, the UN Fundamental Geospatial Data themes are a good place to start. In a geospatial infrastructure the model underlying any data is crucial to its onward use. Promotion and distribution of models in technically rigorous form alongside simple, digestible documentation should be a prerequisite for all institutional arrangements.

Most, if not all, infrastructures partition data content into a number of fundamental themes and the UN-IGIF methodology is no exception. Note that these partitions do not always necessarily match the institutional boundaries defined within SP1. Indeed, such an approach should not be seen as defining exclusive boundaries, but merely a high level grouping of data content.

Models should fulfil a requirement for interoperability.

The next set of subsections focus on the 14 Global Fundamental Data themes as defined under the UN-IGIF[7], and how Water can be represented in them, referencing models and standards which may already exist as a starting point.

4.2 The Global Fundamental Geospatial Data Theme of Water

The fundamental theme of 'water' or hydro is central to this Guide's purpose. This is the area where data representing Water is centralised. Data in this theme can represent any of the broad array of Water features such as Oceans and Seas, Internal Waters including rivers, watercourses, lakes and reservoirs, wetlands and glaciers. Also within the domain of this theme are the extents to which 'water' or hydro influences physical processes, its qualities as a natural resource, and the many uses made of it in relation to human existence.

Although other Fundamental Gespatial Data Themes include 'water' or hydro by reference (described in the next section), this section articulates the nature of Water Data in UN-IGIF terms and defines some of its primary qualities, which form core elements within geospatial data.

Water is characterised by several phenomena:

i) It is four-dimensional. Because of its dynamic nature, its "flow", Water is characterised by movement in time. So, attribution of time is often a far more primary concern in Water based data.
ii) The primary temporal measurements associated with 'water' or hydro are Tides and Flow. Tides and tidal currents, caused by gravitational effects, and the flow of rivers and watercourses influence all water-based geospatial data to some degree. Many of the aspects of the fundamental themes described in the next section stem from this dynamic nature of the medium.
iii) Water's dynamic nature and its impermeability make it a technically challenging phenomena to measure. The cost of data acquisition is very high compared with much terrestrial acquisition and its characteristics make it difficult to analyze via satellite imagery in some cases. Hydrographic survey is still a highly skilled field with a high degree of processing involved in the creation of usable data. This cost of data acquisition has always been high, and the impacts on datasets reflect this. Hydrographic datasets are often premium priced, and rely on a long historical backlog of data due to the cost of periodic resurvey.
iv) Data associated with Water reflects uncertainties in, for example, data quality and uncertainty models and zoning via delimitation, rather than the demarcation of terrestrial zones.

These aspects are reflected in any model describing Water features, whether oceans and seas or internal waters. The links with the overall SP1 and SP6 Pathways are crucial:

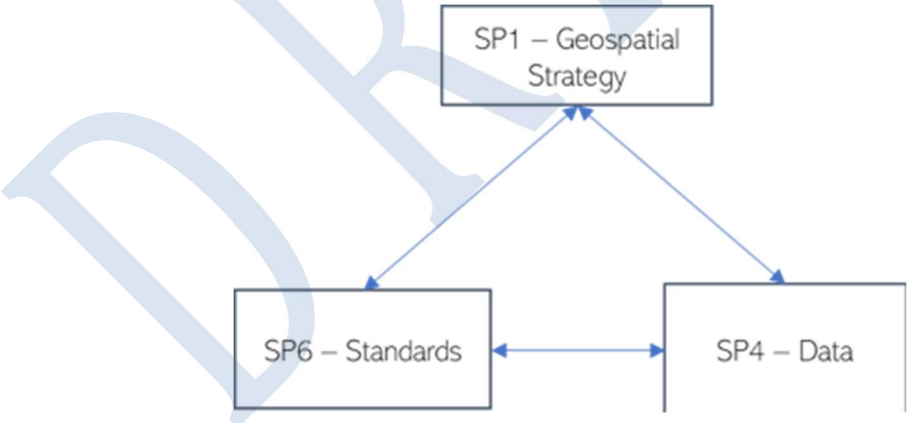


Figure 3: Linking strategy with standards and data.

This is the starting point for an integrated approach to the 'water' or hydro environment. In the remainder of this section we look at how the geospatial data content of the UN-IGIF can accommodate a Water dimension by examining the most relevant parts of the fundamental themes.

Themes undoubtedly will reflect the country's delineation of responsibilities, its physical geography, priorities, neighbours, and other factors, and will naturally develop over time. By understanding both the unique defining infrastructure elements and the characteristics of the domain, Water can be represented within a country's UN-IGIF Action Plan and fulfil the Vision of an integrative approach across the geospatial data spectrum.

4.3 Other Global Fundamental Geospatial Data Themes

Global Geospatial Reference Frame has many aspects which affect Water elements of the geospatial infrastructure. A reference frame provides the mechanism for measurement of any spatial data, giving a meaning relative to the Reference Frame of "where" the data is. A "position" is meaningless without it being referenced to some form of reference frame.

The GGRF represents a single, consistent reference frame that can enable interoperability across an infrastructure, a region, and globally. Ultimately, the goal of clarity within any exchange of geospatial data is defined by "where it is" – clarity of location is dependent on clarity of the associated reference frame as well.

Within the hydrographic domain, often mapping and charting is referenced to old, historical, and possibly obsolete datums. Due to the cost of acquiring and processing marine data (often far greater than the cost of terrestrial data acquisition) older datums can exist in official datasets for many years. In addition, legislative instruments may reference old agreements and treaties referencing locations. Referencing these datasets can pose challenges. In these cases textual recording of such positions and datums can form part of its metadata.

Modern Hydrographic charts are mandated by content standards to use WGS84. This has modernised many older datasets, and all modern survey outputs for charting use WGS84. WGS84's relationship with GGRF/ITRF is, for the most part, manageable in the context of mapping and charting with minimal practical differences. Conformance to standards and an awareness of the issues is an important part of the infrastructure. Modern content standards such as IHO S-100 allow a range of both horizontal and vertical reference frames in their frameworks. For many reuse cases, and for domestic use, a sound reconciliation between horizontal datums is crucial for all elements.

Resolution of vertical datum differences between land and tidal water areas often require the production and definition of a correction surface. These surfaces are often key to production of data which is integrated in coastal zones and tidal watercourses and should be a priority for infrastructures. Accurate vertical datum harmonisation is key to data management for flood management and modelling of coastal zone processes for many stakeholder groups.

Geographical Names are crucial to any national geospatial infrastructure. Within Oceans and Seas names frequently take on significant geopolitical dimensions and have international considerations, from the content of the name itself and the geospatial limits associated with it. Part of establishing Custodianship Arrangements should be to ensure clear responsibilities, models and standards relating to naming that extend well into the domain (e.g., including islands, low tide elevations, subsurface features as well as rivers, lakes and regions), to curate what can be an extensive historical and complex archive, and to ensure domestic and international requirements are met (e.g. language, translations, pronunciations, display and colloquialisms). A framework for representing and defining names of marine features exists in the IHO standards and guidance is contained in IHO B-6. INSPIRE and the United Nations Group of Experts on Geographical Names' Glossary of Terms for the Standardization of Geographical Names and Manual for the National Standardization of Geographical Names are examples of best practice approaches to harmonising naming and language across multiple domains.

Addresses are normally conceived of in the context of land and buildings for identification of named locations and underpin many functions of local and national government. Consideration of the 'water' or hydro environment is generally a spatial relationship; ensuring that land/water boundaries are stored and clear and that custodianship arrangements promote such clarity. As with many other themes, where the domains intersect is often an area which requires precise definitions; for example, addresses of water-borne vessels whose locations may move, or ensuring the delimiting area of addresses are coincident when they include 'water' or hydro components, such as residential perimeters on the coast or on waterways. Addresses may use named, located 'water' or hydro-based identifiers which should be harmonised within models for Geographical Names. Addresses for major marine infrastructure such as large ports, terminals, and vessel berths are crucial for international trade and their accuracy and interoperability can have a substantial impact on the efficiency of infrastructure.

Functional Areas underpin the "zoning" process and, as noted in SP1 and SP2, Functional Areas must contain adequate expressivity to describe Water-based zones as well as the numerous and complex domestic and terrestrial features within this theme. As described in SP1, Functional Areas as a theme will include Administrative Areas with a significant international and transboundary element and with significant geopolitical implications. Both the foundational data, Baseline, Territorial Sea and EEZ are within this theme as well as MSP and planning zones such as Fishing Limits, Planning Zones, Flood limits and local jurisdictions for Local Authorities, Ports and other regulatory authorities. Transboundary agreements and treaties require clear, unambiguous representation which is interoperable with national implementations of their principles. IHO content standards under S-100, S-121 and S-57/S-101 contain minimum themes for Administrative and Functional Areas. An example of Marine Administrative Areas is contained in INSPIRE. A national implementation may be influenced heavily by local geography and institutional arrangements.

Land Parcels and Properties **-** An integrated Cadastre is fast becoming a reality in many established infrastructures and is starting to be recognized in domain standards as well. The connection between geo-regulation and Cadastral management is significant and within the

'water' or hydro environment the relationship between Cadastral and Functional Areas should be close and clearly defined. International Organization for Standardization (ISO) 19152 is an international standard which apportions Rights, Responsibilities and Restrictions to collections of geospatially delimited features. Recent work is extending this to Marine Administrative Areas. This will result in a sound conceptual foundation for an integrated cadastre which can be built on and adapted to country requirements. As with administrative areas, models for cadastre should be defined which meet domestic requirements and ensure spatial harmonisation between institutions.

Elevation and Depth - Depth, as the corollary of elevation provides unique challenges and tests as to the interoperability of the domains of data relating to Water and can be used as a test case to assess the extent of the integrative power of an UN-IGIF implementation. At its heart, depth and elevation are both measurements from a reference surface – and should be viewed conceptually as two complementary aspects of the same phenomena. A closely derived concept is the contour line, a line of equal depth or elevation and, specific to the marine domain, a depth area, an area where all depths fall between two defined values. These are the fundamental building blocks of any model integrating elevation and depth.

To have both elevation and depth referenced to the GGRF is essential to an integrated infrastructure and the modeling and custodial arrangements should ensure that both aspects are clearly defined to meet user needs. Harmonization of vertical datums is a particular issue between land and sea data and is crucial for an integrated infrastructure. Water is, of course, often subjected to tidal forces. The dynamic nature of the medium means that at its core, Water data has a more complex vertical datum and also an implicit temporal quality to it. Many marine infrastructures, oriented primarily at hydrographic charting, use multiple vertical datums in order to represent "safest" margins to their primary users. Chart datums, based predominantly on Lowest Astronomical Tide and clearances/elevations referenced against Highest Astronomical Tide or Mean High Water Springs mean there is a requirement to hold a multiplicity of vertical datums, for them to co-exist within geospatial datasets and for accurate and reliable tidal recording and modeling to be an integral part of the data infrastructure. By contrast, most terrestrial infrastructures are founded around a single referenced vertical datum and their quality is its consistency around that datum. The meeting point of depth and elevation should be a particular focus point. In order to enable interoperability between elevation and depth data in coastal zones, the last 20 years have seen an increase in technologies for the creation of correction surfaces.

Depth is one of the four dimensions of Water and appears in an incredibly broad range of contexts. Application models such as data acquisition through survey, selective (shoal) mapping of depths, tides and currents, flood mapping, erosion and many other elements of the spatial infrastructure depend on sound modeling, data management and interoperability. There may be substantial dependencies between institutions and use cases – for instance elevations of navigationally significant features. References such as INSPIRE (elevation) and IHO standards provide conceptual foundations for integrated approaches to modeling Elevation and Depth and should be a starting point for an UN-IGIF implementation's Geospatial Strategy and Action Plan in relation to this theme.

Geology and Soils data should include the ability to integrate Water-specific elements including seabed, riverbed, wetlands and coastal regions as well as the effect of water such as permeability and flooding. Bathymetric and backscatter data is a means to gain information about the substrate, both in shape and type. This can be used to identify habitats, bottom types, geomorphology and contribute to risk analyses of coastal erosion and slope stability, to name a few.

Land Cover/Land Use - Land Use and Cover data must include consideration of Water in its modelling and is a key component in many management elements of the SDGs. Climate change impacts, Flood management, Conservation and MSP can all be included in a harmonised classification system of "Use". Clearly defined boundaries (where the Land Meets the Sea) are crucial to ensure accuracy of delimitation and the dependencies on Cadastre, MSP and Administrative Areas are key to efficient data representation. As referenced in the fundamental data themes, Land use, like functional areas, are often required in disaggregated levels to allow local, regional and national infrastructure to function. Data Models and custodianship arrangements need to be able to accommodate such flexibility through interfaces and an integrated Strategy and Action Plan. The Data Inventory should be able to explain how such interoperability is achieved in the hierarchy as well as across the entire spatial domain.

4.4 Acquisition and Management

Within the 'water' or hydro environment, cost is a major factor, as well as management of old data and the need to ensure proper custodianship. The cost of acquisition inevitably leads to the inclusion of a larger quantity of older data (given the cost of its renewal), so most survey programmes are highly selective, predicated on where it is needed most. This can be in areas of perceived high risk (serving the needs of the navigation community), areas of high temporal change (due to seafloor condition or aftermath of natural disasters) or for a host of other reasons, for example mapping critical habitats for endangered species, identifying the extents of highly productive areas for commercial fisheries, protection of the ecosystem and other infrastructure developments.

The cost of acquisition and processing of marine data is high. This influences use and management practices throughout the processing and supply chain.

There is a need, therefore, in the 'water' or hydro environment to ensure resource decisions account for the high cost and benefits of multi-use data. Because of the high acquisition cost, the need to survey for multiple purposes is vitally important. This is not always possible but should be a large part of the consideration.

Acquisition also needs to take into account all opportunities to get data through surveys for other purposes, e.g., exploration and science. There is also a need to promulgate surveys for other purposes – to reach out to user communities and conduct extensive user needs analysis.

The high cost has other consequences:

- The need to establish Custodianship with an appreciation of the broad use cases for such data and the high cost of its acquisition.
- Archives assume greater significance with marine data. The requirement to hold comprehensive archives, alongside populated metadata in a structured form is vital.

Unlike the terrestrial domain countries rarely survey their entire region to a consistent scale given the high costs involved, so many hydrographic producers prioritise capture to areas which are used heavily.

4.5 Data Quality

Data Quality is a frequent topic in all geospatial data domains and is of particular interest in the 'water' or hydro environment. Although current data has a certain value (and is the subject of many use cases) historical data is of profound importance for scientific research (for example climate change and tidal modeling). Data Quality is an essential component of metadata for all content and extensive models are devoted purely to the subject of data quality which can extend over multiple sub-domains and sub-genres.

4.6 Custodianship

Custodianship is a major principle within the UN-IGIF and one where the UN-IGIF data theme roadmap plays a key role. Assigning custodianship within Water data has some specific challenges, similar in nature to those seen in previous sections of this guide. In data terms, custodianship recognizes the "authoritative" nature of the custodian. The responsibility for interoperability of data should be implicit in the role of the custodian.

Custodianship is inseparable from Identifiers in Data.

In data terms, as already noted, there are specific aspects with maritime data in terms of legal liability that increase the responsibilities of institutions. These may then influence the use of, for example, digital signatures and secure communications channels to ensure data integrity. For other types of 'water' or hydro-related data in the scientific domain, there is often no legal liability and standards may not be well established and metadata not understood or completed rigorously.

Custodianship confers a requirement to maintain identifiers.

Persistent, unique identifiers are a key element of data under custodianship. When data is defined, an identifier is created and retained for its lifecycle. Themes need to define the form and content of such identifiers, ideally within an overarching standards framework. This, essentially (from a technical standpoint), is what custodianship is, the authority over data which represents a real-world entity. Its identifier is the map from the entity to its logical representation(s). Custodianship infers a strong requirement to maintain such mappings. The 'water' or hydro environment can place many challenges in this respect as data acquisition costs and its dynamic nature can make identifiers difficult to maintain.

4.7 Interoperability

If consideration is given to the Fundamental Geospatial Data Themes and 'water' or hydro aspect is represented in the models describing the structure of data within all the domains in the infrastructure, then interoperability can be developed as the infrastructure grows and matures.

Interoperability of data content is fundamental. With custodianship, interoperability defines how data “moves” within an infrastructure. This view of freely moving data is the key transformative vision of an integrated geospatial infrastructure. Standards have an important part to play in this process. The key to the success is to:

> Ensure **interoperability** between the data representing ‘water’ or hydro and the rest of the geospatial domain

How should such interoperability be achieved? The ‘water’ or hydro environment, as described elsewhere in this guide, can be overtly predicated on meeting international conventions but these conventions may not be concerned primarily with non-navigable waterways, and hence miss more complex use cases involving water supply, flood management, leisure and coastal and intertidal zones.

Models to describe these areas can be complex, whereas SOLAS charting is relatively simple. The example below contrasts the INSPIRE model for Watercourse network models and Rivers within IHO S-101. Each model represents different essential facets of the nature of a river, its flow, width, geometry, network characteristics, names and identifiers.

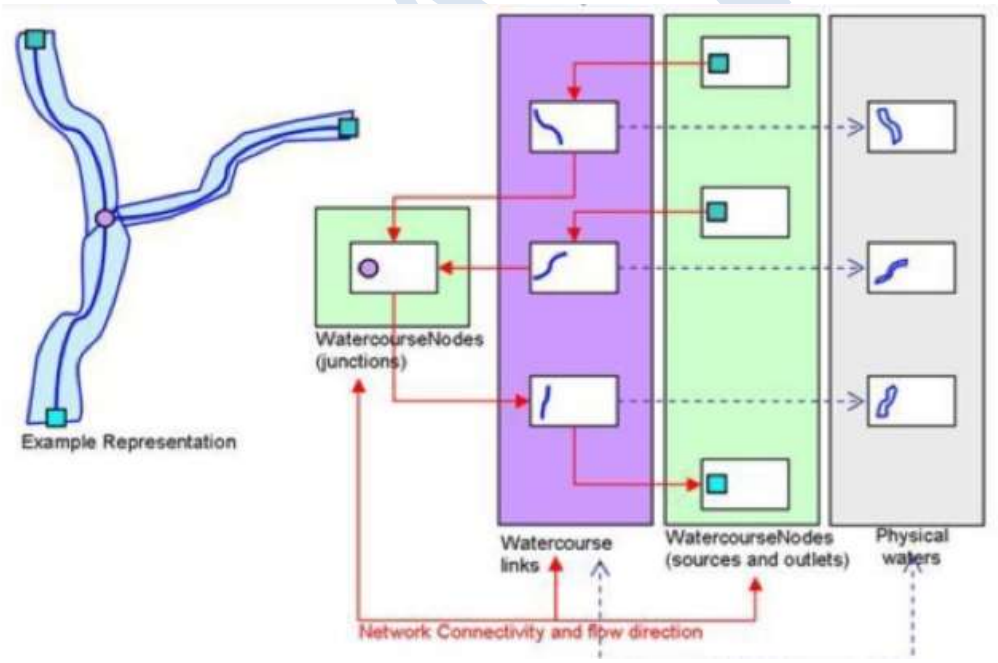


Figure 4a – TITLE TBC

IHO Definition: **RIVER**. A relatively large natural stream of water. (IHO Dictionary – S-32)				
S-101 Geo Feature: River (RIVERS)				
Primitives: Curve, Surface				
Real World	*Paper Chart Symbol*	*ECDIS Symbol*		
S-101 Attribute	**S-57 Acronym**	**Allowable Encoding Value**	**Type**	**Multiplicity**
Feature name			C	0,*
Display name			(S) BO	0,1
Language		ISO 639-1	(S) TE	0,1
Name	*(OBJNAM) (NOBJNM)*		(S) TE	1,1
Status	(STATUS)	5 : periodic/intermittent	EN	0,1
Scale minimum	(SCAMIN)	See clause X.X	IN	0,1

Figure 4b: Waterways and Rivers, INSPIRE and IHO S-101

So, the establishment of the UN-IGIF must ensure that either:

i) Data exchange between institutions use identical technical content standards, or
ii) Work from a common data model which encompasses all domains.

Interoperability is crucial

As noted elsewhere, the diversity of requirements around 'water' or hydro (International vs domestic) and the fundamentally different qualities of 'water' or hydro such as its flow, its temporal and changing nature can make such requirements challenging. The UN-IGIF's pathways provide guidance for designing such interoperability when implementing the Fundamental Geospatial Data Themes.

Interoperability should deliver the ability to transform data between two different models (independently of format) using automated transformations rather than requiring manual interventions. Automated transformations convert data instances (features, attribution, geometry types/datums and metadata) from one domain to another. The domains in question are often embodied in content standards or derived directly from them.

The issues, frequently in the maritime domain are:

i) Extremely specific combinations of features and attributes are required to satisfy strict SOLAS requirements that may not be captured or met in domestic data capture programs.
ii) Datums between terrestrial and 'water' or hydro-based data collection may not be harmonised.

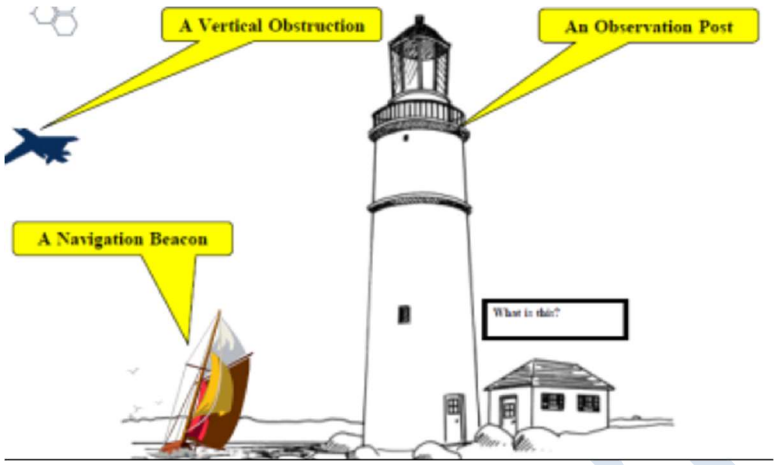


Figure 5: Differences of interpretation of features

Ultimately, a practical model must be arrived at which expresses each entity, its identifier, component parts and the relationships it has with other entities along with a defined association to "where" it is. This assessment and encoding of a real-world entity has a long and well established technical methodology and results in the construction of models which describe the structures used across the infrastructure for storing, managing and encoding geospatial data. The overarching ISO19100 series of standards presents a general feature model which can be adapted for any number of different domains. The ISO framework is implemented by IHO and Open Geospatial Consortium (OGC) standards. Under the ISO approach a model is formed of a domain with features, identifiers, and names alongside its location.

Models should not be confused with formats. The model is the representation of the data, its structure, relationships and entities defined. The format is the digital encoding for exchange of the data between participants.

The initial data framework within the hydro environment, therefore, should place great emphasis on ensuring commonality of underlying data models and interoperability between data models for all domains established within the infrastructure and focus on the interface between domains where they exist.

Some examples where different domains may need to harmonize data and modeling are:

- Baseline points where established on land.
- Coastal zone delimitation. Navigationally significant land features.
- Common depth area delimitations between major ports and hydrographic office inputs/outputs.
- Vertical Datum definitions and types for reconciling land and sea datasets.
- Coordinates used in environmental legislative frameworks for MPAs which then require promulgation via navigational charts as restricted areas of operation.

The data inventory, established as part of SP4, should record model characteristics, pathways and interoperability details between participants in all the geospatial domains and their custodians.

4.8 Actions – the Geospatial Framework

The National Integrated Geospatial Information Framework defined in the UN-IGIF should represent the 'water' or hydro, especially the maritime, elements alongside all other content seamlessly. The framework produces a description of what is held, its defining models and the definitions of content.

In the hydrographic domain, as with many of the other SPs, the challenge is to harmonize the domestic, country needs and requirements with those defined under international conventions and obligations. For instance, the requirement to produce navigational charts forces the existence of a focused survey program to ensure safe navigation and the production of datasets reflecting international standards for navigational charts ("depth areas" containing delimited areas of maximum and minimum depth) as well as the raw survey data (and its metadata). Similarly, nearly 200 data "types" are defined by electronic charts (normally, but not always, aggregated together in a single logical data store).

It is not difficult to find examples where states have institutions responsible for implementation and maintenance of aids to navigation, ports with significant amounts of charted infrastructure, canal waterways, waterborne transportation and trade. The state may also require many different kinds of reuse of marine data, e.g. energy production, domestic legislative purposes (exploration, research, MSP). Some of these institutions will produce data for their own purposes with a secondary responsibility to the hydrographic office.

4.9 Data Supply Network

Methods of delivery – during the last 20 years the method of delivery of all geospatial data has undergone a seismic shift. The advent of web mapping and the range of technologies supporting it promoted a decentralized approach. Previously, geospatial data was invariably transported wholesale and viewed within standalone GIS only. This necessitated a physical transfer of data permanently from one location to another. When the OGC and others developed early web services, web mapping from geospatial web services with portrayal and data content specified became a reality. Web Mapping, with the advent of vector tiling and various mapping frameworks is now a well-defined area with many participants and a fast rate of development.

In the supply chain for mainstream geospatial data, distribution via Application Programming Interfaces (APIs) is fast becoming the preferred method among many providers. In this case data is not permanently transferred, only downloaded and rendered when required. In the Marine domain, however, mapping and charting remains a static use case with navigation under ECDIS requiring timestamped safety critical data in place for live navigation. Hydrographic charting is not a real time use case like much geospatial data; charts are constructed from multiple data sources, then issued to recipients.

So, there is often a disparity of data supply between core marine hydrographic data (however much it is distributed online) and its reuse via web service APIs. Due to the frequently diverse data models (as noted in the previous section) integrated datasets are often scarce.

The other reason for static data transfer is where large network latency and speed of transfer of large data volumes are a consideration. Within big data fields and data science API access is often not efficient enough to consider data science. High performance and analytical systems must cache data locally for optimal performance.

4.10 Overall outcomes – Testing the outputs.

In terms of measuring the outcomes of the UN-IGIF Strategic Pathway 4 – Data, the following observations are made:

i) The inclusion of Water elements and marine data within the integrated infrastructure increases the range and scope of the infrastructure and ensures clarity over custodianship and content.
ii) A focus on interoperability and inclusion to harmonize disparate international/domestic requirements will enable coordination of the marine parts of the infrastructure.
iii) Only through focused resourcing of interoperability will potential benefits and cost savings identified in the UN-IGIF be realized. Integration between national infrastructure, the international ecosystem and the geostatistics community is achievable through a systematic sharing of technology and data modelling expertise throughout the infrastructure. Therefore, education and communication is vital.

Figure 6: UN-IGIF Data outcomes.

In terms of testing the outputs – what characterizes an UN-IGIF approach and its outcomes?

i) Existence of 'water' or hydro elements within a centrally coordinated infrastructure. This should represent all forms within the national infrastructure – Oceans and Seas (for coastal states), inland waterways, rivers, lakes, watercourses, and wetlands.
ii) An approach to interoperability where defined use cases are implemented in models which are integrated. A model of persistent, unique identifiers which is similarly integrated and implemented by custodians across the infrastructure.
iii) Clarity of definition and content at borders between domains, e.g., Land, Sea, internal Waters and boundaries. Coastline is a particular focus. This harmonizes datums, content, and metadata. It should cover use cases and stakeholders, e.g., ports and harbours, marine protected areas, flood management/sea levels, mapping and scientific/research purposes.

5. Innovation (Strategic Pathway 5)

With the accelerated digital transformation of the hydro domain, innovation is critical to ensure systems and practices are kept relevant. Innovation offers the opportunity for governments, businesses, and academia to leapfrog to modern marine geospatial information management systems and practices. Innovation as the centerpiece of UN-IGIF holds true for the sustainable implementation and use of marine geospatial information. Its sustainability is also critical to sustain the positive impacts and value of marine geospatial information. The promotion of innovation requires awareness of the potentially disruptive trends in the hydro domain which could be addressed within the four key elements of: 'Technological Advances', 'Innovation and Creativity', 'Process Improvement' and 'Bridging the Geospatial Digital Divide'.

The marine domain often leads the charge when it comes to innovation and new programs can take advantage of it to leverage newly established technology and process improvements - giving them an opportunity to leapfrog aging systems and standards that consume valuable resources. For example, data collection within the maritime domain is an expensive prospect and innovation can lead to faster, cheaper and more accessible data collection.

Recognizing innovation as a critical pathway early in a program's development lifecycle can help to pave the way for advances in technology, creative solutions to problems, process improvement, and bridging the geospatial digital divide.

In the marine domain there are a few strong support mechanisms to help make innovation a priority.

i) relying on a wide variety of marine scientists and other professionals, including academia having new ideas and applying other people's work to leverage for their own needs,
ii) making collaboration easy through open platforms, open access and open source,
iii) there is a very strong private sector network that often supports innovation through technology assistance and training.
iv) joining international institutions like the IHO via their working groups to provide access to resources like capacity building and the newly established IHO Technology and Innovation Laboratory.

In short, it is important to remember the importance of innovation and the benefits that a commitment to it can provide.

A burdensome regulatory environment can stifle innovation so there needs to be a balance. To some extent the process flow should be innovation influences standards which influences technology and regulations; this should be a continuous process as innovation evolves. It is important to emphasize that regulations should be kept at a minimum and just to the strict use of information products that could be legally liable, because too many regulations may restrict innovation.

5.1 Trends (disruptive) relevant for the 'water' or hydro (for consideration/discussion)

5.2 How to promote and ensure a culture and conducive ecosystem for innovation to be applied (for consideration/discussion)

Challenges (for consideration/discussion)

Actions and tools (for consideration/discussion)

Case studies (for consideration/discussion)

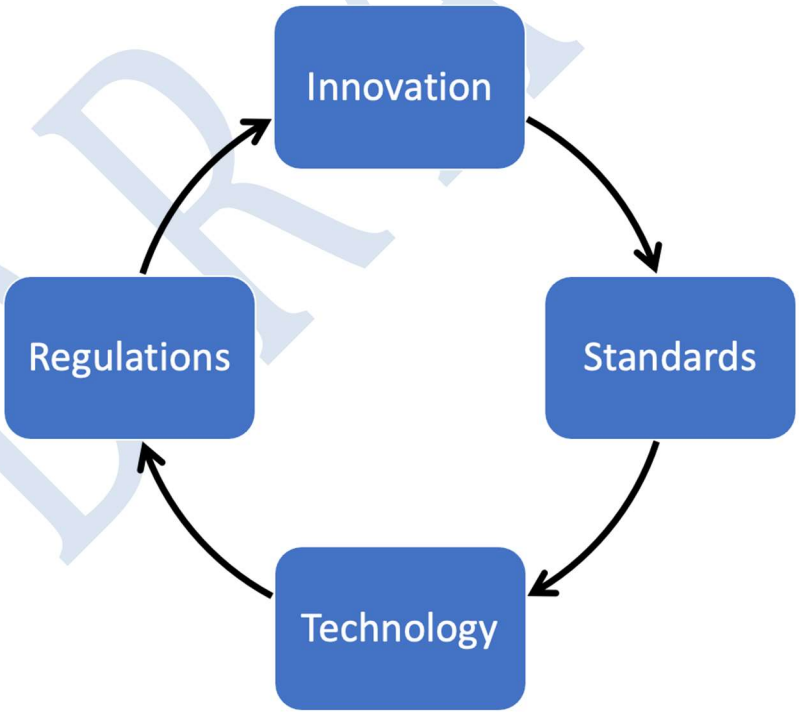


Figure 7 – Inter-relationships between innovation, regulation, standards, and technology

6. Standards (Strategic Patway 6)

6.1 Introduction

Hydrography, as a science, was historically built on as a firm requirement for hydrographic charting, propelled by the international requirement for safe and efficient shipping to underpin global trade and defence. Still a major driver (alongside scientific and environmental research) the production of hydrographic charts shapes much of the geospatial data in the marine domain and its availability to the broader community. Indeed the MSDI movement was borne out of the IHO's Marine Spatial Data Infrastructures Working Group (MSDIWG) with its roots in standardization efforts and the realization of the value of geospatial data representing the seas and oceans.

The globalization of the ENC as the mandated regulated primary means of navigation for commercial shipping is a success of international cooperation through geospatial standards. The IHO standards base covers acquisition, compilation, validation, encoding, portrayal and update within a global type approval regime for commercial navigation systems used in some of the most challenging and safety critical regimes in the world. Standards underpin this entire ecosystem of interlocking parts, so it is not surprising that many of the standards in the 'water' or hydro environment stem directly from this use case.

Water or hydro, however, has a much greater reach, as do the potential use cases associated with it. Most states' geospatial infrastructure will cover the mapping of waterways, lakes, coastal zones, estuaries, wetlands and other categories of land use where 'water' or hydro plays a significant role.

A Key defining characteristic of marine geospatial data is the requirement to meet international obligations as well as satisfying domestic

As was noted in SP1, frequently the delimiting of institutional arrangements separates land from sea resulting in a gap between models and their inability to span the border; this often results in duplication and mismatch within coastal zones. Additionally, a mismatch between production of geospatial data for defence and civil purposes can result in similar mismatches between datasets produced in different parts of the national infrastructure.

Standardization of geospatial data in all domains has the ability to give an expressible power to data from different sources, whether from different global states or from institutions within the same geospatial infrastructure. Shipping, as one of the most globalised industries in the world, is acutely focused on international standardisation while geospatial data production for internal waters is more often produced to satisfy internal needs and requirements.

This section focuses on how these needs can be reconciled using standardisation, best practices and the unique challenges of standardisation within the domain of Water.

6.2 The Community of Practice

As noted many times in this document, one of the key differentiators of the 'water' or hydro environment is the often complex relationship between international and transboundary issues and topics and domestic/national agendas. The UN-IGIF Community of Practice, in relation to Standards for the Water Domain, is a case in point which bears some closer examination. A National Standards Strategy under UN-IGIF, managed by the national standards committee will promote interworking between the communities domestically but also regionally and internationally.

In the Maritime Domain, the International and National Standards bodies together form the community of practice.

The diagram below shows a typical infrastructure with various institutions and some example interoperable data interfaces. In the diagram the National Standards Strategy and its steering committee oversee all the organizations and their activities in relation to standards, including international and regional representations. This responsibility should not be seen as overheads.

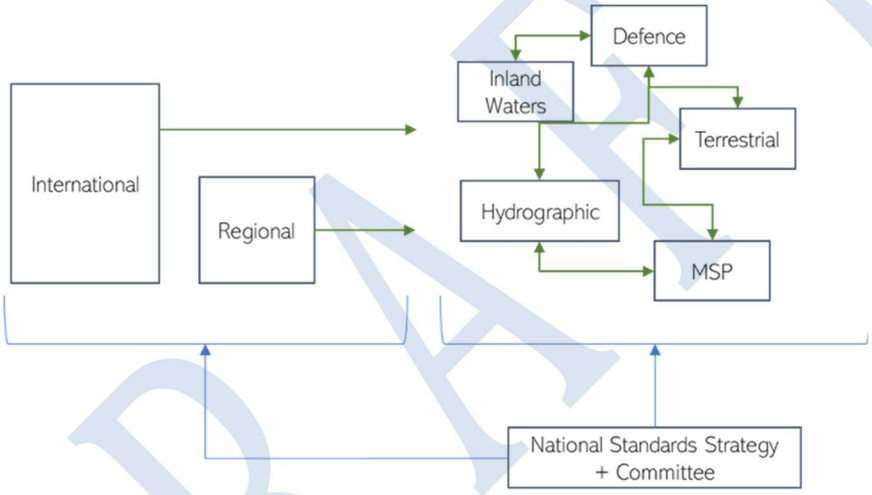


Figure 8: How A "Multi-Thematic" National Strategy oversees domestic and international standards

In the maritime context, particularly hydrography, the international influence is considerable on standards and regional groups, primarily the Regional Hydrographic Commissions (RHCs), act as valuable implementation testbeds and are a forum for exchange of best practices. Many of the RHCs have extensive MSDIWG subgroups as well (e.g., Meso American & Caribbean Sea Hydrographic Commission (MACHC), Southern African and Islands Hydrographic Commission (SAIHC), Baltic, Arctic, East Asia) able to contribute to best practices and regional norms.

Figure 9: Inland Electronic Navigational Chart (IENC) (to be included)

The influence of international standards on hydrography is felt at all levels, from data acquisition, through to data management, cartography, validation and distribution and it is easy for hydrographic standards to sit in isolation of national and domestic standards and their management. It is vital to integrate, through interoperability, common semantic models and institutional arrangements, the data management processes and standards across the infrastructure. Areas such as inland waterways, coastal zones and large inland bodies of water

will require standards to meet international mandates as well as domestic agendas. Inland Waterways are a prime example where the Inland Electronic Navigational Chart (IENC) standard covers features in the domain of safe navigation, but domestic data standards may cover domains of water flow, flood management and planning. Harmonizing these requires a methodology and structured approach. Hydrography, with its core stemming from internationally standardized navigational charts, has developed a comprehensive framework, IHO S-100, which encompasses many hydrographic, meteorological and maritime domains and is probably one of the most significant developments in such frameworks in the marine domain available.

Integrating International standards with national requirements is a major challenge.

This combination of national and international groups and representation forms the true Community of Practice, bodies with shared goals working cooperatively using open, consensus-based standards. It represents the truly integrative approach and shows how the 'water' or hydro environment can act as a catalyst in establishing international relationships in pursuit of the UN-IGIF Outcomes and SDGs.

Internationally, the standards ecosystem is dominated by the IHO, the only international standards development organiser solely devoted to standards in the 'water' or hydro environment. The IHOs flagship standards framework, IHO S-100, has achieved maturity in the last few years alongside its content standard product specifications and the IHOs comprehensive geospatial registry, and continues to be developed to meet the needs of many stakeholders.

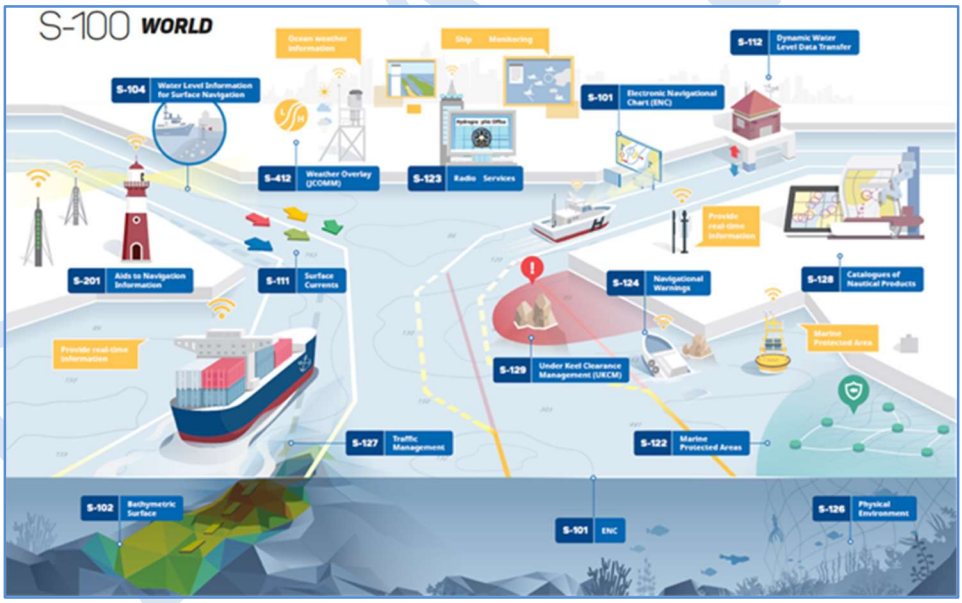


Figure 10: The S-100 ecosystem

Inland, there is no one single model which will meet all stakeholder and community requirements, and local geography will also likely form and influence the standards implemented. However, interoperability with the marine sector is always highly desirable for many reasons (see earlier Value Propositions). Policy/Governance (as detailed) should set this out as an objective and enable a roadmap to it. For instance, Ports and Harbours form major interface points between land, sea, and internal waterways where standards for terrestrial data, spatial, mapping, commercial, and logistics meet hydrographic standards and survey.

A position on open standards vs proprietary and industry standards should be enabled, detailing the extent to which a commitment to open standards can be adopted. This may not be across all institutions – the production of marine data is frequently performed within Commercial Off-the-Shelf (COTS) packages but the transfer of data between institutions (via download or API) should use open standards as far as possible, probably mandated by policy at a national level.

The INSPIRE model is worth consideration as an example of how a regional standards approach has defined an abstract framework and content standards covering all of the hydro environment for a number of stakeholders.

6.3 The Importance of Open Standards

Open data is data which is freely available to be used, modified and shared by anyone. Open Standards are those standards which are free to use, implement and share. Many spatial data infrastructures are built on open standards (the IHO standards base is completely Open, as are all OGC standards and many broader standards in the 'water' or hydro environment). Many studies have been done evaluating the value of Open standards and open data to stakeholders and this should be part of the UN-IGIF considerations.

A useful reference in application of Open Standards is the combined IHO/OGC/ISO Guide to the use of Geospatial Standards. Although not specific to any domain it presents an integrated view of the use of standards from the perspective of the leading open standards development organisations globally. This publication is currently undergoing thorough review and update and accurately reflects the standards landscape and best practices from the IHO and the OGC.

6.4 Standards and Interoperability

Standards development in the 'water' or hydro environment reflects, again, the diverse nature of the domain and the contrast between international concerns and domestic/regional perspectives. Many guides to standards reference lists of standards, their component parts and hierarchies. Such lists are incomplete by definition as they invariably omit national and domestic standards, profiles and encoding guidelines that may exist as well.

There is no single exhaustive list of standards necessary for implementation with the Water domain.

Some standards are necessary as a prerequisite for implementation within certain marine domains. IHO S-57 and S-101 implement navigational charting with IHO and IEC standards tightly regulating equipment. The ISO framework is ubiquitous across all geospatial domains and IHO S-100 draws heavily from it in order to define a set of marine-specific product specifications.

Many existing institutions have skills in data modeling and a comprehensive knowledge of standards gained from lifetimes of experience working with geospatial data. The most important elements, from the perspective of this guide are to:

i) Ensure the 'water' or hydro environment is adequately represented in the UN-IGIF data inventory, Data Framework and Metadata.
ii) Work to establish interoperability between those standards adopted for international requirements (e.g. Navigational Charting) and standards used for representation of domestic and regional structures.

iii) To ensure participation in the community of practice encompasses the Water community.

Within the standards community interoperability is the quality which allows data to be reused by others. In the UN-IGIF context, and in the context of Water as an integrated element within a geospatial infrastructure, interoperability of data under standards means that data conforming to standards and representing the 'water' or hydro environment can be used by all participants and stakeholders alongside the other elements of the infrastructure without requiring "special" considerations or manual effort.

As detailed in this section, interoperability can be considered (and assessed) in two complementary ways, reflective of the two main elements of geospatial standards:

i) Technical Interoperability, where standards are mostly concerned with a content neutral technological interoperability. This can be, for instance, harmonising digital formats or API technologies.
ii) Semantic Interoperability. Ensuring the model used to represent the digital data is interoperable with others. This, in a standards context, then is only concerned with those geospatial standards which model particular domains, rather than the digital formats or encodings used.

In the context of the 'water' or hydro environment the standards focus is primarily on semantic interoperability, rather than technical interoperability because of the diverse nature of the domains involved.

Within the marine sphere, as noted, there is a dominance of international hydrographic standards (e.g. IHO S-100) and ISO standards under the ISO19100 framework which define the foundation for many geospatial infrastructures.

The IHO provides ISO standards base oriented towards international standardisation over much of the oceans and seas and their phenomena but an abundance of models also exist in other 'water' or hydro environments. For example:

- Inland Waterway navigation under the IENC set of standards.
- INSPIRE provides a comprehensive set of models for Water in many contexts including watercourses and administrative areas.
- Defence standards defined by the North Atlantic Treaty Organization (NATO)-supporting Defense Geospatial Information Working Group (DGIWG) such as Additional Military Layers (AML) are important components in the global framework.

In order to achieve the UN-IGIFs outcomes

i) Each custodian must be given the authority and responsibility to publish and maintain their definitions and implementation of models and data implementing those models.
ii) Where interoperability is required the Governance and policy elements of the UN-IGIF must assign responsibility for that interoperability: this can be achieved through each participating institution, a national infrastructure or through partnering arrangements with third parties.
iii) Communication is vital and well publicised models with normative definitions are crucial to ensuring informed interoperability and an efficient infrastructure.

Data models used by Specialist working groups and within the domain of the National Community of Practice should be charged with the responsibility of ensuring semantic interoperability. Enabling and managing such interoperability of models is a challenging process. Often models are built into proprietary GIS for production of standardised data. This has the advantage of producing a COTS product for specific purposes but can be restrictive in engineering interoperable solutions without customisations.

Progressive, incremental development can be made to all models to accommodate local nuances and integrate terrestrial and marine domains. What is important, from the UN-IGIF Direction Setting perspective, is to acknowledge and record such customisations and maintain a knowledge base of which standards are being implemented, their scope/limitations and roadmaps and how transformations of data and knowledge of the standards can map the different domains to meet many different needs.

The initial UN-IGIF Baseline Survey of standards across the infrastructure is a good place to start. The baseline survey should take into account how (and to what extent) the major international conventions are met, e.g. SOLAS (through charts, whether produced nationally or on behalf of), UNCLOS and its zones, together with the requirements for domestic mapping (e.g. internal waters, their boundaries, depths vs centrelines and flow models) and should arrive at a managed, universal understanding of how Water is approached across the entire infrastructure and the dependencies that exist.

Start with inclusion of all 'water' or hydro standards in the IGIF Baseline Survey.

A subsequent gap analysis will likely cover national, regional (e.g., immediate neighbours and stakeholders) and international elements and how they should be addressed. This can then take in existing obligations where they are built on the geospatial framework; for instance, pollution control, fishing limits and MSP and how their fulfillment works alongside regional and international compliance. The UN-IGIF Standards Inventory should aim to cover all Water standards alongside all other standards and also highlight where there may be substantial overlap in domain content (e.g. coastal zone, waterways, inland waters).

6.5 Geostatistics

The UN-IGIF makes a particular point of contributing to the geo-statistical framework in order to contribute to the SDGs and the ability of Water data to do that should be a prime consideration when considering standards. Standards and Statistics are wholly reliant on consistent, frequently global definitions. Again, a reliable interoperability mechanism backed up by a comprehensive data framework forms the foundation of this capability with standards playing a key role in its implementation.

Geospatial places a further requirement on interoperable geospatial data.

The challenge of deeper integration with geostatistics is the requirement to transform data to models for statistical production which will require international harmonisation. This is likely to increase the requirement for intelligent transformation of data and the technical methods which support it. This is in addition to the need to support international and domestic obligations within data (identified as a key element of the UN-IGIF and Water) and points to an enhanced requirement for skills in data transformation, modeling, interoperability and standards. Standards have a key role to play in ensuring such broad interoperability and

education and a commitment to developing skills in key personnel are crucial to reaping long term benefits in line with the value propositions identified.

7. Partnerships (Strategic Pathway 7)

A core part of the "People" influence of the UN-IGIF is partnerships and this is highlighted in the WG-MGI Use Case principle "Develop data-sharing partnerships". This is described briefly in the introduction to this document, Section X.X.

As with many other aspects of the 'water' or hydro environment there is a national/international aspect to be addressed. Because many phenomena, wildlife and natural features span international boundaries, the establishment of partnerships frequently require international collaboration to be truly effective. Thus, regional partnership organizations can have great significance. Of particular note in partnerships is the extensive use made of partnerships for data acquisition and management, as a direct by-product of the high costs of acquisition across the entire Water Domain. There is, consequently, a large reliance on extensive partnership networks in the 'water' or hydro environment.

A more recent development globally is the emerging field of Crowdsourced data. Most official institutions gather data from private sector networks and citizens but the advent of inexpensive, Global Positioning System (GPS)-enabled handheld mobile devices, greater connectivity and reduced cost availability of applications has greatly increased the ability of the public to contribute to geospatial data gathering. In the 'water' or hydro environment this is seen less so than in terrestrial domains (there is no direct parallel on a scale with OpenStreetMap). However, the greater cost of marine data acquisition potentially confers a high value on data sourced from citizens if suitably validated and attributed with appropriate metadata. The rise in the popularity and potential of this data gathering should be acknowledged.

The other crucial aspect of establishing partnerships is to support transformational research - innovation is essential, as is participation in global research efforts. Education and participation in the global community are vital. Partnerships with trade organisations and sharing of common data models can ease interoperability of collected data.

The challenge within the 'water' or hydro environment is one of managing partnerships across multiple sectors, across boundaries internationally and also with internal stakeholders.

Example formal partnerships:

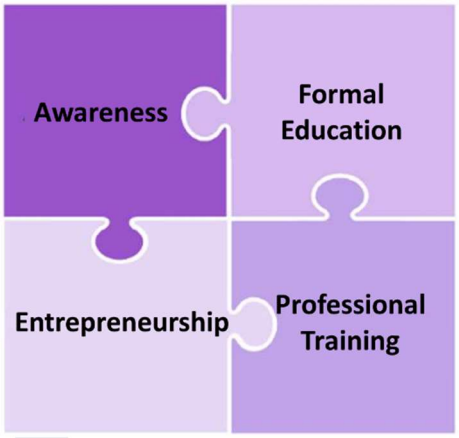
i) The Global Ocean Observing System (GOOS)
ii) The ARGO program
iii) The GEBCO Seabed 2030 Project

And less formal partnership networks:

i) Whale spotting
ii) Catch/bycatch reporting systems for fishing

8. Capacity and Education (Strategic Pathway 8)

Under the UN-IGIF capacity building is defined as the "process of developing and strengthening the skills, instincts, abilities, processes and resources that organisations and communities need to survive, adapt and thrive in a fast-changing world". Capacity building may suggest building something new and the term "capacity development" is therefore often used to demonstrate the process of building on existing skills and knowledge.



The United Nations Working Group on Marine Geospatial Information urges participation in capacity development opportunities when resources allow and actively transfer knowledge, tools, and techniques that facilitate the collection, management, and sharing of marine geospatial information to developing counterparts.

UN frameworks, like UN-IGIF and the Framework for Land Administration (FELA), stress capacity and capability development and education. Capacity development is a useful tool to aid countries and other stakeholders in collecting and managing their marine geospatial information. However, limitations on available resources for capacity development are recognized; Member States are encouraged to focus on the active transfer of knowledge of tools and techniques that facilitate the effective collection, management, and sharing of marine geospatial information.

Member States are also encouraged to focus on making their own marine geospatial information available as this can help countries without data enter the geospatial community by alleviating costs associated with initial data collection.

In the 'water' or hydro environment the specific challenges are:

i) Traditional, highly specialized skills due to the nature of the domain.
ii) The requirement for capacity to satisfy national and international responsibilities.
iii) The diversity of areas in which the 'water' or hydro environment exists and requires consideration.

The UN-IGIF structure places capacity and education directly alongside the operational areas of the implementation, shown in the following diagram:

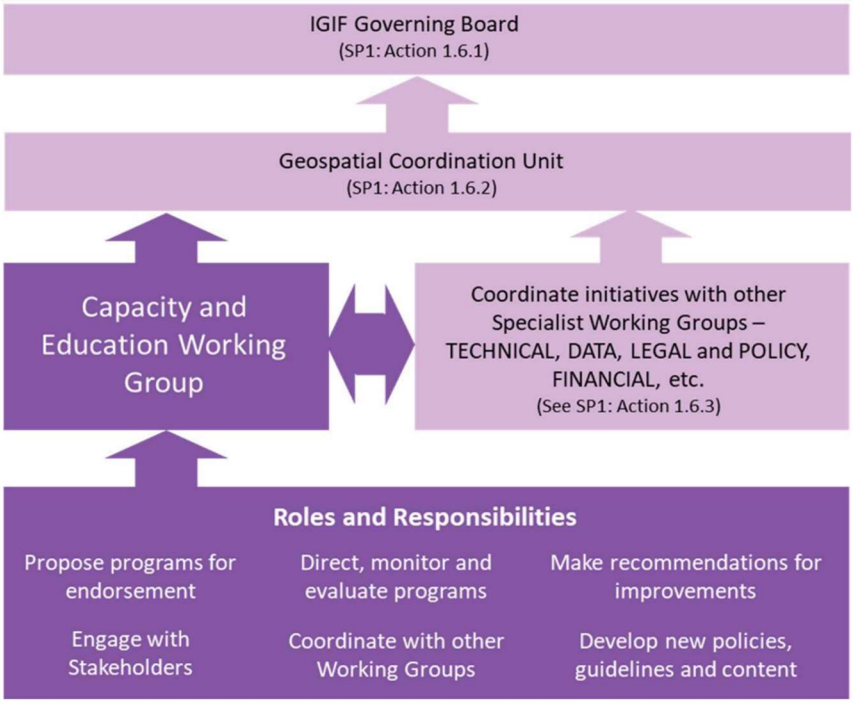


Figure 11: TITLE to be included

The measurement of the success of any capacity development under the United Nations Development Programme (UNDP) is that it leads to change which is sustained by those whom it is meant to benefit. Any programme must also be sustainable long-term, and generated and guided by those for whom it is meant to empower. Measuring the success of a development programme is therefore an integral part of the UN-IGIF process.

Capacity Development programmes should, therefore, take note of the unique challenges of the hydro environment and the specialist skills required and seek to make sure they are covered by the programs proposed by the Capacity and Education Working Group. Some specific targets could be:

i) Ensuring that education and training across the infrastructure represent all domains.
ii) That development content represents a consistent view of those domains which complement, not contradict, each other.
iii) That state-specific and regional/global elements are well represented.
iv) That certification is internationally accredited where such structures exist.

Some examples of existing capacity development programmes are:

i) Under the Inter-Regional coordination committee of the IHO a capacity building and technical cooperation programme works with international partners and regional IHO groups to develop states' capacity according to need. This is done through accredited international training programmes and technical cooperation visits. The programme covers many different sub-domains including Governance as well as Production.

ii) IHO regional ENC coordination centres (RENCs) establish cooperation and training programmes between member states to ensure harmonisation of data content and validation.

9. Communication and Engagement (Strategic Pathway 9)

From a government/institution perspective, open communication and dissemination of data enables better, evidence-based, understanding of decisions made. This also allows third parties and the public to analyse and validate information/decisions derived from data or to question it.

Use and re-use of data is more efficient and can spur innovation and benefit within the private sector.

Internal Communication should focus on essential details such as standards, metadata, interoperability, and discoverability. Messaging should highlight how these elements increase our ability to do more with the data generated and to potentially a higher return on investment when others do innovative things with available data.

External Communication should include similar messages, but also include the value of citizen science, Indigenous knowledge, and other non-traditional ways of obtaining and disseminating geospatial data. External messaging should highlight that the more everyone contributes, the better the product will be for everyone.

9.1 Identifying Stakeholders within the Water Domain

Suggestions for potential stakeholders to engage in the 'water' or hydro environment are listed below based on the categories included in the UN-IGIF SP. These are only suggestions but could be used to start a stakeholder analysis by looking for comparative national/regional equivalents.

Politicians and Policy Makers	• Bodies enacting legislation across all Marine space • International Relations
Government Organisations	• Statutory functions, e.g., charting, pollution, maritime safety, Search and Rescue
Multilateral Organisations and development/donor programmes	•
UN Agencies and other national governments/NGOs	• UN-SDG

	• IHO / RHC
Geospatial Information Users	• Mapping and charting • Marine transportation • Ports and Harbours
Scientific Organisations	• Oceanographic institutions • Tidal modeling • Universities
Private Sector suppliers	• Geospatial analytics • Transportation research and analysis
Government Sector suppliers	•
Professional Bodies	• Fishing organisations
Consumers and Citizens	• Map users • Postal Services and routing • Leisure and tourism

Other classification models of stakeholders exist. For example, the figure below described stakeholder classifications according to the OGC:

Figure 12: Classes of Stakeholders

The OGC Marine Spatial Data Infrastructure Concept Development Study also identified a comprehensive list of stakeholders who may wish to make use of marine geospatial information.

MSDI Stakeholders	Policy Makers	Data Producers	Data Processors	Data Handlers	End Users
Academic and educational institutions		✓	✓	✓	✓
Archaeology, marine, hydrography, ecology science					✓
Authorities: Port Authority, Marine Transportation	✓	✓		✓	✓
Commercial data / analytic providers		✓	✓		
Diplomatic and national security officials	✓				✓
Enviromental Protection Agencies	✓				
Federal, state, provincial government agencies	✓	✓	✓	✓	✓
Fishing companies					✓
GIS and Information Technology		✓			
Insurance companies	✓	✓	✓		✓
Internet and Social Media Providers		✓		✓	
International Intergovernmental Organizations	✓				
Local Government Agencies	✓			✓	
Mapping and GIS experts			✓		
Marine and Oceanographic boards and groups	✓	✓	✓	✓	✓
Military Organizations	✓	✓	✓	✓	✓
Mining companies					✓
NGO Service Providers					✓
Port managers and harbormasters					✓
Public Authorities	✓				
Public Works	✓				✓
Researchers for climate conservation					✓
Search and rescue officials					✓
Shipping and cruise ship companies					✓
Software developers			✓		
Standards Developing Organizations	✓				
The General Public		✓			✓
Transportation			✓		✓
Untility companies/organizations: Oil and Gas, Power		✓			✓

Figure 13: TITLE to be inserted

Once the stakeholders are identified the UN-IGIF presents a rigorous pathway for defining communication plans and review/benchmarking of its effectiveness. This includes a Geospatial Brand definition and methods for engagement.

- Stakeholders and users are actively engaged in the process of strengthening integrated geospatial information management;
- There is a heightened awareness and understanding about geospatial information within all levels of government and across all industry sectors;
- There is an increase in the use of geospatial information within government, the private sector and the broader community;
- The community has a strong sense of trust in government provided geospatial information and the confidence to use it;
- There is an increase in transparency and more clear, open, and simplified means in dealing with government;
- There are opportunities to engage with government, contribute to and influence government policy and process;
- There are increases in business opportunities for both government and the private sector through an increased awareness of government activities and user needs; and
- There is a positive change in working relationships between government and industry resulting in greater synergy that leads to significant accomplishments.

Figure 14: UN-IGIF Outputs

9.2 Measuring Communication and Engagement (to be drafted)

9.3 Strategic messaging and engagement (to be drafted)

Find successful use-cases that show the benefits of using the UN-IGIF and marine geospatial information. Make users give their "success stories" so the messages are not just said from the "UN" Point at county-initiated, country lead, country owned.

To do: How do we find success stories and how do we compile? Where do we collect and work with this material?

9.4 Communication strategy, plans and methods (to be drafted)

Describe and make communication material that explains that the UN-IGIF is agreed within the UN and this could be used by countries to explain to their own decision makers to motivate actions connected to geospatial information.

How do we make the UN-IGIF available in an accessible way?

(Should we work separately in silos, in the different working groups, Marine/land or should we work together? Ensuring the integration between land and marine, maybe together?)

[1] https://www.linz.govt.nz/
[2] https://www.ordnancesurvey.co.uk/
[3] www.ukho.gov.uk
[4].
[5] From “Marine Cadastre in Europe study by The World Bank (https://iho.int/mtg_docs/com_wg/MSDIWG/MSDIWG9/MSDIWG9-07F2-Marine_Cadastre_Europe.pdf)
[6] (Although this is normally the EEZ it is not stated but largely accepted, more by omission, i.e., charting the High Seas isn’t covered by any international convention).
[7] Reference required for the Global Fundamental Geospatial Data Themes.