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Implementation and adoption of standards for the global geospatial information community

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Note by the Secretariat

Summary

The present paper contains the report prepared jointly by the Open Geospatial Consortium (OGC), Technical Committee 211 of the International Organization for Standardization (ISO/TC 211) and the International Hydrographic Organization (IHO) on the implementation and adoption of standards for the global geospatial information community for consideration by the Committee of Experts on Global Geospatial Information Management.

At its twelfth session, held from 3 to 5 August 2022, the Committee of Experts adopted decision 12/113, in which it expressed its appreciation for the collaborative efforts and work of the three international standards development organizations in developing and preparing standards for the measurement and monitoring of the Sustainable Development Goals, advancing data access and data sharing, including towards the ongoing response to the coronavirus disease (COVID-19) pandemic, and disaster risk reduction and management, as well as their support with regard to marine spatial data infrastructure (land-sea interface) and management, and encouraged the development of fundamental and domain-specific standards to address and monitor specific Sustainable Development Goals. The Committee also welcomed the many examples of how countries were using the "Guide to the role of standards in geospatial information management".

In this present report, the three organizations elaborate on their collective efforts. They provide details of the work of the Open Geospatial Consortium on the development of modernized open application programming interface standards, including demonstrations of technology based on real world requirements under the Consortium's initiatives for collaborative solutions and innovation. In 2022 and running through 2023, there were 24 ongoing initiatives covering a broad range of requirements related to, for example, climate services, disasters, land-water interfaces, digital twins and open science. The integration of geospatial information, statistics and other data to address access to and integration of location information under the findability, accessibility, interoperability and reusability principles continues to be a core focus of the Consortium's community. The work of that community includes a strong focus on improving connections with standards developed by the Consortium, such as application programming interface features and environmental data retrieval, International Hydrographic Organization standards (e.g., S-122 on marine protected areas) and ISO standards (e.g., ISO 19152 on the Land Administration Domain Model, inclusive of the proposed part on marine space).

The report includes an account of the progress of ISO technical committee 211 in its collaboration with a number of United Nations agencies and other organizations. This includes updates regarding changing technology and business environments; modernization of geodetic infrastructure; continued progress in the

* E/C.20/2023/1

development of the multi-part ISO 19152; the ISO 19144 series on land cover and land use; and ISO 19160 on addressing standards.

The report further presents the advances made by the International Hydrographic Organization on the S-100 Universal Hydrographic Data Model standard to support the creation and maintenance of interoperable marine data product services that are compliant with the ISO 19100 series of geographic information standards. A significant breakthrough was made in that regard through the formal adoption by the International Hydrographic Organization of its S-100 road map leading towards global provision of S-100-based data services covering a great variety of marine data themes from 2026 onward.

The report also provides an overview of the work of standards development organizations regarding the use of geospatial standards in supporting the measurement and monitoring of the Sustainable Development Goals; presents how the organizations are working to strengthen their interaction with the Committee's regional committees, functional groups and thematic networks in practice; and discusses practical examples of the use of geospatial standards in support of the Goals, including a collection of user stories showing how standards have helped countries to work towards specific Goals.

I. Introduction

1. The International Hydrographic Organization (IHO), the Technical Committee 211 of the International Organization for Standardization (ISO/TC 211), and the Open Geospatial Consortium (OGC) work in partnership to leverage their respective mandates, missions, and membership expertise to advance Findable, Accessible, Interoperable and Reusable (F.A.I.R.) principles and Standards to meet the goals and objectives of the Committee of Experts and the global geospatial information community. They continue to increase cooperation through formal liaison agreements and joint initiatives to produce standards and good practice recommendations that could not be fully achieved by working in isolation. The ultimate goal is to ensure Member States take a high-level policy decision to ensure globally that open standards are the default starting point for all geospatial and location requirements.

2. The Committee of Experts is invited to take note of the present report and to express its views on the activities and plans of the three Standards Development Organizations and their development and contribution to the implementation and adoption of open standards for the global geospatial information community. Points for discussion and decision are provided in paragraph 38.

II. Role of Standards in Geospatial Information Management

Support to the implementation of the UN-IGIF

3. After the third edition of the 'Role of Standards in Geospatial Information Management' (Standards Guide) was endorsed at the eleventh session of the Committee of Experts, the team of representatives from the three Standards Development Organizations (SDOs) continue to work together, have the Standards Guide available as a web publication[1], and continue to receive and act on feedback.

Geospatial standards in measuring and monitoring the SDGs

4. The SDOs continue to maintain and advance a framework of geospatial standards and good practices that support the mapping, visualization, analysis and forecasting related to the seventeen goals. SDOs general purpose geospatial standards continue to be adopted by technology suppliers worldwide to make it easier for the user community to implement F.A.I.R. solutions that are broadly compatible for collaboration and data sharing. SDOs domain specific standards are helping to address specific SDG goals such as addressing hunger, health, and sustainable communities. Some specific examples of SDOs support to the Sustainable Development Goals (SDGs) over this past year include: Goal 2: Zero Hunger (ISO/TC 211 Land Cover/Land Use); Goal 3: Good Health and Well Being (OGC Health Spatial Data Infrastructure Data Model); Goal 9: Industry, Innovation and Infrastructure (all SDOs general purpose standards apply); Goal 11: Sustainable Cities and Communities (implementation of OGC CityGML, OGC Indoor Mapping Data Format Community Standard); Goal 13: Climate Action (SDO General Purpose Standards, OGC Open API: Environmental Data Retrieval); Goal 14: Life Below Water (IHO Electronic Navigational Chart, S-102 – Bathymetric Surface, S-111 – Surface Currents, and S-129 – Under Keel Clearance).

[1] http://standards.unggim.ogc.org/index.php

III. Update from the Open Geospatial Consortium (OGC)

Introduction

5. The OGC and its more than 500 members from across the private and public sectors have guided the advancement of open standards and associated good practices to make geospatial information F.A.I.R. in support of global requirements. Through its member meetings, workshops, forums, summit events, and practical results demonstrated via its twenty-four on-going Collaborative Solutions and Innovation Program (COSI) initiatives covering a broad range of topics, OGC is addressing an expanding range of geospatial interoperability challenges facing the international community. The OGC is leading the dialogue on the implications of fast changing technology and community trends. Over the past year, OGC has focused on a range of topics relevant to the SDGs including a multi-year continued focus on improved support to disaster response, increased coordination within the hydro domain, and innovation related to climate services. OGC is continuing with its advancement of an open Application Programming Interface (API) standards suite - a modernization and expansion of OGC's Web Services Standards - designed to simplify development and deployment and increase flexibility of applications and to leverage big data and cloud native infrastructure more efficiently.

Adoption and implementation of OGC General Purpose Geospatial Standards

6. The program to modernize OGC Web Services into more easily implementable Open API Standards is well underway, with OGC API - Features, OGC API - Tiles, OGC API - Processes, OGC API - Environmental Data Retrieval and OGC API - Common now being implemented in major commercial and open-source geospatial technologies supporting the global community.

7. The OGC APIs for Features and Tiles are helping to bring fundamental geospatial data to all types of users, from geospatial professionals to consumers in a simple and flexible manner that was impossible with the previous generation of Standards. This approach enables better access to geographic information and decision making by citizens, regardless of their level of technological sophistication.

8. The OGC API - Environmental Data Retrieval[2], provides greater capability to discover and query big data sources in a location and time context. This standard has broad applicability and is being implemented in major national and international hydro-meteorological offices to help reduce the complexity of discovery and access to critical data supporting weather and climate analyses and forecasts,

9. OGC Web Services and OGC Sensor Web Enablement (SWE) Services, continue to be implemented in hundreds of commercial, open source, and custom developed geospatial technologies and Internet of Things deployments worldwide. These implementations support greater understanding and decision making related to water resource management, emergency and disaster management, meteorology and ocean science; smart, safe, and resilient cities, communities and infrastructure; and many other areas of high relevance to attainment of the SDGs. As with the Web Service Standards, the Sensor Web suite of Standards are being rebuilt using a modern API approach to maximize the flexibility of the standards in real-world scenarios.

10. GeoJSON, a widely used standard from the Internet Engineering Task Force (IETF) has enabled broad consumption of simple feature-based geospatial data with the user working in "lat-lon" and not having to understand the complexities of Coordinate Reference Systems (CRSs). However, some users do need to work in alternative CRSs or use more complex geometric representations of their data, so OGC is developing the

[2] https://ogcapi.ogc.org/edr/ 2
http://cite.opengeospatial.org/teamengine/

Features and Geometries JSON (JSON-FG) Standard to allow those added capabilities, while still permitting GeoJSON files to be valid data according to the JSON-FG Standard.

Adoption and implementation of OGC Domain Specific Standards

11. The OGC continues to support SDGs related to resilient infrastructure and livable cities through expanding implementations of OGC CityGML and associated Application Domain Extensions, IndoorGML, and the Indoor Mapping Data Format (IMDF) Community Standard. These standards allow the creation of detailed 3D city models / digital twins and indoor navigation capabilities that support a range of urban planning, energy efficiency, public safety, accessibility, city service provision, and other applications. These standards have been implemented in commercial and open-source products and are in active implementation across municipalities in Europe, Asia, and North America.

Engagement with regional committees of UN-GGIM and other international bodies

12. Beyond coordination with ISO/TC 211 and IHO, the OGC works with a number of other standards-setting or domain-focused organizations to ensure that common principles are in place for the use of location information. For example, OGC and buildingSMART International are investigating the use of APIs to access diverse representations of the built environment (e.g., buildings and infrastructure) in common environments to improve collaboration without the need for expensive data transformations. OGC is also engaged with ISO/TC-204 (Intelligent Transport Systems) to assist in developing implementable instances of Standards used in land and sea transport, including for autonomous vehicles.

Compliance Testing Resources

13. As part of OGC's compliance testing and certification program[2], OGC continues to publish compliance tests for standards, often soon after the standards are published. These tests are open source software and permissively licensed to permit developers to test their own work before creating software. OGC also offers a certification program using the tests and OGC evaluation of test results to formally mark software that is proven to properly implement OGC standards.

Innovation and standards development

14. Unique to OGC is the COSI program, that brings sponsors and participants together to collectively work on solving common problems across multiple domains. The COSI program uses real world scenarios and demonstrations of results and is closely connected to the standards program. Testing OGC (and IHO and ISO) standards using practical use cases results in improvements based on implementations and shortens the adoption cycle of new and existing standards.

15. In 2022 and carrying on into 2023, OGC leads or participates in the following initiatives:

(a) The **ACCORD** project supports a new climate-neutral construction approach. The aim is to digitize approval and compliance processes in the planning of construction projects based on open and neutral standards for data exchange. This supports the targets of the EU Green Deal as well as the new European Bauhaus initiative and the goals of the United Nations Framework Convention on Climate Change (co-funded by the European Union)

(b) The **All Data for Green Deal (AD4GD)** project enables co-design and shape this data space as an open hub for F.A.I.R. data and standards-based services. Man-made climate change is the great challenge of our time. At the

political level, there are numerous initiatives to meet this challenge. At the heart of these initiatives is often the integration of local, national and global data with simulation models and modern analysis methods.

(c) The goal of **CHEK** is to facilitate digital building permit procedures for municipalities. Geodata, as well as the possibility to represent buildings three-dimensionally a Building Information Model (BIM), helps in this process. The CHEK model contains all information about the building's components, materials and properties. In addition, personnel are to be trained further, processes in the administration are to be renewed, and more emphasis is to be placed on technology (This project has received funding from the European Union's Horizon Europe programme under Grant Agreement No.101058559).

(d) The **Climate Resilience Pilot,** designed to accelerate our collective readiness for accessing, fusing, and analyzing data from the climate change services and modeling communities with earth observation and social science data to contribute to the global push for achieving climate resilience.

(e) The **CLIMOS** project aims to help mitigate the emergence, transmission, and spread of pathogens (sand fly focus). This will only work if data sets from different areas, such as health and earth observations, can be linked together. This project is co-funded by the European Union.

(f) **CLINT** (Climate Intelligence) project will result in development of an Artificial Intelligence framework (Climate Intelligence) composed of Machine Learning techniques and algorithms to process big climate datasets for improving climate science in the detection, causation, and attribution of extreme events.

(g) **DEMETER** is a large-scale project involved in the deployment of farmer centric interoperable smart farming-IoT based platforms delivered through a series of twenty pilots across eighteen countries (fifteen states in the EU). DEMETER is funded by the European Union's Horizon 2020 research and innovation programme under grant agreement No. 857202.

(h) The **Disaster Pilot 2023** is prototyping provision of online and offline earth observation, health, and other critical data for first responders. A multi-year effort, the OGC Disaster Pilot 2023 continues, with a focus Analysis Ready Data (ARD) and decision ready indicators (DRI).

(i) **DIS4SME** aims to provide high quality specialized training courses on location data interoperability, The main objective of DIS4SME is to educate and retrain entrepreneurs and managers, employees or job seekers through high quality specialized training courses. The project ties in with the strategy for the digital transformation of the EU.

(j) The **e-shape** initiative brings together decades of public investment in earth observation and cloud capabilities into services to the people, the industry, the decision-makers and the researchers. E-shape will promote the development and uptake of twenty-seven cloud-based pilot applications, addressing the SDGs, the Paris Agreement, and the Sendaï Framework. The pilots will build on GEOSS and on the Copernicus data pool and computational infrastructure. The e-shape project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement 820852.

(k) **IHO-OGC Federated Marine SDI Phase III** demonstration pilot shows how Marine Spatial Data Infrastructure (MSDI) can unlock valuable data and information beyond the traditional providers and consumers of hydrographic data. Specifically, the pilot includes one or more land/sea interface scenarios to demonstrate how federated MSDI can provide simple, secure access across borders and domains, and improve the connections

between terrestrial and marine foundational communities based on exercising both IHO´s S-1XX and OGC API Standards under a scenario of a ship grounding in Western Alaska just south of the Arctic Circle.

(l) **ILIAD – Digital Twin of the Ocean** has over fifty partners are building the solutions and infrastructure to monitor the marine environment with their own and public datasets and services. OGC is involved in several areas focusing on social science and digital twin of the Ocean APIs. Standards-based methods to discover, access, and process data of various types and in an appropriate variety of formats will enable open ecosystem integrations and the market of applications. These will be built on the OGC APIs linked to the multimodal semantic layer provided by the OGC Definition Server.

(m) The **InCASE** project is investigating how these principles can be applied specifically to data measurements from sensors, etc., in the field. This project is funded by the European Environment Agency. Earth observation data and measurement results must be discoverable and well documented. To do so, they must comply with relevant standards to ensure compatibility between different data sources. Compliance with such standards significantly improves the value of the data. Users can thus develop different services and monitor policy objectives.

(n) **Geotech Interoperability Experiment (IE)** contributes to improving GIS - BIM connectivity to exploit the standardization resources already available from the OGC and other organizations as an input for resources to share geotechnical engineering data in the appropriate context for users.

(o) **OGC Sprints** are collaborative events driven by rapid code development to implement and test specific capabilities of a technical approach or standard. Most OGC API standards are refined and tested via these events so that each final standard is proven to be implementable and useful.

(p) OGC Testbeds are OGC's largest Innovation Program initiatives. Testbeds boost research and development to make location data and information more F.A.I.R. Testbeds provide a unique opportunity for sponsors to tackle location data and processing challenges together with the world's leading geospatial and information technology experts. **OGC Testbed-18** focused on three high level threads: Advanced Models and Data, Catalogs, filtering, and Moving Features and Future of Open Science and Building Energy interoperability.

(q) The Horizon Europe project **USAGE** (Urban Data Space for Green Deal) aims to provide solutions and mechanisms to make city-level environmental and climate data available to inhabitants.

(r) **UxS Command and Control IE** tests the suitability of a Command-and-Control model for Unstaffed Systems (UxS) in a real-world environment. The goal of this IE is to assess whether the data model is suitable for multi-domain, multi heterogenous vehicle use and demonstrate exchange of command-and-control information.

IV. Update from Technical Committee 211 of the International Organization for Standardization (ISO/TC 211)

Introduction

16. ISO/TC 211 Geographic information/Geomatics manages ISO's geospatial standards. Its vision is to support a sustainably prosperous future by providing, in

cooperation with others, a set of standards that enable better management of geographic information. This is achieved through collaboration, harmonization, and outreach.

17. ISO/TC 211 now consists of thirty-seven Participating and thirty-four Observing Members which are national standards bodies, having welcomed Jamaica as a new member in 2023. ISO/TC 211 collaborates with numerous liaisons, including ISO committees and external organizations. Key internal ISO liaisons include integrated transport, digital twins, and smart cities. For more information, refer to the Strategic Business Plan available at the ISO/TC 211 website. Freely available resources such as UML models and XML schemas for supporting standards implementations are also found on ISO/TC 211 website. The committee is active in the ISO work towards machine readable standards and the ISO online standards development tool pilot.

18. ISO is now more focused on sustainability, particularly climate change in support of the United Nations Call for Action on Adaptation and Resilience. The focus is on standards in energy production, transport, and construction. The new ISO Climate Change Coordination Committee recognises the value of geospatial information and standards in planning and monitoring sustainability.

Sustainable Development Goals (SDGs).

19. Geospatial standards support the broader objectives of the 2030 Agenda for Sustainable Development: general purpose geospatial standards that are important for industry and infrastructure, and those standards in direct support to the Committee of Experts, specifically in the areas of geodetic referencing, land administration, land cover and land use, and addressing. ISO provides tools to help technical committees to map their projects to the SDGs[4]. ISO/TC 211 collects user stories showing how our standards have helped countries work towards specific SDGs (see https://committee.iso.org/sites/tc211/home/standards-in-action/united-nations.html).

General purpose geospatial standards and aligning with the business environment.

20. Several geospatial standards are so basic that users are not always aware of them being implemented. Standards that describe data in a uniform way (specifications, metadata and quality, and geographic point location by coordinates) are widely used. Other examples of these hidden standards cover the process of relating national coordinate reference systems to global geodetic reference systems (so that two or three numbers can represent a place on the earth), and the calibration of remote sensing devices. As geospatial technology becomes mainstream, some of the "specialist" standards are implemented in more mainstream software, such as the common implementation of spatial technology in relational databases. As the IT environment changes, geospatial standards need to change; for example, ISO/TC 211 has begun its first project looking at a JSON encoding.

Participation in standardization and advancing implementation.

21. The requirements for standardization are identified by the user community and therefore stakeholder participation is essential. In many cases, international organizations develop domain specifications based on the ISO/TC 211 and OGC standards, for example the IHO, World Meteorological Organization (WMO), and the Defence Geospatial Information Working Group (DGIWG). Our 2023 Standards in Action seminar attracted some twenty presentations with speakers from nine countries, covering 'digital twins and geospatial standards', 'technologic trends', 'GIS for digital transformation', 'smart mobility', and 'ISO and sustainability'; the presentations will be available on the ISO/TC 211 website.

Increasing engagement with UN-GGIM regional committees.

22. ISO/TC 211 is in conversation with the regional committees of UN-GGIM for Africa, Arab States and Europe to explore how ISO/TC 211 can support Member States in those regions, and to facilitate members from those regions in engaging in standards development nationally. This has included presenting with OGC at the most recent plenary meeting of UN-GGIM: Arab States. ISO/TC 211 already has liaison relations with the regional committees of UN-GGIM for Americas and Asia and the Pacific.

Coordinate Reference Systems.

23. ISO/TC 211 supports the implementation of the Global Geodetic Reference Frame (GGRF) by developing standards, e.g.

(a) ISO 19111 "Referencing by coordinates", which describes coordinate reference systems and transformations between them - how to represent a location in numbers.

(b) ISO 19161-1 "International terrestrial reference system (ITRS)", which adopts the work of the International Union of Geodesy and Geophysics (IUGG), the International Association of Geodesy (IAG) and the International Astronomical Union (IAU) to show how to "realize" national and regional coordinate reference systems in alignment with the worldwide ones, such as global navigation satellite system (GNSS).

(c) ISO 19127 "Geodetic Register" which specifies the ISO Geodetic Register (ISOGR)[3] and its associated Control Body. The Control Body consists of convenors nominated by the International Association of Geodesy (IAG) and of international geodetic experts. The register contains official parameters and transformations for national and regional coordinate reference systems and is freely available on-line.

24. ISO/TC 211 is a partner and member of the Committee's Subcommittee on Geodesy (SCoG) and will be working with the subcommittee and also the United Nations Global Geodetic Centre of Excellence (UN-GGCE) towards a sustainable Geodetic Register. Many geospatial users today are familiar with the EPSG Dataset and Registry managed by the International Association of Oil and Gas Producers (IOGP) and the OGC CRS registry. ISO/TC 211, OGC, and the IOGP have published a description of the different purposes of these registers and the interactions between them.

Land Administration

25. ISO/TC 211 engages with OGC, IHO, International Federation of Surveyors (FIG), United Nations Office of Legal Affairs' Division for Ocean Affairs and Laws of the Sea (DOALOS), the World Bank, the Food and Agriculture Organization of the UN (FAO), and the United Nations Human Settlement Programmme (UN-Habitat), and are running an extensive revision of ISO 19152:2012 "Land Administration Domain Model (LADM)" with confidence that the proposed new parts to this standard will cover the organizational requirements. The result of this revision will be a multi-part standard: 1) General Conceptual Model; 2) Land Registration; 3) Marine Georegulation; 4) Valuation Information; 5) Spatial Planning; and 6) Implementations. Currently Parts 1, 2, 3, 4 and 5 have been initiated and are part of the ISO/TC 211 work programme. Parts 1 and 3 were available for public comment in early 2023 (ISO Enquiry Stage), and parts 2,4, and 5 should be

[3] https://registry.isotc211.org

available for public comment by the time of this meeting. A proposal for Part 6 is under preparation.

Land Cover and Land Use (LCLU)

26. LCLU are essential and fundamental data themes used by millions of professional users globally across a wide variety of applications. While the explosion of Location Intelligence tied to these essential data layers continues at a pace, the growing need for an agreed upon LCLU meta language is more urgent than ever, to facilitate international analysis. ISO 19144-2:2012 “Geographic information - Classification systems -- Part 2: Land Cover Meta Language (LCML)” was developed under the leadership of FAO. FAO is leading the revision, and developing ISO 19144-3, a similar meta language standard for Land Use. The revised ISO 19144-2 received public comments in early 2023 and should be published by the end of 2023. ISO 19144-3 should be available for public comment later in 2023. We plan a part 4 to establish a register of land cover and land use classifications. The ISO/TC 211 Advisory Group for Land Cover and Land Use is commenting on the draft recommendations for these core data themes, as requested by the UN-GGIM: Europe Working Group on Core Data.

Addressing

27. An address provides structured information for the unambiguous determination of an object, such as a house or apartment building. Addresses are essential for the management of cities, for governance and public administration generally, for service delivery in the public and private sector, and they can give people status or (legal) identity in society. ISO 19160-2 supports the Universal Postal Union’s initiative, “Addressing the World – An Address for Everyone”, which promotes the establishment of national addressing infrastructures to the benefit of all. The multi-part ISO 19160 - Addressing, provides the standards required for a country’s addressing infrastructure, such as a conceptual data model; terminology; good practices for assigning and maintaining addresses; how to measure the quality of address data; and international postal addressing, the latter jointly developed with the Universal Postal Union (UPU). During the inter-sessional period the following progress was made:

(a) ISO 19160-2 *Addressing -- Part 2: Assigning and maintaining addresses for objects in the physical world* completed public comment and may be published by the next meeting. ISO 19160-2 specifies how to plan, implement and maintain addresses and corresponding address data in order to gain maximum benefits for governance and society in the long run. It is a tool against which Governments could measure the objectives, principles and goals conformance of their address policies for a good practice and governance framework. This standard supports the first goal of the United Nations Integrated Geospatial Information Framework (UN-IGIF), namely, enabling geospatial (address) information governance, policy and institutional arrangements that ensure effective geospatial (address) information management, accommodate individual organizational requirements and arrangements, and that are aligned to national and global policy frameworks. The standard is also useful for those involved in slum upgrading, as addresses are often assigned when housing conditions in settlements are being improved.

(b) ISO 19160-4 *International postal address components and template language* was published in April 2023; it is based on the Universal Postal Union’s UPU S42 international addressing standard and was developed jointly with the UPU.

V. Update from the International Hydrographic Organisation (IHO)

Marine Geospatial Framework

28. The IHO continues to work on its S-100 Universal Hydrographic Data Model framework to support the creation and maintenance of interoperable maritime data product specifications compliant with the ISO-19100 series of geographic information standards. The S-100 infrastructure which includes the Geospatial Information Registry[4]. Feature Catalogue and Portrayal Catalogue builder have been developed and are now embedded into the process of the development and maintenance of data product specification. S-100 based product specifications assigned to IHO, the International Association of Light Authorities (IALA), the Intergovernmental Oceanographic Commission (IOC), the Inland ENC Harmonization Group (IEHG), the World Meteorological Organization (WMO), the International Electrotechnical Commission (IEC) and NATO are being maintained on the IHO website[5].

29. Edition 5.0.0 of S-100, released in December 2022, represents the culmination of experiences of the past five years in testing and development against S-100. Several extensions have been incorporated in order to support the enhancement of standards based on the S-100 framework with requirements from stakeholders to meet safety and efficiency in digital marine. Major extensions are Real Time Functionality to implement temporal extent to facilitate time sensitive representations of data such as water level; Encryption to increase security to better align with e-Navigation frameworks of IMO; Interoperability Framework and Harmonized Portrayal; Metadata Discovery to improve the functionality for data discovery and Language Packs to support multilingual for S-100.

Interoperability in the navigation system

30. IHO has developed the S-98 specification for data product interoperability in S-100 navigation systems to de-clutter displays; reduce information overload; resolve conflicts; and improve the overall quality and clarity of information presentation to mariners when multiple S-100 based data products are simultaneously displayed on-screen data product. The specification describes interoperability for S-100 based product specifications - S-101 Electronic Navigational Chart, S-102 Bathymetric Surface, S-104 Water Lever Information, S-111 Surface Current and S-129 Under Keel Clearance Management.

Product standards development

31. S-100 based product specifications have been developed and tested according to the S-100 Implementation Decade (2020-2030) roadmap. Edition 1.1 of the premium product S-101 ENC was released in May 2023. S-164 Test Data Sets for S-100 navigation systems based on the S-100 related products to be used for navigation are now under development too with a first edition soon to be released to be available for industry partners for the software design, development and testing and evaluation. The work on the product specification S-130 Polygonal Demarcations of Global Sea Area, which is primarily intended for encoding the extent of global sea area using a system of unique numerical identifiers is progressing well.

[4] http://registry.iho.int/

[5] https://iho.int/en/s-100-universal-hydrogrhaphic-data-model

Testbed and Innovation Program

32. IHO operates a project named S1OOP - *S-100 Open Online Platform* that is aimed to be the foundation for a digital ocean and accelerate the wide adoption of the S-100 hydrographic framework by jointly developing and making available the technical requirements needed to overcome any S-100 implementation barriers. The project installed four themes: Theme 1 - Online viewer; Theme 2 – Data Production and Protection; Theme 3 – Open source management; and Theme 4 – Knowledge and Capacity. The new Singapore-IHO Innovation and Technology Laboratory (IHO Lab) established in Singapore in October 2021 is aimed to accelerate innovation in the field of hydrography through sandbox implementation of new S-100 standards under construction. The IHO Lab embarked four pilot projects: Automated conversion of S-57 Electronic Navigation Chart (ENC) to S-101 next generation ENC; Development of a digital infrastructure for S-131 marine harbor infrastructure; S-100 ECDIS capable of displaying S-102 with S-101; and IHO and IALA collaboration to demonstrate interoperability of S-101 and S-125 at sea.

Marine Spatial Data Infrastructure (MSDI)

33. MSDI has been highlighted as an important component of the future development of hydrographic offices. As there is either no, or very little, basic teaching material available for MSDI training that is free of charge for IHO Member States, IHO has established basic MSDI training material, in order for IHO Member States and the respective Regional Hydrographic Commissions to conduct basic MSDI education/training. The MSDI training material is now freely available on IHO web page under MSDIWG Body of Knowledge https://iho.int/en/body-of-knowledge. A MSDI e-learning program has also been developed to enable people to access MSDI teaching externally and even receive the teaching online. The MSDI teaching material is available on the IHO's website for free. The e-learning interactive material can be downloaded or used on YouTube.

34. The F.A.I.R Data Principles are used widely in the geospatial community, promoting and supporting knowledge discovery and innovation as well as data and knowledge integration, and sharing and reuse of data. The F.A.I.R. principles do not strictly define how to achieve a state of "F.A.I.R.ness". Rather they describe a continuum of features, attributes, and behaviors that will move a digital resource closer to that goal. The principles help data and metadata to be ‘machine readable’, supporting new discoveries through the harvest and analysis of multiple datasets. In order to have a hydrographic offices approach to the F.A.I.R. Data Principles, IHO will establish guidelines on how IHO’s Member States can use the principles in their work with their national and regional MSDI and together with the OGC MDWG establish a MSDI F.A.I.R. principles checklist.

35. The concept of digital twins is now widely used and in the marine community, the application as Digital Twin of the Ocean or Digital Twin of the Sea are now under development. Digital twins provide a framework for creating a digital truth about the physical environment. Through simulations that show the cause and effect of an event happening, digital twins help policymakers and decision-makers make informed decisions to prevent incidents from occurring or mitigate the event’s impacts. A digital twin should be seen as a digital replica of a living or non-living physical entity. By combining the physical and the virtual world, data is provided enabling the virtual entity to exist at the same time with the physical entity. As seen from a MSDI perspective this has to be an important component in marine digital twin applications. The MSDI will be able to provide the datasets in order to create a highly complex virtual model that is the exact counterpart (or twin) of a physical thing. The ‘thing’ could e.g., be a harbor, sailing route, marine protected area. Connected sensors on the physical asset collect data that can be mapped onto the virtual model. Anyone looking at the marine digital twin can now see crucial information about how the physical thing is doing out there in the real world. A

marine digital twin will be a vital tool to help operators understand not only how products and initiatives are performing, but how they will perform in the future. Analysis of the data from the connected sensors, combined with other sources of marine information, will allow e.g. agencies to make predictions. In order to have a hydrographic office approach to the marine digital twins, IHO will establish recommendations to IHO's Member States on how MSDI and national hydrographic offices can be part of digital twins effort in the future.

36. Noting the needs of the UN-IGIF and the Operational Framework for Integrated Marine Geospatial Information Management (UN-IGIF-Hydro), it is important to ensure that there is better alignment and integration for a uniform approach to data management between land and sea. There are numerous common elements within the UN-IGIF, UN-IGIF-Hydro and MSDI, and simple connections could be made which would bring the definitions up to date. Consequently, IHO has now initiated a process for updating/modifying the IHO publication C-17 in response to the UN-IGIF and UN-IGIF-Hydro. The focus of a new version of C-17 will be on how hydrographic offices can act in response to the UN-IGIF and the UN-IGIF-Hydro and the broader global perspective, and will focus on some of the working issues, like data consistency, data quality, multiple-use best practices, business models, the F.A.I.R. principles, marine digital twins etc. and for the UN-IGIF and UN-IGIF-Hydro to define broader use cases.

Global coverage of seabed topography

37. In order to improve the incomplete image of the ocean's seabed topography from all available data resources, IHO has continued to develop its "Crowdsourced Bathymetry campaign" and its supporting guidance document (IHO B-12). In addition, significant developments have been undertaken to the IHO´s Data Centre for Digital Bathymetry (DCDB) to enhance uploading, data viewing and download functionality. The resulting GEBCO (General Bathymetric Chart of the Oceans) grid of global ocean seabed topography is publicly available under open data policy terms for download and re-use. The grid is now updated on an annual basis, the 2021 grid now has 20.6% coverage, an increase of more than 14% over the past 4 years.

VI. Points for discussion

38. The Committee of Experts is invited to:

a) Take note of the present report of the SDOs and express its views on their progress, work and plans;

b) Encourage broad use of the Standards Guide to support the implementation of standards-based solutions that ensure interoperability, data sharing, and flexibility to adapt to changing data sources and technologies;

c) Urge Member States and other relevant entities of the United Nations to participate, through membership and resource provision, in the international geospatial standards development processes and meetings of the SDO's; and

d) Urge Member States to set policy that starts with open standards as a default for geospatial and location information programmes.