



FUTURE OF THE SEAS & OCEANS INITIATIVE

**Scoping Document: Enabling Digital Twin Ocean Capability.**

*To evaluate and support activities and underpinning infrastructure required to enable the development of Digital Twin Ocean capability.*



United Kingdom 2021



**Summary**

As part of the UK G7 Presidency in 2021, a G7 Ocean Decade Navigation Plan was agreed providing a framework for G7 collaboration in support of the UN Ocean Decade. The Digital Twin Ocean capability was identified as one of three ‘spotlight activities’ to advance as part of the FSOI’s global ocean observing work to support the UN Ocean Decade societal outcomes of a ‘predicted’, ‘accessible’, and an ‘inspiring and engaging’ ocean. The goal is to bring together G7 digital ocean initiatives, including their relationships with wider digital earth initiatives, and to share best practice. A ‘digital twin’ ocean<sup>1</sup> will transform the way we study the ocean, enhance scientific knowledge, and provide a key tool for policy and decision-making.

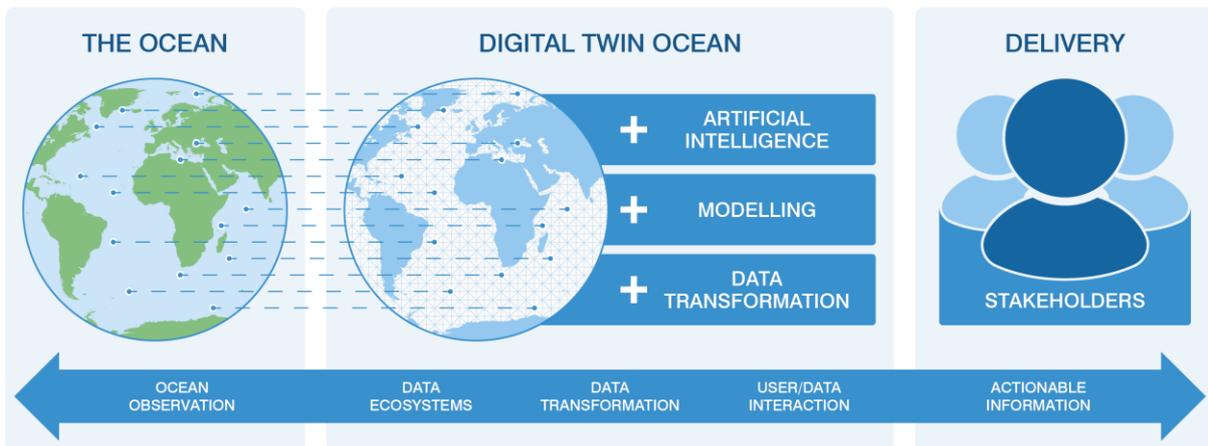


Figure: Illustration of the components of a Digital Twin of the Ocean: An interoperability environment in which marine data can be combined with other (e.g. environmental or social) datasets to add value. Users can access, manipulate, and analyse marine and related information, including testing scenarios and interventions.

**1. Background Information**

As part of the UK G7 Presidency, an Ocean Action was developed under the Climate and Environment Ministerial Track. The agenda included support for the UN Decade of Ocean Science for Sustainable Development (UN Ocean Decade) and support for the Global Ocean Observing System (GOOS) through the Future of the Seas and Oceans Initiative (FSOI). As an outcome of the UK G7 Presidency, a G7 Ocean Decade Navigation Plan was agreed as a framework for G7 collaboration in support of the UN Ocean Decade. Three initial ‘spotlight activities’ were identified on Net Zero Ocean Capabilities, Digital Twin Ocean (this paper) and Global Ocean Indicators. It was agreed that these ‘spotlight activities’ will be executed through the G7 FSOI.

<sup>1</sup> A ‘digital twin’ is a virtual representation that serves as the real-time digital counterpart of a physical object or process.

Digital twin capability brings together data with models, AI/Machine Learning (ML) and data sciences interactive tools to advance the way we integrate, analyse and explore data, including testing out scenarios and management interventions. Applied to the ocean this will accelerate ocean knowledge and give tools to decision makers. Whilst collecting observations allows us a small window into our ocean, a digital twin will allow a more complete view of our ocean by bringing observations together with models and using big data tools to ultimately provide an easily accessible, flexible and fully resolved (in space and time) representation of our seas and ocean for scientists, governments, marine operators and marine users.

There is significant interest in the development of digital twin technologies applied to the ocean. The Digital Twin of the Ocean (DITTO) Programme has been developed and approved as a UN Ocean Decade Programme, and programmes such as the EU Destination Earth have captured imagination. However, to realise the exciting vision and potential of Digital Twin Ocean Technologies, significant effort is needed to develop and integrate the required key components of underpinning capability.

A digital twin requires E-infrastructure that includes not just computers and data storage hardware, but also the software, networks, security and standards, all of which needs development. This 'spotlight activity' therefore has links to the FSOI Action Area 3 proposed activity on Data Sharing and Data Infrastructures.

To deliver digital twins of the ocean, we need:

- a) A **fit for purpose observing** system, which is the fundamental underpinning to any digital twin.

Specifically, the digital twins of the ocean will have needs of the ocean observing network, informed by users. GOOS activities in co-design will need expert contributions on user requirements from Digital Twins and the Co-Design (ObsCoDe) UN Ocean Decade project proposed by GOOS should be supported to include Digital Twin engagement.

- b) A **data infrastructure** that frees up access to ocean observations through data communication and management in a timely way following the Findable, Accessible, Interoperable, Reusable (FAIR) data principles.

Specifically, it is suggested building upon technical infrastructure already being developed under WMO, extending WIS2.0 and the OpenGTS to improve open access and global interconnects for ocean observations and integration between ocean and other data.

Open data is a key part of the Digital Twin approach and should be encouraged. The IOC Oceanographic Data Exchange Policy (2019)<sup>2</sup> and WMO Resolution 42 set the framework in which data should be shared, and supporting these policies is key to success of the Digital Twin Ocean concept.

- c) A **data lake** on which marine observed data and other data resources are accessible along with the computing capacity to add value to these data.

Data from diverse activities and sources must be collated in interoperable forms onto Cloud computing or High-Performance Computing (HPC) architectures to allow the data engine access to transform and add value to the data. The protocols to do this are dataset dependent and will require effort to develop.

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<sup>2</sup> [https://www.iode.org/index.php?option=com\\_content&view=article&id=51&Itemid=95](https://www.iode.org/index.php?option=com_content&view=article&id=51&Itemid=95)

- d) A **data engine** that supports modelling and AI / ML tools to access, manipulate, analyse and visualise marine information to maximise the understanding and value from these data.

Oceanography has yet to significantly benefit from the AI and data revolution, and the focus must be to develop the tools to add value to ocean observations, through combining them with ocean models and AI / ML.

The ocean cannot be seen in isolation from the adjacent earth system components, and increasingly modelling and digital twin activities will be cross-thematic. The G7 is well placed to lead on the modelling of our ocean coupled to the atmosphere and our coastlines to create the ocean component in a coherent Digital Twin Earth.

- e) An **interactive layer** allowing users to visualize, interact and tailor the data, scenarios and models to meet their needs.

Access to the tools in the data engine through which the data is accessed should be flexible and be able to serve a range of users and use types. If the interactive layer through which users access the data is not powerful but easy to adapt, and use, then the value in the Digital Twin will not be realised. These interfaces do not yet exist and must be developed.

- f) A series of **federated cloud-based modelling and simulation platforms**, providing access to data, advanced computing infrastructure, software, AI applications and analytics

Users of ocean information will need to combine marine and non-marine data. There are going to be a number of Digital Twins Oceans developed for different purposes so developing a range of use cases from policy to science to operational services is needed to ensure uptake and to demonstrate the value in the Digital Twins. One of the priority use cases for Digital Twins should be in engaging the public and improving Ocean Literacy.

UN Ocean Decade proposals related to/contributing to Digital Twin Ocean capability include (but not limited to):

- ObsCoDe: a GOOS proposal to develop underpinning observation infrastructure, co-designed with models.
- Seabed 2030: a collaborative project between the General Bathymetric Chart of the Oceans (GEBCO) and the Nippon Foundation with the aim to facilitate the complete mapping of the global ocean floor by the year 2030.
- Foresea: proposed programme from OceanPredict for developing the ocean modelling assimilation capability and building a seamless ocean information value chain, from observations to end users.
- CoastPredict: a GOOS proposal to co-design an integrated framework for a global coastal ocean observing and forecasting system.
- DITTO: programme to establish and advance a digital framework on which all marine data, modelling and simulation along with HPC capacities, AI algorithms and tools.

Funding programmes on Digital Twinning include (but not limited to):

- UKRI Constructing a Digital Environment Strategic Priorities Fund
- EU H2020 Innovation project to establish a pilot Digital Twin of the Ocean with €12M funding for a three-year project.

- Destination Earth: Starting with a Digital Twin on Weather induced and Geophysical Extremes and on Climate Change Adaptation<sup>3</sup>, the ambition is to achieve a full digital twin of the Earth through a convergence of the digital twins already offered
- Canada's Ocean Supercluster is an industry-led cluster that seeks to transform and connect the ocean economy in Canada. One of the key strategic pillars is investing \$18M developing and advancing digital twin technology for the ocean<sup>4</sup>

## **2. Description of Activity and next steps**

While there is much excitement about the vision and potential of Digital Twin Ocean capability, effort is needed to develop and evaluate the required underpinning infrastructure and protocols, and align effort to develop, share and integrate these components. The digital twin ocean concept offers a new framework that requires close linkages between key components of underpinning infrastructure including ocean observations, data processing, and modeling and forecasting. The G7 FSOI Action Area 3 priorities have been integrated into this framework to explore needs and linkages across the G7 action areas.

**Phase 1:** Establish a Task Team to organise a Workshop which will evaluate status, gaps and needs for underpinning infrastructure and protocols to enable the Digital Twin Ocean capability. The Workshop will provide important foundational assessment to support the development of the UN Ocean Decade Digital Twins of the Ocean (DITTO) Programme, and identify areas for focussed effort and development:

Proposed Workshop goals:

- a) Review current seamless data integration, including physical, chemical and biological data, and needs to make our data holdings 'data science ready'.
- b) Review needs for cooperation on ocean modelling (reanalysis, analysis and forecasting)
- c) Review existing digital twin ocean activities, highlight capabilities and needs, horizon scan regarding new capability developments (including broader environmental digital twinning)
- d) Identify next steps for bringing together 'building blocks' capability for digital twin oceans and agree on priority areas for development.
- e) Identify targeted pilot projects to take forward R&D work.

**Phase 2:** To be discussed following report on outcomes of phase 1, in coordination with the DITTO Programme.

## **3. Resourcing**

Phase 1: A virtual/hybrid workshop (hosting to be supported by Defra), plus 20% FTE support from G7 FSOI Coordination Centre. G7 expert engagement in the planning and execution of the workshop.

Phase 2: to be determined.

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<sup>3</sup> <https://ec.europa.eu/digital-single-market/en/destination-earth-destine>

<sup>4</sup> <https://oceansupercluster.ca/project/digital-offshore-canada-zones-extracotieres-numerique-du-canada/>