ILIAD Discussion (PDII)

Fri. Nov 13, 2026 2:00 PM - 3:30 PM JST | Fri. Nov 13, 2026 5:00 AM - 6:30 AM UTC | Room C (201) (2F)

Oral C5 A Federated Ocean-Earth Digital Twin Ecosystem: Connecting EDITO, Destination Earth and Open Standards

Chair: Bente Lilja Bye, Marco Oliveira

2:00 PM - 2:05 PM JST | 5:00 AM - 5:05 AM UTC

[cMFDCOEL-01] Intro: From project twins to an ecosystem of twins

*Bente Lilja Bye[1] (1. BLB (Spain))

2:05 PM - 2:15 PM JST | 5:05 AM - 5:15 AM UTC

[cMFDCOEL-02] What Survives ILIAD? From 22 Local and Thematic Twins to Reusable Building Blocks

*Arne Jørgen Berre[1] (1. SINTEF (Norway))

2:15 PM - 2:25 PM JST | 5:15 AM - 5:25 AM UTC

[cMFDCOEL-03] Making the analytics travel: Iliad application packages from local twins to EDITO

*Marco Oliveira[1] (1. INESC TEC (Portugal))

2:25 PM - 2:35 PM JST | 5:25 AM - 5:35 AM UTC

[cMFDCOEL-04] Building Blocks for AI-Ready Ocean Data: An Interoperability Architecture for Digital Twins of the Ocean

*Robert Atkinson[1] (1. OGC (Germany))

2:35 PM - 2:45 PM JST | 5:35 AM - 5:45 AM UTC

[cMFDCOEL-05] Digital Ocean Twins as an Emerging Tool for Advancing Ocean Literacy: Opportunities and Challenges

*Lara Veylit[1] (1. SINTEF Ocean (Norway))

2:45 PM - 2:55 PM JST | 5:45 AM - 5:55 AM UTC

[cMFDCOEL-06] If Odysseus had a DTO: From Iliad practices to digital twin Earth development standards

*Sigmund Kluckner[1] (1. IEEE France / self (France))

2:55 PM - 3:05 PM JST | 5:55 AM - 6:05 AM UTC

[cMFDCOEL-07] NorDITO: Building Norway's digital twin of the ocean.

*Konstantinos Christakos[1] (1. Norwegian University of Science and Technology (Norway))

3:05 PM - 3:30 PM JST | 6:05 AM - 6:30 AM UTC

[cMFDCOEL-08] Discussion: What is the minimum interoperability contract for a federated Digital twin of the ocean

*Bente Lilja Bye[1] (1. BLB (Spain))

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[cMFDCOEL-01] Intro: From project twins to an ecosystem of twins

*Bente Lilja Bye[1] (1. BLB (Spain))

Digital Twins of the Ocean are moving from individual research demonstrators towards operational, distributed and increasingly interconnected infrastructures. The completion of the ILIAD Digital Twins of the Ocean project provides an opportunity to examine which components of local and thematic digital twins can persist, travel between infrastructures and contribute to a wider ecosystem of Digital Twins of the Earth.

ILIAD demonstrated a federated, standards-based approach encompassing local and thematic digital twins, interoperable data and services, semantic harmonisation, portable analytical workflows and links to the European Digital Twin Ocean infrastructure. The challenge now is to move from interoperability within individual initiatives towards interoperability between digital-twin ecosystems.

This session connects ILIAD results and their continuation with EDITO, the Destination Earth Digital Twin Engine, IEEE P3501 and related OGC standardisation, and emerging European initiatives including SEADOTs and EOSC-Marine. Short contributions will examine semantic interoperability, portable application workflows, infrastructure federation, cross-domain Digital Earth standards and pathways for onboarding local and regional twins into persistent infrastructures.

Rather than presenting individual projects, the session asks a common question: **what is the minimum interoperability contract that allows a local Digital Twin of the Ocean to become a reusable component of a European and ultimately global federation of Digital Twins?** The concluding discussion will identify practical requirements and opportunities for collaboration between DITTO, European initiatives and international standards communities.

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[cMFDCOEL-02] What Survives ILIAD? From 22 Local and Thematic Twins to Reusable Building Blocks

*Arne Jørgen Berre[1] (1. SINTEF (Norway))

ILIAD developed and demonstrated 22 local and thematic Digital Twins of the Ocean across a wide range of marine applications. Beyond the individual pilots, one of the project's main legacies is the set of reusable architectural principles, data-space concepts and interoperability mechanisms that can support future digital-twin ecosystems.
This presentation will highlight what can be taken forward from ILIAD: its federated architecture, common Digital Twin pipeline, interoperable data and services, semantic approaches, portable analytical components and experience with distributed data ownership and access.
The focus is on the lessons learned from moving from individual pilots toward a more connected ecosystem of Digital Twins of the Ocean, and on which building blocks, modules and design principles can be reused in future regional, European and global DTO initiatives.

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[cMFDCOEL-03] Making the analytics travel: Iliad application packages from local twins to EDITO

*Marco Oliveira[1] (1. INESC TEC (Portugal))

Many ocean Digital Twin applications begin as standalone analytical models, research scripts or locally deployed workflows configured for a specific computing environment. These implementations produce valuable scientific results, although they are frequently difficult to discover, reproduce, transfer between infrastructures, integrate into operational systems, replicate, or deploy in other Digital Twin infrastructures

The ILIAD project addressed this challenge by extending the concept of the Application Package defined in the OGC Best Practice (BP) for Earth Observation Application Packages. That BP specifies how applications can be described, packaged with their dependencies, and deployed on exploitation platforms, using technologies such as the Common Workflow Language, containers, and the OGC API – Processes. Building on this foundation, ILIAD refined the packaging guidelines for ocean and Digital Twin workflows and developed a standards-based processing service layer supporting the full application lifecycle.

The resulting architecture combines portable workflow descriptions and containerised tools with registries and execution services. OGC API – Records supports the registration, discovery and retrieval of Application Packages, while Processes API supports their deployment and execution as interoperable processing services. The same packaged workflow can therefore be prepared for execution across personal computers, cloud systems, clusters and HPC environments.

ILIAD also explored interoperability with broader European Digital Twin infrastructures. A translation tool was developed to transform suitable CWL-based packages, facilitating their deployment as processes on platforms such as EDITO. Several ILIAD workflows were translated and deployed using this approach, enabling the use of the European infrastructure as the computing backbone for Local DTs, while also revealing practical constraints related to workflow complexity, storage models, and infrastructure-specific requirements.

The main contribution is a practical transition pathway from research code to an operational, reusable service. The presentation will discuss architectural decisions, implementation experiences and remaining challenges related to portability, reproducibility, security, infrastructure heterogeneity and operational sustainability.

Acknowledgements: This work has received funding from the European Union's Horizon Europe Research and Innovation Programme under the Grant Agreement No. 101136903, through the project INESCTEC.OCEAN - Centre of Excellence in Ocean Research and Engineering (HORIZON-WIDERA-2023-ACCESS-01 - Teaming for Excellence) and National Funds from the Portuguese Republic.

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[cMFDCOEL-04] Building Blocks for AI-Ready Ocean Data: An Interoperability Architecture for Digital Twins of the Ocean

*Robert Atkinson[1] (1. OGC (Germany))

A digital twin of the ocean is only as trustworthy as the data flowing through it. Ocean information arrives from many communities, from physics and biology to fisheries and socio-economics, in different structures, described with different metadata, and named with different vocabularies. Forcing all of it into one common schema fails, because it either loses what each community depends on or grows into a superset no one can validate. And as digital twins increasingly rely on automated and AI-driven analysis, a further problem appears: a machine arriving at a dataset cannot reliably tell what it means, how good it is, or how it was produced, so it guesses, and confident, plausible, unaccountable answers are exactly what a decision-support twin cannot afford.

This talk presents a practical answer developed openly within OGC and its community. Interoperability requires handling four things together: APIs, schemas, semantic models, and vocabularies, and above all a way to declare how they join up. Rather than another standard, the approach is an architecture of composable, independently testable building blocks that bind structure, discovery, meaning, and provenance into machine-actionable artifacts. Meaning is declared and resolvable, provenance is assembled step by step, and correctness is checked automatically. The result is data that is interoperable, auditable, and AI-ready, whose lineage a person or an agent can trace back to the observation behind it.

Illustrated with marine worked examples, the talk introduces the Oceans Information Model, used as the basis for interoperability in the ILIAD Digital Twin of the Ocean. It shows how the same building blocks can make ocean data reusable across borders and platforms by reusing common standard models, and how declared meaning reduces the risk of AI hallucination. It is offered as a shared basis for discussion, consolidating recent pilots and testbeds rather than proposing a single mandate.

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[cMFDCOEL-05] Digital Ocean Twins as an Emerging Tool for Advancing Ocean Literacy: Opportunities and Challenges

*Lara Veylit[1] (1. SINTEF Ocean (Norway))

Digital twins of the ocean (DTOs) have the potential to be an ideal digital tool to enhance ocean literacy due to their interactive capabilities and integration of data from multiple disciplines. However, DTOs are vulnerable to misuse and to be misinterpreted by users, which could hinder users' ability to act as responsible ocean stewards. In this work, we assess whether DTOs can be useful affective learning tools for advancing ocean literacy, considering the possible mismatch between the technological complexity of DTOs and the needs of non-technical end users. We particularly highlight the importance of co-designing DTOs for explicit user groups in collaboration with experts from a range of fields, including Human-Computer Interaction (HCI) researchers and information designers, to develop effective and accessible user interfaces. We cautiously conclude that DTOs can be useful affective learning tools for improving collective ocean literacy via attitudinal change and can facilitate reaching high-level policy objectives (per the goals of initiatives such as the EU DTO and the UN Ocean Decade) when user needs (such as those of decision makers) are prioritized.

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[cMFDCOEL-06] If Odysseus had a DTO: From Iliad practices to digital twin Earth development standards

*Sigmund Kluckner[1] (1. IEEE France / self (France))

Digital Twins of the Ocean (DTOs) leverage advances in computing and data storage to improve ocean research and management through enhanced simulations, monitoring, and predictions. DTOs are an emerging field, with diverse approaches resulting in unique implementations. DTOs are currently developed for different localizations, time and geographic resolutions, and goals; their common denominator is the goal to support decision making through Digital Twin enabled simulations on ‘what-if’ scenarios.

Standardization and best practices enable interoperability and comparability across DTO systems, connecting data storage, models, simulation tools, and user interfaces from different domains. This enables the creation of a trusted ecosystem with consistency, accuracy, and reliability while still allowing proprietary innovation. Common data formats, protocols, metadata standards, and vocabularies reduce redundancy, minimize integration costs, and promote scalability. DTOs can then incorporate more variables or complex interactions without sacrificing quality, remain adaptable to new technologies, and support transparency and reproducibility.

Clear standards and practices prevent fragmented efforts and accelerate global DTO adoption, improving decision-making for environmental and societal resilience. They streamline processes and ensure interoperability across technical and human layers and can shorten implementation timelines and improve communication among engineers and stakeholders.

The EU-funded Iliad project aimed to integrate localized DTOs for sectors like aquaculture, oil spill, offshore wind, or citizen science. Each pilot combines domain-specific engineering with digital systems practices, which were documented in the “Iliad Compendium”. Newly developed practices and standards from DTO projects are encouraged to be documented and shared with the broader digital twin and ocean research communities, for example on the Ocean Best Practices System OBPS or in professional societies like IEEE Oceanic Engineering Society.

Standards and best practices are essential for DTO development, ensuring interoperability, scalability, and trust. Initiatives like IEEE P3501 exemplify efforts to align practices globally, accelerating innovation and supporting resilient ocean management.

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[cMFDCOEL-07] NorDITO: Building Norway's digital twin of the ocean.

*Konstantinos Christakos[1] (1. Norwegian University of Science and Technology (Norway))

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[cMFDCOEL-08] Discussion: What is the minimum interoperability contract for a federated Digital twin of the ocean

*Bente Lilja Bye[1] (1. BLB (Spain))

Discussion

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