

interTwin

D2.6 Final report on Innovation Management, Exploitation and Sustainability

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Abstract

Key Words

Innovation Management, Exploitation, IP Management

The document provides an update of the innovation processes, guidelines and instruments along with the exploitation activities and plans as defined in D2.2 and followed in D2.4.

interTwin is a project to co-design and implement the prototype of an interdisciplinary Digital Twin Engine (DTE), that enables the implementation of application-specific Digital Twins (DTs).

In this deliverable, the progress of innovation management activities are presented.

- For the Understanding the Market, Technological and Political Context the market analysis is expanded to provide a broader understanding of the upstream, horizontal and downstream markets and the relevance to interTwin, main stakeholders are listed including ongoing collaboration opportunities and actions, the progress of the External Expert Advisory Board meetings organization and feedback is provided. Also an annex provides the list of news tracked under technology watch
- For the results collection and IP management, the detail of the 49 results collected is provided, including their ownership, IPR, access license. Key Exploitable Results information is expanded indicating the subcomponents included for each of them and the main achievements.
- For the exploitation progress, the summary of the final business modelling workshops organized is provided, including the Business Model Analysis to understand the sustainability and impact of the project and the work performed. The exploitation success stories for each of the Key Exploitable Result is provided - including those for Further Research, the creation of new Products and Services (or the improvement of already existing ones) and standardization efforts.

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Terminology / Acronyms	
Term/Acronym	Definition
DT	Digital Twin
DTE	Digital Twin Engine
KER	Key Exploitable Result
DoA	Description of Action
GA	Grant Agreement
CA	Consortium Agreement
DestinE	Destination Earth
EEAB	External Expert Advisory Board
EOSC	European Open Science Cloud
ETP4HPC	European Technology Platform For High Performance Computing
EuroHPC	European High-Performance Computing Joint Undertaking
HPC	High-Performance Computing
HTC	High-Throughput Computing
IEG	Innovation and Exploitation Group
IMS	Innovation Management System
IP	Intellectual Property
IPR	Intellectual Property Rights
PEST Analysis	Political, Economic, Social and Technological Analysis
TRL	Technology Readiness Level
TCB	Technical Coordination Board
AMB	Activity Management Board
WfMSs	Workflow Management Systems

Terminology / Acronyms: <https://confluence.egi.eu/display/EGIG>

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Executive summary

The document provides an update of the interTwin project innovation processes, guidelines and instruments along with the exploitation activities and plans as defined in D2.2 and followed in D2.4 progress reports. interTwin is a project to co-design and implement the prototype of an interdisciplinary Digital Twin Engine (DTE), that enables the implementation of application-specific Digital Twins (DTs).

In this deliverable, the final status and progress of innovation management activities are presented.

- For the Understanding the Market, Technological and Political Context the analysis has been extended to provide a broader view of how the project has influenced the political evolving landscape. The different stakeholders shortlisted in D2.4 have been extended and the assessment of the achieved collaborations and activities has been updated in the corresponding annex. The report of the final External Expert Advisory Board meeting is provided along with the main conclusions. Also an annex provides the updated list of news tracked under technology watch.
- For the results collection and IP management, the detail of the 42 results collected at M22 has been expanded to 49 at the end of the project M36, including their ownership, IPR, access license. Key Exploitable Results information is expanded indicating the subcomponents included for each of them.
- For the exploitation progress, the final report of the business modelling workshops is provided, including the public workshop on “How the interTwin Innovation Management System is used to foster projects' Exploitation and Sustainability” and the “Impact Driven Workshop - Assessment of impact across projects” organized in the last part of the project. The Business Model Analysis has been completed expanding the exploitation strategy of the project. The progress of all the exploitation activities for each of the Key Exploitable Result is provided - including those for Further Research, the creation of new Products and Services (or the improvement of already existing ones) and Standardization efforts and an initial set of early success stories have been shortlisted.

interTwin has contributed to democratising science, our services have enabled communities all-around Europe to develop solutions that tackle the data problems of the next decade.

1 Introduction

interTwin co-designs and implements the prototype of an interdisciplinary Digital Twin Engine (DTE) - an open-source platform based on open standards, that enables the development and implementation of application-specific Digital Twins (DTs). Its functional specifications, development and implementation are based on a co-designed interoperability framework and conceptual model of a DT for research - the DTE blueprint architecture. The ambition of interTwin is to create consensus on a common approach to the implementation of DTs that is applicable across a wide spectrum of scientific disciplines that will facilitate developments and interoperability across different DTs.

1.1 Scope and Purpose

As part of Work Package WP2 (Innovation Management and Communications), Task T2.1 (led by EGI.eu) deals with Innovation Management and Exploitation. This deliverable D2.6 builds from the previous Innovation Management Progress report D2.4 and presents the progress towards the plan for the last year of the project as defined in D2.2. The document builds on the innovation processes, guidelines and instruments along with the exploitation plans¹. This report also recaps on how the exploitation activities have turned into success stories that grant the sustainability of project results and their impact.

The activities outlined in this report address the main achievements in the implementation of the **innovation management system** of the project and towards the different main activities of the work package. This includes:

- For the Market, Technological and Political Context, (1) a wrap up of the market analysis, including the relevant policy elements, the opportunities and achievements arising from the interTwin project and the related technology watch; (2) A summary of the stakeholder mapping and how the different stakeholders contributed to the project. (3) The final feedback from the External Expert Advisory Board (EEAB) and collaborations that have emerged from the collaborations with the EEAB members. Altogether has ensured the project would remain relevant from the evolving market and political landscape and has enabled to leverage the market-pull opportunities arising from the feedback collected from external sources
- The final project results identified at the end of the project with all the necessary information related to Ownership, IP Rights, Access Conditions and an update on the 6 Key Exploitable Results of the Project. It has enabled de-risking of any IP-related matters of the project and leveraging the technology-push opportunities arising from the technical work within the project.
- An update of the exploitation activities performed or planned at M36 that ensure the results will be further developed, re-used and adopted beyond the project context and after the end of the project highlighting success stories.

¹ <https://zenodo.org/records/10721988>



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With the help of T2.2 (Dissemination, Communications and Engagement), and completing the stakeholder engagement of D2.5, the main project stakeholders are identified and engagement actions assessed, to ensure maximum accessibility and reuse of the results and hence to maximize the emergence of project outcomes.

The development of the plan was co-advised by the Innovation and Exploitation Group and EEAB members.

1.2 Structure of the document

This document contains the innovation management and exploitation progress for the project. The introduction provides the basics of the project including the context and framework, and some important definitions. Section 2.1 includes the update of the interTwin Market, Technological and Political Context at the end of the project. Section 2.2 describes the progress in the results collection and IP Management. Section 2.3 provides the progress towards the exploitation activities, sustainability, impact and success stories. Finally, Section 3 exposes conclusions.

1.3 Framework and Context

The work to be performed by the Innovation Management plan is described in Task 2.1 of WP2 of interTwin DoA. It entails the definition of an Innovation Management System that,

- *Implements and conducts an operational innovation management process that ensures all project results are systematically captured, assessed for exploitation readiness and validated along with an improvement cycle to strengthen them.*
- *Organises relevant meetings and hands-on workshops (e.g. on business models) that will support the complete innovation management lifecycle.*
- *Coordinates dissemination and the implementation of the exploitation plan, monitoring dissemination effectiveness and potentially changing market landscapes, responding to feedback and the potential for new business opportunities.*

The main task outputs are:

- **D2.2. Innovation Management and Exploitation Plan**
- **D2.4 Innovation Management and Exploitation Report and Updated Plan.**
- D2.6 Final report on Innovation Management, Exploitation and Sustainability (this deliverable)

And the policy briefs:

- RP1 Policy Brief
- RP2 Policy Brief
- RP3 Policy Brief

D2.6 Final report on Innovation Management, Exploitation and Sustainability

This deliverable is built from previous ones D2.2 and D2.4 and describes the progress in the 3 main activities of the plan till the end of the project. Some parts of D2.6 are directly taken or derived from the previous deliverables to ensure the correct readability of the document. Other sections such as the plan and the procedures are omitted in this deliverable to focus on the added value aspects and the project progress.

This deliverable complements the other deliverables in WP2 referring to the dissemination task

- [**D2.1. Communication, Dissemination and Engagement Plan**](#)
- [**D2.3. Communication, Dissemination and Engagement Activity Report and Updated Plan**](#)
- [**D2.5. Final report on Communication, Dissemination and Engagement**](#)

In the above, the main target groups and target audiences need to be in line with the main stakeholders. In the middle of the project period, dissemination activities will aim to promote the uptake of project results and key exploitable results. At the end of the project, successful exploitation will be disseminated as success stories.

This deliverable also follows the procedures described in D1.1 / D1.3 - Quality and Risk Management Plan, and contributes to the development of the [**Data management plan D1.2 / D1.4**](#)

In this deliverable a high-level description of each of the components produced by the project is provided. Further information on these can be found in the initial versions of the deliverables written under the technical work packages. Further detail can be found in the following deliverables that were scrutinized for the realization of this deliverable:

Updated versions of the Blueprint and Interoperability Deliverables:

- [**D3.3 Interoperability protocols for data, metadata and workflow semantics across disciplines and research infrastructures report**](#)
- [**D3.5 DTE blueprint architecture, functional specifications and requirements analysis third version**](#)
- [**D3.7 Report on software architecture concepts based on DestinE and InterTwin**](#)

Updated versions of the Components design deliverables

- [**D4.7 Final version of the DTs capabilities for climate change and impact decision support tools including validation reports**](#)
- [**D4.8 Final version of the DT capabilities for High Energy Physics, Radio astronomy and Gravitational-wave Astrophysics including validation reports**](#)
- [**D7.5 Updated report on requirements and thematic modules functionalities for the environment domain**](#)
- [**D7.6 Updated report on requirements and thematic modules functionalities for the physics domain**](#)
- [**D5.3 Final Architecture design update based on the first experiences**](#)
- [**D6.3 Updated report on requirements and core modules functionalities**](#)

And the final release and integration reports

- [D3.6 DTE Second software release](#)
- [D4.5 Final Architecture design of the DTs capabilities for climate change and impact decision support tools](#)
- [D4.6 Final Architecture design of the DTs capabilities for High Energy Physics, Radio astronomy and Gravitational-wave Astrophysics](#)
- [D5.4 Final DTE Infrastructure software release](#)
- [D6.4 Final release of the DTE core modules](#)
- [D7.7 Final version of the thematic module for the environment domain](#)
- [D7.8 Final version of the thematic module for the physics domain](#)
- [D5.5 DTE infrastructure development and integration report](#)
- [D6.5 Core development and integration on DTs report](#)
- [D7.9 DTE Thematic modules development and integration report](#)

First versions of the deliverables were analysed for the previous versions of the innovation management deliverables.

KPIs and outcome and impact metrics needed to track the success of the project are provided in the Progress Report M36.

It is noteworthy to highlight the work related to the interTwin project is bound to the following legal documents:

- Grant Agreement Nr. 1010583836 between the European Commission and the Coordinator (EGI)
- Consortium Agreement between all project partners

In these documents, specific articles and clauses regulate exploitation, results, ownership and joint ownership, access, and open science among others. Some of those have been included in the definitions (**Annex 1**).

2 Innovation Management and Exploitation Progress (M36)

The Innovation management plan is fully described in D2.2 and built around 3 main activities listed below, to be performed during the project and their corresponding processes and procedures:

- Understanding the Market, Technological and Political Context of the project is crucial to providing the necessary market information to incorporate the project solutions.
- Capture and identify project results to push technologies and services to the market including ownership, and associated IP Rights and access strategy
- Prepare, monitor, and update exploitation, business, and sustainability plans in order to ensure the proper uptake of project results to cover expected pathways to impact, while generating the necessary feedback loop back to all other innovation stages of the project.

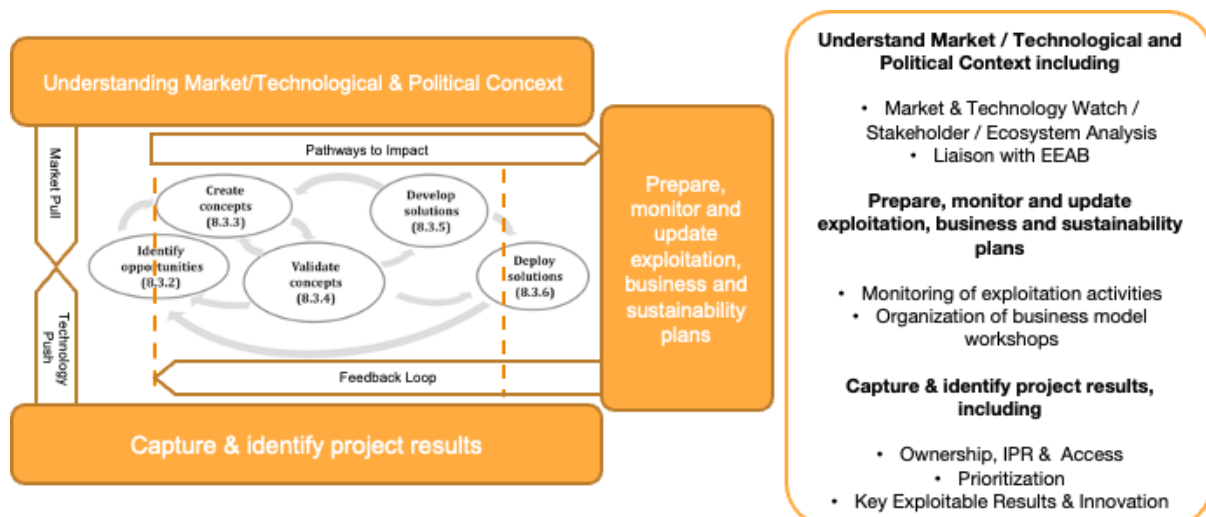


Figure 1 Main innovation management activities

In the following sections, the consolidated report and main achievements for each of the activities is provided.

2.1 interTwin Market, Technological and Political Context Progress (M36)

2.1.1 interTwin achievements in the evolving market, technological and political landscape

The main market addressed in the interTwin project is the Digital Twins Market. Figure 2 depicts the adjacent market verticals (application domains), horizontals (enabling technologies) and downstream (infrastructure). In D2.6 the emerging market for Digital Twins for science has been added, spanning from the traditional industrial-driven general one.

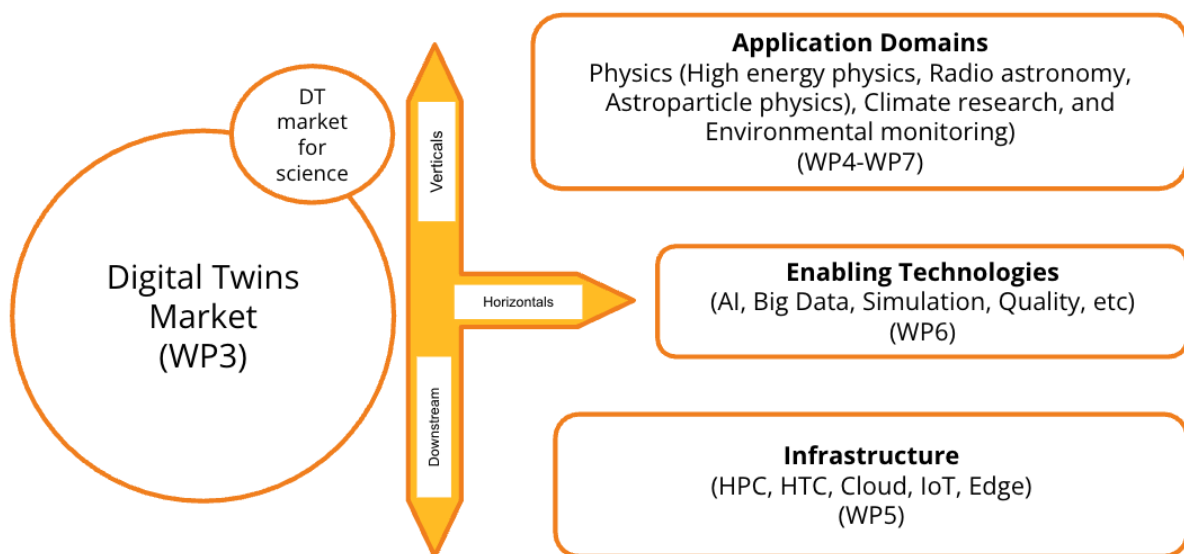


Figure 2 interTwin Key Markets

The global Digital Twin market size was valued at USD 11.12 billion in 2022, and grew to 16,75 billion in 2023, 24,97 billion in 2024 and is expected to grow at a compound annual growth rate (CAGR) of 34.2% from 2025 to 2030, according to a report by Grand View Research². Other reports also predict even higher CAGRs up to 60% annually reaching 73,5 billion by 2027³, or 42,6% and that the market will reach a size of USD 137,67 billion by 2030.⁴

This growth will be enabled by upgraded infrastructure technologies in the compute continuum -from the Edge-to-Cloud to HPC, and boosted by the emergence of GenAI mega-trend - along with specific artificial intelligence (AI) and big data analytics used to collect, analyse, and manage data from physical assets in real-time, creating a virtual replica of the physical asset.

² <https://www.grandviewresearch.com/industry-analysis/digital-twin-market>

³ <https://www.mckinsey.com/featured-insights/mckinsey-explainers/what-is-digital-twin-technology>

⁴ https://www.ey.com/en_in/insights/technology/digital-twins-creating-intelligent-industries

Geographically, the European digital twin market has also grown significantly, as such, generated a revenue of USD 7,075.2 million in 2024, and is expected to grow at a CAGR of 33.5% from 2025 to 2030 driven mainly by automotive and transport.

Key market players like Siemens, GE, IBM, and Microsoft are leading across the different verticals: Siemens, a major player providing digital twin solutions across various industries, particularly in manufacturing and industrial automation, GE in the utilities sector, IBM provides digital twin solutions integrated with AI and analytics, targeting diverse industries like automotive, aerospace, and manufacturing, Microsoft, through its Azure platform, offers robust digital twin services that cater to smart buildings, smart cities, and industrial IoT applications. Other key European players are ABB, Schneider Electric, Robert Bosch.

The emergence of digital twins for science

As stated in D2.4 commercial adoption of Digital Twins has been happening across various verticals, including manufacturing, healthcare, aerospace, automotive, smart cities, energy and utilities, and construction and is spanning over the traditional domains at extremely high rates as stated above.

The rise of digital twins for science has been growing during the interTwin project timeline and has motivated relevant publications such as a special issue within nature computational science⁵ or national studies such as the *foundational research gaps and future directions for digital twins* by US NSF⁶. They highlight Digital Twins as those virtual, continuously updated models of physical and socio-technical systems that can accelerate discovery and improve decision-making across domains (engineering, climate, medicine, cities) and highlight several opportunities and recommendations both from a technological and policy point of view. Digital Twins enable faster scientific discovery and hypothesis testing, operational decision support for policy and emergency response, cross-domain reuse and economies of scale and the creation of new industry and public services. interTwin project has tackled those opportunities in the following ways:

Opportunity 1: A faster scientific discovery and hypothesis testing: interTwin project has demonstrated how Digital Twins can be extremely useful also in science because they allow researchers to simulate complex systems in changing environments and predict how they will behave under different conditions while being able to adjust depending on real-time gathered data. This helps researchers optimize their experiments, improve their understanding of complex phenomena, and develop more effective strategies for managing environmental systems.

Opportunity 2: Operational decision support for policy and emergency response: interTwin environmental use cases have created Digital Twin prototypes that can inform

⁵ <https://www.nature.com/collections/feicjiideh>

⁶ <https://nap.nationalacademies.org/catalog/26894/foundational-research-gaps-and-future-directions-for-digital-twins>

adaptation, disaster response and planning with policy-relevant scenarios, which is one of the motivations behind EU DestinE⁷.

Opportunity 3: Cross-domain re-use and economies of scale: interTwin modular approach of the Digital Twin Engine has enabled the reuse of core, infrastructure and thematic components across domains (such as data lakes, orchestration, AI and quality frameworks, etc), reducing duplications and are available for being deployed in further initiatives.

Opportunity 4: The creation of new industry and public services: Open sourced components foster the industrial adoption of the components enabling consultancy and support services. Core components have been incorporated to EGI Operational Services available for European research communities within the EGI Federation.

Enabling technologies - the emergence of AI and GenAI mega-trends

Within D2.4 main commercial initiatives linked to AI and Digital Twinning were analyzed such as NVIDIA, Intel, Microsoft Azure, Amazon, Google indicating the need for promoting European Open Source alternatives to prevent the lock-in to non-european commercial solutions.

During the 3 years of the project the attention and massive adoption of AI technologies has dramatically increased: the global artificial intelligence market size was estimated at USD 279.22 billion in 2024 and is projected to reach USD 3,497.26 billion in 2033, expanding at a CAGR of 31.5% from 2025 to 2033⁸. This makes all AI-related results of the project especially relevant. Within Europe this emergence has been tackled politically as the AI Act has come into force 1st October 2024⁹. This has been followed by the strategies and plans that include future investments over 1 billion part of the Coordinated Plan on AI¹⁰, which includes an AI Innovation Package¹¹ and the launch of AI Factories¹² linked to EU-based supercomputing facilities, and the actual adoption of the AI Strategy has been kick-started on 7th October 2025¹³.

One of the initial implementation initiatives is the GenAI4EU flagship initiative¹⁴, with close to €700 million funding planned in Horizon Europe, the Digital Europe Programme, and the European Innovation Council. The objective of Gen4AI regarding science:

*Leveraging GenAI to drive new levels of productivity and capability for researchers in both the private and public sectors, fostering innovation and scientific advancements.*¹⁵

⁷ <https://destination-earth.eu/>

⁸ <https://www.grandviewresearch.com/industry-analysis/artificial-intelligence-ai-market>

⁹ <https://digital-strategy.ec.europa.eu/en/policies/regulatory-framework-ai>

¹⁰ <https://digital-strategy.ec.europa.eu/en/policies/plan-ai>

¹¹ https://ec.europa.eu/commission/presscorner/detail/en/ip_24_383

¹² <https://digital-strategy.ec.europa.eu/en/policies/ai-factories>

¹³ <https://digital-strategy.ec.europa.eu/en/policies/apply-ai>

¹⁴ <https://digital-strategy.ec.europa.eu/en/policies/genai4eu>

¹⁵ https://eic.ec.europa.eu/eic-funding-opportunities/eic-accelerator/eic-accelerator-challenges-2025/genai4eu-creating-european-champions-generative-ai_en



Opportunity 5: The emergence of GenAI mega-trend creates the opportunity for extensions of the use cases or follow up projects that re-use the scenarios created by the digital twins and democratises their use for non-technical end-users, such as policy makers, by the creation of novel interfaces that translate their requirements into concrete assessments and increase scale and speed of DT deployment across different scientific domains.

On the infrastructure side - breaking silos across the compute continuum

Digital twinning requires an operational compute infrastructure able to operate across the whole compute continuum¹⁶. While commercial initiatives are providing end-to-end solutions, Edge, IoT, Cloud and HPC are well-established markets, within Europe there are a large quantity of compute resources used for scientific purposes that need to be adapted to tackle the challenges of Digital Twins.

- EGI has been providing world-class infrastructure for data-intensive computing to scientific communities (along with private and public sectors), representing over 100k users over the last 15 years¹⁷. It has been instrumental for the achievement of the Nobel Prize in Physics 2013 awarded to François Englert and Peter W. Higgs¹⁸. This was followed in 2017 by the Nobel Prize for the groundbreaking detection of gravitational waves awarded to the LIGO/VIRGO collaboration¹⁹. Their work relied on a distributed computing platform that included some of Europe's largest research data centres, federated through EGI services.
- EuroHPC²⁰ has been deploying top500 supercomputing infrastructure available for scientific research, including 3 systems on the Top 10 (JUPITER, LUMI and LEONARDO)²¹ and 11 supercomputing facilities available for cross cutting research²². Its scope has been extended to tackle future AI challenges by the creation of the so-called AI-Factories²³ that recently (on 14th October 2025) has announced the extension of the initial systems (Meluxina, Leonardo, Lumi, MareNostrum5, Discoverer and Vega among initial AI Factories)²⁴ adding 13 new AI-factory antennas²⁵
- In the recent years, the European Open Science Cloud (EOSC)²⁶ has also started to be fully operational as the EOSC EU Node²⁷, procured by the European

¹⁶ <https://eucloudedgeiot.eu/enabling-technologies-for-the-compute-continuum-what-should-europes-priorities-be/>

¹⁷ <https://www.egi.eu/article/egi-foundation-turns-15/>

¹⁸ <https://www.nobelprize.org/prizes/physics/2013/summary/>

¹⁹ <https://www.nobelprize.org/prizes/physics/2017/summary/>

²⁰ https://eurohpc-ju.europa.eu/index_en

²¹ https://www.eurohpc-ju.europa.eu/eurohpc-supercomputers-put-europe-forefront-global-supercomputing-2025-06-10_en

²² https://www.eurohpc-ju.europa.eu/supercomputers/our-supercomputers_en

²³ <https://digital-strategy.ec.europa.eu/en/policies/ai-factories>

²⁴ https://www.eurohpc-ju.europa.eu/ai-factories/ai-factories-systems_en

²⁵ https://www.eurohpc-ju.europa.eu/eurohpc-ju-selects-ai-factory-antennas-broaden-ai-factories-initiative-2025-10-13_en

²⁶ https://research-and-innovation.ec.europa.eu/strategy/strategy-research-and-innovation/our-digital-futurescience/european-open-science-cloud-eosc_en

²⁷ <https://open-science-cloud.ec.europa.eu/>



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Commission was launched in October 2024, providing a set of data, tools and services to researchers across Europe. EOSC aims to catalyse access for researchers and machines to high-value, machine-actionable research data and other digital objects produced along the research life cycle, such as software and publications. It should enable interoperability of data across and within disciplines, and (re-)use of data by linking them with related tools and services, in line with the 'FAIR' (Findability, Accessibility, Interoperability, Reusability) data principles.

Opportunity 6: The different initiatives have traditionally been evolving in silos despite the overall need for interoperating is well acknowledged in all the areas. interTwin has successfully tackled all those aspects by federating Cloud -including EOSC EU Node, HTC, HPC -including EuroHPC to deploy and operate Digital Twin applications.

Market verticals - interTwin solutions to serve Research Infrastructures

Research infrastructures²⁸ and technology infrastructures²⁹ are the backbone of Europe's research and innovation system. They range from advanced laboratories, large scientific instruments and data centres to pilot lines, testbeds and clean rooms. Together, they support the full innovation cycle – from frontier science to the validation and deployment of new technologies. This makes them essential for Europe's scientific excellence, competitiveness and technological sovereignty.³⁰

As explained in D2.4, interTwin use cases cover Astrophysics, High Energy Physics and Radioastronomy on the one hand, and Climate research and environmental monitoring on the other hand. Concretely the interTwin project been aiming to play a transformative role in advancing major European research infrastructures shortlisted part of the ESFRI RI catalogue³¹ represented by interTwin partners institutions.

Within Astrophysics, High Energy Physics and Radioastronomy domain following RIs and interest groups are represented by interTwin partners: VIRGO Collaboration³² in preparation of the future Einstein Telescope³³, MeerKat in preparation of the future SKAO (Square Kilometer Array Observatory)³⁴ and the future set-up HL-LHC³⁵.

They have implemented the following use cases of the project:

²⁸ https://research-and-innovation.ec.europa.eu/strategy/strategy-research-and-innovation/our-digital-future/european-research-infrastructure_en

²⁹ https://research-and-innovation.ec.europa.eu/research-area/industrial-research-and-innovation/technology-infrastructure_en

³⁰ https://research-and-innovation.ec.europa.eu/strategy/strategy-research-and-innovation/our-digital-future/european-strategy-research-and-technology-infrastructure_en

³¹ <https://ri-portfolio.esfri.eu/ri-portfolio/>

³² <https://www.virgo-gw.eu/>

³³ <https://www.et-gw.eu/>

³⁴ <https://www.skao.int/en>

³⁵ <https://home.cern/science/accelerators/high-luminosity-lhc>



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- WP4.1 Lattice QCD Simulations - High Energy Physics³⁶
- WP4.2 Detector simulation - High Energy Physics³⁷
- WP4.3 Noise simulation for radio astronomy³⁸
- WP4.4 VIRGO Noise detector DT - Astrophysics³⁹

Opportunity 7: High-energy-physics, astrophysics and radio astronomy domains are very scientific focused. They depend on the publicly available compute and data infrastructure, and the main driver is to optimize the usage of infrastructures to facilitate and deliver scientific impact and hence increase the impact of public investment.

Within Climate and Environmental domain, the following organizations are represented by interTwin partners: the ENVRI Community⁴⁰, IS-ENES (European Network for Earth System Modeling)⁴¹, GEO (Group on Earth Observation)⁴² the EARSel (European Association of Remote Sensing Laboratories)⁴³, PANGEO⁴⁴, among others.

They have been tackled within the following use cases of the project:

- WP4.5 Climate Change Future Projections of Extreme Events (storms & fire)⁴⁵⁴⁶
- WP4.6 Early Warning for Extreme Events (floods & droughts)⁴⁷⁴⁸
- WP4.7 Climate Change Impacts of Extreme Events (storms, fire, floods, drought)⁴⁹⁵⁰

Within Europe, one of the biggest political endeavours is Destination Earth (DestinE), a flagship initiative to develop a highly accurate digital model of the Earth (i.e. a digital twin of the Earth) to model, monitor and simulate natural phenomena, hazards and the related human activities. DestinE is an essential pillar of the European Commission's efforts towards the Green Deal⁵¹ and Digital Strategy⁵².

Opportunity 8: Environmental use cases have a high potential to deliver societal benefits. interTwin has demonstrated how DestinE potential applications can efficiently use

³⁶ <https://www.intertwin.eu/intertwin-use-case-lattice-qcd-simulation>

³⁷ <https://www.intertwin.eu/intertwin-use-case-a-particle-detector-data-driven-digital-twin-for-high-energy-physics>

³⁸ <https://www.intertwin.eu/intertwin-use-case-a-digital-twin-to-simulate-noise-in-radio-astronomy>

³⁹ <https://www.intertwin.eu/intertwin-use-case-virgo>

⁴⁰ <https://envri.eu/>

⁴¹ <https://is.enes.org/index.html>

⁴² <https://earthobservations.org/>

⁴³ <https://earsel.org/>

⁴⁴ <https://pangeo.io/>

⁴⁵ <https://www.intertwin.eu/intertwin-use-case-a-digital-twin-for-projecting-wildfire-danger-due-to-climate-change>

⁴⁶ <https://www.intertwin.eu/intertwin-use-case-extreme-rainfall-temperature-and-wind-weather-extremes-as-a-result-of-climate-change>

⁴⁷ <https://www.intertwin.eu/intertwin-use-case-flood-early-warning-in-coastal-and-inland-regions>

⁴⁸ <https://www.intertwin.eu/intertwin-use-case-a-digital-twin-for-drought-early-warning-in-the-alps>

⁴⁹ <https://www.intertwin.eu/intertwin-use-case-a-digital-twin-for-projecting-the-occurrence-of-tropical-cyclones-due-to-climate-change>

⁵⁰ <https://www.intertwin.eu/intertwin-use-case-deploying-floodadapt-a-digital-twin-for-flood-impact-modelling-anywhere-on-earth>

⁵¹ https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en/

⁵² https://commission.europa.eu/system/files/2020-02/communication-shaping-europes-digital-future-feb2020_en_4.pdf



European-based compute and data infrastructure. Hence, bringing them to operational services represents an outstanding opportunity for DestinE to deliver value to policy makers.

Overall, the implementation of the use cases has been co-designed by the user communities and has contributed to harnessing digitalization and building critical new capabilities⁵³ such as data management and analysis, AI across infrastructures facilitated by the Digital Twin Engine. The modular design of interTwin has permitted that tools developed within a given domain have been reused across different disciplines, hence decreasing the barriers and strengthening the cooperation between scientific domains⁵⁴ and hence resulting in cost savings. By embracing open standards and federated architectures, interTwin made it much easier for researchers working within research infrastructures and related communities and institutions to access high-performance computing and data resources distributed across domains and different national and institutional boundaries.

2.1.2 Liaison with External Stakeholders – Stakeholder management outcomes

In D2.3 the different types of stakeholders were described and D2.4 provided a comprehensive list of specific institutions, organizations, research infrastructures and projects has been compiled and a short assessment of their relevance for interTwin and expected Dissemination, Exploitation and engagement actions has been considered. The following table summarizes the main findings. Within D3.1, D3.4 and D3.5 the technical uptake is also assessed for them.

In D2.6 we provide a mapping of the different stakeholders within every layer of the market explained before. It is noteworthy to mention that many initiatives have solutions across the markets e.g. it is usual that projects working on a specific application domain develop their own technology stack that includes software, middleware and data and compute infrastructure. Also advocacy groups in enabling technologies (AI, Data Analytics, etc) collaborate across layers, with application verticals that become the users of the technologies and need infrastructure providers to deploy and run those applications. Therefore all those are closely bound.

⁵³ https://research-and-innovation.ec.europa.eu/strategy/strategy-research-and-innovation/our-digital-future/european-strategy-research-and-technology-infrastructures_en

⁵⁴ https://research-and-innovation.ec.europa.eu/strategy/strategy-research-and-innovation/our-digital-future/european-strategy-research-and-technology-infrastructures_en

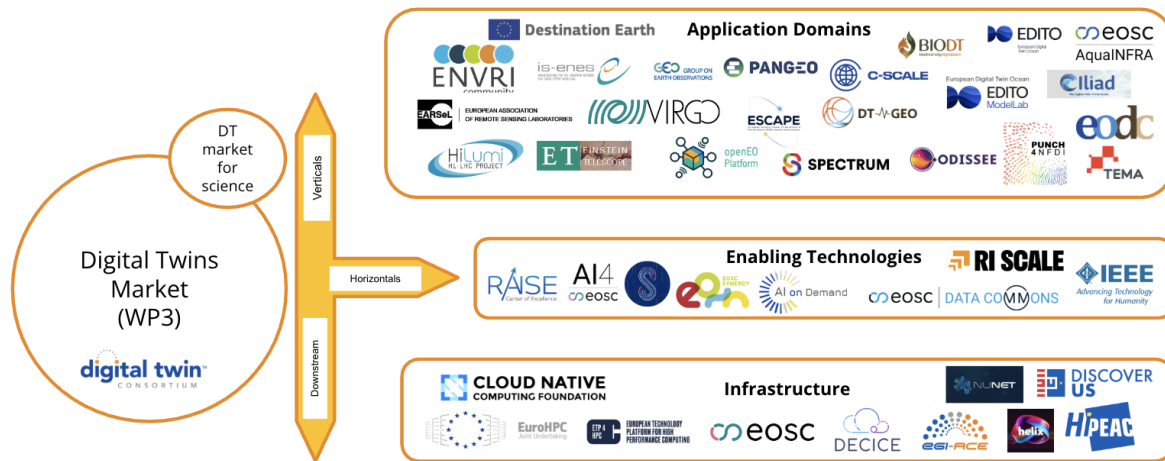


Figure 3 Mapping of Key Stakeholder per Market layer

Another relevant mapping is the approach from D2.4 where the different stakeholders are also mapped as Research Infrastructures, Research Projects, Interest and Advocacy Groups and SMEs and general industrial players.

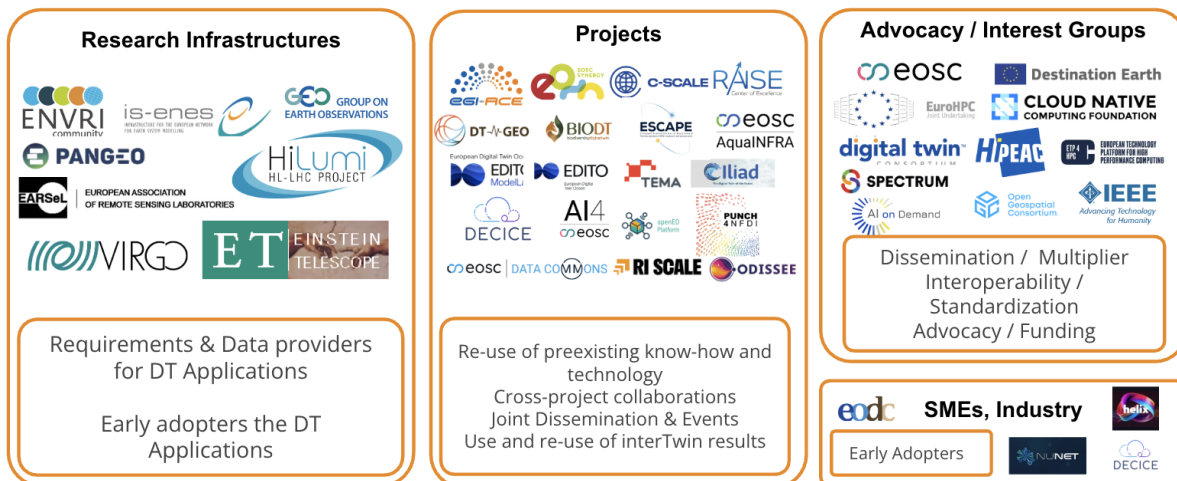


Figure 4 Mapping of Key Stakeholder per User Group Type

They can be relevant as Providers (technology, data, know-how, feedback), as potential -early- Adopters (use and re-use of interTwin results), as Multipliers (joint dissemination, marketplaces, communities) or as Funders (buyers, funding agencies, public procurements, etc)

- Research infrastructures as described in the previous chapter are key stakeholders for the different DT Applications. They have provided the necessary data, requirements for successfully running interTwin use cases.
- Previously existing Research Projects such as, EGI-ACE, EOSC Synergy, C-SCALE, RAISE CoE, openEO platform, ESCAPE are already finalized. They provided initial background, infrastructure, technologies, tools and know-how that have been used, extended and enhanced by the interTwin project.

- Co-existing research projects such as sister projects DT-Geo, BioDT, DT of the Ocean related projects, DT-Iliad, Aqualnra, EDITO Infra, EDITO-Modellab, or public authorities related TEMA or technology related projects such as iMagine and AI4EOSC. They had shared objectives offering cross-collaboration opportunities - such as the organization of joint dissemination activities for broader impact in relevant ecosystems and communities (EOSC, DestinE, BDVA, EGU, CHEP), interoperability and standardization efforts (IEEE , OGC), and to discuss potential use and re-use of interTwin's results.
- New research projects have emerged as follow-up project collaboration, adopting interTwin's results or specific components - such as EOSC Data Commons, RI-SCALE, ODISSEE. Also several proposals for competitive funding have been submitted including joint efforts with interTwin partners and other initiatives such as AI4EOSC.
- Interest and Advocacy groups, such as major European initiatives such as Destination Earth, EuroHPC, EOSC, do not only offer the funding but long-term direction and strategy for project results adoption on the policy side and an active user community. On a cluster level interTwin has been in contact with multiplier initiatives such as HiPEAC, ETP4HPC, SPECTRUM, CloudNative Foundation, providing the wider dissemination opportunities (events, roadmapping, open source collaboration sandbox, etc).
- Industrial Engagement and SMEs and public authorities: As stated in D2.2 and D2.4 interTwin is a project targeting mainly scientific communities (to improve scientific infrastructures and the delivery of scientific results), the project has made effort to engage with industrial players and SMEs, such as EODC, Nunet.io⁵⁵, HelixML⁵⁶ or to assess the re-usability of the components and services on industrial domains e.g. in the frame of DECICE project -including several SME partners

The concrete listing of institutions and activities, including the type of initiative, role, market domains, relevance for interTwin and dissemination and exploitation actions is provided in **Annex 1**.

2.1.3 External Expert Advisory Board (EEAB). Summary Feedback and Progress

The External Expert Advisory Board (EEAB) of the interTwin project provides strategic and technical guidance to the Technical Coordination Board (TCB), ensuring that the project's architecture and outputs are scientifically robust, interoperable, and relevant across domains. Composed of 5–7 leading experts from the European and international digital twin ecosystem, the EEAB contributes feedback through annual meetings and targeted consultations. Its role extends to supporting dissemination and exploitation by fostering cross-project collaboration and identifying adoption pathways. Feedback from the 2023–2024 meetings has already shaped interTwin's Blueprint Architecture and software releases, emphasizing hybrid modeling approaches, validation frameworks, user

⁵⁵ <http://Nunet.io>

⁵⁶ <https://helix.ml/>



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interaction design, and opportunities for international cooperation, particularly with U.S. research initiatives.

Full description of the roles, processes are described in D2.2 and the progress and summary of the first 2 meetings in D2.4. In this deliverable the final meeting, general feedback and outcomes is provided.

Table 1 shows the summary of EEAB meetings:

Table 1 EEAB expected meetings

Meetings	Timeline	Scope
1st EEAB Meeting – co-located with EGI Conference 2023	June 2023	Present the early version of the Blueprint deliverable and gather feedback before the review
2nd EEAB Meeting - Online	June 2024	Present a 1st complete picture of the Digital Twin Engine and early version of Use Cases
3rd EEAB Meeting - co-located with EGI Conference 2024	October 2024	Gather feedback to incorporate to the final release. Aim for exploitation -focus on end users and potential adopters and impact

3rd EEAB Meeting – co-located with EGI Conference 2024 (October 2024)

The final EEAB meeting was organized in October 2024 with the following participation

- Anabela de Oliveira - LNEC
- Valentine Anantharaj - ORNL
- Arnau Folch - CSIC

They were given a status update of the project including the newer versions of the Blueprint Architecture and Interoperability, including the plans towards the 2nd release of SW components, the overall progress of the project and the Key Exploitable Results and general ideas for preparing the exploitation of the project. They provided feedback on potential dissemination and exploitation opportunities such as publications and training opportunities, ideas to foster the cross-collaboration between projects, and feedback coming from the state of play of digital twins in the US.

The EEAB members congratulated interTwin for its significant technical and scientific progress, highlighting its strong potential to play a key role in shaping the emerging European and international Digital Twin ecosystem. The EEAB acknowledged the project's achievements in interoperability, blueprint architecture design, and community engagement.

Following were the main recommendations and the way interTwin has tackled them:

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Recommendations on dissemination: interTwin should offer proper training to all those elements that are more likely to be adopted. Main target groups to focus are the Scientists (as they are the first end-users we want) or Policy Makers, but also the operations people from compute infrastructures from which the digital twin engine modules would be executed.

interTwin has increased the number of events and activities targeting the different stakeholders as indicated in D2.5. A technical workshop targeting infrastructure operators and developers was organized at the HiPEAC Conference along with a presentation at the Industrial session. Several webinars to present the different use cases and thematic modules were organized and are available on the interTwin youtube channel. Workshops were also organized at EGU 2025 and ESA living planet, and 2 discovery labs were organized in Ghent and Wien targeting Policy makers

Recommendations on industrialisation: From the Infrastructure community if there is a blueprint architecture industry can get in, the Major technology companies (IBM, Microsoft, AWS, NVIDIA, Argo)_ will have a reference architecture to start with. From the US perspective interTwin can compete with those companies. Biggest systems are already on the market (hence they are not national), but public providers will still need to rely on the created ecosystem and can create and offer testbeds to them. Creating such testbeds are seen as high-risk activity from an industry perspective - that would not be feasible on private systems and there is value from interTwin in this direction.

As suggested, the initial testbed⁵⁷ setup in the project have been extended and made available also to external users. TOSCA templates in Infrastructure Manager, enable launching the applications to be executed by major vendors if needed, were made available Demos were prepared for major events such as EGU 2025, at ISC 2025 a BoF session on Digital Twins was organized.

Recommendations on “Data as the new Oil”. The AI Framework has a good opportunity, from the hype nowadays and people are willing to invest in it. Following a Data-centric thinking on SW development - we need ways to get information out of data. It is important for interTwin to think about how it can get a position there. Beyond data being the new oil (and on a higher level thinking) we are entering the knowledge era (bridging from the information era to knowledge era). As such we will have multiple scientific emerging areas such as Biology and Health sciences, Climate, Nuclear / Astrophysics, High Energy Physics that will need to overcome challenges from the increasing need for data processing. There must be interoperability across domains (there is a lot of fragmentation / no real interoperability nowadays). AI is changing the landscape and perspective. There is an opportunity to develop ontological frameworks enabled by AI that would move projects like this to the next level.

⁵⁷ <https://www.intertwin.eu/dte-testbed>



2.2 interTwin Project Results & IP Management Progress (M36)

2.2.1 interTwin background

One of the first duties of the project was to provide support to gather the background information of the partners to feed the consortium agreement. The list has been compiled and stored at the corresponding Confluence repository.⁵⁸ In M36 the number of identified elements increased to 74. For all of them, the access information for implementation and exploitation has been provided together with the WP under which those elements are needed and the contact person and link for accessing those open elements.

2.2.2 interTwin results

The project objectives⁵⁹ and foreseen Key Exploitable Results (KERs)⁶⁰ each have their own associated stakeholder engagement level. Presented below are the baseline results, KERs, outputs and impacts, as described in the DoA. The KERs serve as the basis to structure the concrete Exploitation activities developed in the project. In M36 the number of identified results has increased to 49 components and subcomponents and 6 Key Exploitable Results. 17 of them are new developments, and 25 are extensions, modifications or improvements over pre-existing codes.

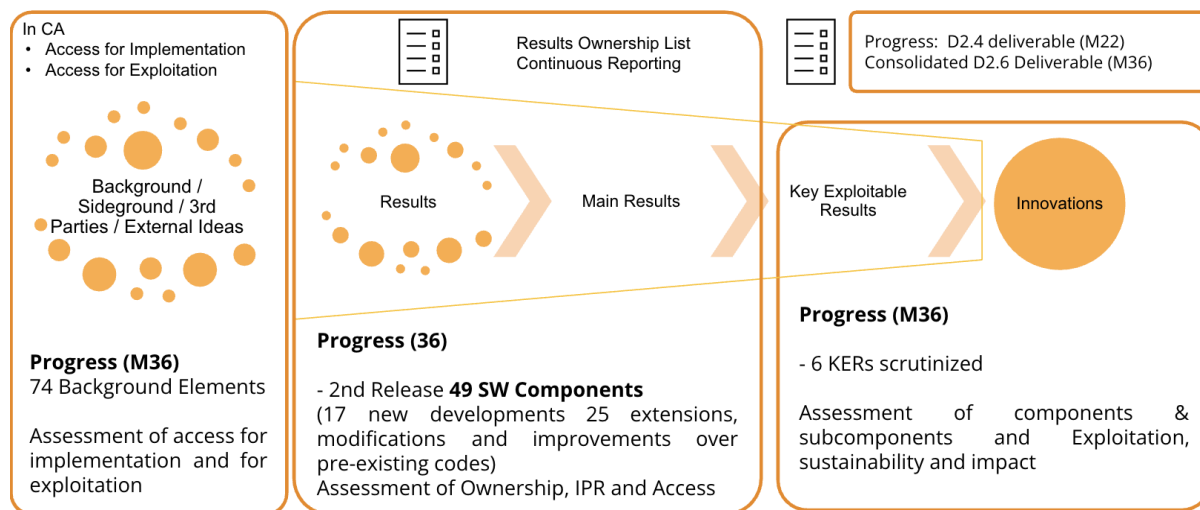


Figure 5 interTwin results consolidated progress

The details of the results are provided in the next chapter (Technology Value Chain). **Annex 3** provides the summary table of results including Ownership, IPR and Access.

⁵⁸ <https://confluence.egi.eu/display/interTwin/1.+Background> (restricted to Consortium members)

⁵⁹ [interTwin Project Objectives](#)

⁶⁰ [interTwin Key Exploitable Results](#)

Conclusions of IP Management provisions

In line with IP Management strategy explained in D2.2, D2.4 and the DoA, each partner owns the results they have generated (unless otherwise stated in a written agreement). As such each partner has been responsible to apply and validate the necessary and validate the Intellectual Property Right and Access License assigned to each of their results.

Results include mainly software components, know-how, services linked to those and standardization efforts linked to their interoperability:

- All the software results have been licensed under free and open source software licenses to facilitate the modular approach of the digital twin engine, hence, no joint ownership (as per definition of the Grant Agreement) has been necessary for the Digital Twin Engine. Some of the components that were jointly developed by some project participants are jointly owned by them and indicated as such.
- Written results linked to project developed know-how (such as SW documentation, dissemination material) are shared under creative commons CC BY, following open science provisions of the grant agreement, unless there were legitimate reasons needing to ensure confidentiality (e.g. protection of personal data, GDPR, etc).
- All other exploitable project results (data, framework, publications, guidelines, resources) were made available under Creative Commons license and adhered to the Horizon Europe Open Access Policy for all peer-reviewed scientific publications self-archived as open access via Zenodo.
- As explained before, in case of legitimate interest, confidentiality was preserved by setting the necessary conditions under NDA agreements. For instance, despite the open nature of the project, NDAs have been requested for the EEAB members – in order to ensure knowledge can be shared without restrictions and hence to be able to get as good feedback as possible

2.2.3 interTwin Technology Value Chain

The detail of interTwin results is provided in this chapter, as depicted in **Figure 6**, the main layers in the technology value chain are:

- Infrastructure modules represent the federated data and compute resources involved in modelling and simulation tasks, including HPC, HTC, Cloud, Quantum computing resources and Data repository and its Authentication and Authorization Infrastructure (AAI), Orchestration and Federated Data Management.
- Digital Twin Core modules offer horizontal capabilities to facilitate the creation and operation of data-intensive and compute-intensive DT applications including workflow composition modules supporting big data analytics, AI and Data Fusion, Quality Verification and Real-time data acquisition and processing.

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- Digital Twin Thematic Modules are add-ons providing capabilities tailored to the needs of specific groups of applications that can become part of the core modules if they can be in the interest of further communities.
- Application/Scientific Domain are the actual use case implementations of Digital Twins for the different scientific domains of the project

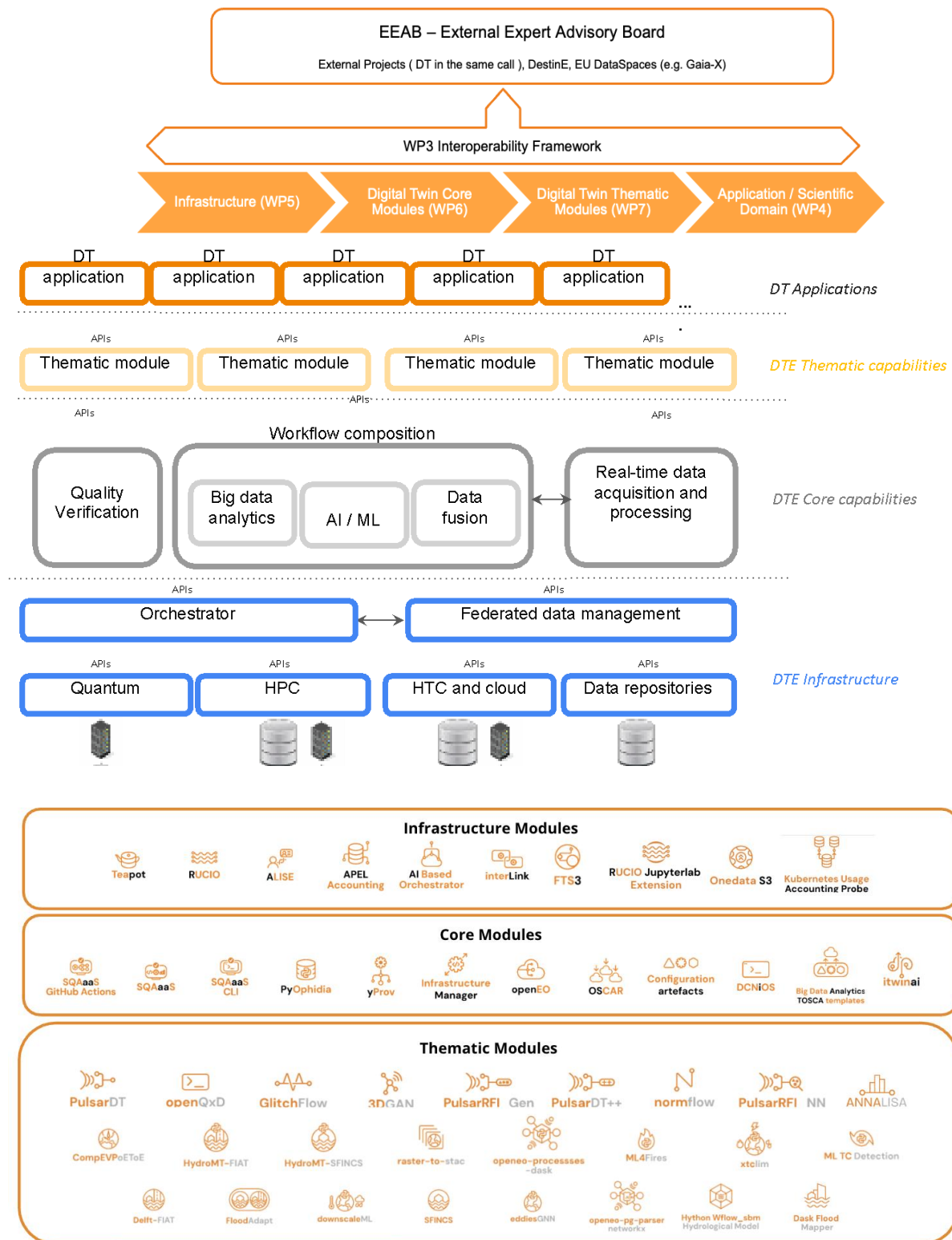


Figure 6 interTwin Technology Value Chain and Building Blocks Mapping



Target Users:

- DT Developers interact with interTwin DTE, seen as PaaS, developing DT applications and occasionally thematic modules tailored to the needs of specific user communities.
- DT End Users access the DTE as a SaaS via the DT applications developed by the DT developers. An end user can choose an "out of the box" DT application and connect it to its use case (physical twin) or configure the needed parameters for their experiments.
- The DT Infrastructure Providers provide computational resources, storage, and eventual connection with the physical twin living in the real world.

DTE Technology providers are mainly project partners within interTwin. They can also eventually become target users (e.g. when provider of Thematic Modules needs to use DTE Core and Infrastructure modules)

Infrastructure Modules (WP5)

- Description: Infrastructure stands for the federated data and compute resources involved in modelling and simulation tasks, including HPC, HTC, Cloud, Quantum computing resources and Data repository and its Authentication and Authorization Infrastructure (AAI), Orchestration and Federated Data Management. This block represents the underlying data infrastructure and server orchestration capabilities. This includes storage, processing, and management of data related to DTs, as well as the orchestration of servers to ensure efficient execution of all operations in the DTE
- Lead Users: DT infrastructure providers (such as System Administrators) and DT developers aiming to build DT services leveraging compute and data infrastructures
- Components: [AI Based Orchestrator](#), [ALISE](#), [APEL](#), [Kubernetes Accounting](#), [FTS3](#), [interLink](#), [Rucio](#), [Teapot](#), [Onedata S3](#), [RUCIO Jupyterlab Extension](#)
- Key Exploitable Result: KER1, KER 5, KER6
- Key Documentation:
 - [D5.3 Final Architecture design update based on the first experiences](#)
 - [D5.4 Final DTE Infrastructure software release](#)
 - [D5.5 DTE infrastructure development and integration report](#)

Digital Twin Core Modules (WP6)

- Description: Digital Twin Core modules offer horizontal capabilities to facilitate the creation and operation of data-intensive and compute-intensive DT applications including workflow composition modules based on big data analytics, AI and Data Fusion, Quality Verification and Real-time data acquisition and procession. This block encompasses essential functionalities necessary for maintaining the integrity and efficiency of the DTE. Core capabilities include quality control (QC) and verification functions, workflow generation capabilities, and data acquisition and processing using Machine Learning (ML). Developers can interact with these core functionalities



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to fine-tune the operation of DT Applications, ensuring that the applications perform as intended.

- Lead Users: Mainly DT Developers needing to interface with interTwin DTE core and thematic modules. Notably, not all core modules are necessary for every DT application, e.g. they depend on the different infrastructures, environments and specific needs (e.g. AI/ML, openEO, etc) that would require users to have that specific domain expertise.
- Components: [Big Data Analytics TOSCA Templates](#) and [Configuration Artifacts,, DCNIOs, Infrastructure Manager, itwinai, openEO](#) ([openEO Spring Driver](#), [openEO Web Editor](#)), [OSCAR](#), [Ophydia/PyOphydia](#), [SQAaaS Github Actions](#), [SQAaaS CLI](#), [yProv](#)
- Key Exploitable Result: KER1, KER3, KER4, KER6
- Documentation:
 - o [D6.3 Updated report on requirements and core modules functionalities](#)
 - o [D6.4 Final release of the DTE core modules](#)
 - o [D6.5 Core development and integration on DTs report](#)

Digital Twin Thematic Modules (WP7)

- Description: Are add-ons providing capabilities tailored to the needs of specific groups of applications that can become part of the core modules if they are of interest to other communities. The Thematic Modules form the second block, providing specific functionalities that DT Applications use to execute their processes and achieve their objectives. These modules cater to specialised requirements, and they can vary based on different application areas or themes. Developers have access to these modules to customise the DTs according to specific needs.
- Lead Users:
 - o DT Developers: which will be using the DT engine components (thematic and core modules) to build a new DT application. Developers will directly access the thematic modules described here and can customise them, as well as the workflow, to meet specific needs for new users.
 - o DT End Users - End-users (scientists, policy makers, stakeholders): which will be directly using the DTs applications to be implemented in WP4. The scope of the DT applications in interTwin is quite broad. Some users will access the data and visualisation capabilities offered by the application to collect relevant findings from a scientific standpoint for some of them, whereas others will have a stronger focus on decision making and planning. E.g. DT applications that enable the simulation of what-if scenarios and sensitivity analyses to understand for example how anthropogenic forcings can impact Climate Extreme Events in future projection data.
- Components:
 - o Physics: [3DGAN](#), [GlitchFlow](#), [normflow](#), [openQxD](#), [PulsarDT](#), [PulsarDT++](#), [PulsarRFI Gen](#), [PulsarRFI NN](#), [ANNALISA](#)
 - o Environmental: [Delft-FIAT](#), [downscaleML](#), [eddiesML](#), [emergence.compound](#), [ESG Pull Rucio](#), [FloodAdapt](#), [HydroMT](#), [HydroMT-FIAT](#), [HydroMT-SFINCS plugin](#), [HydroMT-WFLOW plugin](#), [Hython](#)



Wflow_SBM Hydrological Model, ML4Fires, ML TC detection, openeo-pg-parser-networkx, openeo-processes- dask, RA2CE, raster-to-stac, SFINCS, Wflow, xtclim, Dask Flood Mapper

- Key Exploitable Result: KER1, KER6
- Documentation:
 - o D7.5 Updated report on requirements and thematic modules functionalities for the environment domain
 - o D7.6 Updated report on requirements and thematic modules functionalities for the physics domain
 - o D7.7 Final version of the thematic module for the environment domain
 - o D7.8 Final version of the thematic module for the physics domain
 - o D7.9 DTE Thematic modules development and integration report

Application / Scientific Domain (WP4)

- Description: are the actual use case implementations of Digital Twins for the different scientific domains of the project. This block represents the software applications which developers use to create, manage, and configure the Digital Twins (DTs), and which DT Users use to execute the DTs for their research or decision-making purposes
- Lead Users:
 - o DT developers: the current deliverable provides them with an opportunity to gain insight into different components, data integration strategies, and computational models required to build an effective digital twin. It would allow them to incorporate new features, leverage components, improve scalability, support evolving problems over time, and ensure interoperability.
 - o DT users (end users): the specified deliverable facilitates data sharing, integration, and analysis among various stakeholders and scientists. By establishing a common framework for communication, researchers and stakeholders will be able to exchange information, validate models, and collaboratively address climate change impacts and suggest mitigation measures.
- DT Applications: All the different DTs: Early warning for Extreme events. WildFire Hazard Map Generation, Tropical Cyclone Detection, Extreme Events impacts, Radio Astronomy, High Energy Physics, Lattice QCD, Gravitational Wave - Astrophysics⁶¹
- Documentation:
 - o D4.5 Final Architecture design of the DTs capabilities for climate change and impact decision support tools
 - o D4.6 Final Architecture design of the DTs capabilities for High Energy Physics, Radio astronomy and Gravitational-wave Astrophysics
 - o D4.7 Final version of the DTs capabilities for climate change and impact decision support tools including validation reports
 - o D4.8 Final version of the DT capabilities for High Energy Physics, Radio astronomy and Gravitational-wave Astrophysics including validation reports

⁶¹ <https://www.intertwin.eu/use-cases>



2.2.4 Key Exploitable Results Progress (M36). Components & IP Management

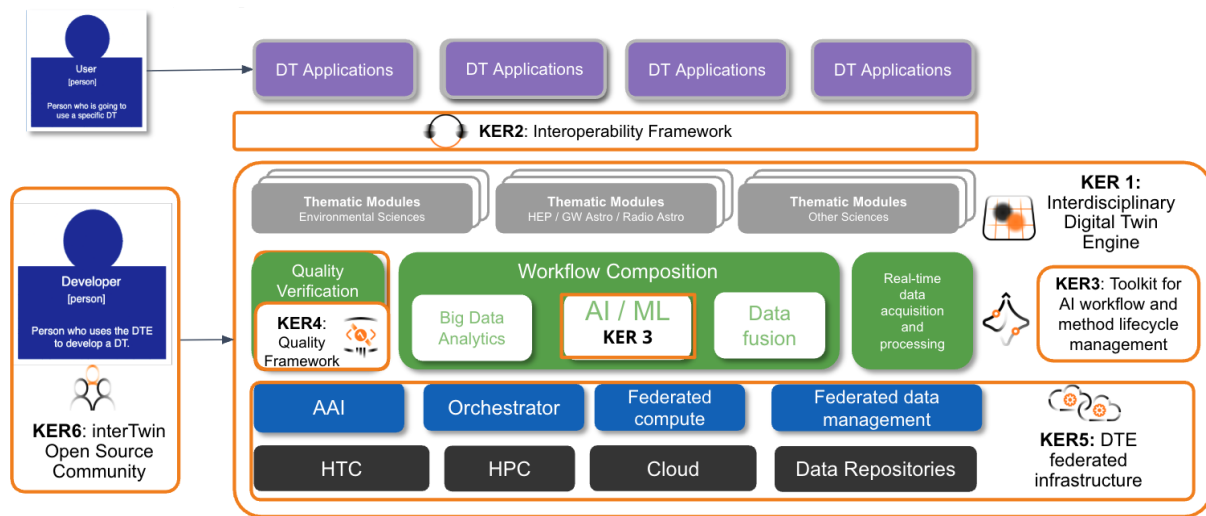


Figure 7 KERs mapping in interTwin blueprint architecture

KER1: Interdisciplinary Digital Twin Engine

Description: A software platform that provides generic and tailored functional modules for data-driven and process-based modelling to facilitate the development and deployment of Digital Twins that address scientific problems in different domains.

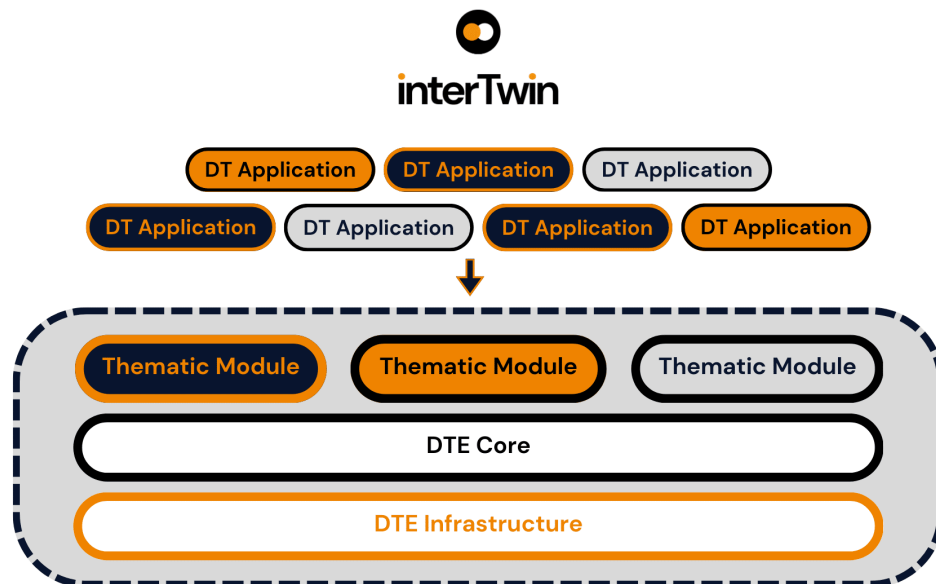


Figure 8 interTwin DTE

The interTwin Digital Twin Engine (DTE) is an open-source integrated platform underpinned by open standards, APIs, and protocols. It facilitates the development and

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implementation of specific Digital Twins. The DTE supports the setup, configuration and exploitation of Digital Twins.

The interTwin DTE consists of the layers explained before,

- The DTE Infrastructure Modules provide specific capabilities for implementing Digital Twins, such as federated data and computing resources needed to run modelling and simulation tasks on the computing infrastructure
- The DTE Core Modules offer cross-domain capabilities, simplifying the creation and operation of data-intensive and compute-intensive DT applications
- The DTE Thematic Modules (currently: Environment and Physics) are add-ons providing capabilities tailored to the needs of specific application groups. They implement core functionalities for a DT but domain specific. They can evolve into core modules following successful adoption by multiple resource communities across different domains.

The Digital Twin Applications are user-centric implementations of DTs workflows, leveraging the DTE's capabilities to meet specific use case requirements. It encompasses all the components and subcomponents of the project that are not part of the Digital Twins

Following is the summary of all the components of the DTE:

Thematic Modules:

- Physics: [3DGAN](#), [GlitchFlow](#), [normflow](#), [openQxD](#), [PulsarDT](#), [PulsarDT++](#), [PulsarRFI Gen](#), [PulsarRFI NN](#), [ANNALISA](#)
- Environmental: [Delft-FIAT](#), [downscaleML](#), [eddiesML](#), [emergence.compound](#), [ESG Pull Rucio](#), [FloodAdapt](#), [HydroMT](#), [HydroMT-FIAT](#), [HydroMT-SFINCS plugin](#), [HydroMT-WFLOW plugin](#), [Hython Wflow SBM Hydrological Model](#), [ML4Fires](#), [ML TC detection](#), [openeo-pg-parser-networkx](#), [openeo-processes-dask](#), [RA2CE](#), [raster-to-stac](#), [SFINCS](#), [Wflow](#), [xtclim](#), [Dask Flood Mapper](#)

DTE Core Modules:

- [Big Data Analytics TOSCA Templates](#) and [Configuration Artifacts](#), [DCNIOS](#), [Infrastructure Manager](#), [itwinai](#), [openEO](#) ([openEO Spring Driver](#), [openEO Web Editor](#)), [OSCAR](#), [Ophydia/PyOphidia](#), [SQAaaS Github Actions](#), [SQAaaS CLI](#), [yProv](#)

DTE Infrastructure Modules

- [AI Based Orchestrator](#), [ALISE](#), [APEL Kubernetes Accounting](#), [FTS3](#), [interLink](#), [Rucio](#), [Teapot](#), [Onedata S3](#), [RUCIO Jupyterlab Extension](#)

Target Groups: Developers, Users, Operators

IP Protection / IPR: Copyright distributed under Free and Open Source Licence



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Table 2 KER1 Subcomponents. DTE Core Modules IPR & Access License

DTE Core Modules	Owner	License
OSCAR	UPV	Apache 2.0
dCNiOS	UPV	Apache 2.0
Ophidia/PyOphidia	CMCC	GPLv3
yProv	UNITN	GPLv3
SQAaaS	UPV, LIP, CSIC/UNICAN	GPLv3
SQAaaS Github Actions	CSIC/UNICAN	GPLv3
SQAaaS CLI	CSIC/UNICAN, LIP	GPLv3
Infrastructure Manager	UPV	GPLv3
Configuration Artifacts	UPV	Apache2.0
Big Data Analytics TOSCA templates,	UPV	Apache 2.0
itwinai	CERN, FZJ	Apache 2.0
openEO (openEO spring driver, openEO web editor)	EURAC, EODC, WWU Munster, TU Wlen	Apache 2.0

Table 3 KER1 Subcomponents. DTE Infrastructure Modules IPR & Access License

DTE Infrastructure Modules	Owner	License
interLink	INFN	Apache 2.0
Teapot	DESY	Apache 2.0
ALISE	KIT	MIT
FTS3	CERN	Apache 2.0
RUCIO	CERN	Apache 2.0
AI Based Orchestrator	INFN	Apache 2.0
APEL Accounting	STFC UKRI	Apache 2.0
Kubernetes Accounting	EGI, CESNET	Apache2.0
Onedata S3	ACK Cyfronet AGH	Apache2.0
RUCIO Jupyterlab Extension	CERN	Apache2.0



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Table 4 KER1 Subcomponents. DTE Thematic Modules IPR & Access License

DTE Thematic Modules	Owner	License
DTE Physics Thematic Modules	Owner	License
openQxD	CSIC	GPLv2
normflow	ETHZ	MIT
PulsarDT PulsarDT++ PulsarRFI_Gen PulsarRFI_NN	MPIfR (under HTW Berlin, PUNCH4NFDI collaboration)	GNU AGPLv3
GlitchFlow	INFN (under Ligo & Virgo Collaboration)	GPLv3
3DGAN	CERN	MIT
ANNALISA	INFN (underLigo & Virgo Collaboration)	GPLv3
DTE Environmental Thematic Modules	Owner	License
ML TC Detection	CMCC, UNITN	GPLv3
ML4Fires	CMCC	Apache 2.0
eddiesGNN	UNITN	GPLv3
xtclim	CERFACS	Apache 2.0
downscaleML	EURAC	GPLv3
emergence.compound	CNRS	CeCill-C
openeo-processes-dask, openeo-pg-parser- network	EODC, EURAC	Apache 2.0
raster-to-stac	EURAC	MIT
FloodAdapt	Deltares	MIT
HydroMT-SFINCS	Deltares	GPLv3
HydroMT-FIAT	Deltares	GPLv3
Hython Wflow_Svm Hydrological Model	EURAC	CC BY4.0
Dask Flood Mapper	TU Wien	MIT

KER2: Interoperability Framework: Guidelines, Specifications, and Blueprint Architecture

Description: The interTwin interoperability framework aligns technical approaches and foster collaboration in modelling and simulation application development across scientific domains.



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Target Groups: Developers, Users, Operators

IP Protection / IPR: Creative Commons. CC BY 4.0

Table 5 KER2 Subcomponents. IPR & Access License

Components / Subresults	Owner	License
D3.2	Project Partners - Collective work	CC BY 4.0
D3.3	Project Partners - Collective work	CC BY 4.0
D3.4	Project Partners - Collective work	CC BY 4.0
D3.5	Project Partners - Collective work	CC BY 4.0
D3.7	Project Partners - Collective work	CC BY 4.0

KER3: Toolkit for AI workflow and method lifecycle management

Description: AI-based methodologies to extract application sector-specific information from research data at the large scale level in a real-time manner and increase the efficiency and accuracy of simulation and modelling outputs.

Target Groups: Developers, Users, Operators

IP Protection / IPR: Copyright, under Free and Open Source Licence

Table 6 KER3 Subcomponents. IPR & Access License

Components	Owner	License
itwinai	CERN, FZJ	Apache 2.0

Summary of Achievements

- Integration in major EuroHPC systems (LUMI HPC and JUPITER Booster system) along with Vega that was already integrated
- Integration with other DTE Components: SQAaaS, OSCAR, interLink, IM and TOSCA templates, yProvML
- Integration with DT Applications: 3DGan, GlitchFlow, Pulsar Detection, Normflow -on the Physics domain, and Hython and xtclim on the Environmental domain. Full list of integrations⁶²

KER4: Quality Framework

Description: Tools for automated quality measures and trust, development of standard quality mapping and indicators for appropriately communicating differences in qualities

⁶² <https://itwinai.readthedocs.io/latest/getting-started/plugins-list.html>



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of inputs and outputs from digital twins, addressing issues such as data and model pedigree, accuracy, and service maturity (i.e. increased TRLs)

Target Groups: Developers, Users

IP Protection / IPR: Free and Open Source Licence, Creative Commons

Table 7 KER4 Subcomponents. IPR & Access License

Components	Owner	License
SQAaaS Platform	UPV, LIP, CSIC/UNICAN	GNU GPLv3.0
SQAaaS Github Action	CSIC	GNU GPLv3.0
SQAaaS CLI	CSIC/UNICAN / LIP	GNU GPLv3.0
JePL	CSIC	Apache 2.0
service-qa-baseline	CSIC	CC-BY-SA 4.0
FAIReva	CSIC	Apache 2.0
Ophidia Workflow Validation Tool	CSIC	GNU GPLv3.0
Ophidia Workflow Reporting Plugin	CSIC	GNU GPLv3.0

Summary of Achievements

- SQAaaS has been used by all the developers of DTE modules to improve the quality of the components which are then integrated directly by the DT Applications.
- 14 components have earned EOSC-Synergy badges, one Gold, six Silver and seven Bronze badges (D3.6)
- SQAaaS has been integrated with other DTE components such as Ophidia, yProv, OSCAR and DCNiOS, itwinai

KER5: DTE federated infrastructure integrated with EOSC and EU Data Spaces

Description: Federated distributed compute platform providing access to distributed data and integrating HTC, HPC, Cloud and Quantum Computing capabilities for processing.

Target Groups: Users, Operators

Protection: Free and Open Source Licence

Table 8 KER5 Subcomponents. IPR & Access License

Components	Owner	License
interLink	INFN	Apache 2.0



Teapot	DESY	Apache 2.0
ALISE	KIT	MIT
FTS3	CERN	Apache 2.0
RUCIO	CERN	Apache 2.0
AI Based Orchestrator	INFN	Apache 2.0
APEL Accounting	STFC UKRI	Apache 2.0
Kubernetes Accounting	EGI, CESNET	Apache2.0
Onedata S3	ACK Cyfronet AGH)	Apache2.0
RUCIO Jupyterlab Extension	CERN	Apache2.0

Summary of Achievements:

- All components ready: interLink, CVMFS, Teapot, Rucio, FTS, Indigo PaaS Orchestrator, APEL, Kubernetes Accounting, Onedata S3, RUCIO Jupyterlab Extension
- Scientific community facilities including Data, Cloud, HTC and HPC compute resources are federated and available.
- Access to all computing resources (EuroHPC Vega, Julich Cloud and HPC, UKRI Cloud, GRNET, KBFI, PSNC, EODC and Vilnius).
- Testbeds available: Compute: VEGA, Juelich, GRNET, KBFI, PSNC. Data: VEGA, PSNC and Vilnius. Pilot: VEGA, Juelich, EODC
- Integration with EOSC, DestinE and Data Spaces tested in D3.7
- Prototype integration with Quantum System at CESGA

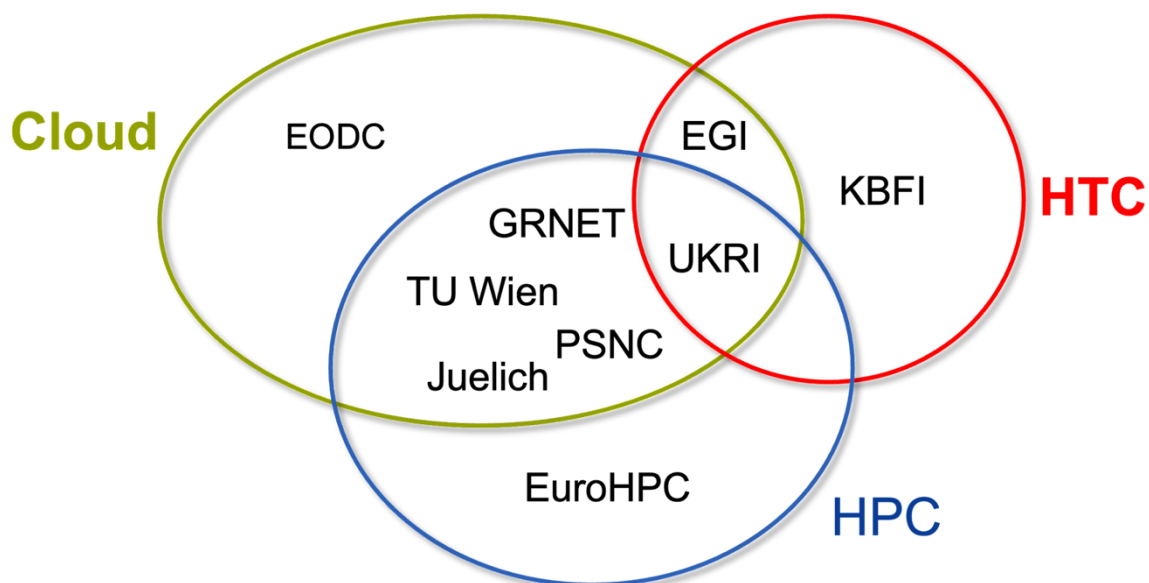


Figure 9 Infrastructure providers

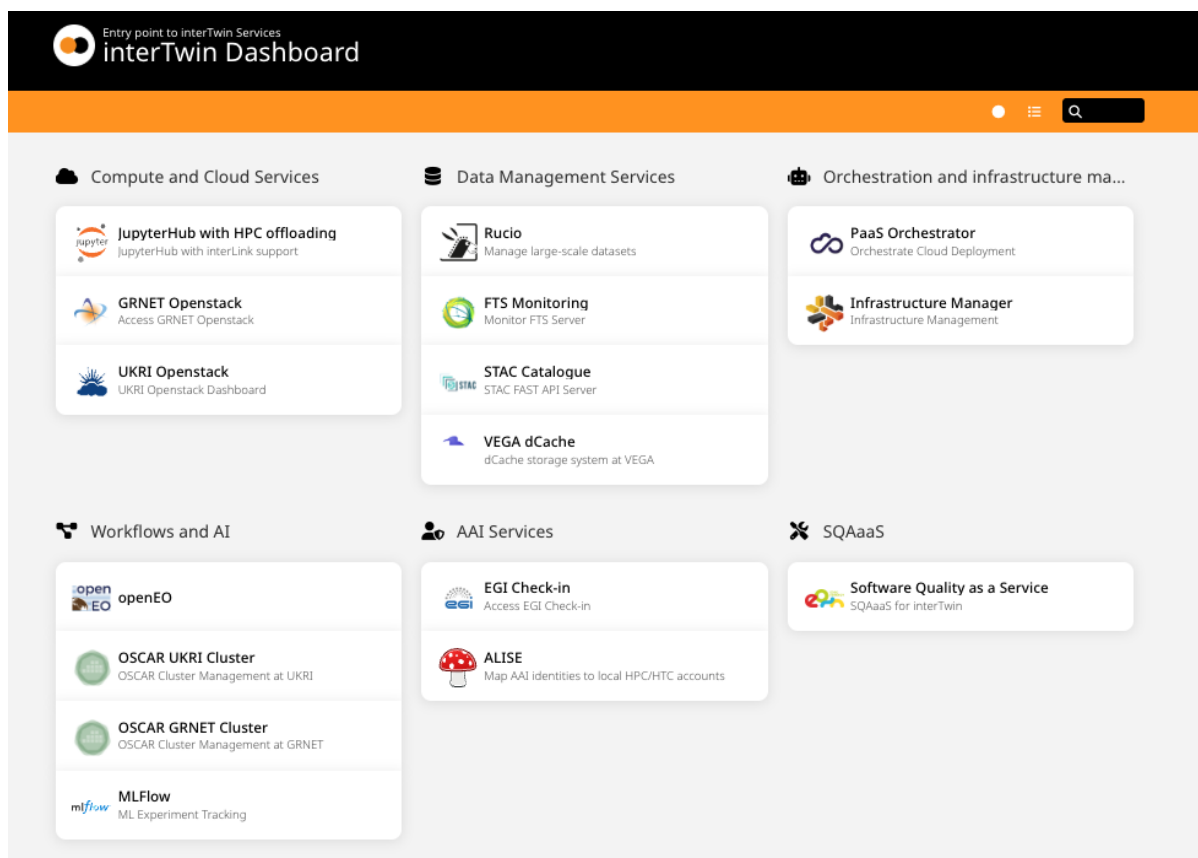


Figure 10 interTwin Testbed Dashboard

KER6: interTwin Open Source Community

Description: The community of DT application developers, users and operators that is responsible for the design, development, and maintenance of the DTE code base.

Target Groups: Developers, Users, Operators

IP Protection / IPR: CC BY 4.0. Community Guidelines based on guidelines for OpenEO including handling of Repositories, Reviews, etc. Code of Conduct and Conflict.

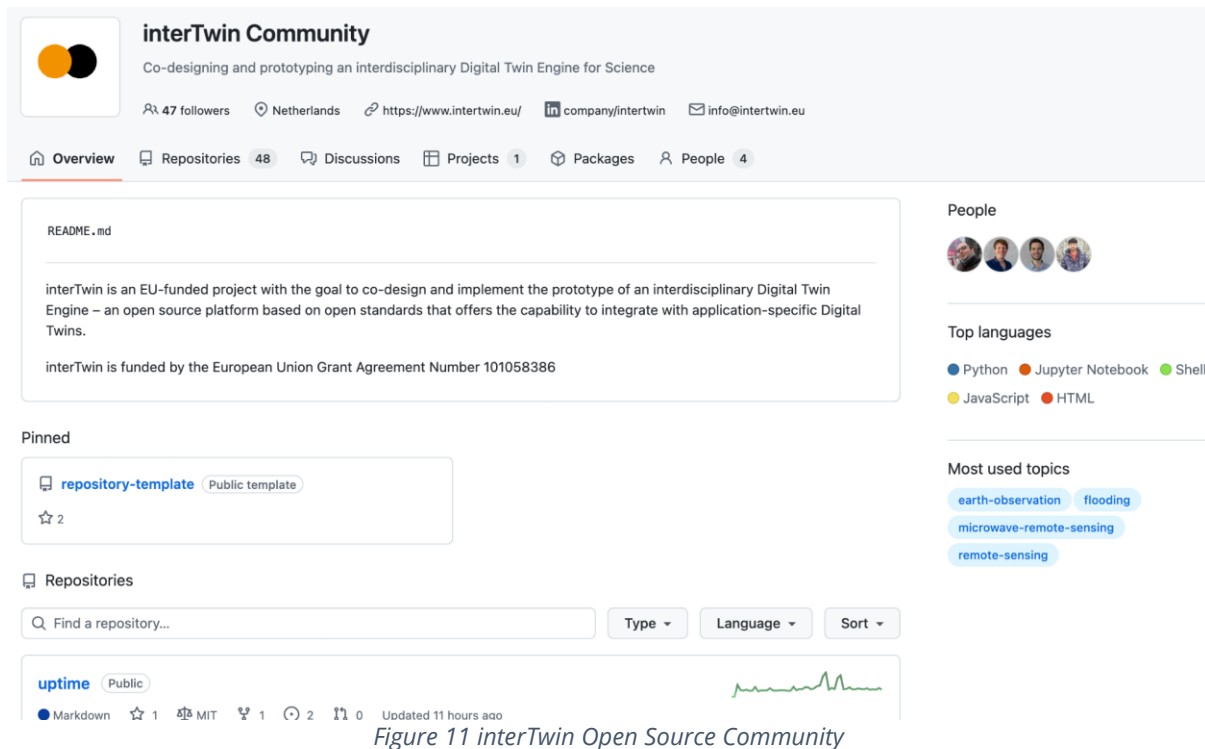


Figure 11 interTwin Open Source Community

Summary of Achievements:

- interTwin Github Organization available
- SQAaaS GitHub actions script available to automatize Quality assessment
- 48 Repositories, 45 members, 47 Followers
- Templates and GitHub Repository Management Rules created
- Contribution to other open source collaborations - in the RadioAstronomy use case with PUNCH4NFDI⁶³, in the Gravitational Waves with Ligo and Virgo Collaborations and longer existing open source initiatives (RUCIO, openEO, SQAaaS, Infrastructure Manager, etc) that are maintained from the corresponding own repositories.

2.3 interTwin Exploitation Achievements (M36)

D2.4 provided an expanded version of the Exploitation and IP management plans. D2.6 provides a consolidated report on the main exploitation achievements. It includes the work with the innovation and exploitation group, the organization of business modelling workshops, the strategy for results valorisation and collecting the exploitation success stories that grant the sustainability of the project.

⁶³ <https://www.punch4nfdi.de/>



2.3.1 Innovation and Exploitation Group (IEG) extended to all consortium

The Innovation and Exploitation group (IEG) is the project board established to provide advice and support on the innovation management activities of the project. Drives implementation of the project's knowledge and protection strategy and collects and maintains the information related to project KERs as well as updating and monitoring dissemination and exploitation plan in line with the innovation management task (T2.1) and gives direction and facilitates discussion for capturing opportunities and developing initial technical concept candidates.

During the first 6 months – the first IEG meeting was organized during the physical meeting in Madrid. During it, the content of the Innovation Management System and the innovation management plan, including procedures and processes was presented and validated. It was useful to kick-start the work, to let KER champions understand their advisory role and to get relevant feedback to fine-tune the content for this Deliverable.

In the second period of the project (M12-24) the communications among the IEG Members were increased. In January 2024 the 2nd main meeting was organized to synchronize and update the Innovation Management Strategy in general and each of the KERs in particular. This meeting was followed by 1-on-1 interactions with KER champions in order to update the plans of the KERs. During the F2F meeting in Vienna, the Business Model Training organized was tailored to trigger discussion among KER champions on the possible business models to foster the exploitation of the KERs.

In the final period of the project it was decided to extend the discussions of the Innovation and Exploitation Group to the whole consortium to ensure all partners were aware of the decisions needed for the overall uptake of the project. In the last period 3 meetings were organized during all hands meetings. First one, during the f2f meeting in October 2024, the need for an agreement to develop and support a Digital Twin Engine as a Service was discussed, and it was agreed that was not necessary due to the modular nature of the components and the way they are supported by the open source community and different valorisation strategies were agreed. In the online meeting held in February 2025, a hands-on workshop was organized using mural (figure 12) for all the partners to assess the overall exploitation, sustainability of the services, success stories and impact - that has been used to update the tables in this deliverable.



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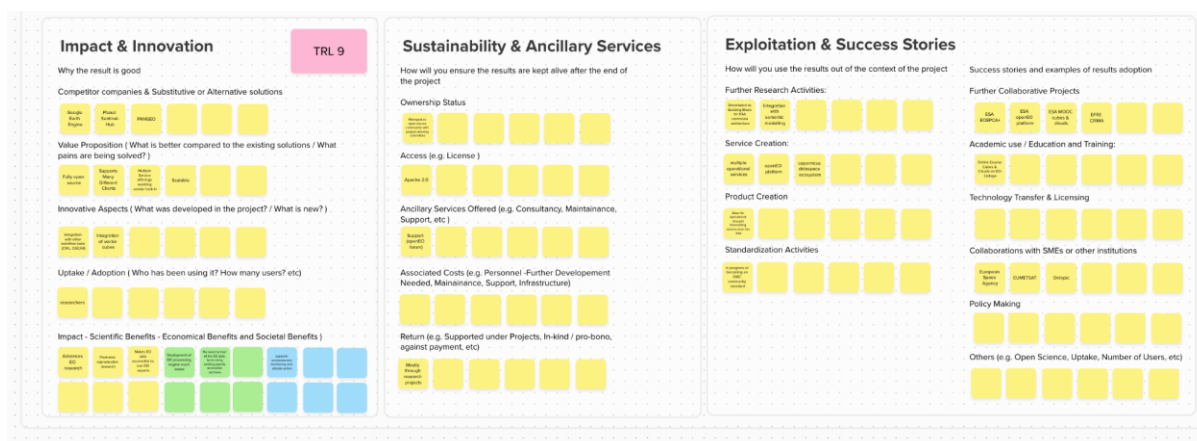


Figure 12 Sample of the mural-based hands-on session

The F2F meeting at the final event, in June 2025 was focused on disseminating the final results, assessing the impact delivery and validating project sustainability.

2.3.2 Organization of Business Model Workshops and Webinars

As explained in D2.2 and D2.4, to ensure all partners are well aligned in Horizon Europe innovation and exploitation matters a specific training on different aspects of business modelling, IP management and software licensing has been organized along the project duration.

Business Model Planning Training Objectives:

- Align partners with interTwin innovation management system
- Help partners along Intellectual Property Management matters
- Assess software licensing mechanisms
- Access to results
- Help to prepare the Exploitation plans & Exploitation Agreements needed
- Help to foster sustainability of project results and maximize impact of the project
- Expand Horizons & Learn new useful knowledge

While the initial plan in the DoA was aiming to organize a single workshop on innovation management activities, it was decided to organize more on a structured approach based on partners demand and usefulness of the sessions

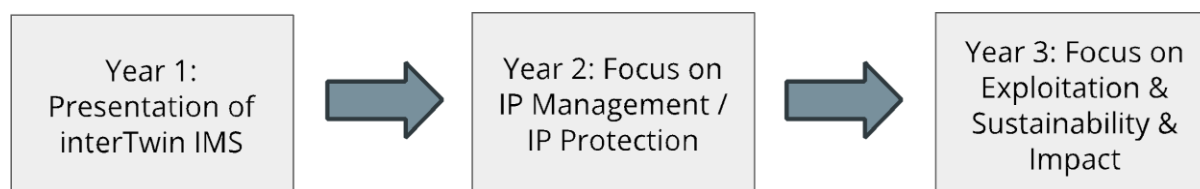


Figure 13 interTwin Business Model Training Plan

During the first year, the main aim was to present interTwin partners the Innovation Management System so that they understand the framework created to comply with the Exploitation and IP management rules of the Grant Agreement. A webinar was held November 2023 and the milestone related to the Business Modeling Workshop was

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completed. It was a good opportunity to discuss with the partners on the future training needs on exploitation.

During the second year, the focus switched to enhancing partners' capabilities on IP Management and IP Protection. For this, several external experts in IP management and business modeling were presented. Across Legal was chosen, due to the adequacy of the training proposed to the needs of the project and the economic quotation. The main coach, Malcolm Bain, has delivered training for ASTP Proton⁶⁴ for many years and has extensive experience helping EC projects on their exploitation purposes. Training sessions were held with them: (1) An online webinar to present the foundations for IP Management and open source software licensing to the project participants and (2) A hands-on physical workshop to discuss how those foundations are being applied to the project. Other specific webinars on patenting or business creation were also considered, aimed at teaching partners about its opportunities (and challenges), but finally dismissed since any of those were part of the exploitation strategy of any of the partners.

The 3rd year the focus shifted to deliver workshops on exploitation and impact delivery. First one was called 'How the interTwin Innovation Management System is used to foster projects' Exploitation and Sustainability' was held on 12th December 2024 and had two main objectives, to align partners on the exploitation needs of the project for the last year, and to disseminate the Innovation Management System created externally across projects to transfer the knowledge across EGI community. The last workshop was held in the final event in Santander, in June 2025, under the name 'Impact Driven Workshop - Assessment of impact across projects' bringing together several projects EuroScienceGalaxy, iMagine and EOSC Focus to share the different approaches on how impact has been evaluated.

Annex 4 provides further information on the different trainings delivered so far.

2.3.3 Business model analysis and updated exploitation strategy

An initial Business Model Analysis was presented in D2.4 showing different valorisation paths for the project. One of the challenges of the project is to develop a proper exploitation plan that ensures the sustainability of the project, taking into account the academic nature of many of the partners. As explained in the earlier chapter, the choice of working on Open Source SW solutions facilitates the collaboration among partners but also needs an understanding of how value is created out of those.

Valorisation strategies for Open Source projects

In order to assess a meaningful Business Model for Open Source projects it is necessary to understand where the value of open source relies. Many companies have managed to build and grow their businesses around open source software (OSS). There are many examples of large software developers making hundreds of millions a year and are valued

⁶⁴ <https://www.astp4kt.eu/>



in the billions, such as MongoDB, elastic, databricks⁶⁵, major companies and initiatives such as Google⁶⁶ or Linux Foundation⁶⁷ embrace Open Source at the core of many of their products and have become de-facto industry standards and many best practices⁶⁸ have been created around. A study about the impact of open source software and hardware on technological independence, competitiveness and innovation in the EU economy ⁶⁹ concluded that *the OSS pool contributes significantly to the EU's GDP, and that an increase of 10% in contributions would generate between 0.4% and 0.6% additional EU GDP per year. On a cumulative basis, the study estimates that, up to 2018, the contribution of OSS to EU GDP, and contributions of EU employees to OSS, yield a cost-benefit ratio of slightly above 1:10.* According to the study only 20% of ICT project costs are usually in licensing fees, while 80% of ICT project costs comes from other implementation costs, such as further development, consultancy/management, customization, integration, data migration, training and maintenance and support.

This also applies to interTwin, the value of interTwin components relies not that much on the code itself but on the services that can be built around. For each software component many different result types can be valorised:

- Software Code. Delivering it under Free and Open Source, gives access to anyone to use and re-use the code – with the limitations and provisions given in the specific SW licenses. They are perfect to increase the user bases and to promote the sharing of results between academics and comply with Open Science rules. Copyright is usually not enforced and large open source projects become collective work of many heterogeneous authors. On the other side Free and Open Source (FOSS) licenses imply software is delivered ‘as is’, without any warranty or liability and the commercial use even if not limited, needs to understand the limitations of the licenses to assess the adequacy of the projects.
- Know-How on the implementation. Much of the value of Open Source projects rely on the expertise that is generated around the technologies developed, being able to develop value-added services, training, support or further code development. Consulting opportunities arise for Software Integration, customisation or maintenance and user support
- Methodologies. Methodologies implemented by software code have the potential of being patented if they are novel and inventive, which can become a valuable IP asset.
- Data: Datasets needed, used and generated by the software code, as stated by the EEAB “data is the new oil”.
- Documentation: Software code can be complex and may be only usable if they are properly documented. Hence, it is a very important step for the creation of software products.

⁶⁵ <https://companiesmarketcap.com/>

⁶⁶ <https://opensource.google/>

⁶⁷ <https://www.linuxfoundation.org/resources/open-source-guides/setting-an-open-source-strategy>

⁶⁸ <https://opensource.guide/>

⁶⁹ <https://op.europa.eu/en/publication-detail/-/publication/29effe73-2c2c-11ec-bd8e-01aa75ed71a1/language-en> Blind, K.; Böhm, M., Grzegorzewska, P., Katz, A., Muto, S., Pätsch, S., Schubert, T. (2021).



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- Presentations, Training Material, Tutorials, Examples to complement the documentation and are also very important for user engagement.
- Branding related to the SW components can also become, such as logos and trademarks can be protected and become an IP Asset that can be valorised.

Therefore there is high valorisation potential for the project for the support services that can be generated from the software project, including the definition of Software as a Service (SaaS), user support service from experts -for the integration, customization or further development, maintenance and support and education and training.

Specifically within the interTwin project we consider the following approaches

- Open Science. “As Open As possible” (as closed as necessary)
- All Software components available as Open Source software Products
- Creation of Open Source Community supporting the software Products
- Creation of new services over the Software (such as Digital Twin Engine as a Service, Quality as a Service, SaaS)
- Standardization efforts & Interoperability and transfer to already Existing Services and Initiatives (EGI, DestinE, EOSC, etc)
- Follow up under research projects / Collaborative projects (e.g. Horizon Europe)
- Integration to already existing Open Source projects (Rucio, FTS, OpenEO)
- Policy Making
- Collaboration with SMEs / Industry

In interTwin, as most Open Source Software initiatives, the inherent value of the components relies on the know-how from project partners on how to develop, deploy and execute them. As such, complementary to the free Open Source distribution of interTwin software products expected exploitation paths

- Service Creation: the creation of services over the Software (such as Digital Twins developed, the Quality as a Service, Infrastructure Manager, etc) not only help with the uptake of the results but also to secure funding to cover the maintenance, support, and hence contribute to the sustainability of those. Those have been captured under Key Exploitable Results 1, 4 and 5 (see below the list of KERs).
- Standardization: also plays an important role, not only by ensuring the results are well aligned with the current existing standards to ensure maximum interoperability across systems, but also to try to create or influence them, being part of standardization working groups, etc. This is captured under Key Exploitable Result 2.
- Product Creation: Many software products will be created – not only as part of the Digital Twin Engine but also linked to the specific core and thematic modules. Those have been captured under Key Exploitable Results 1 and 3 and will be made available under the Open Source Community on Key Exploitable Result 6, which will facilitate its uptake whether for further research initiatives or industrial adoption.

Crossing the innovation chasm

interTwin has demonstrated technical excellence and scientific relevance across its use cases (e.g. climate, astrophysics). The next challenge is to translate this innovation into operational, scalable, and sustainable adoption across research infrastructures, public services, and industry. The Digital Twin Engine has been proven in a prototype environment, demonstrated with pilot use cases (scientific DTs) and integrated across federated data and computing infrastructure test beds (TRL 6). All the DTE modules are open sourced and they can interoperate, however still some work is needed to have fully operational services reaching operational exploitation, sustainable service provision, and market readiness (TRL 8-9)

A good framework describing the processes needed is Geoffrey Moore's Crossing the Chasm⁷⁰ that identifies the critical barrier between early technology enthusiasts and mainstream adopters. Innovations succeed not only because of their technical brilliance, but because they manage to move from prototype to product, from visionary users to pragmatic adopters. In the Technology Adoption Lifecycle, the "chasm" lies between early adopters (research visionaries) and the early majority (operational implementers). Scientific Digital Twin (DT) technologies in Europe — and interTwin in particular — currently sit at this inflection point.

Innovation Adoption Curve

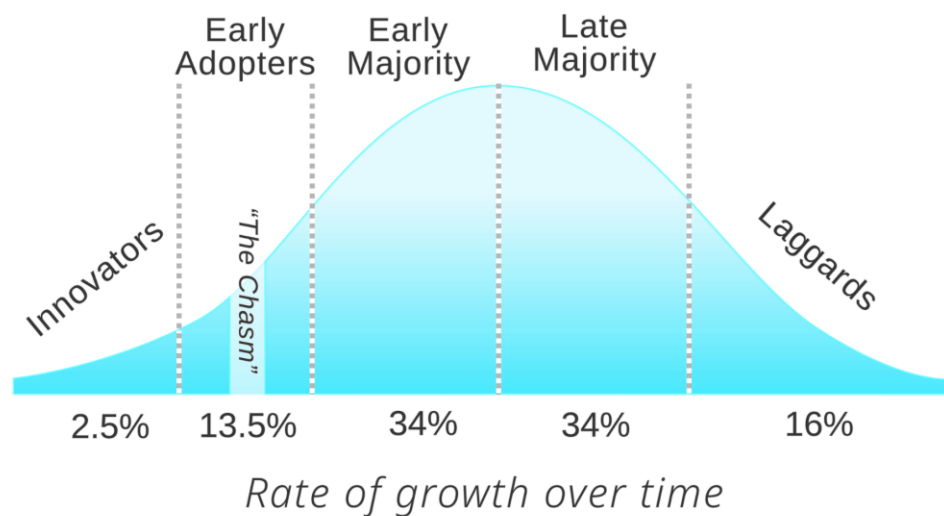


Figure 14 innovation chasm⁷¹

⁷⁰ Crossing the Chasm: Marketing and Selling High-Tech Products to Mainstream Customers, Geoffrey Moore.

⁷¹ By Jim McKeeth - Own work, CC BY-SA 4.0, <https://commons.wikimedia.org/w/index.php?curid=176770780>

Table 9 Adoption User Group Segments

Adoption Segment	User Group	interTwin achievement
Innovators	Technical Pioneers (Project partners, DTE Component Developers)	Part of the interTwin consortium the Digital Twin Engine and all the Infrastructure, Core and Thematic Module have been created
Early Adopters	Research Teams (Project Partners, Scientific teams developing DTs)	Part of the interTwin consortium the Digital Twin use cases have been co-designed and validated by Scientific communities
Early Majority	interTwin Users (external scientific communities, Infrastructure operators, data platforms, SMEs, public agencies)	Target groups for post-project uptake.
Late Majority	Conservative industry and public authorities	Long-term impact group

During the project an initial group of external early adopters/early majority have already been addressed. There are main strategies for further pushing the adoption:

- Evolving a whole product offering - by the consolidation of the Digital Twins enabled by the Digital Twin Engine or the creation of new ones.
- Promoting the stand-alone usage of DTE components that can reach out maturity faster (and not necessarily linked to DT application, such as infrastructure modules, AI capabilities, QA services, etc)
- Onboarding DTE services into already existing platforms (EGI, EOSC, DestinE, etc) to ensure operational support is ready.

Realistic funding mechanisms needed

A traditional cost-benefit analysis includes the costs associated with the strengthening of DTE products and services, components integration, optimization, development of new capabilities or enhancement of existing ones, maintenance and support. Each of those need to consider personnel costs, infrastructure operations and (if needed) licensing and access to third parties.

Revenue streams can be generated from Private (such as sales, R&D collaboration agreement, etc) or Public sources (competitive project funding, public procurement, etc) or be covered in-kind by the partners owning the services part of their line operations (or research activities)

While several valorization approaches are being pursued, most of the efforts are not yet marketable till the Technology Readiness Level is increased (starting to raise interest among SMSs but, as stated by EEAB members, it is still too risky for industrial laggards). Hence, the adoption of project results by the project partners is considered at this point one of the most effective ways to continue, especially if funding is covered by awarded follow up projects (Horizon Europe, National Funding). During the project huge effort has been made in order to discuss and find the proper project calls that ensure follow-up funding.



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For this reason part of the success stories we have collected the awarded competitive projects that ensure the sustainability, the cases of internal adoption of interTwin services and components and those efforts targeted to raise the industrial interest

Industrial adoption has indeed started

Notwithstanding not yet being the biggest source of revenue in the short term, considerable effort has been made to raise the industrial interest. As such, dissemination and engagement activities at industrial events have been organized (HiPEAC 2025, EGU 2025, ESA Living Planet 2025, ISC2025, among many others). 2 discovery labs have been organized targeting policy makers and public authorities. The establishment of the Open Source Community (KER6) acts as an enabler for the industrial uptake of all components. interLink has been adopted by [Nunet.io](https://nunet.io) and HelixML, DECICE project and other opportunities are being tackled from the Sandbox of CloudNative foundation. openEO is collaborating with EODC, IBM, DLR, VITO and Collaborations with European Space Agency, EUMETSAT and Ontopic, Tosca templates and configuration artifacts ready to deploy with major infrastructure platforms (including AWS, Azure, Google, etc). Overall interTwin technologies have been integrated into world-class EuroHPC supercomputers, are ready to deploy DTs on EOSC EU Node and to further develop DestinE related applications that will further raise the industrial interest.

2.3.4 KERs Exploitation Success Stories

The following is the Exploitation Progress for each of the KERs – in line with expected Exploitation Paths described in D2.2 and expanded in D2.4. The following Exploitation Paths are considered for all the components:

- Further Research: Assess new project opportunities for use/ reuse of results, including Cross collaboration with other DT-sister projects (DT-GEO, BioDT), Digital Twins of the Ocean, DestinE, or follow up project opportunities with project partners.
- Product Creation: SW sub-components available from interTwin repository, including proper Technical and User documentation and supported by Open Source community. Enhancement of already existing SW products
- Service Creation: Platform-as-a-Service provisioning by the EGI Federation through open access, Software as-a-Service of specific core components – such as the Quality Framework or the enhancement of already existing services – such as Infrastructure Manager, EGI Federated Cloud or the creation of new services such as the EGI HPC.
- Standardization: Alignment with standards and contribution to improving already existing standards (e.g. OGC) and the creation of new standards (e.g. IEEE standard for Digital Twin of the Earth)

At M36, the exploitation is showing the following achievements:

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- **Further Research:** Project has been re-using and further enhancing results from 6 previous projects (EOSC-Hub, EOSC-Enhance, CoE RAISE, C-SCALE, openEO platform, ESCAPE). Active cross-project collaboration with several parallel projects and initiatives (DT-Geo, BioDT, DestinE, DT-Iliad/Digital Twins of the Ocean). Discussions with other 3 projects (Digital Twin Factory, DECICE and AI4EOSC) resulted in the adoption of the interLink module by the Digital Twin Factory and DECICE project partners and joining forces with AI4EOSC in a use case and for the preparation of follow up proposals. Among many other collaborations (as described below and in D3.5) 3 follow up projects have been awarded that include the use and further development of interTwin results (EOSC Data Commons and RI-SCALE and ODISSEE) and altogether there are collaborations with ca.20 projects.
- **Product Creation:** 49 Software Components are available from the interTwin website and github repository, highlighting itwinai and interlink that have high potential for adoption and uptake as part of KER3 and KER5. For those a specific website, with full documentation, training material and tutorials have been created. Other products such as RUCIO, openEO, yProv, Ophidia, SQAaaS were enhanced and integrated with DT Thematic Modules.
- **Service Creation:** Digital Twinning has been included in the overall EGI Federation strategy 2025-2030. interTwin DTE components and know-how has contributed to the creation of the new EGI HPC service. 2 other services are being improved/enhanced: KER4: Quality Framework - SQAaaS is a fully operational service that has been enhanced during the project and the EGI Infrastructure Manager.
- **Standardization:** Alignment with standards fully explained in the Interoperability guidelines (D3.3). In collaboration with DT-Iliad, interTwin is collaborating to the creation of a new standard DT of the Earth. As a result, the creation of the WG was formally accepted under IEEE-SA P3501 working group - Recommended Practice for the Development of Digital Twins of the Earth and kickstarted in January 2025.

The following tables include further details for each of the KERs:

Table 10 KERs Exploitation Progress Tables

KER1: Interdisciplinary Digital Twin Engine
<i>A software platform that provides generic and tailored functional modules for modelling and simulation to facilitate the development and deployment of Digital Twins that address scientific problems in different domains.</i>
Exploitation Success Stories
Further Research Key interTwin DTE components and know-how being followed up in several projects (EOSC Data Commons, RI-SCALE, ODISSEE, EOSC Beyond)



KER1: Interdisciplinary Digital Twin Engine

Specific components are also backed by further collaborative projects such as ESC EOEPKA+ ESA openEO platform, ESA MOOC cubes & clouds, EFRE CRIMA. openEO has been adopted/collaborating with EODC, IBM, DLR, VITO and Collaborations with European Space Agency, EUMETSAT and Ontopic

Core components such as the Infrastructure Manager, OSCAR and other DTE modules integrated in the US Chameleon Cloud Framework under the Discover-US exchange. OSCAR and interLink have also been incorporated to VEGA for execution as a result of a joint activity with AI4EOSC

yProv has been integrated in the Ophidia framework, itwinai, SQAaaS, OpenEO offering new future opportunities. It is also further developed under EOSC Beyond. Collaboration UNTN and Valentine Anantaraj (ONRL), member of the EEAB on provenance yProv integrated with Infrastructure Manager

Thematic components such as xclim (CERFACS) have been granted follow up national projects (TRACCS, pc4extending) where it is reused on climate extremes use cases (under pc4) and part of climate services (under pc). Service for risk assessment is available under IRISCC project

Some of the DTE components have been incorporated in 2025 to a new set of project proposals (in Horizon Europe and other national initiatives). Any follow up projects granted will be included as success stories granting the continuity of the component or group of components.

Product Creation

DTE as a product. i.e. SW components have been made available for use & reuse – from GitHub and as single components or subset of components. Technical and User documentation has been created and updated for each of the components. Noteworthy to mention the DTE is not a monolithic component, instead follows a modular approach. As such different entry points for the developments / composing workflows are available depending on the needs of the DT. In the final release the number of available components has increased to 49.

Service Creation

During the project the DTE service is prototyped by the deployment of the 10 DT use cases, successfully achieving TRL 6. The thematic modules and the results of the use cases are being adopted by the Research infrastructures. It is planned to further develop environmental digital twins to bring them to full operational services TRL9 in the next 2-3 years.

KER1: Interdisciplinary Digital Twin Engine

Digital twinning has been incorporated to EGI strategy 2025-2030 as part of the key service offering to become part of the ESFRI roadmap of Research Infrastructures for which the interTwin has been instrumental.

Key components of the Digital Twin Engine have been incorporated to the creation, enhancement or integrated into EGI services (e.g. EGI Check-in integrated in DTE core components and mapped as TOSCA Templates to be executed by EGI Infrastructure Manager, several DTE core components have been incorporated in the newly created EGI HPC service).

Standardization Activities

Alignment with current standards, as explained in the interoperability deliverable D3.3

Academic Use/ Education & Training

Webinar series have started on the technologies. Specific tutorials have been developed for some core components (itwinai, interLink, openEO). They will be made available from interTwin website, GitHub, interTwin youtube and/or within partners own dissemination channels and webs.

Technology Transfer / Licensing

All DTE components shared under Open Source licenses - facilitating the sharing across partners and the uptake among other projects and SMEs.

KER2: Interoperability Framework: Guidelines, Specifications, and Blueprint Architecture

The interTwin interoperability framework aligns technical approaches and foster collaboration in modelling and simulation application development across scientific domains.

Exploitation Success Stories

Further Research / Collaborative Projects:

Collaboration with DT-Iliad and DT ocean and Cross-project collaboration with BioDT, DT-GEO and DestinE for the creation of a joint european glossary on digital twins,

Standardization Activities:

KER2: Interoperability Framework: Guidelines, Specifications, and Blueprint Architecture

Contribution to the creation of the Working Group from IEEE for the Standardization of DT of the Earth, in collaboration with DT Iliad, The creation of the WG was formally accepted under IEEE-SA P3501 working group - Recommended Practice for the Development of Digital Twins of the Earth and kickstarted in January 2025.

Alignment with interoperability standards, e.g. CWL, (as described in D3.4), OGC standard is in the process of incorporating openEO as community standard, has been getting feedback from the community in March and April 2025⁷²

Interoperability with DestinE, Data Spaces and EOSC has been tested along the use cases explained in D3.7.

Alignment with EOSC Interoperability Framework (as described D3.5) include EOSC core-services (AAI, Accounting, Monitoring, Helpdesk & Configuration Database), EOSC Compute Federation (Hybrid cloud orchestration, workload management & software distribution) and EOSC Exchange (e.g. Notebooks, PaaS Orchestrator, AI/ML Integration and Scalable Big Data Tools). Use case has permitted to test the integration of a Digital Twin in EOSC EU Node.

Technology Transfer/ Licensing:

Some of the interTwin DTE components are expected to be evaluated under DestinE (also thanks to the activities in follow up projects such as RI SCALE). In particular the DataLake and the AI Framework.

Part of the Interoperability assessment with EOSC, interTwin Core services and components TOSCA templates and Configuration artifacts are available to be executed at EOSC EU Node.

Open Science:

All deliverables are made available open access via multiple channels such as interTwin managed web pages, and Zenodo. A scientific publication has been prepared describing the overall interTwin framework and it is expected to be published short after the end of the project

KER3: Toolkit for AI workflow and method lifecycle management

AI-based methodologies to extract application sector-specific information from research data at the exabyte-scale level in a real-time manner and increase the efficiency and accuracy of simulation and modelling outputs

Exploitation Success Stories

Further Research / Collaborative Projects:

⁷² <https://www.ogc.org/requests/ogc-looks-to-adopt-openEO-as-community-standard-seeking-public-comment-before-moving-to-vote/>



KER3: Toolkit for AI workflow and method lifecycle management

itwinai core component will be further developed in the awarded follow up projects EOSC Data Commons, RI SCALE and ODISSEE, and has been further incorporated in new project proposals in 2025.

itwinai has been successfully integrated with other core, infrastructure and thematic components which will also facilitate the future collaboration between partners.

Product Creation:

Available for download and maintained by the interTwin Open Source Community via GitHub repository technologies, already 2 forks of it. Technical and User documentation has been created and maintained in a specific *itwinai* landing web page. Specific branding has been created including Logo and visual identity.

Technology Transfer/ Licensing :

itwinai is part of the core-module building blocks of the Digital Twin Engine

itwinai has been adopted internally by CERN e.g. in some pilots with AtmoRep and MLPF.

Potential use of the *itwinai* library by ECMWF to make it available for the DestinE initiative.

Open science:

Expected publication for the integration of OSCAR + interLink + *itwinai*. Many dissemination activities such as presentation at ACAT 2024 - also submitted to other conferences (PASC24 and PASC25, accepted to EuCAIFCon 2024). Progress of AI work has also been presented in major conferences with industrial presence – such as NVIDIA GTC or ISC 2025

KER4: Quality Framework

Tools for automated quality measures and trust, development of standard quality mapping and indicators for appropriately communicating differences in qualities of inputs and outputs from digital twins, addressing issues such as data and model pedigree, accuracy, and lack of knowledge.

Exploitation Activities & Progress

Further Research / Collaborative Projects:

The SQAaaS platform is a project outcome from the EOSC Synergy project which has been further developed in interTwin. It is a component that is also included in the cross-project collaborations with DT-GEO sister project, where the platform is used

KER4: Quality Framework

for the FAIR evaluation of project Data – whereas in interTwin it is used for the evaluation of the quality of the SW components and Workflows.

Product Creation:

SW packages available from open repositories or downloaded and maintained by the Open Source Community via repository tech such as GitHub. Full documentation is available from GitHub repository and specific component website (<https://sqaaas.eosc-synergy.eu/#/>). There is specific branding and logo to maximize the dissemination of the component.

Service Creation:

Definition of a Quality Framework as a service (SQaaS) - deployment in production that includes automated QA assessment capabilities for: Source code, (web) Services and Data FAIRness that enables easy integration of new tools, testing frameworks, etc. to allow customized checks.

Technology Transfer/ Licensing:

SQaaS is part of the core module building blocks of the Digital Twin Engine acting as of the QA module within the DTE architecture

SQaaS has been integrated to other infrastructure, core and thematic components that will enable the QA assessment as the components are further used and developed after the project.

Open science:

Open access available via multiple channels such as interTwin managed web pages and specific SQaaS landing page

Scientific paper describing the component and its features: “Software Quality Assurance as a Service: Encompassing the quality assessment of software and services” (<https://doi.org/10.1016/j.future.2024.03.024>)

KER5: DTE federated infrastructure integrated with EOSC and EU Data Spaces

Federated distributed compute platform providing access to distributed data and integrating HTC, HPC, Cloud and Quantum Computing capabilities for processing.

Exploitation Activities & Progress

Service Creation:

interTwin test-bed available for executing test applications
<https://www.intertwin.eu/dte-testbed>



KER5: DTE federated infrastructure integrated with EOSC and EU Data Spaces

Federated HPC infrastructure, know-how and technologies used for the creation of the EGI HPC service. Several meetings with Service Owner, and key infrastructure providers have been contacted -including Vega and EGI Federation members in interTwin offering HPC capabilities - such as GRNET and University of Vilnius willing to offer their capabilities.

Service will be maintained and managed as part of the EGI Service Catalogue offering policy-based access. (Policy-based: users are granted access based on policies defined by the EGI resource providers or by the EGI Foundation; such policies usually apply to resources being offered with “sponsored use” to meet some national or EU level objective, i.e., a country may offer resources with “sponsored use” to support national researchers involved in international collaborations.).

EOSC EU Node procurement includes EGI Infrastructure manager, for which the TOSCA Templates and Configuration Artifacts for interTwin Core components have been made available to the whole EOSC community, and use cases have been implemented using the EOSC Innovation sandbox.

Policy Making:

Policy Recommendations for federation of HPC resources compliant with EuroHPC Access Policies. Policy Recommendations for federation of HPC resources to be pushed to SPECTRUM project (Access Policies).

Part of SPECTRUM project ETP4HPC WG on HPC iterated the federation white paper that will be published during 2025.

INFN has also adopted InterLink also in the context of the **AI INFN initiative** of the Fifth National Scientific Committee, to submit Machine Learning pipelines to HPC and HTC centers.

Product Creation:

interTwin Infrastructure modules available from main interTwin website: <https://www.intertwin.eu/dte-infrastructure-modules/>

SW component interLink being promoted as stand-alone product, ready for Use and Re-use: <https://interlink-project.dev/> and included as CNCF Sandbox project.

Technology Transfer/ Licensing:

KER5 are the infrastructure module building blocks of the Digital Twin Engine acting as the components that enable the data and compute federation of infrastructures necessary for the project implementation, including use cases from both physics (CERN, Virgo) and climate research (CMCC, EURAC) communities



KER5: DTE federated infrastructure integrated with EOSC and EU Data Spaces

interLink adopted by INFN under the project Heterogeneous Resource integration for scientific workflows/pipelines used to enable a seamless provisioning of heterogeneous resources to k8s-based workload manager

Collaboration with [NUNET.io](https://nUNET.io), HelixML and DECICE project. Other potential adopters under conversation.

In the context of LISA (Laser Interferometer Space Antenna) DDPC (Distributed Data Processing Center), CNES is using Interlink to prototype a hybrid execution of LISA pipelines on either Kubernetes or Slurm resources.

Infrastructure Modules have been tested and in some cases adopted by major EuroHPC supercomputing facilities - not only the ones represented at the project (VEGA, Jupiter), also CINECA, CESGA, LUMI, etc.

Overall adoption of interLink can be found in following link (<https://github.com/interlink-hq/interLink/blob/main/ADOPTERS.md>)

KER6: interTwin Open Source Community

The community of DT application developers, users and operators that is responsible for the design, development, and maintenance of the DTE code base.

Exploitation Activities & Progress

Community Creation

- The interTwin Github Organisation is available and initial templates and guidelines for publication of the several releases described based on the quality framework
- The community has free registration following approval processes guided by open science commons principles
- Currently the community is growing mainly from the project partners contributing to the different components. It is expected that the community grows across user communities as the Digital Twins use cases show results.

Scientific communities have been also collaborating in their own open source activities, such as the radio astronomy use cases will be maintained by their own community together with PUNCH4NFDI partners, or the use case on gravitational waves by the VIRGO/Ligo Collaboration.

3 Conclusions: interTwin Impact and Legacy

The interTwin project has successfully delivered an interdisciplinary, open-source Digital Twin Engine (DTE) that has set a reference for the European Digital Twin for Science ecosystem. Its achievements extend across scientific, technological, and socio-economic dimensions, laying the groundwork for sustainable exploitation and industrial uptake of Digital Twin technologies.

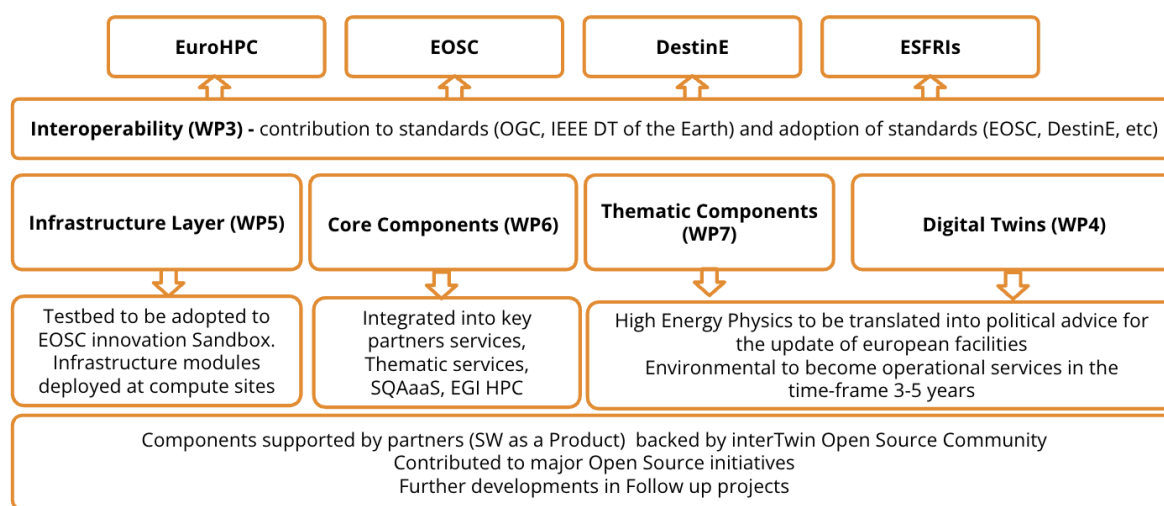


Figure 15 Summary of interTwin Uptake

In all, interTwin has contributed to democratising science, our services have enabled communities all-around Europe to develop solutions that tackle the data problems of the next decade.

Some indicators for interTwin impact and legacy

- Number of Key Exploitable Results: 6
- Number of Results (SW Components): 49, including 17 new developments and 32 extensions or enhancements of preexisting results. Software components may include the code, documentation and all related material (training, tutorials, dissemination materials, videos, website)
- Digital Twin Engine and its modules have been co-designed and validated by 10 use cases across different Scientific domains
- Exploitation done through follow-up research, the creation and enhancement of products, services, standardization and policy making.
- Each partner owning the project results is committed to sustaining them, adopting them for the organizations, part of their service or product offerings or under follow-up research and development collaborative projects (European or national)



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- interTwin has contributed directly to the award of 3 projects that are following up the development of different Digital Twin Engine modules. Several other proposals have also been submitted recently.
- interTwin has been collaborating (use, reuse of modules, know-how, etc) in at least 20 projects.
- interTwin has been adopted by 6 SMEs, the number of which is expected to increase in the coming years.
- interTwin has federated Compute and Data facilities across the whole continuum including HPC (EuroHPC), HTC, Cloud, Data, including EuroHPC Vega, Julich Cloud and HPC, UKRI Cloud, GRNET, KBFI, PSNC, EODC and Vilnius, and CESGA Quantum Computing facility.
- interTwin has successfully integrated compute and data facilities EuroHPC, EOSC, DestinE and ESFRIs granting interoperability of those.



4 Annexes

Annex 1: Definitions

The keywords "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [RFC 2119](#)⁷³.

Table 11 Definitions

Definition	Description	Reference
Exploit(ation)	<i>The use of results in further research and innovation activities other than those covered by the action concerned, including among other things, commercial exploitation such as developing, creating, manufacturing, and marketing a product or process, creating, and providing a service, or in standardisation activities</i>	interTwin Grant Agreement
Innovation	<i>A new or changed entity, realising, or redistributing value. An entity is anything perceivable or conceivable, such as a product, service, process, model, method, or a combination of thereof. They can be material, immaterial or imagined.</i>	ISO56000 ⁷⁴
	<i>The successful exploitation of new creations (inventions) which can be used to produce tangible benefit, satisfying needs and wants.</i>	Innovation Radar ⁷⁵
Innovation management system	<i>Set of interrelated or interacting elements of an Organization / Project to establish strategies, policies and objectives and Processes to achieve those objectives with regard to innovation</i>	ISO56000
Innovation Policy	<i>Intentions and direction of an Organisation as formally expressed by its top management with regard to innovation</i>	ISO56000
Innovation Strategy	<i>Plan to achieve objectives with regard to innovation</i>	ISO56000
Process	<i>Set of interrelated or interacting activities that use inputs to deliver an intended result</i>	ISO56000
Background	<i>Any data, know-how or information — whatever its form or nature (tangible or intangible), including any rights such as intellectual property rights — that is:</i> • <i>(a) held by the beneficiaries before they acceded to the Agreement and</i>	interTwin Grant Agreement

⁷³ <https://datatracker.ietf.org/doc/html/rfc2119>

⁷⁴ <https://www.iso.org/standard/68221.html>

⁷⁵ <https://www.innoradar.eu/methodology>



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	(b) needed to implement the action or exploit the results	
Results	Any tangible or intangible effect of the action, such as data, know-how or information, whatever its form or nature, whether or not it can be protected, as well as any rights attached to it, including intellectual property rights.	interTwin Grant Agreement
	What is generated during the project implementation. This may include, for example, know-how, innovative solutions, algorithms, proof of feasibility, new business models, policy recommendations, guidelines, prototypes, demonstrators, databases and datasets, trained researchers, new infrastructures, networks, etc. Most project results (inventions, scientific works, etc) are 'Intellectual Property', which may, if appropriate, be protected by formal 'Intellectual Property Rights	European Commission Horizon Europe Guidelines ⁷⁶
Key Exploitable Result	A Key Exploitable Result (KER) is an identified main interesting result (as defined above) which has been selected and prioritised due to its high potential to be "exploited" – meaning to make use and derive benefits- downstream the value chain of a product, process or solution, or act as an important input to policy, further research, or education.	European Commission Horizon Europe Guidelines
KER Champion	The KER Champions are responsible for ensuring engagement with all relevant WPs and supporting the provision of information and analysis for each of the assigned KERs. Altogether they form the Innovation and Exploitation Group (IEG)	Own Definition (DoA)
Innovation and Exploitation Group (IEG)	Supports innovation management system processes over the project duration. Drives implementation of the project's knowledge and protection strategy. Collects and maintains the information related to project KERs as well as updating and monitoring dissemination and exploitation plan in line with the innovation management task (T2.1). This includes The management of IPR, access rights of project's background and foreground The maintenance of information related to dissemination and exploitation activities. Gives direction and facilitates discussion for capturing opportunities and developing initial technical concept candidates.	Own Definition (DoA)
Innovation Capacity	Do the project results have the capacity to stimulate further innovations? Does it have the potential to be used in other areas (beyond the project objectives)	Innovation Radar ⁷⁷

⁷⁶ https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/horizon/guidance/programme-guide_horizon_en.pdf

⁷⁷ <https://www.innoradar.eu/methodology>



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Innovation Potential	<i>How much benefit (innovation) can the project results potentially deliver</i>	Innovation Radar
Innovation Management	<i>(EC definition) Management of all the activities related to understanding needs with the objective of successfully identifying new ideas and managing them, in order to develop new products and services which satisfy these needs.)</i>	IP Helpdesk
Intellectual Property (IP)	<i>Refers to creations/products of the mind, such as inventions, research & experimentation, or products of creativity. Like physical property, IP is an asset which can be traded (sold, bought, leased, used, or given away), and is protected by law.</i>	IP Helpdesk Glossary ⁷⁸
Intellectual Property Rights (IPR)	<i>Is the legal right granted to IP owners to protect their IP, enabling people to earn recognition or financial benefit from what they invent or create. Some common types of IPR are:</i> • Copyright (Software, written works, engineering drawings...) – it comes into existence automatically upon the creation of the original work • Patents (Technical inventions) - a monopoly right granted in return for causing the publication of an invention, preventing others to use it without agreement • Database rights (Creation & arrangement of data) - legal rights that protect the creation & management of data) • Design rights (Appearance) • Trademarks • Confidentiality Agreements (Know-how)	IP Helpdesk Glossary
Ownership of results & Joint Ownership	<i>Results are owned by the beneficiaries that generate them. However, two or more beneficiaries' own results jointly if they have jointly generated them and it is not possible to:</i> • <i>establish the respective contribution of each beneficiary, or</i> • <i>separate them for the purpose of applying for, obtaining, or maintaining their protection.</i> <i>The joint owners must agree — in writing — on the allocation and terms of the exercise of their joint ownership ('joint ownership agreement'), to ensure compliance with their obligations under this Agreement.</i>	interTwin Grant Agreement
Access rights for implementing the action	<i>The beneficiaries must grant each other access — on a royalty-free basis — to background needed to implement their own tasks under the action unless the</i>	interTwin Grant Agreement

⁷⁸ https://intellectual-property-helpdesk.ec.europa.eu/regional-helpdesks/european-ip-helpdesk/europe-glossary_en



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	beneficiary that holds the background has — before acceding to the Agreement: - informed the other beneficiaries that access to its background is subject to restrictions, or - agreed with the other beneficiaries that access would not be on a royalty-free basis. The beneficiaries must grant each other access — on a royalty-free basis — to results needed for implementing their own tasks under the action.	
Access rights for exploiting the results	The beneficiaries must grant each other access — under fair and reasonable conditions — to the results needed for exploiting their results. The beneficiaries must grant each other access — under fair and reasonable conditions — the background needed for exploiting their results unless the beneficiary that holds the background has — before acceding to the Agreement — informed the other beneficiaries that access to its background is subject to restrictions. Requests for access must be made — unless agreed otherwise in writing — up to one year after the end of the action. Access rights for entities under the same control	interTwin Grant Agreement
Technology Readiness Levels - TRL	TRL 1 – basic principles observed TRL 2 – technology concept formulated TRL 3 – experimental proof of concept TRL 4 – technology validated in the lab TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) TRL 7 system prototype demonstration in an operational environment TRL 8 – system complete and qualified TRL 9 – the actual system is proven in an operational environment (competitive manufacturing in the case of key enabling technologies; or in space)	European Commission Annex G. Grant Agreement ⁷⁹
Objectives	The goals of the work performed within the project, in terms of its research and innovation content. These will be translated into the project's activities. These may range from tackling specific research questions, demonstrating the feasibility of innovation, and sharing knowledge among stakeholders on specific issues. The nature of the	European Commission Horizon Europe Guidelines

⁷⁹ https://ec.europa.eu/research/participants/data/ref/h2020/wp/2014_2015/annexes/h2020-wp1415-annex-g-trl_en.pdf



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	<i>objectives will depend on the type of action and the scope of the topic.</i>	
Outcomes	<i>The expected effects, over the medium term, of projects supported under a given topic. The results of a project should contribute to these outcomes, fostered in particular by the dissemination and exploitation measures (including the uptake, diffusion, deployment, and/or use of the project's results by direct target groups). Outcomes generally occur during or shortly after the end of the project</i>	<u>European Commission Horizon Europe Guidelines</u>
Impacts	<i>Wider long-term effects on society (including the environment), the economy and science, enabled by the outcomes of R&I investments (long term). It refers to the specific contribution of the project to the work programme's expected impacts described in the destination. Impacts generally occur sometime after the end of the project.</i>	<u>European Commission Horizon Europe Guidelines</u>

Annex 2: Detail of Stakeholder Mapping

Table 12 Stakeholders Mapping

Initiatives / Institutions	Type	Role	Market Domains	Relevance for interTwin	D&E Actions
Destination Earth (DestinE) / EUMETSAT / ESA	Public Initiative	User	Climate / Environmental Application Domain	ECMWF partner of interTwin, DT of Extremes (DOA) Relevant components (D3.1): DestinE Digital Twin Engine (DestinE DTE) DestinE Data Lake (DEDL) DestinE Core Service Platform (DESP)	Planned piloting activities in the context of T3.2 and technological exchange (both ways) Technology exchange together with DT-Geo , BloDT and EDITO-Infra (D3.1) Initial contact has been made with the C-SCALE, Fenix and Destination Earth (DestinE) for the Data Federation needs Joint use case (FloodAdapt) enabled shared knowledge on interoperability and the generation of a use case accessing DestinE Data Lake (D3.7)
EOSC	Public Initiative, Interest Group	User / Multiplier	Cloud Infrastructure Downstream Market	EOSC Portal onboarding of services (EOSC Exchange), EOSC IF (DoA)	Alignment between the interTwin interoperability framework and the EOSC IF - especially in the relevant areas (e.g. AAI) - that have been integrated in interTwin DTE core services as AAI mechanism. TOSCA Templates and configuration artifacts in Infrastructure manager enable the deployment and usage of interTwin DTE core elements in the EOSC EU Node. This has been tested as part of a use case. (D3.7)
EGI-ACE	Project	Provider	Infrastructure Downstream Market	EOSC Computing platform / AAI	Extend the DTE infrastructure with providers coming from the EGI Federation and EOSC Computing platform, use EGI Check-in AAI (D3.1)
Escape	Project	Provider	Physics Application Domain	ESCAPE Data Lake Blueprint	Adoption of the ESCAPE data lake Blueprint and services in interTwin (D3.1) interTwin, apart from sharing some of the communities with ESCAPE (CERN and VIRGO), could benefit from the data lake architecture developed in the project, and named DIOS (D3.1). In particular the File transfer functionality is implemented by the FTS ⁸⁰ service and the Data

⁸⁰ <https://fts.web.cern.ch/fts/>



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					orchestration by the Rucio ^{81[2]} service both developed at CERN.
C-SCALE	Project	Provider	Climate/Environmental Application Domain Infrastructure Downstream Market	Access of Copernicus data federation, possible technology exchange (openEO, EO-MQS based on STAC)	Know-how transferred to interTwin part of the C-SCALE project partners (EODC, LIP, DELTARES, etc) including the data access and technology contributions (D3.4) C-Scale components and services developed in the project which are relevant to the interTwin architecture blueprint are the FedEarthData , the EO-MQS and the openEO API. (D3.1) C-SCALE know-how on EO workflows used including contact with C-SCALE, Fenix and Destination Earth (DestinE) for the Data Federation needs (RP1)
openEO platform	Project	Provider	Climate/Environmental Application Domain	Implements data access and processing federation based on openEO API and a common process-graph definition.	Understand from partners in interTwin part of the openEO platform project (EODC, EURAC, WWU, TU Vienna) the data access and technology
DigitalTwin Consortium	Interest Group	Multiplier, Standardization Body	Digital Twins	Definitions and Digital Twin glossaries (https://www.digitaltwinconsortium.org/glossary/), Working group on Digital Twins for Research and Academia: https://www.digitaltwinconsortium.org/working-groups/academia-research/	Mapping of the concepts, such as the Digital Twin systems into the next version of the Blueprint architecture (DoA). Definition (D3.4)
GAIA-X	Public Initiative / Interest Group	Provider, Multiplier	Cloud Infrastructure Downstream Market Data Horizontal	Cloud and Sovereign data federation in Europe.	Participation in technical WGs and architecture alignment (DoA) The activity of Gaia-X is also driven by WGs where members of the Gaia-X ASBL can participate and contribute to. For instance, both EGI Foundation and INFN as Gaia-X members are contributing to the Architecture and AAI WG. (D3.4)
EU Data Spaces and SIMPL	Public Initiative	Provider	Data Horizontal	Access to Sectoral Data space data via integration of the SIMPL framework	Analysis of the first version of the SIMPL MVP in 2024. interTwin integration with SIMPL evaluated in (D3.7), to understand the type of data which could be made available for interTwin DTE and use cases. (D3.4)
TECH-01-2021 Projects - DT-Geo	Projects	User	Digital Twins Climate/Environmental Application Domain	Projects funded in the same call (TECH-01-2021 Projects) as interTwin	Analysis of architectures and synergies to be put in place also thanks to DG-Connect driven initiative. DT-Geo , BloDT and interTwin organizing monthly meetings MoU - Collaboration Agreement being prepared

⁸¹ <https://rucio.cern.ch/>



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					Participation in Joint Activities & Events - EOSC Symposium 2023 and 2024, etc Participation in Joint Position Paper - White paper on interTwin Members of interTwin EEAB
TECH-01-2021 Projects - BioDT	Projects	User	Digital Twins Climate/Environmental Application Domain	Projects funded in the same call (TECH-01-2021 Projects) as interTwin	Analysis of architectures and synergies to be put in place also thanks to DG-Connect driven initiative. DT-Geo, BioDT and interTwin organizing monthly meetings MoU - Collaboration Agreement being prepared Participation in Joint Activities & Events - EOSC Symposium 2023, etc Participation in Joint Position Paper - White paper on interTwin Members of interTwin EEAB
Climate related EuroHPC projects eflows4HPC, Cheese CoE	Project	User	Climate / Environmental Application Domain HPC Infrastructure Downstream Market	EuroHPC Projects in the DT-Geo roadmap	T4.5 Paper -Climate Change Future Projection of Extreme Events <i>G. Accarino, D. Donno, F. Immorlano, D. Elia, G. Aloisio (2023). An Ensemble Machine Learning Approach for Tropical Cyclone Localization and Tracking from ERA5 Reanalysis Data. Earth and Space Science.</i> https://doi.org/10.1029/2023EA003106
In relation to climate and weather modelling, the EuroHPC Joint Undertaking is managing some prominent R&I projects including: * ESIWACE3 (Center of Excellence for weather and climate - phase 3) * MAELSTROM (MAchine Learning for Scalable meTeoROlogy and climate) * HiDALGO2 Project CoE (HPC and Big Data Technologies for Global Challenges) which simulates violent weather phenomena.	Projects	User / Provider	Digital Twins HPC Infrastructure Downstream Market	EuroHPC Projects related to Climate & Weather phenomena.	Meeting ESIWACE3 during EuroHPC Summit Week 2025 to check synergies.
COE Raise	Project	Provider	AI Horizontal	AI technologies and knowledge	RAISE presentation at Kick off meeting AI know-how reused for interTwin for the creation of the AI Toolkit including itwinai



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				CERN-related LHC Use Case: https://www.coe-raise.eu/event-reconstruction	
Other DT Projects: CogniTwin : COGNITWIN - Cognitive plants through proactive self-learning hybrid digital twins Manufacturing domain: Circular TwAIN project HORIZON-CL4-2021-TWIN-TRANSITION-01-07: Artificial Intelligence for sustainable, agile manufacturing AgriFood domain: DEMETER project DIGITbrain is an EU innovation program which has the vision to unleash manufacturers' innovation potential through Digital Twins.	Projects	User / Provider?	Digital Twins in other application domains	Development of Digital Twins within other domains (manufacturing, industry 4.0, etc) Mapping of DT-Related standards	DT projects have been analysed for possible re-use of interTwin technologies.
ENES , members of the earth observation community active in GEO (Group on Earth Observation) and EARSeL (European Association of Remote Sensing Laboratories) .	Research Infrastructure / Interest Groups	Providers / Multipliers	Climate/Environmental Application Domain	Datasets to be used	Datasets used part of Environmental Use Cases
HL-LHC	Research Infrastructure	Providers / Users	Physics Application Domain	DT aimed to improve the HL-LHC infrastructure	WP4.1 Lattice QCD Simulations - High Energy Physics WP4.2 Detector simulation - High Energy Physics
PANGEO	Research Infrastructure	Providers / Users	Climate/Environmental Application Domain		
Einstein Telescope (ET)	Research Infrastructure	Providers / Users	Physics Application Domain	Use Case	WP4.4 VIRGO Noise detector DT - Astrophysics
VIRGO	Research Infrastructure	Providers / Users	Physics Application Domain	Use Case	WP4.4 VIRGO Noise detector DT - Astrophysics



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ENVRI	Research Infrastructure / Interest Groups	Providers / Users	Climate/Environmental Application Domain	Data & Tools can be used Access to community Synergies with ENVRI-HUB	Requirements for Environmental Use Cases, EEAB early feedback
ENVRI-FAIR / ENVRI-HUB-NEXT	Project	Providers / Users	Climate/Environmental Application Domain	Marketplace for Services, Data, Knowledge and use cases https://envri-hub.envri.eu/	Requirements for Environmental Use Cases
IRISCC	Project	Providers / Users	Climate/Environmental Application Domain	Marketplace for Services, Data, Knowledge and use cases related to climate	Requirements for Environmental Use Cases. Services generated in interTwin use case onboarded to IRISCC
FENIX	Project / Infrastructure	Providers / Users	Infrastructure Downstream Market	Openstack & Infrastructure manager has been integrated in FENIX part of DT-GEO so it could potentially open opportunities to run interTwin on FENIX	Use or re-use Fenix infrastructure & data. Learnt from federation strategy of Fenix. Initial contact has been made with the C-SCALE, Fenix and Destination Earth (DestinE) for the Data Federation needs
ETP4HPC	Interest Group	Providers / Multiplier	HPC Infrastructure Downstream Market	DestinE Roadmapping Discussions (https://etp4hpc.eu/digital-continuum/#destine)	Learnt from the DestinE-related presentations.
EuroHPC	Public / Private Partnership	Funding	HPC Infrastructure Downstream Market	interTwin aims to federate EuroHPC facilities (e.g. Vega) Collaborations with EuroHPC funded projects interTwin aims to test federation of Quantum facilities	VEGA has been federated in the interTwin system. interTwin tools incorporated and tested in CINECA (Leonardo) and CESGA (Finisterrae)
TEMA	Project	User (Public Administration)	Climate/Environmental End Users	Adoption of Climate Related DTs	Webinar on Environmental digital twins targeting Public Authorities
AI4EUROPE / AI-on-Demand	Project	Multiplier	AI Horizontal	Channel for dissemination and exploitation AI-related results (e.g. KER3, itwinai, etc) AI-Assets: https://www.ai4europe.eu/contribute/ai-asset (https://www.ai4europe.eu/research/ai-catalog) Projects: https://www.ai4europe.eu/contribute/project (https://www.ai4europe.eu/ai-community/projects)	Market place channel used as dissemination of AI capabilities developed in interTwin



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				Education & Training https://www.ai4europe.eu/contribute/education (https://www.ai4europe.eu/education/education-catalog)	
iMagine	Project	Provider / User	Climate/Environmental Application Domain		Synergies between projects assessed. Follow up efforts within RI-SCALE project coordinated by EGI
HiPEAC	Project / Community	Multiplier	Infrastructure Downstream Market	Dissemination channel (e.g. events, web, news, newsletter) HiPEAC Conference: https://www.hipeac.net/2024/municipality/ Webinar: https://www.hipeac.net/webinars/ HiPEAC Magazine: https://www.hipeac.net/news/#/magazine/ HiPEAC Vision: https://www.hipeac.net/vision/#/latest/ Projects: https://www.hipeac.net/network/#/projects/	interTwin has been disseminated using HiPEAC channels (HiPEAC magazine). Participation at the industrial session of the HiPEAC Conference 2025 Workshop organized
DiscoverUs	Project / Community	Multiplier	Infrastructure Downstream Market	Channel for dissemination and exploitation	Exchange under DiscoverUs permitted the deployment of an interTwin use case (DT Flood) using Infrastructure Manager and OSCAR cluster.
Digital Twins of the Ocean - DT-Iliad, Aquainfra , EDITO-Infra , EDITO-ModelLab :	Project	Provider / User	Digital Twins Climate/Environmental Application Domain Infrastructure Downstream Market	Developing Digital Twins of the Ocean - leveraging Data, Infrastructures (Cloud, HPC, etc) Interoperability with EOSC and DestinE. Working with the Digital Twins of the Oceans Potential Data-Providers. Validation of Reference Architectures / DTE / Interoperability / Co-Creation of DTs - use cases	Participation in the Joint sessions of ECMWF and DT-GEO, BioDT to align with DestinE interoperability. Organization and participation of Joint sessions at the EOSC Symposium 2024 to evangelize the EOSC ecosystem on Digital Twinning as relevant use case for the community Collaboration linked to the creation of a Digital Twin of the Earth IEEE standard leading to the formal creation and acceptance of a Working Group to develop the standard



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BlueLobster	Company / SME	Multiplier	Climate/Environmental Application Domain	Partners in DT of the Ocean Projects Aqualnra & Iliad	Contact established at EOSC Symposium 2023
SPECTRUM	Project	User / Multiplier	Physics Application Domain	Roadmapping for HEP	Digital Twin requirements and emerging needs, recommendations and know-how have been transferred to SPECTRUM -part of the landscape analysis and use cases.
DECICE	Project	User	Infrastructure	Interest on interLink	Meetings to assess collaboration opportunities - interLink has adopted by DECICE project that includes European SMEs such as E4, SYNNO, BigTRI and NAG
AI4EOSC	Project	User/Multiplier	AIHorizontal	Interest on itwinai	Several meetings took place to assess collaboration opportunities resulting in follow-up proposals joining forces to bring AI capabilities developed in interTwin
ODISSEE	Project	User	AI, Horizontal, Physics Application Domain	interest on itwinai	interTwin work on itwinai and interTwin know-how generated in the use cases will be continued in ODISEE project
CNES Digital Twin Factory	Project	User	Digital Twins Climate/Environmental Application Domain	interest in environmental Digital Twins	The Digital Twin Factory (DTF, 2024-2026) project, coordinated by the French National Centre of Space Studies (CNES). Held several meetings. CERFACS know how developed in the environmental use cases has been transferred -resulting on a collaboration with Quantqube SME



Annex 3: Business Model Workshops

1st Internal Business Model Webinar - the interTwin Innovation Management System

Short Description:

- Motivation & Context: interTwin project advancing. First version of interTwin Blueprint architecture was presented along with the first set of technical deliverables covering user requirements and technological choices and expected architecture and developments for interTwin solutions. Innovation Management processes have been set up and early expected results spotted. As the first project review is approaching - it is time to gear up the exploitation to not only understand the technologies under development but the opportunities for their use and re-use after the end of the project.
- Purpose: This webinar aims to refresh interTwin partners on the innovation management processes established within the project, providing examples on how the project is addressing the collection of Results, Key Exploitable Results and emerging Innovations, and how it is expected to work on the exploitation and sustainability plans related to them.

Target Audience: Project Partners aiming to ensure that the results are duly captured and exploited.

Channel: Webinar - to be recorded

Access: Limited to project partners & video recording accessible to partners

Date: 23 November 2023

Announcement: "The interTwin project is advancing! The first version of interTwin Blueprint architecture was presented along with the first set of technical deliverables covering user requirements and technological choices and expected architecture and developments for interTwin solutions. Innovation Management processes have been set up and early expected results are emerging. As the first project review is approaching - it is time to gear up the exploitation to not only understand the technologies under development, but also to identify the opportunities for their use and re-use after the end of the project."

2nd Internal Business Model Webinar - Introduction to IPR and SW Open source licensing (Malcolm Bain)

Short Description:

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- Motivation & Context: interTwin project is currently at the middle of the project. First release of the SW components has recently been published and have been made available under the interTwin community GitHub and early feedback is being collected to incorporate it at the second release. As they are part of the Digital Twin Engine, it is important to assess under which conditions access will be made available. Part of intellectual property (IP) interTwin strategy is to deliver all project outputs following open science principles as stated in the Grant Agreement, and as such, SW components are expected to be distributed under open source licenses (and hence under the copyright stated in each license)
- Purpose: This webinar aims to refresh interTwin partners on the fundamental concepts of legal protection of R&D results, including Intellectual Property (Copyright, Databases), and Industrial property (patents, trademarks, trade secrets, etc), Software Licensing and Business Models.

Learning Objectives

- Participants understand the core concepts of software and data licensing
- Participants understand scope and implications of Open Science and Open Source licensing
- Participants have awareness of software and data-based business models (particularly in science context).
- Participants understand the link between open source and business and technology exploitation opportunities

Activities:

- Presentation of software and data licensing basics
- Presentation of software and data-driven innovation and business models. Interactive case-based discussion
- Discussion of licensing exploitation options and open science

Target Audience: IEG-KER Champions, SW component owners and Project Partners aiming to ensure that the components are properly licensed.

Channel: Webinar

Access: Limited to project partners & related projects. Video recording accessible to partners

Date: 30 May 2024 - 11.00-12.30

Announcement: "interTwin project is currently at the middle of the project. First release of the SW components has recently been published and have been made available under the interTwin community GitHub and early feedback is being collected to incorporate it at the second release. As they are part of the Digital Twin Engine, it is important to assess under which conditions access will be made available. Part of intellectual property (IP) interTwin strategy is to deliver all project outputs following open science principles as



stated in the Grant Agreement, and as such, SW components are expected to be distributed under open source licenses (and hence under the copyright stated in each license). This webinar aims to refresh interTwin partners on the fundamental concepts of legal protection of R&D results, including Intellectual Property (Copyright, Databases), and Industrial property (patents, trademarks, trade secrets, etc), Software Licensing and Business Models."

3rd Business Model Workshop - F2F Hands-on-session on SW Open source licensing (Across Limits)

Short Description:

- Motivation & Context: interTwin project is currently at the middle of the project. First release of the SW components has recently been published and have been made available under the interTwin community GitHub and early feedback is being collected to incorporate it at the second release. As they are part of the Digital Twin Engine, it is important to assess under which conditions access will be made available. Part of intellectual property (IP) interTwin strategy is to deliver all project outputs following open science principles as stated in the Grant Agreement, and as such, SW components are expected to be distributed under open source licenses (and hence under the copyright stated in each license)
- Purpose: This F2F workshop aims to expand on the theoretical foundations explained in the webinar, refresh interTwin partners on the fundamental concepts of legal protection of R&D results, including including Intellectual Property (Copyright, Databases), and Industrial property (patents, trademarks, trade secrets, etc), Software Licensing and Business Models.

Learning Objectives

- Participants apply the core concepts of software and data licensing to SW components to the specific components developed in the project
- Participants discuss how Open Source licensing choices align with Open Science, business models and their further valorisation & use (exploitation)

Activities:

- Go through the project related SW components & modules and discuss about the implications or the license choices
- Discussion of business models & licensing exploitation options and open science for interTwin SW components

Target Audience: IEG-KER Champions, SW component owners and Project Partners aiming to ensure that the components are properly licensed.

Channel: F2F & Online for those who cannot attend

Access: Limited to project partners & related projects. Video recording accessible to partners

Date: 13 June 2024 - 11.15 - 13.5

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Announcement: "interTwin project is currently at the middle of the project. First release of the SW components has recently been published and have been made available under the interTwin community GitHub and early feedback is being collected to incorporate it at the second release. As they are part of the Digital Twin Engine, it is important to assess under which conditions access will be made available. Part of intellectual property (IP) interTwin strategy is to deliver all project outputs following open science principles as stated in the Grant Agreement, and as such, SW components are expected to be distributed under open source licenses (and hence under the copyright stated in each license). This F2F workshop aims to expand on the theoretical foundations explained in the webinar by presenting some examples from the interTwin project.

4th Business Model Webinar - How the interTwin Innovation Management System is used to foster projects' Exploitation and Sustainability

Teaser: Foster Exploitation and Sustainability in your Horizon Europe Project. The case of interTwin

Short Description:

- Motivation & Context: As interTwin has reached its final year, our Key Exploitable Results are identified and duly progressing, it is time to reflect on how the innovation management system has been used to successfully set up and use for understanding the project landscape, gathering the project results (including ownership, IP and access conditions). interTwin is ready to gear up on understanding how those results will be duly exploited, ensuring their sustainable use and adoption after the end of the project, and we are eager to share our experiences with other Horizon Europe projects and other interested stakeholders. At the same time, we are looking forward to discussing our approach from colleagues outside of the interTwin project.
- Purpose: This webinar aims to reflect on how the innovation management processes have been implemented and will focus on how the plans toward the exploitation and sustainability of project results will be done by the end of the project.

Target Audience: Project Partners from Horizon Europe projects aiming to ensure that the results are duly captured and exploited, and innovation management practitioners from other projects, institutions and research infrastructures aiming to learn how an innovation management system can be successfully implemented.

Channel: Webinar

Access: Public. Video recording accessible to partners and on YouTube channel.

Date: 12th December 2024

Announcement: As interTwin has reached its final year, our Key Exploitable Results are identified and duly progressing, it is time to reflect on how the innovation management system has been used to successfully set up and used for understanding the project



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landscape, gathering the project results (including ownership, IP and access conditions). interTwin is ready to gear up on understanding how those results will be duly exploited, ensuring their sustainable use and adoption after the end of the project, and we are eager to share our experiences with other Horizon Europe projects and other interested stakeholders. At the same time, we are looking forward to discussing our approach with colleagues outside of the interTwin project.



5th Business Model Workshop - Impact Driven Workshop - Assessment of impact across projects

Teaser: Workshop aiming to highlight different experiences and methodologies used to highlight and assess the impact across projects

Short Description:

- Motivation & Context: As interTwin is coming to an end, it is time to reflect on the impact that has generated. Assessing the impact of a project is not only limited to the scientific advances but also economic and societal benefits are very important. The European Commission has developed a Key Impact Pathways methodology that helps to assess the socio-economic impact of research projects and programmes at large, but there are a number of methodologies.
- Purpose: This workshop will present different approaches around the assessment of socio-economic impact of research activities, will bring together experiences from different projects showing together with interTwin the impact brought by those endeavours.

Target Audience: Project Partners from Horizon Europe projects, and innovation management practitioners across projects, institutions and research infrastructures, communications specialists aiming to learn how impact can be shown and policy makers aiming to assess the success of the projects in terms of impact brought back to taxpayers

Channel: Face to Face Workshop at EGI Conference 2025

Access: Public.

Date: Thursday, 5th June, 17.00-18.30. EGI Conference 2025

Contributors: interTwin, iMagine, EuroScienceGalaxy, EOSC Focus

Announcement: Assessing the impact of a project is not only limited to the scientific advances but also economic and societal benefits are very important. The European Commission has developed a Key Impact Pathways methodology that helps to assess the socio-economic impact of research projects and programmes at large, but there are a number of methodologies. During this workshop, different approaches around the assessment of impact of research activities, and experiences from different projects such as iMagine and EuroScienceGateway, together with interTwin, showed the impact achieved through these different methodologies.

Annex 4: Results Ownership List

Table 13 Results Ownership List

Results Ownership List	Single or joint ownership result	Result Owners	Will the owners exploit the result?	In which form will the result be made available to other consortium members and/or third parties?	Does the exploitation of the results require access to consortium members background ?	If yes- Measures taken/envisaged to give access to the background required for exploitation	Does the exploitation of the results require access to third party IPR?	If yes- Measures taken/envisaged to give access to the required IPR
01. Interdisciplinary Digital Twin Engine	Single	EGI Foundation	Yes	Open Source	Yes	Open Source	Yes	Open Source
02 .Interoperability Framework: Guidelines, Specifications, and Blueprint Architecture	Joint	Collaborative work of all project partners having contributed to the results	Yes	Open Access	No	N/A	No	N/A
03. Toolkit for AI workflow and method lifecycle management	Single	Partner owning the SW components & tools	Yes	Open Source	Yes	Open Source	Yes	Open Source
04. Quality Framework	Joint	CSIC/ LIP / UPV	Yes	Open Access Open Source Free License	Yes	Open Source	Yes	Open Source
05. DTE federated infrastructure integrated with EOSC and EU Data Spaces	Single	Owners of each of the subcomponents	Yes	Open Source	Yes	Open source	Yes	Open Source
06. interTwin Open Source Community	Joint	Collective work of all project partners	Yes	Open Access Open Source	Yes	All components stored in the github under open source license. All documentation under	Yes	Access as specified by each specific component

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						CC. Open access to GitHub		
07. OSCAR. Extensions/Development or Modifications	Single	UPV	Yes	Open Source Other - as as service	Yes	Access under Open Source license	Yes	Access under Open Source license
08. dCNIOS. New development	Single	UPV	Yes	Open Source Other - as as service	Yes	Access under Open Source license	Yes	Access under Open Source license
09. PyOphidia. Extensions/Development or Modifications	Single	CMCC	Yes	Open Source Other - as aservice	Yes	Access under Open Source license	Yes	Access under Open Source license
10. yProv. Extensions/Development or Modifications	Single	UNITN	Yes	Open Source Other - as as service	Yes	Access under Open Source license	Yes	Access under Open Source license
11. SQAaaS Platform. Extensions/Development or Modifications	Joint	UPV, LIP, CSIC/UNICAN	Yes	Open Source Other - as as service	Yes	Access under Open Source license	Yes	Access under Open Source license
12. SQAaaS GitHub action. New Development	Joint	CSIC/UNICAN	Yes	Open Source Other - as as service	Yes	Access under Open Source license	Yes	Access under Open Source license
13. SQAaaS CLI. New Development	Joint	CSIC/UNICAN / LIP	Yes	Open Source Other - as as service	Yes	Access under Open Source license	Yes	Access under Open Source license
14. Infrastructure Manager. Extensions/Developments or Modifications	Single	UPV	Yes	Open Source Other - as as service	Yes	Access under Open Source license	Yes	Access under Open Source license
15. Configuration Artifacts and Big Data Analytics TOSCA templates. New Development	Single	UPV	Yes	Open Source	Yes	Access under Open Source license	Yes	Access under Open Source license
16. Itwinai. New Development	Joint	CERN / FZJ	Yes	Open Source	Yes	Access under Open Source license	Yes	Access under Open Source license
17. openEO. (openEO spring driver, openEO web editor). Extensions/Development or Modifications	Joint	EURAC, EODC, WWU, Munster. TU Wien	Yes	Open Source	Yes	Access under Open Source license	Yes	Access under Open Source license
18. interLink. New Development	Single	INFN	Yes	Open Source	Yes	Access under Open Source license	Yes	Access under Open Source license



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19. Teapot. New Development	Single	DESY	Yes	Open Source	Yes	Access under Open Source license	Yes	Access under Open Source license
20. ALISE. New Development	Single	KIT	Yes	Open Source	Yes	Access under Open Source license	Yes	Access under Open Source license
21. FTS3. Extensions/Development or Modifications	Single	CERN	Yes	Open Source	Yes	Access under Open Source license	Yes	Access under Open Source license
22. Rucio. Extensions/Development or Modifications	Single	CERN	Yes	Open Source	Yes	Access under Open Source license	Yes	Access under Open Source license
23. INDIGO. PaaS Orchestrator. AI Based Orchestrator. Extensions/Development or Modifications	Single	INFN	Yes	Open Source	Yes	Access under Open Source license	Yes	Access under Open Source license
24. APEL Accounting. Extensions/Development or Modifications	Single	STFC UKRI	Yes	Open Source	Yes	Access under Open Source license	Yes	Access under Open Source license
25. openQxD. Extensions/Development or Modifications	Single	CSIC	Yes	Open Source	Yes	Access under Open Source license	Yes	Access under Open Source license
26. normflow. Extensions/Development or Modifications	Single	ETHZ	Yes	Open Source	Yes	Access under Open Source license	Yes	Access under Open Source license
27. PulsarDT. Extensions / Developments or Modifications	Single	MPIfR (HTW Berlin PUNCH4NFDI Open Source collaboration)	Yes	Open Source	Yes	Access under Open Source license	Yes	Access under Open Source license
28. PulsarDT++. Extensions / Developments or Modifications	Single	MPIfR (HTW Berlin PUNCH4NFDI Open Source collaboration)	Yes	Open Source	Yes	Access under Open Source license	Yes	Access under Open Source license
29. PulsarRFI_Gen. Extensions / Developments or Modifications	Single	MPIfR (HTW Berlin PUNCH4NFDI Open Source collaboration)	Yes	Open Source	Yes	Access under Open Source license	Yes	Access under Open Source license



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30. PulsarRFI_NN. Extensions / Developments or Modifications	Single	MPIfR (HTW Berlin PUNCH4NFDI Open Source collaboration)	Yes	Open Source	Yes	Access under Open Source license	Yes	Access under Open Source license
31. ML-TC Detection. Extensions / Developments or Modifications	Joint	CMCC/UNITN	Yes	Open Source	Yes	Access under Open Source license	Yes	Access under Open Source license
32. ML4Fires. New Development	Single	CMCC	Yes	Open Source	Yes	Access under Open Source license	Yes	Access under Open Source license
33. eddiesGNN. New Development	Single	UNITN	Yes	Open Source	Yes	Access under Open Source license	Yes	Access under Open Source license
34. xtclim. Extensions/Developments or Modifications	Single	CERFACS	Yes	Open Source	Yes	Access under Open Source license	Yes	Access under Open Source license
35. downscaleML. New Development	Single	EURAC	Yes	Open Source	Yes	Access under Open Source license	Yes	Access under Open Source license
36. CompEVPoEToE. New Development	Single	CNRS	Yes	Open Source	Yes	Access under Open Source license	Yes	Access under Open Source license
37. openeo-processes-dask. Extensions/Developments or Modifications	Joint	EODC, EURAC	Yes	Open Source	Yes	Access under Open Source license	Yes	Access under Open Source license
38. openeo-pg-parser-networkx. Extensions/Developments or Modifications	Joint	EODC, EURAC	Yes	Open Source	Yes	Access under Open Source license	Yes	Access under Open Source license
39. raster-to-stac. New Development	Single	EURAC	Yes	Open Source	Yes	Access under Open Source license	Yes	Access under Open Source license
40. FloodAdapt. Extensions/Developments or Modifications	Single	Deltares	Yes	Open Source	Yes	Access under Open Source license	Yes	Access under Open Source license
41. HydroMT-SFINCS. Extensions/Developments or Modifications	Single	Deltares	Yes	Open Source	Yes	Access under Open Source license	Yes	Access under Open Source license
42. HydroMT-FIAT. Extensions/Developments or Modifications	Single	Deltares	Yes	Open Source	Yes	Access under Open Source license	Yes	Access under Open Source license
43. Hython Wflow_sbm Hydrological Model.	Single	Deltares	Yes	Open Source	Yes	Access under Open Source license	Yes	Access under Open Source license



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Extensions/Developments or Modifications								
44. Kubernetes Accounting. Extensions/Developments or Modifications	Joint	EGI, CESNET	Yes	Open Source	Yes	Access under Open Source license	Yes	Access under Open Source license
45. Onedata S3. Extensions/Developments or Modifications	Single	ACK Cyfronet AGH)	Yes	Open Source	Yes	Access under Open Source license	Yes	Access under Open Source license
46. RUCIO Jupyterlab Extensions/Developments or Modifications	Single	CERN	Yes	Open Source	Yes	Access under Open Source license	Yes	Access under Open Source license
47. Glitchflow. Extensions/Developments or Modifications	Single	INFN (under Virgo / Ligo Collaboration	Yes	Open Source	Yes	Access under Open Source license	Yes	Access under Open Source license
48. ANNALISA. Extensions/Developments or Modifications	Single	INFN (under Virgo / Ligo Collaboration	Yes	Open Source	Yes	Access under Open Source license	Yes	Access under Open Source license
49. Dask Flood Mapper	Single	TU Wien	Yes	Open Source	Yes	Access under Open Source license	Yes	Access under Open Source license

Annex 5: Technology Watch tracked news

Table 14 Technology Watch Table

	Tags	url
OGC Seeks Public Comment on openEO as a Community Standard	Standardization, OpenEO, OGC	https://www.ogc.org/requests/ogc-looks-to-adopt-openeo-as-community-standard-seeking-public-comment-before-moving-to-vote/
Google Open Source	open source	https://opensource.google/
Open Source Guides	open source	https://opensource.guide/



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Setting an Open Source Strategy	open source	https://www.linuxfoundation.org/resources/open-source-guides/setting-an-open-source-strategy
Tech Trends report 2026 SURF.nl	TechTrends	https://www.surf.nl/en/themes/futuring/tech-trends
openEO platform: a Federated Open Earth Observation Platform	OpenEO	https://eo4society.esa.int/projects/openeo/
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The rise of digital twins	DigitalTwins	https://www.nature.com/collections/feicjiideh
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Get ready for Machine Learning on Civo GPU Nodes... from your Minikube!	interLink, kubernetes	https://youtube.com/watch?v=zhIrsMqPiOg&si=Pvg2gURyQa8dmqDG
Eviden leads consortium to provide "Simpl-Open" OSS Data Spaces Middleware to the European Commission Eviden	SIMPL, Eviden	https://eviden.com/insights/news/eviden-leads-consortium-to-provide-simpl-open-oss-data-spaces-middleware-to-the-european-commission/
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BMW - IPCEI Next generation Cloud Infrastructures and Services	IPCEI, cloud	https://www.bmw.de/Redaktion/EN/Artikel/Industry/ipcei-cis.html
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The Eclipse Foundation Launches the Eclipse Dataspace Working Group to Foster Global Innovation in Trusted Data Sharing Eclipse News, Eclipse in the News, Eclipse Announcement	eclipse, open source, data spaces	https://newsroom.eclipse.org/news/announcements/eclipse-foundation-launches-eclipse-dataspace-working-group-foster-global



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AI Act: an agreement was reached BDVA	AI, AI-Act, BDVA	https://bdva.eu/ai-act-reaching-agreement
Become a Partner of the Pact	ClimateServices	https://climate-pact.europa.eu/get-involved/become-partner-pact_en
Copernicus: November 2023 – Remarkable year continues, with warmest boreal autumn. 2023 will be the warmest year on record Copernicus	Copernicus, ECMWF, ClimateServices	https://climate.copernicus.eu/copernicus-november-2023-remarkable-year-continues-warmest-boreal-autumn-2023-will-be-warmest-year
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AI and supercomputers join forces to tackle global challenges	Raise	https://cordis.europa.eu/article/id/443638-ai-and-supercomputers-join-forces-to-tackle-global-challenges?WT.mc_id=exp
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Use Cases Catalogue	DestinationEarth, DestinE, ECMWF	https://destination-earth.eu/use-case/
Destination Earth	DestinationEarth	https://stories.ecmwf.int/destination-earth/index.html
Joint Workshop HiDALGO in HiPEAC - HiDALGO2	DigitalTwins, HPC	https://www.hidalgo2.eu/joint-workshop-hidalgo-in-hipeac/
A journey through the landscape of ethical AI with etami - European Big Data Value Forum	AI, AI-Ethics	https://european-big-data-value-forum.eu/session/a-journey-through-the-landscape-of-ethical-ai-with-etami/
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Green Deal Funding Alert - September 2023	GreenDeal	https://cor.europa.eu/en/news/Pages/green-deal-funding-alert-september-2023.aspx?trk=feed_main-feed-card_feed-article-content
Call for marine biodiversity (monitoring) data DTO-BIOFLOW	DT-Oceans, marine	https://dto-bioflow.eu/marine-biodiversity-data-open-call
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EigenRisk Adds Fathom To Its Global Catastrophe Risk Platform	FloodAdapt, Flood, Eigenrisk, Fathom	https://www.fathom.global/newsroom/eigenrisk-adds-fathoms-to-catastrophe-risk-platform/
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Musk 'considering' pulling X from EU over probe • The Register	communication	https://www.theregister.com/2023/10/19/musk_x_europe/
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How Fenix Infrastructure advances research in multiple scientific domains FENIX	Fenix, federation, impact	https://fenix-ri.eu/news/how-fenix-infrastructure-advances-research-multiple-scientific-domains
DSBA releases 'Technical Convergence Discussion Document' - Data Spaces Business Alliance	data spaces	https://data-spaces-business-alliance.eu/dsba-releases-technical-convergence-discussion-document/
european-big-data-value-forum-valencia-spain etp4hpc	DestinationEarth, ETP4HPC	https://www.etp4hpc.eu/events/european-big-data-value-forum-valencia-spain-657.html
EGI joins CESGA in celebrating their milestone: the new quantum computer Qmio - EGI	quantum, federation	https://www.egi.eu/article/egi-joins-cesga-celebrating-new-quantum-computer-qmio/?utm_source=linkedin&utm_medium=social&utm_campaign=20231023_qmio_cesga&trk=feed_main-feed-card_feed-article-content
The Macro-Roadmap - EOSC Association	EOSC, Roadmap	https://eosc.eu/roadmap
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SponsorLink: trying something new-ish for OSS sustainability	OpenSource, Sustainability, sponsorlink, GitHub	https://www.cazzulino.com/sponsorlink.html
SQLitePCLRaw and open source sustainability	OpenSource, Sustainability	https://ericsink.com/entries/sqlitepclraw_sustainability.html
Open source is a wonderful thing, but AI is exposing its weaknesses by Enrique Dans Enrique Dans Oct, 2023 Medium	OpenSource, Sustainability	https://medium.com/enrique-dans/open-source-is-a-wonderful-thing-but-ai-is-exposing-its-weaknesses-0d416f99d64a



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The strategic significance of open source in Europe	OpenSource	https://youtube.com/watch?v=ocunAD2w9eY&si=En0vudldjaZS9cUA
Vortex-io décroche 2,5 M€ pour créer le premier service européen de prévision des inondations et des sécheresses	FloodAdapt, market, vortex-io	https://toulouse.latribune.fr/entreprises/business/2023-04-06/vortex-io-decroche-2-5-m-pour-cree-le-premier-service-europeen-de-prevision-des-inondations-et-des-secheresses-957927.html
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The Biodiversity Digital Twin: A new solution to support protection and restoration of ecosystems	BioDT	https://www.youtube.com/@BiodiversityDT
Understanding DT-GEO: A Digital Twin for GEOphysical Extremes	DT-Geo	https://www.youtube.com/watch?v=BKd72SyltIQ
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20 years with EGI: an interview with Isabel Campos Plasencia - EGI	Cloud, CSIC, EGI	https://www.egi.eu/article/20-years-with-egi-an-interview-with-isabel-campos-plasencia/
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Tci wp real time digital twins final	ETP4HPC, DigitalTwins, TransContinuum	https://www.etp4hpc.eu/pujades/files/TCI-WP-Real-time-digital-twins_FINAL.pdf
Ver "Supercomputers and Digital Twins explained by the #DigitalEU director for science infrastructure" en YouTube	DigitalTwins, European Commission	https://youtu.be/pcXIBSdoAVk
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<i>Making some of the Integrated Forecasting System open source ECMWF</i>	ECMWF	https://www.ecmwf.int/en/about/media-centre/news/2022/making-some-integrated-forecasting-system-open-source
<i>BioDT: a new solution to protect and restore ecosystems BioDT</i>	DigitalTwins, BioDT	https://biodyt.eu/events/webinar-biodiversity-digital-twin-protection-restoration-ecosystems
<i>Météo-France-led international partnership wins bid to develop Destination Earth's on-demand extremes digital twin</i>	DestinationEarth, DigitalTwins, ESA	https://stories.ecmwf.int/m-t-o-france-wins-bid-to-develop-destination-earth-s-on-demand-extremes-digital-twin/index.html
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<i>EU to develop a digital twin of Earth to better predict climate impact</i>	DigitalTwins, DestinationEarth	https://www.siliconrepublic.com/innovation/eu-commission-digital-replica-earth-climate
<i>Earth digital twin project launches - eeNews Europe</i>	DigitalTwins, DestinationEarth	https://www.eenewseurope.com/en/earth-digital-twin-project-launches/
<i>ISO - ISO 23247-1:2021 - Automation systems and integration — Digital twin framework for manufacturing — Part 1: Overview and general principles</i>	DigitalTwins, Standardization, Manufacturing	https://www.iso.org/standard/75066.html
<i>(PDF) Digital Twin Architecture and Standards</i>	DigitalTwins, IIoT, Standardization	https://www.researchgate.net/publication/337673936_Digital_Twin_Architecture_and_Standards
<i>Report of TWG Digital Twins: Landscape of Digital Twins Zenodo</i>	DigitalTwins, Standardization, Landscape	https://zenodo.org/record/6556917#.YyqwWljtYao
<i>Considerations for Digital Twin Technology and Emerging Standards: Draft NISTIR 8356 Available for Comment NIST</i>	DigitalTwins, Standardization	https://www.nist.gov/news-events/news/2021/04/considerations-digital-twin-technology-and-emerging-standards-draft-nistir
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Destination Earth	DigitalTwins, DestinationEarth, European Commission	https://digital-strategy.ec.europa.eu/en/policies/destination-earth
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Destination Earth	DestinationEarth, DigitalTwins	https://digital-strategy.ec.europa.eu/en/library/destination-earth
Digital Ecosystems for developing Digital Twins of the Earth: The Destination Earth case	DigitalTwins, DestinationEarth	https://publications.jrc.ec.europa.eu/repository/handle/JRC124802
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