



interTwin

The interTwin Digital Twin Engine components for environmental DTs

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3rd Destination Earth User Exchange, Darmstadt



Funded by the
European Union

The interTwin project is funded by the European Union - Grant Agreement Number 101058386

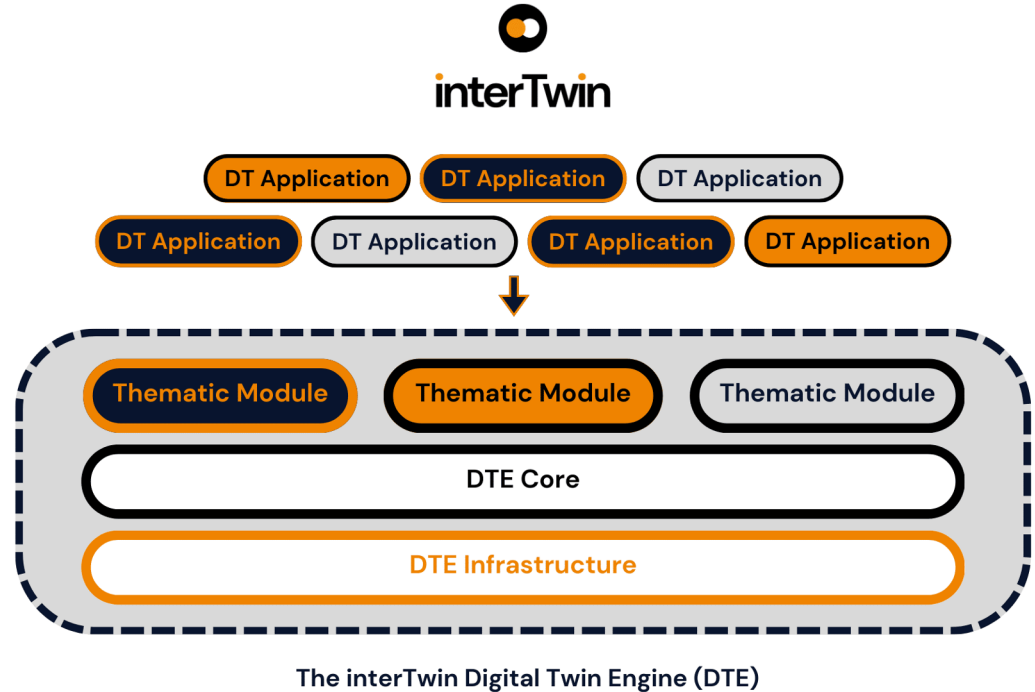


interTwin - Digital Twin Engine for science

Co-designs and implements the prototype of an **interdisciplinary Digital Twin Engine**

Open-source platform based on **open standards** offering the capability to develop **application-specific Digital Twins (DTs)**

Piloted by a large spectrum of **diverse use cases** from **physics** and **environmental** sciences





EGI Foundation as coordinator

30

Participants, including 1 affiliated entity and 2 associated partners

Consortium at a glance

10
Providers

cloud, HTC , HPC
resources and
access to
Quantum systems

11
Technology
providers

delivering the
DTE infrastructure
and horizontal
capabilities

14
Community
representants

from 5 domains
requirements and
developing DT
applications and
thematic modules

1.09.22 - 31.08.25

Budget 11,7 M euro



Objective 1. Co-design, develop and provide a Digital Twin Engine that simplifies & accelerates the **development of complex application-specific DTs** that benefits researchers, business and civil society



Objective 2. Co-design a Digital Twin Engine blueprint architecture that provides a conceptual framework for the development of DTs supporting **interoperability, performance, portability & accuracy**.



Objective 3. Extend the technical capabilities of the **European Open Science Cloud with modelling & simulation tools** integrated with its compute platform



Objective 4. Ensure trust and reproducibility in science through **quality, reliability and verifiability of the outputs** of Digital Twins



Objective 5. Demonstrate data fusion with complex modelling & prediction technologies



Objective 6. Simplify DT application development with tools to **manage AI workflows and the model lifecycle** while reinforcing open science practices





Climate research and Environmental Monitoring Use Cases

Tropical Cyclones Detection

CMCC, CNRS, Univ. of Trento



WildFire Hazard Map Generation

CMCC, CNRS, Univ. of Trento

Early warning for Extreme events

Deltares, EURAC, Technical Univ. of Wien



Extreme events impacts

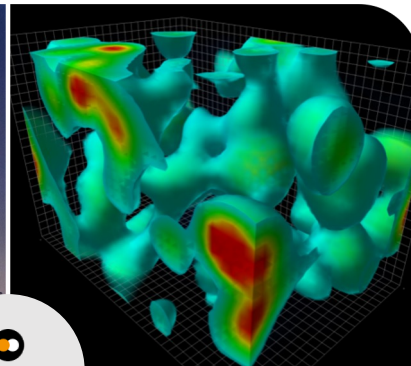
CERFACS, EURAC, Deltares





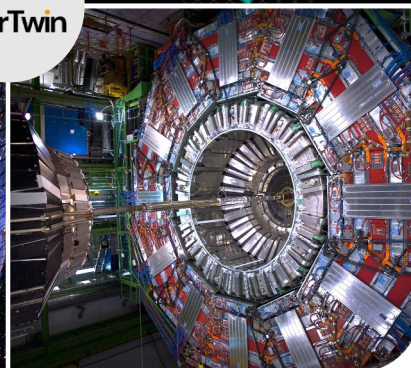
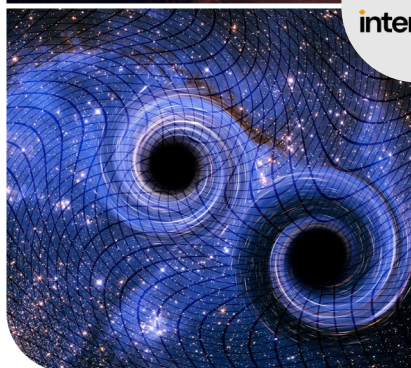
Physics Use Cases

**Radio Astronomy
Noise simulation**
Univ. of Heidelberg,
Max Planck Society



**Lattice QCD
Simulation DT**
CSIC, ETHZ

**VIRGO Gravitational
Wave
Interferometer DT**
INFN



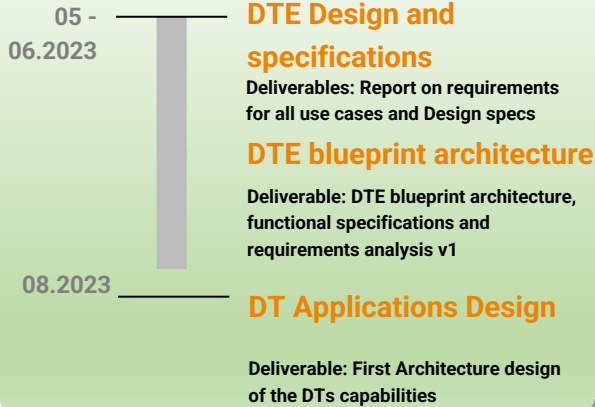
**High Energy
Physics Detector
Simulation DT**
CERN, CNRS



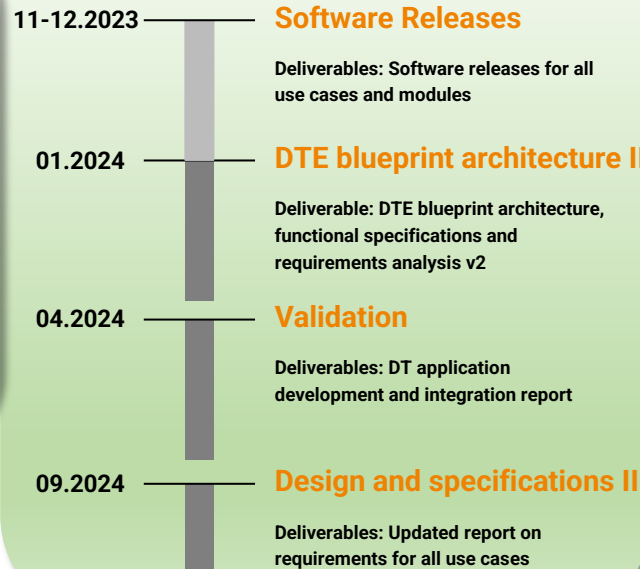


Timeline

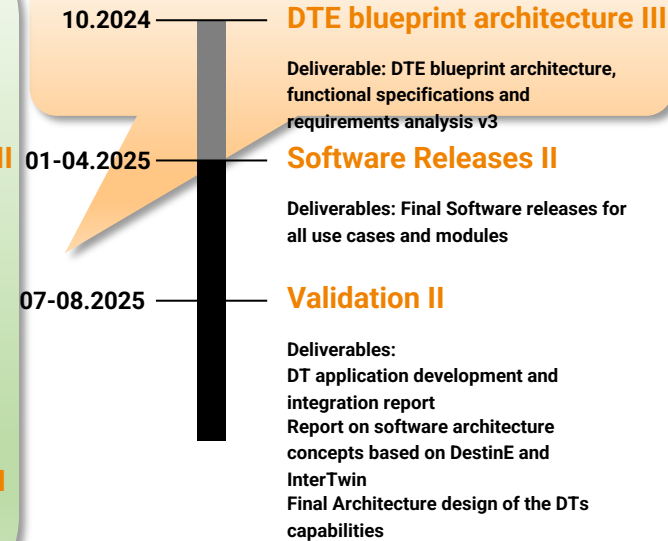
Project Year 1 COMPLETED



Project Year 2 COMPLETED



Project Year 3 Focus now!



2023

2025

2024



interTwin DTE First Release

interTwin DTE first release available on our Website

<https://www.intertwin.eu/intertwin-digital-twin-engine/>

- 38 components in Total
- New components developed and extension to existing software
- <https://github.com/intertwin-eu>



Core DTE Modules

InterTwin Core DTE Modules

[Read more](#)



DTE Infrastructure Modules

InterTwin DTE Infrastructure Components

[Read more](#)



Thematic Modules: Environment

InterTwin Thematic Modules: Environment

[Read more](#)



Thematic Modules: Physics

InterTwin Thematic Modules: Physics

[Read more](#)



Core DTE Modules

itwinai

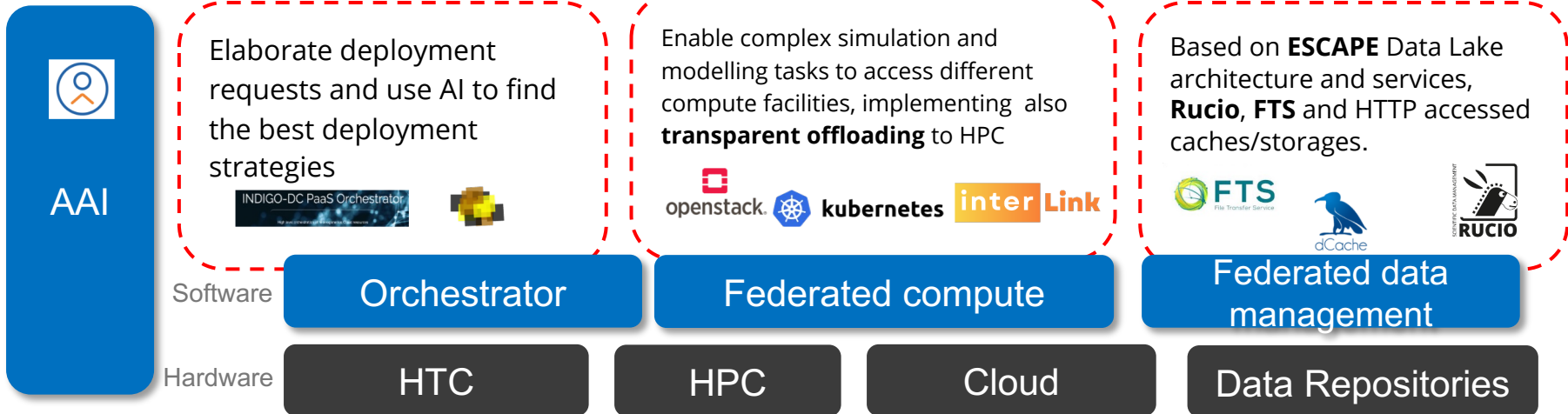
Description

itwinai is a Python library that streamlines AI workflows, while reducing coding complexity.

It seamlessly integrates with HPC resources, making workflows highly scalable and promoting code reuse. With built-in tools for hyper-parameter optimization, distributed machine learning, and pre-trained ML models, itwinai empowers AI researchers. It also integrates smoothly with Jupyter-like GUIs, enhancing accessibility and usability.



DTE Infrastructure Modules





DTE Core Modules

Automated DT Validation in connection with workflow provenance



yProv

Distributed data analysis embedded with specific workflow tools



Connecting Real-time data with serverless processing



OSCAR



Workflow Composition

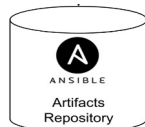
Quality Verification

Big Data Analytics

AI / ML

Data fusion

Real-time data acquisition and processing



Standardized deployment of Big Data Analytics tools



Generic ML / AI training framework with support to workflow management and model validation

DTE Thematic Modules for Environment

Thematic Modules for Environment

examples:

- Data gathering, filtering, cleaning, harmonisation, augmentation.
- Vector data processing, weather station data filtering and harmonisation
- Climate data downscaling using Machine learning
- STAC Collections generation from raster datasets

interTwin DTE Environment Modules



Thematic Module: ML TC detection

Providing a set of Python modules for supporting the processing and analysis of TC-related data...

[Read more](#)

February 10, 2024



Thematic Module: ML4Fires

Addressing wildfire analysis and prediction by providing tools that allow users to pre-process data, choose...

[Read more](#)

February 10, 2024



Thematic Module: eddiesGNN

Providing a set of Python modules for supporting processing...

[Read more](#)

February 10, 2024



Thematic Module: xtclim

Providing a python package implementing an unsupervised Deep Learning method, a Convolutional Variational Auto-Encoder (CVAE)...

[Read more](#)



Thematic Module: downscaleML

Providing a Python package, designed to streamline the process of climate data downscaling using machine...

[Read more](#)



Thematic Module: CompEVPoE

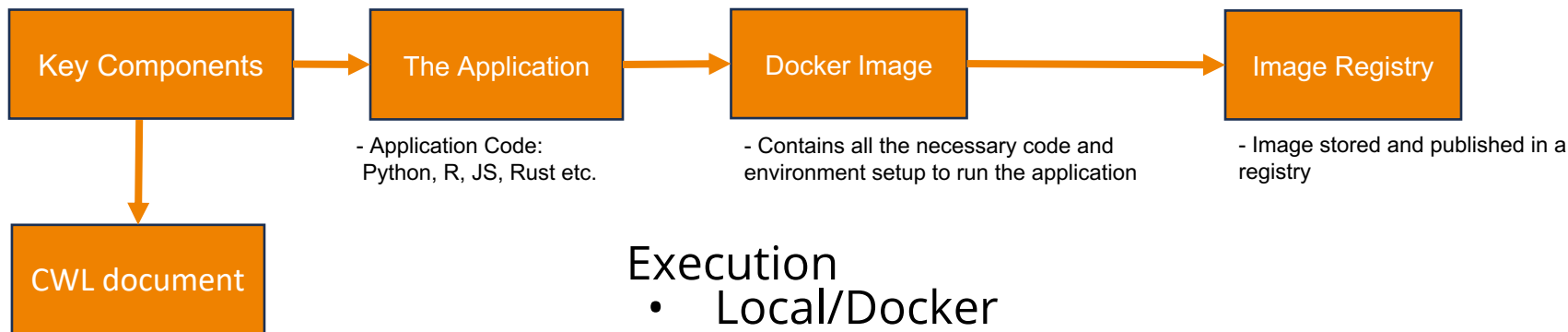
Providing a set of R functions for determining if periods of emergence (PoE) and/or time...

[Read more](#)



Linking Environment Thematic Modules into workflows via OGC Application Packages

“Describes how to package EO computational workflows targeting their execution automation, scalability, reusability and portability while also being workflow-engine and vendor neutral.”



- Application Code:
Python, R, JS, Rust etc.

- Contains all the necessary code and
environment setup to run the application

- Image stored and published in a
registry

CWL document

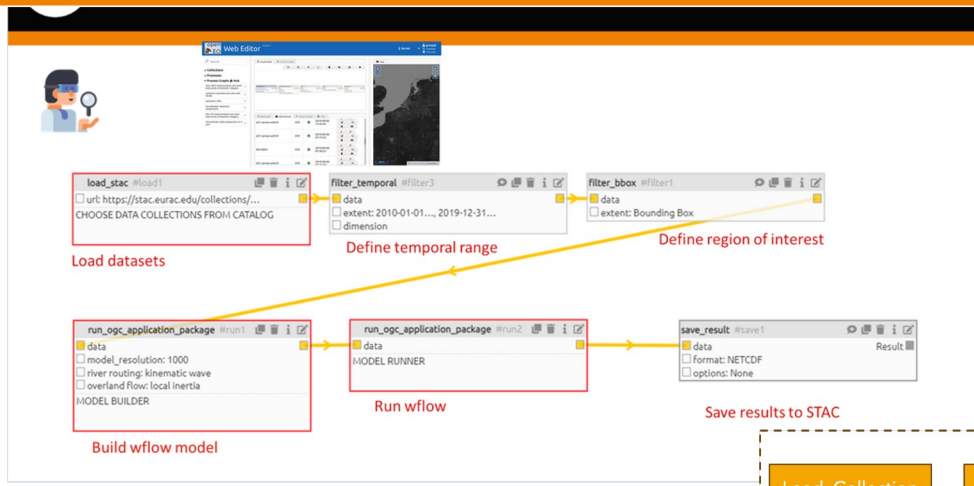
- Interface to setup define:
 - Inputs and Outputs
 - Steps
 - Requirements (Containers, Resources...)

Execution

- Local/Docker
 - Cwltool, Toil, CWL-Airflow
- In Kubernetes
 - Application Deployment and Execution Service (ADES) → ZOO-Project



Application Packages openEO Integration



Load datasets

Define temporal range

Define region of interest

Build wflow model

Run wflow

Save results to STAC



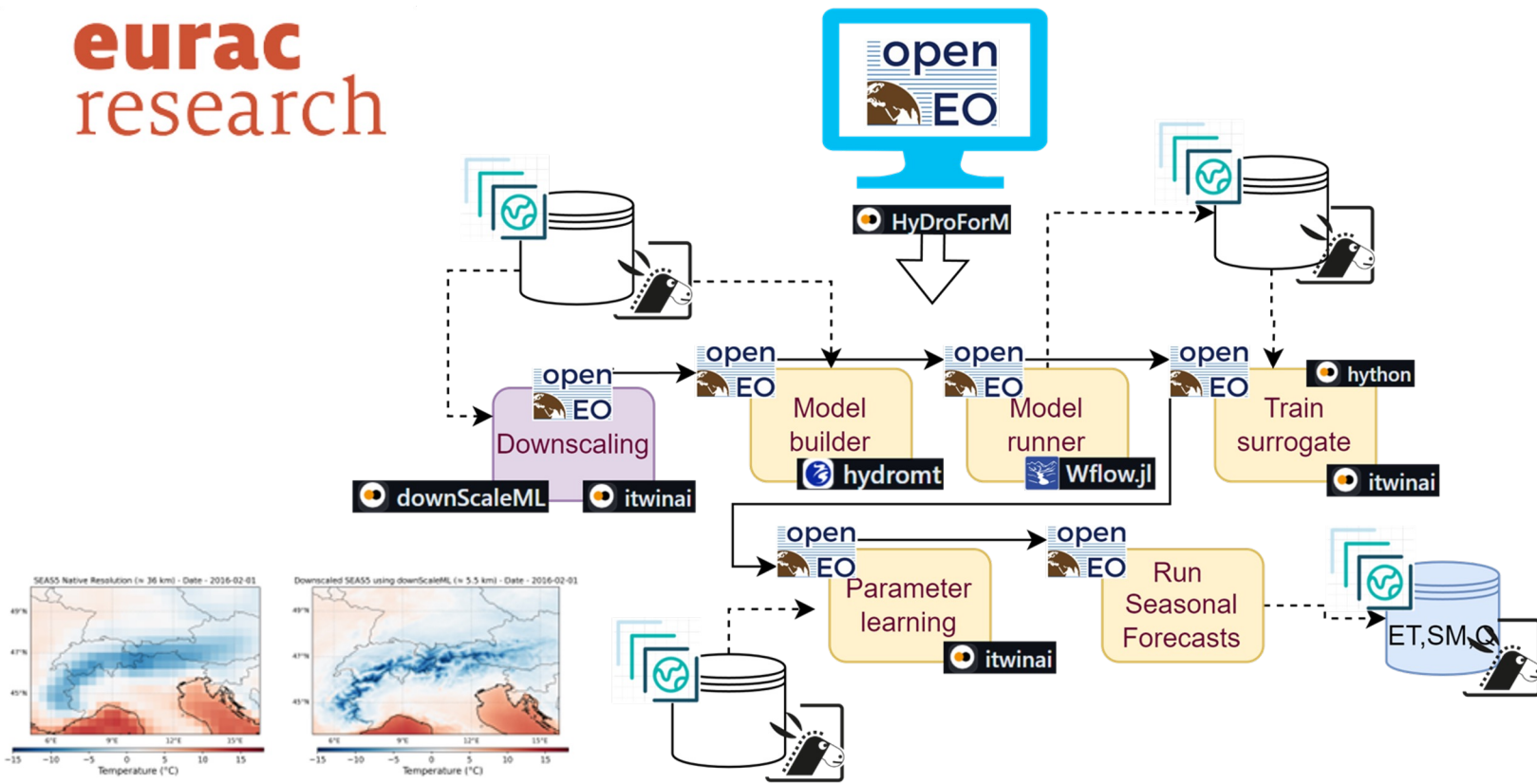
eurac
research

The JSON Process graph is **split**, and the processing is redirected to the CWL executor to run the Application Package, returns a result back to OpenEO for postprocessing



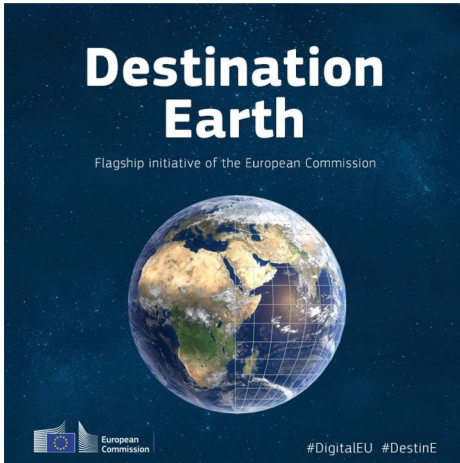
Drought Early Warning in the Alps DT Workflow

eurac
research



Interoperability & Link with DestinE

interTwin has a dedicated activity of piloting with **DestinE** thanks to **ECMWF** and **EODC** as members of the project



Pilots of data handling across interTwin and DestinE Data Lake and Climate DT are under implementation in collaboration with **DELTA RES**



- Data caching from DestinE into interTwin DataLake
 - Via [Polytope client](#) and [HDA](#) integration from DEDL
- interTwin DataLake STAC integration to expose outputs via HDA



Conclusions



Efficient co-design process with Communities use cases leading to Blueprint Architecture and DTE modules definition



First Release available, new components opensourced in our Github community
[.https://github.com/interTwin-eu](https://github.com/interTwin-eu), working towards final release in Q1/2025



Transparent integration with HPC providers for AI/ML training and advanced simulations



Final DTs prototypes available online in Q2/2025



Checkout our poster: “Empowering Science through Digital Twins: The interTwin project”

Thank you!

Questions?



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