

# interTwin



## Projekt interTwin: Izdelava in upravljanje digitalnih dvojčkov za znanost

Andrej Filipčič  
Mreža znanja, 2024



Funded by the  
European Union

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

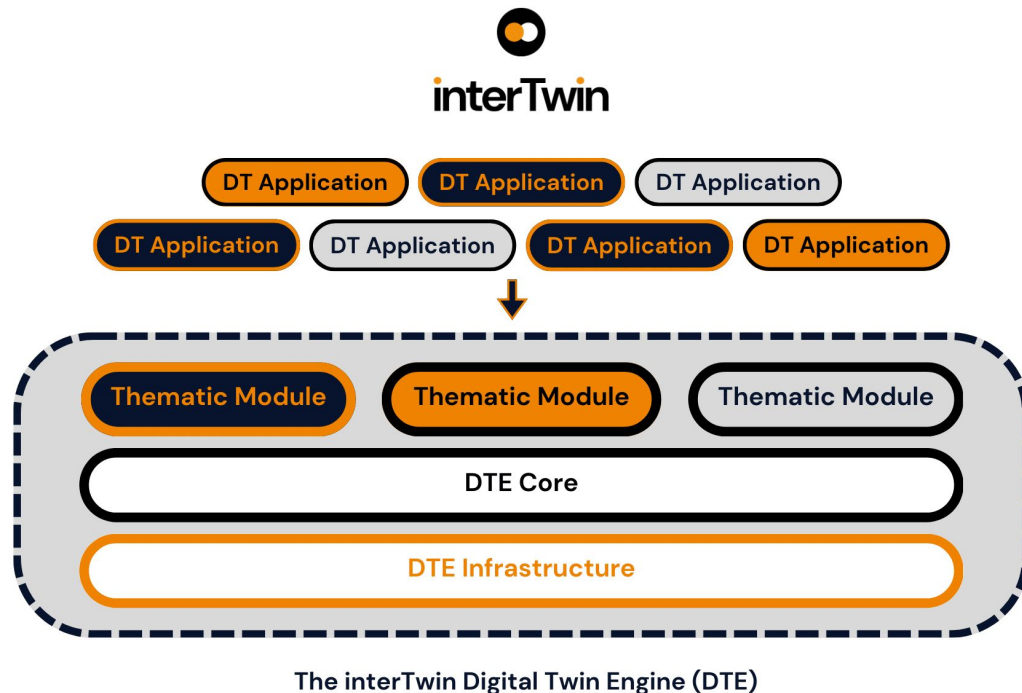


# interTwin - Digitalni dvojčki za znanost

Sooblikovanje in implementacija prototipov **interdisciplinarnih pogonov za Digitalne Dvojčke**

Odprtokodna platforma z **odprtimi standardi** za razvoj specifičnih aplikacij za **digitalne dvojčke (DT)**

Pilotska implementacija s **širokim naborom** uporabniških primerov od **fizike do okoljskih znanosti**



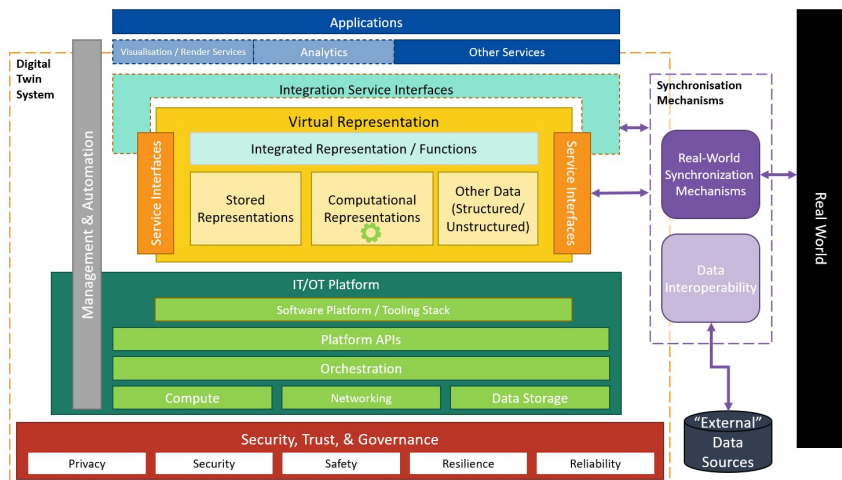


# Digitalni dvojčki (DT)

Digitalni dvojček (DT) je virtualna reprezentacija fizičnega objekta, procesa ali sistema. Narejen je s pomočjo informacij, pridobljenih iz enega ali več izvorov podatkov, kot na primer senzorji, historični modeli, kot tudi podatki zajeti v realnem času.

<https://www.digitaltwinconsortium.org/glossary/glossary>

<https://www.deltares.nl/en/expertise/projects/digital-twins>



Type	Industry	Cities & (air)ports	Environment
Goal	Life cycle management	“Smart” cities & (air)ports	Decision support, risk management & dissemination
Interventions	Adaptive design	Spatial planning and policymaking	System operation (e.g. sluices & locks) & policymaking
Cost reduction	R&D, construction & maintenance costs	Design, construction & maintenance costs	Disaster risk reduction, climate adaptation & biodiversity protection
System representation	Single object with many components	Many objects	Many systems
Timespan	Seconds - 5 years	Days - 10 years	Days or decades



1.09.22 - 31.08.25

Proračun 11,7 M€

Fundacija EGI kot koordinator

30

**Partnerjev**, skupno z 1 pridruženim in in 2 povezanimi članoma

Konzorcij

10  
Ponudnikov  
oblak, HTC, HPC,  
dostop do  
Kvantnih sistemov

11  
Ponudnikov  
tehnologij  
infrastruktura  
DTE in  
horizontalne  
zmožljivosti

14  
Predstavniki  
skupnosti  
Iz 5 domen, razvoj  
aplikacij DT in  
tematskih modulov



**Cilj 1. Sooblikovanje, razvoj in zagotavljanje mehanizma digitalnih dvojčkov, ki poenostavlja in pospešuje razvoj kompleksnih digitalnih dvojčkov, prilagojenih posameznim aplikacijam, kar koristi raziskovalcem, podjetjem in civilni družbi.**



**Cilj 2. Sooblikovanje načrta arhitekture “Digital Twin Engine” (DTE), ki zagotavlja konceptualni okvir za razvoj DT, ki podpira interoperabilnost, zmogljivost, prenosljivost in natančnost**



**Cilj 3. Razširitev tehničnih zmogljivosti evropskega odprtega znanstvenega oblaka z orodji za modeliranje in simulacijo, integriranimi v računalniško platformo.**



**Cilj 4. Zagotavljanje zaupanja in ponovljivosti v znanosti s kakovostjo, zanesljivostjo in preverljivostjo rezultatov digitalnih dvojčkov.**



**Cilj 5. Predstaviti združevanje podatkov s kompleksnimi tehnologijami modeliranja in napovedovanja**



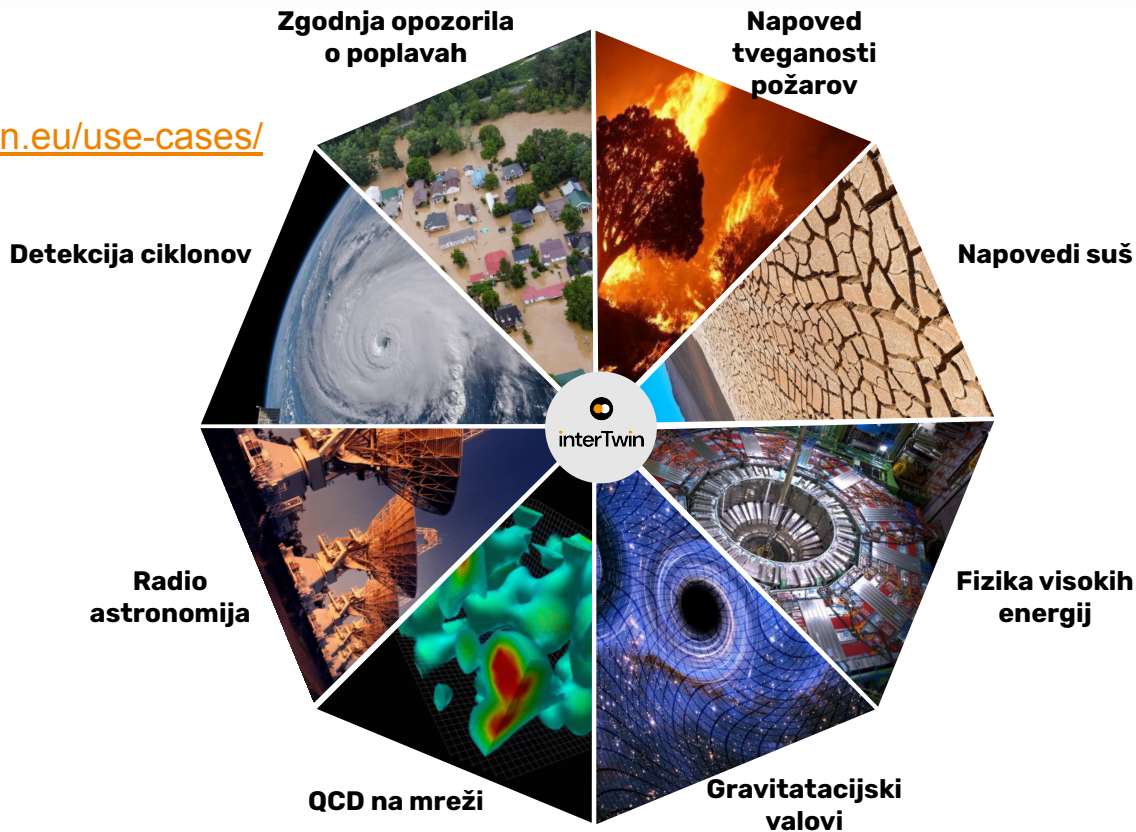
**Cilj 6. Poenostaviti razvoj aplikacij DT z orodji za upravljanje delovnih tokov umetne inteligence in modela življenjskega cikla ter hkrati okrepiti prakse odprte znanosti**





# interTwin - primeri uporabe

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



# Primeri: Klimatske raziskave in okolje

**Detekcija ciklonov**  
CMCC, CNRS, Univ. of Trento



**Generiranje map za napovedi požarnih tveganj**  
CMCC, CNRS, Univ. of Trento



**Zgodnja opozorila o ekstremnih dogodkih**  
Deltares, EURAC, Technical Univ. of Wien



**Vpliv ekstremnih dogodkov**  
CERFACS, EURAC, Deltares





# DT - Tropski cikloni in požari

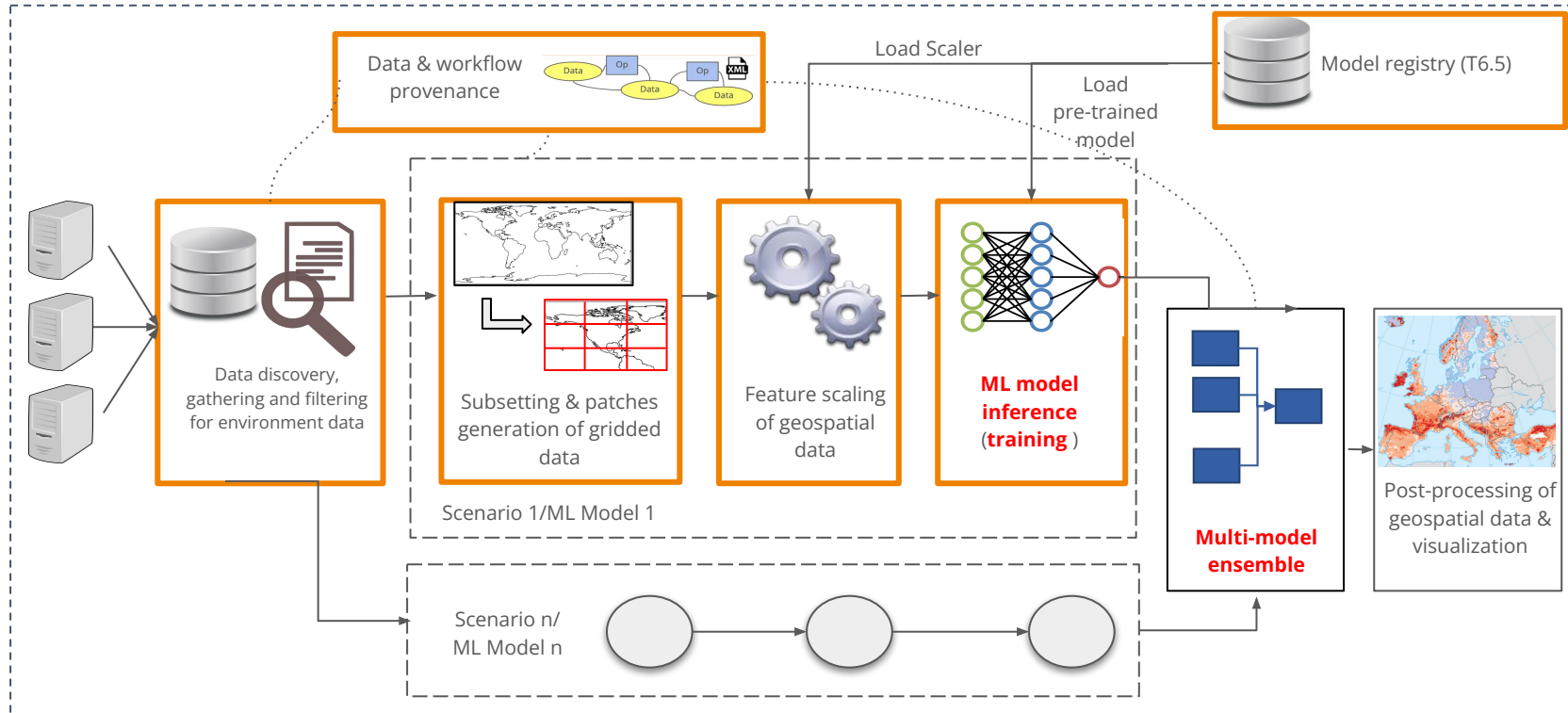


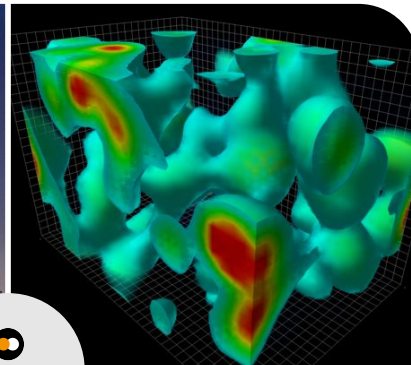
Image courtesy of Donatello Elia (CMCC)





# Primeri: fizika

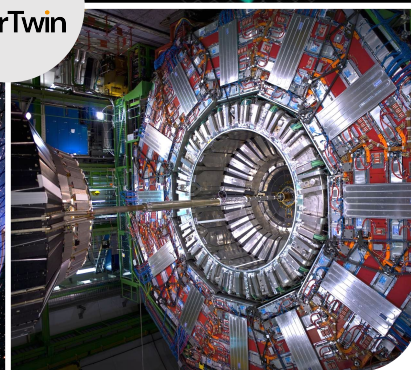
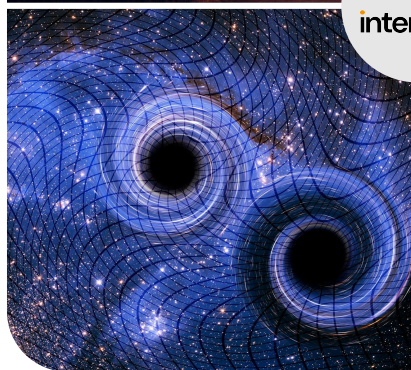
**Radio astronomija**  
**Simulacija šuma DT**  
Univ. of Heidelberg,  
Max Planck Society



**QCD na mreži**  
**Simulacija DT**  
CSIC, ETHZ, CNRS



**VIRGO Gravitacijski**  
**valovi**  
**Interferometer DT**  
INFN



**Fizika visokih**  
**energij**  
**Simulacija**  
**detektorja DT**  
CERN, CNRS





# DT detektorja delcev

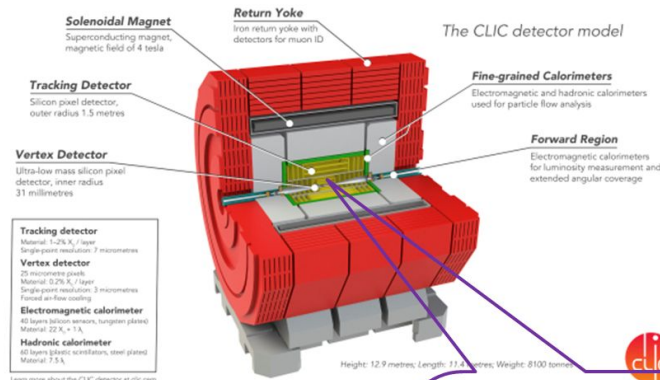


## Prototip detektorja & optimizacija

“Data-driven” orodja, ki simulirajo odziv detektorja z integriranimi pogoji obratovanja iz testnih postavitev (testni žarek)

## Strojno učenje v realnem času

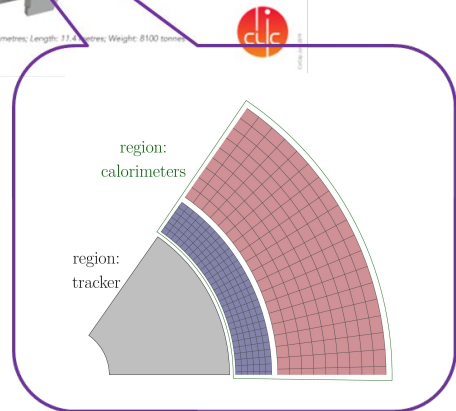
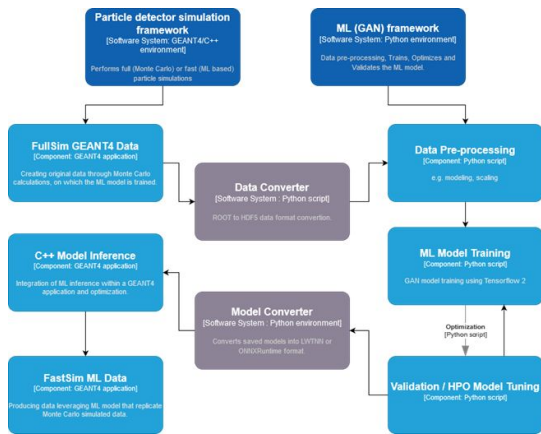
Prilagoditev detektorjev in konfiguracije zajema podatkov glede na pogoje obratovanja (run conditions)



## Preverjanje kvalitete in validacija ogrodja

Modeliranje konvergence in zanesljivosti generiranih podatkov - monitoriranje

Razvoj okolja za preverjanje simuliranih vzorcev v sodelovanju s skupnostjo fizike visokih energij





# Časovnica

## Leto 1

### Zaključeno

#### Načrti in specifikacije DTE

Rezultati: Poročilo o zahtevah za vse primere uporabe in specifikacije

#### DTE načrt arhitekture

Rezultati: DTE načrt arhitekture in specifikacije funkcionalnosti in analiza zahtev

#### DT načrt aplikacij

Rezultati: Prvi načrt arhitekture in zmogljivosti DT

## Leto 2

### Zaključeno

#### Programska oprema

Rezultati: programska oprema za vse primere uporabe in module

#### DTE načrt arhitekture II

Rezultati: DTE načrt arhitekture in specifikacije funkcionalnosti in analiza zahtev V2

#### Preverjanje

Deliverables: DT application development and integration report

#### Design and specifications II

Deliverables: Updated report on requirements for all use cases

## Project Year 3

## Sedaj!

#### DTE načrt arhitekture III

Rezultati: DTE načrt arhitekture in specifikacije funkcionalnosti in analiza zahtev V3

#### Programska oprema II

Rezultati: Končna verzija programske opreme za vse primere uporabe in module

#### Preverjanje II

Rezultati: Poročilo o razvoju in integraciji aplikacij DT  
Poročilo o konceptih arhitekture programske opreme na podlagi DestinE in InterTwin  
Končna zasnova arhitekture zmogljivosti DT

2023

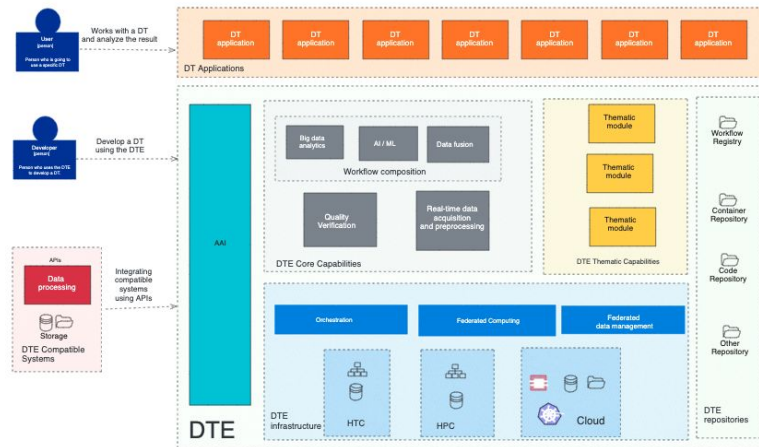
2025

2024



# DTE Blueprint and co-design

- Second version of the Blueprint architecture and design specifications is available in [Zenodo](https://zenodo.org/record/1444444)
- Final version is planned for Q4 2024



It also includes the analysis of relevant initiatives and projects (*Destination Earth, EOSC, ESCAPE, C-Scale, Digital Twin Consortium and EU Data Spaces, DT-GEO and BioDT*) to identify potential architectural components that can be incorporated within the interTwin context and where interoperability is desirable.



# interTwin DTE Prva izdaja

interTwin DTE prva izdaja programske opreme dosegljiva na

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

- 38 komponent
- Razvoj novih komponent in razširitev obstoječe programske opreme
- <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.



# interTwin DTE First Release



CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS

## EOSC-Synergy SQA badges:

- 7 components earned a Bronze badge
- 1 earned a Silver badge
- **1 has earned a Gold badge**



### synergy-software-gold

Awarding the foundational quality criteria for software, according to the <https://indigo-dc.github.io/sqa-baseline/> guidelines

Verified  
Last verified by Canvas Badges on Oct 13, 2024

Re-verify Badge

Issued on Mar 10, 2023 at 12:20 PM

### EARNING CRITERIA

Receivers must complete the earning criteria to earn this badge

- QC.Acc
- QC.Lic
- QC.Met
- QC.Doc
- QC.Srv
- QC.Sec
- QC.Ver

[View External Criteria](#)

### NARRATIVE

SQAaaS assessment results for repository <https://github.com/71778bc181664d135690e7a6db550c0879e10335>, branch: [main](#)

InterTwin Release man... Open issues Switch filter

Summary

- sqaas-step-action 1.1.1
- ITRM-48 HydroMT release 0.9.3
- ITRM-22 Evtval 0.2.1
- ITRM-18 jProv release 1.0.2
- ITRM-12 HydroMT-FIAT plugin 0.3.2
- ITRM-9 FloodAdapt release 0.0.1
- ITRM-6 AcSim release 1.0
- ITRM-24 ML4Fires 1.0 release
- ITRM-16 ML Tropical Cyclones detection rel...
- ITRM-21 3DGAN release 1.0.0
- ITRM-31 openeo-spring-driver first release ...
- ITRM-03 dCNIDS release 0.0.1

InterTwin Release management / ITRM-31 OSCAR v3.0.0

RELEASE VALIDATED

Details

- Type: Release
- Priority: Low
- Component/s: OSCAR
- Release Number: 3.0.0
- Release Type: Minor
- Security: No
- Vulnerabilities:
- Release Description: <https://github.com/gjrcyag/oscars/releases/tag/v3.0.0>

Description: None

Attachments

drop files to attach, or browse.

People

- Assignee: Caterina Alarcón Marín
- Reporter: Mario David
- Watchers: 0

Dates

- Created: 08/Jan/24 12:30 PM
- Updated: 22/Feb/24 5:33 PM
- Release Expected Date: 29/Nov/23

InterTwin Release Management Dashboard

Filter Results: intertwin Release Management Unresolved

T	Key	Summary	Components	Release Number	Status
1	ITRM-31	openeo-spring-driver first release 1.2.0	openEO Spring driver	1.2.0	RELEASE IN PREPARA...
2	ITRM-36	Gwpy first release	Gwpy	0.1	RELEASED PLANNED
3	ITRM-14	RAZCE networkmodel subModule 0.1 (first release)	RAZCE networkmodel subModule	0.1	RELEASED PLANNED
4	ITRM-13	Global Flood Monitoring release 0.1	Global Flood Monitoring	0.1	RELEASED PLANNED

1-4 of 4

Issue Statistics: interTwin Release management (Component)

Components	Count	Percentage
DelIT-FIAT	1	2%
3DGAN	1	2%
ALISE	1	2%
CompEvPoEToE	1	2%
dCNIDS	1	2%
downscaleML	1	2%

Pie Chart: interTwin Release management

Status

Total issues: 43

- RELEASE VALIDATED: 39
- Released planned: 3
- Release in preparation: 1

90% RELEASE VALIDAT...

Recently Created Chart: interTwin Release management



# DTE Jdrne komponente



Automated DT Validation in connection with workflow provenance



yProv



Distributed data analysis embedded with specific workflow tools

COMMON WORKFLOW LANGUAGE



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



UNIVERSITAT POLITÈCNICA DE VALÈNCIA



# DTE Infrastrukturne komponente

**Vega EuroHPC**  
Razvoj, validacija,  
testiranje na velikem  
vzorcu podatkov

  
AAI




Elaborate deployment requests and use AI to find the best deployment strategies



Software


Orchestrator

Enable complex simulation and modelling tasks to access different compute facilities, implementing also **transparent offloading** to HPC



Federated compute

Enable **ESCAPE** Data Lake architecture and services, **RUCIO**, **FTS** and HTTP accessed caches/storages.



Federated data management

Hardware

HTC

HPC

Cloud

Data Repositories





# DTE Tematski moduli za okolje

## Tematski moduli za okolje

primeri:

- Zbiranje, filtriranje, čiščenje, usklajevanje in dopolnjevanje podatkov.
- Obdelava vektorskih podatkov, filtriranje in usklajevanje podatkov vremenskih postaj
- Zmanjševanje velikosti podnebnih podatkov z uporabo strojnega učenja
- Ustvarjanje zbirk STAC iz rastrskih podatkovnih nizov

### 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](#)

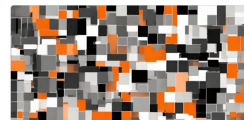


#### Thematic Module: downscaleML

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

[Read more](#)

February 10, 2024



#### Thematic Module: CompEVPoEToE

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

[Read more](#)

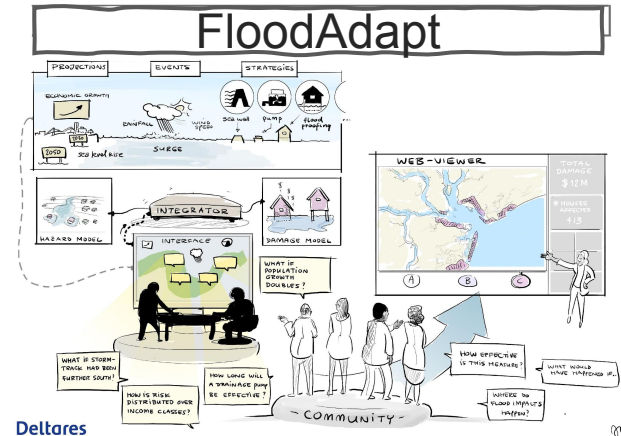
February 10, 2024

# Interoperability & Link with DestinE

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



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





# Zaključek



Učinkovit proces sooblikovanja s primeri uporabe skupnosti, ki vodi do načrta arhitekture in komponent DTE



Prva različica programske opreme DTE, nove komponente so na voljo v [.https://github.com/interTwin-eu](https://github.com/interTwin-eu), Končna verzija v Q1/2025



Transparentna integracija s ponudniki HPC za treniranje AI/ML in napredne simulacije, velik potencial za Tovarne Umetne Inteligence



Prve aplikacije DT v Q2/2024, končni prototipi v Q2/2025



Nekatere komponente razvite v interTwin so že vključene v projekte HE s pričetkom v 2025.