ESA DIGITAL TWIN EARTH

Call for expressions of interest

CALL FOR EXPRESSION OF INTEREST:
DEVELOPMENT OF EO-BASED DIGITAL TWIN COMPONENTS AS PART OF THE ESA DIGITAL TWIN EARTH (ESA DTE) PROGRAMME

Ref.: ESA-EOP-SD-TN-0396

Dear Sir/Madam,

The European Space Agency (the "Agency" or "ESA") hereby invites you to submit an Expression of Interest (EoI) in the context of the new ESA DTE programme. EoIs will be used by ESA as inputs to structure the programme implementation and identify initial priorities to drive the first set of Invitations to Tender for the development of EO-based Digital Twin Components.

EoIs shall be submitted following the guidelines provided in Section 5 by e-mail to:
eoscience@esa.int

Deadline for submission of the EoI is 15th of May 2023.

Questions can be sent before the 10th of May to eoscience@esa.int
(Responses and questions will be publicly available at dte.esa.int)

1. Background

In the next decades population growth is expected to amplify current pressures on critical resources such as fresh water or food systems, intensify the stress on land and marine ecosystems and increase environmental pollution and its impacts on health and biodiversity. These challenges will be further exacerbated by global warming and the likely impacts of climate change in the Earth system and human activities, especially on most vulnerable populations.

Responding to these challenges requires a quantum leap in the way we observe, understand and predict the dynamic evolution of the Earth systems and its complex interactions with human activities and ecosystems. Digital Twins (DTs) have recently emerged as a ground-breaking solution to these needs. Based on an effective integration of heterogeneous data, advanced models, AI and high-performance computing capabilities, Digital Twins shall offer high precision digital replicas of Earth system components, boosting our capacity to better understand the past and monitor the present state of the planet, assess its changes, and simulate its potential evolution under different (what-if) scenarios at scales compatible with decision making.

The European Commission (DG CONNECT) launched "**Destination Earth**" (DestinE, https://digital-strategy.ec.europa.eu/en/policies/destination-earth) to address this challenging and ambitious goal. Since December 2021, DestinE is jointly implemented by ESA, ECMWF, and EUMETSAT with progressive entry in operations of core service platform, data lake and first digital twins on climate change adaptation and weather-induce extremes. DestinE plans to advance towards a full digital replica of the Earth in 2030 by gradually integrating additional DTs in subsequent phases of the programme. In addition, several other Digital Twin initiatives have been launched at international (e.g., WCRP Digital Earths, NASA DT activities), European (e.g., Digital Twin of the Ocean, Horizon Europe projects) and national levels.

The new ESA Digital Twin Earth (ESA DTE) programme aims at contributing to this process by ensuring that latest Earth Observation (EO) satellite capabilities may play a major role in the design and implementation of future operational Digital Twins ecosystems including the potential future evolution of DestinE and other operational DT initiatives in Member States (MSs).

This call for EoI aims at consulting the community to collect feedback to support ESA in the preparation of the first Invitation to Tender for the development of an initial set of EO-based Digital Twin Components.

2. Summary of the ESA DTE Programme

Since the launch of the first Earth Explorers and of the Sentinel missions ESA has achieved a preeminent role as a provider of EO data, while latest EO-based science and R&D activities are opening the door to a new generation of EO data products, novel applications and scientific breakthroughs offering a novel and advanced view on the Earth system, its processes, and its interactions with human activities and ecosystems. These emerging set of capabilities offer unique opportunities for an enhanced and extensive use of EO technology in the development of future digital twins.

With the new ESA DTE programme, ESA aims at supporting MSs to create the conditions for a strong uptake of novel EO capabilities in the future design and implementation of operational Digital Twins. In particular, ESA DTE aims at bringing the latest EO-based products, science and R&D results into a pre-operational level and developing a comprehensive set of novel EO-based Digital Twins Components designed to demonstrate the potential value of EO capabilities as fundamental building blocks of future operational Digital twin ecosystems including the potential evolution of DestinE alongside national digital twin initiatives. To achieve these goals the programme will be articulated across two main pillars:

- **Implementing an ESA EO Data Space** supporting DT developments offering the relevant ESA ecosystem of Earth Observation data and digital services, adopting the DestinE core Service Platform (DESP) as the supporting platform for the ESA DTE programme and expanding its capabilities: e.g., availability of ESA Earth Explorer-, Heritage- and relevant TPM-data for seamless ingestion into Digital Twins.

- **Implementing a set of EO-based Digital Twin Components** (EO DTCs) as EO-based interactive replicas of key elements of the Earth system, our environment and their interactions with human activities and ecosystems with a strong focus on demonstrating the value of EO capabilities in the design and implementation of potential future operational Digital Twins ecosystems: e.g., through DestinE or other relevant European, regional or national initiatives.

This call for EoI refers only to the latter programmatic pillar: Implementing a set of EO-based Digital Twin Components

3. EO-based Digital Twin Components

Latest advances in EO science and research activities are opening the door to the development of a wide variety of novel EO products, innovative EO multi-variate datasets and scientific results that have significantly enhanced our capacity to observe, understand and characterise our planet and its complex and inter-connected processes with remarkable accuracies and resolutions in space and time. Those developments together with new advances in sectorial modelling, computing capabilities, AI and digital technologies offer excellent building blocks to realise novel EO-based Digital Twin Components (EO DTCs) that may contribute and maximise the impact of EO satellite technology in the design and implementation of future Digital Twins ecosystems.

ESA DTE programme will develop and demonstrate, up to a pre-operational level, a set of Digital Twin Components as EO-based replicas of key components of the Earth system and their interactions with human activities and ecosystems with a strong focus on valorising the role of EO capabilities.

EO Digital Twin Component shall be based on the effective integration of 1) advanced EO-based multi-variate data-sets offering an holistic and dynamic data driven description of the Earth system exploiting the latest advances in EO datasets and emerging EO capabilities, and 2) an effective and scientifically sound set of workflows integrating heterogenous data (including satellite, socio-economic and in-situ data), state-of-the-art community/sectorial models, advanced data-driven approaches, AI and hybrid methods allowing advanced data analytics, simulations and what-if scenarios that valorise the role of EO data.

EO Digital Twin Components may follow different architectures and implementation approaches; however, they should respect a number of basic principles:

- EO Digital Twin Components shall focus on key components of the Earth system (and their interactions with human activities and ecosystems), scientific domains, and applications/policy areas where EO satellite data and especially novel and emerging EO capabilities play a major role in observing and characterising key processes and systems (natural and/or anthropogenic), providing unique opportunities for the design and implementation of future operational DTs ecosystems.

- EO Digital Twin Components shall be developed in view of becoming potential additional elements of future operational Digital Twins ecosystems. Therefore, they shall ensure complementarity to DestinE and other existing (e.g., national, or regional) initiatives.

- EO Digital Twin Components shall focus on temporal scales where EO data provides a significant impact in improving the representation of natural phenomena and/or human activity, enhancing simulations and driving/informing what-if scenarios.

- EO Digital Twin Components and shall fully exploit the potential offered by the state-of-the-art EO capabilities for observing and characterising natural processes and/or human activities at resolutions in space and time compatible with decision making needs.

- EO Digital Twin Components shall be developed following high scientific and technical standards, ensuring the use of state-of-the-art data, AI, models, and data-driven processing elements based on thorough and scientifically sound validation and uncertainty characterisation processes.

- EO Digital Twin Components shall be based on a strong community support and shall be developed in view of serving a wide variety of stakeholders. This may include the scientific community (e.g., supporting open science and the active intervention of the scientific community in the continuous evolution of the EO DTCs), policy makers and international and national public institutions (e.g., delivering policy relevant information, supporting resource management and decision-making through what-if scenarios), value added companies (e.g., offering EO DTCs as a basis for building additional solutions and services) and citizens (e.g., supporting education and citizen information).

- EO Digital Twin Components may also be potentially used by ESA and other space agencies as reference tools to support the definition, design and impact assessment of future observing systems.

4. The ESA DTE Programme Phases

The initial phase of the ESA DTE is considered as a phase-in and should last about two years with the following objectives:

- On the platform side, the phase-in will consist in the building of an ESA DTE framework as part of the DestinE context that can host EO DTCs activities within the DESP platform, develop few key functions to enable EO DTCs development, bring ESA (and third party) EO missions as a contribution to DestinE and finally verify the capability to operationally interface through a mature interoperability approach the ESA DTE with ESA MS initiatives.

- On the EO DTC development side, the phase-in will consist on the setup and implementation of a EO DTCs selection process associated to the corresponding implementation of a set of initial components. Planned procurements will include two types of actions:

    - *Lead EO DTCs Development Actions:* medium-size (indicative value ~2Million Euro) community driven projects addressing priority thematic areas with a sufficient level of technical and scientific maturity and strong community support. **Initial thematic priorities will be identified through a community consultation process (this call for EoI) as described below.**

    - *Early EO DTCs Development Actions:* smaller-scale (indicative value ~0.5Million Euro) EO DTCs development projects focusing on less mature themes, communities, scientific components, and development elements. Themes and application domains will be fully open and selected according to the scientific excellence, potential for evolution/scaling-up, expected benefits and interest for the community, usage of EO or DestinE data, reuse of the ESA DTE interfaces and services.

A Mid-term milestone (i.e. ESA DTE Open Workshop) will be organised towards the end of 2024 as an open community consultation to present, assess and discuss the preliminary results of the programme, thematic priorities as well as the efficiency of the integration process with DestinE and potential MS initiatives.

5. Format and assessment of EoIs

ESA DTE will be based a consultation process with EO community, scientist, industry and relevant stakeholders. As a first step, ESA is launching this call for Expressions of Interest inviting the community to express their support to the development of a specific EO DTC and offer their vision and justifications for such a development as a fundamental input to support ESA in structuring the first set of competitions and the potential evolution of the programme.

EoI received will be treated confidentially by ESA and will be assessed by a scientific and technical panel. The review process is expected to identify an initial set of priority domains/themes that will support ESA in the definition of the scope of the first set of Invitations to Tender for the development of EO-based Digital Twin Components to be launched by the end of 2023.

It is expected that similar priorities may be addressed by different EoIs. Therefore, the review process WILL NOT lead to the selection of specific EoIs (or teams), instead ESA plan to evaluate the inputs received and synthesise their content into a set of thematic priorities addressing wide community interests, while responding to the main criterial identified below (final priority domains may cover the aggregated scope of similar EoIs).

An Invitation To Tender will then be issued based on the results of such an assessment and will be open to **all institutions in all participant Member States**[1]. Therefore, the participation to this EoI will not preclude or influence the potential subsequent participation of any individual or institutions in the planned Invitations To Tender.

Interested parties are invited to submit an EoI in the form of a short **(max 4 pages)** white paper, offering their vision and justifications for a specific DTC development, including the following items:

- The name and contact details of the principal proposer (Lead Author), and the names of the additional proposers co-authoring the EoI.
- Clear evidence of strong community back-up, potentially including letters of support from key stakeholder organisations.
- Description of the scientific/application case, target stakeholders and overarching goals of the proposed EO DTC.

[1] *Participant MS to the ESA DTE programme include AT, BE, CZ, EE, FI, FR, DE, HU, IE, IT, LU, NL, NO, PL, PT, ES, SE, CH, UK, SI*

- Expected outputs, impacts and benefits vs existing gaps in scientific knowledge and/or environmental management/policy needs.
- Description of the unique contribution of EO satellite capacity, especially valorisation of novel EO capabilities. How will using ESA (or ESA third party) EO mission data be fundamental to the development of the EO DTC?
- High level description and readiness of the scientific and technical building blocks, including a summary of the development/science needs to be addressed within the ESA DTE programme.
- Complementarity and potential future contribution to the evolution of DestinE and other existing DTs initiatives including national activities.
- Any assumption on the ESA DTE hosting environment.

Criteria to be used in the assessment include:

- Expected impacts, benefits and outputs vs need and gaps.
- Evidence of strong European community support.
- Valorisation of novel EO data capabilities in the design and implementation of the EO DTC.
- Scientific and technical excellence and expected advances vs the state-of-the-art.
- Scientific and technical readiness vs expected goals.
- Complementary to DestinE and other International, European, and national initiatives.

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