Destination Earth

The Destination Earth (DestinE) is a flagship initiative of the European Commission to develop a highly accurate digital model of the Earth on a global scale. This model will monitor, simulate and predict the interaction between natural phenomena and human activities. It will contribute to achieving the objectives of the twin transition, green and digital, as part of the European Commission's Green Deal (https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en) and Digital Strategy (https://ec.europa.eu/info/strategy/priorities-2019-2024/europe-fit-digital-age_en).

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DestinE will unlock the potential of digital modelling of the Earth system at a level that represents a real breakthrough in terms of accuracy, local detail, access-to-information, speed and interactivity. The initial focus will be on the effects of climate change and extreme weather events, their socio-economic impact and possible adaptation and mitigation strategies.

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DestinE will use unprecedented observation and simulation capabilities of DestinE, powered by Europe's HPC computers (https://digital-strategy.ec.europa.eu/en/policies/high-performance-computing) and AI capacity (https://digital-strategy.ec.europa.eu/en/policies/artificial-intelligence). Thanks to this we will be better prepared to respond to major natural disasters, test pathways for adapting to climate change and predict their socioeconomic impact. The initiative also represents a key component of the European strategy for data (https://digital-strategy.ec.europa.eu/en/policies/strategy-data) by consolidating access to valuable sources of data across Europe.

Users of DestinE, including non-scientific experts, will be able to access and interact with vast amounts of Earth system and socio-economic data in order to:

- Perform highly accurate, interactive and dynamic simulations of the Earth system, informed by rich observational datasets. For example, focusing on thematic domains of societal relevance such as the regional impacts of climate change, natural hazards, marine ecosystems or urban spaces.
- Improve prediction capabilities to maximise impact. For example to protect biodiversity, manage water, renewable energy or food resources, and to mitigate disaster risks in a changing world.

- Support EU policy-making and implementation. For example, to assess the impact of existing environmental policies and legislative measures and support future evidence-based policy-making.
- Exploit the potential of distributed and high-performance computing (https://digital-strategy.ec.europa.eu/en/policies/high-performance-computing) (HPC) and data handling at extreme scale. For example through an interactive platform that will host complex digital twins and comprehensive toolkits to develop and operate analytics-based models, with full access to vast amounts of diverse data.

Furthermore, Europe's industrial and technological capabilities will be strengthened through the simulation and observation of the entire Earth system and the use of artificial intelligence (AI) for data analytics and predictive modelling, among other means.

Key Components of the Destination Earth system

DestinE will allow users to access thematic information, services, models, scenarios, simulations, forecasts and visualisations. Underlying models and data will be continuously assessed to provide reliable and actionable scenario predictions.

The main components of the DestinE system are:

The Core Service Platform

The core service platform provides a user-friendly entry point for DestinE users. The platform will provide evidence-based decision-making tools, applications and services, based on an open, flexible, and secure cloud-based computing system. It will coordinate data, cloud and HPC infrastructures and provide access to an increasing number of Digital Twins as they become gradually available via related European Commission and/or national efforts.

The platform will make available relevant AI tools, extreme-scale data analytics and Earth-system monitoring, simulation and prediction capabilities. At the same time, it will provide dedicated resources to DestinE users, allowing them to customise the platform, integrate their own data and develop their own applications.

The platform and the associated DestinE service operations will be the responsibility of the European Space Agency (https://www.esa.int/) (ESA).

The Data Lake

The data lake brings together pre-existing European data holdings from Copernicus, the data holdings of the three Destination Earth implementing entities (ESA, EUMETSAT and ECMWF) and other sources, like the Internet of Things (IoT) and socio-economic data. It also integrates the new data that will originate from the Digital Twins, creating a coherent and self-standing DestinE data space. It will provide access to the data needed for the Digital Twins and the Core Service Platform operations. And it will host user data, shared with the DestinE user community while supporting near-data processing to maximise performance and service scalability.

The Data Lake will be operated by the European Organisation for the Exploitation of Meteorological Satellites (https://www.eumetsat.int/website/home/index.html) (EUMETSAT).

The Digital Twins

Digital twins are digital replicas of the highly complex Earth systems, developed by the European Centre for Medium-Range Weather Forecasts (https://www.ecmwf.int/) (ECMWF).

They are based on a seamless fusion of real-time observations and high-resolution predictive modelling in the thematic areas, starting from the extreme events and climate change adaptation.

The long-term goal is to integrate additional digital twins such as on oceans or biodiversity creating a comprehensive digital twin of the Earth system. The digital twins of DestinE will provide users with tailored access to high-quality knowledge for user-specific scenario development that can support evidence-based decision-making.

The first release of the core service platform, the data lake and the first digital twins will become operational in June 2024. It has been made possible through support from the Commission's Digital Europe Programme.

Horizon Europe (https://ec.europa.eu/info/horizon-europe-next-research-and-innovation-framework-programme_en#relatedlinks) provides research and innovation opportunities that support the further development of DestinE. There are synergies with other relevant EU programmes, such as the EuroHPC Joint Undertaking (https://eurohpc-ju.europa.eu/)and the Space Programme (https://ec.europa.eu/defence-industry-space/eu-space-policy_en), and related national initiatives. The European Commission coordinates the DestinE initiative in close collaboration with the Member States, Associated Countries, scientific communities and technology experts.

The initiative is implemented by three entrusted entities:

1. ECMWF (https://www.ecmwf.int/)
2. ESA (https://www.esa.int/)
3. EUMETSAT (https://www.eumetsat.int/website/home/index.html)

Implementation of the first phase of the initiative started in January 2022 after the European Commission signed Contribution Agreements with the three implementing entities on 15 December 2021. Phase 1 of the implementation concludes with the launch of the DestinE system on 10 June 2024, following the first 2,5 years of intense development. From the day of the launch, users will be able to access the first generation of the infrastructure, data and services. The system will continue to evolve, expand and improve in subsequent phases until 2030.

Active stakeholder engagement is vital for the success of DestinE. It is only through stakeholders guiding its development that DestinE can live up to our vision and build a solution for user community needs. To this end, a co-design approach has been adopted bringing in the stakeholder communities through the following two activities:

Open Stakeholder Dialogue

An open stakeholder dialogue has been established during the first phase (2022-2024) of the activities and will be expanded in the next years. A wide range of contributors will have the opportunity to guide the development of the DestinE system by providing their feedback on their needs and requirements and sharing their experience working and interacting with DestinE outputs. DestinE stakeholders can also help to identify relevant synergies with national and European initiatives and services.

These stakeholders include:

- Member States
- Public sector users
- Research and Development partner
- Entities managing operational applications

A dedicate forum for exchange, the **DestinE User eXchange**, facilitates detailed discussions between the policy users at the EU and national levels. Discussions focus on the application potential, requirements and gaps of the DestinE services. The DestinE User eXchange meets on a regular basis, the first two meetings in Frascati (https://destination-earth.eu/event/welcome-to-the-first-destination-earth-user-exchange/) and Bonn (https://destine.ecmwf.int/news/gaining-momentum-ecmwf-hosts-the-2nd-destine-user-exchange-meeting/) were organised in 2023 and the third one will be organised in October 2024. Further opportunities for engagement and co-development will be developed over time, in line with the maturity of the system.

Targeted User Partnerships

Another pillar of the DestinE stakeholder engagement is the targeted user partnerships. The aim of these partnerships is to design and implement sustainable services throughout the lifetime of DestinE.

Key technology partners and commercial actors can bring their capacity and knowledge to design and implement novel capabilities of DestinE in a way that corresponds to users' specific needs. Similarly, we can build strong technology partnerships to define and design DestinE services through collaboration with, for example, the digital twin projects funded under Horizon Europe.
Examples of these research and development projects are:

- BioDT (biodiversity)
- Intertwin (digital twin engine)
- GEO-DT (geophysical extremes)
- Digital twin of the Ocean (DTO)

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- the GEO-DT (https://dtgeo.eu/)(geophysical extremes)
- Digital twin of the Ocean (https://www.mercator-ocean.eu/en/digital-twin-ocean/) (DTO).

Additional R&D for thematic Digital Twins will be funded from the Horizon Europe work programme (2023-2024) to further enrich the DestinE R&D base.

DestinE will be developed gradually through the following key milestones:

- By June 2024: Development and launch of the first release of the core service platform, the data lake and the first two digital twins on extreme events and climate change adaptation.
- By 2027: Further enhancement of the DestinE system, provision of additional services, breakthrough AI developments and synergies with additional digital twins
- By 2030: A 'full' Digital Twin of the Earth system.
