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Destination Earth

Use Cases Analysis

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Contents

Executive Summary

Destination Earth (DestinE) is an initiative initiated and coordinated by the European Commission's Directorate-General for Communications Networks, Content and Technology (DG CNECT) in support of the European Green Deal[1] and as contribution to the establishment of the Green Deal Data Space, one of several data spaces envisaged in the European Strategy for Data (COM2020 66 final)[2].

The overall objective of DestinE is to develop a service infrastructure that:

- serves specific EU needs based on clearly identified EU policy priorities and user needs in relation to e.g. the Green Deal, and
- is at the same time firmly based on European values, such as commitment to quality and transparency in order to build trust in evidence-based policy-making among all stakeholders.

DestinE will include a shared horizontal layer including computer processing, data, software, and infrastructure and some vertical applications, Digital Twins (DTs), in selected thematic areas responding to priority policy use cases. To identify these priorities, the Joint Research Centre of the European Commission (JRC) has been tasked by DG CNECT to collect a number of potential use cases for DestinE representing needs of policy DGs in the Commission. This document presents 30 use cases received from six policy DGs, the JRC and 5 relevant European stakeholders.

The use cases were preliminarily evaluated and clustered according to their assumed maturity level in terms of policy, scientific and anticipatory potential. Following a series of interactions with all stakeholders consulted, JRC identified two initial DTs on:

- Extreme Earth issues (disaster risk management in relation to extreme weather-induced natural disasters);
- Climate change adaptation issues (primarily food and water supply security).

Another DT on digital oceans (around food and energy issues) was introduced as a suggestion to DG CNECT to be possibly developed in the second phase of DestinE's implementation.

Although this report is certainly neither exhaustive nor fully descriptive e.g. in relation to the assumed maturity levels of the mentioned use cases, it served nevertheless as a useful input to DG CNECT's final definition of the scope of DTs whose development would be prioritized in the course of the DestinE implementation.

[1] COM(2019) 640 final, Brussels, 11.12.2019

[2] https://ec.europa.eu/digital-single-market/en/destination-earth-destine

Introduction and Background

This report is the first deliverable of the administrative arrangement 35713 between DG CNECT and JRC to support the project entitled " MISSION EARTH INITIATIVE - STUDY ON ASSESSING AND PROPOSING AN IMPLEMENTATION ARCHITECTURE (MISSION EARTH STUDY)".

The European Green Deal, and Digital package both identify DestinE as in important project to support the environmental agenda.

Accessible and interoperable data are at the heart of data-driven innovation. *This data, combined with digital infrastructure (e.g. supercomputers, cloud, ultra-fast networks) and artificial intelligence solutions, facilitate evidence-based decisions and expand the capacity to understand and tackle environmental challenges. The Commission will support work to unlock the full benefits of the digital transformation to support the ecological transition. An immediate priority will be to boost the EU's ability to predict and manage environmental disasters. To do this, the Commission will bring together European scientific and industrial excellence* *<u>to develop a very high precision digital model of the Earth</u>.* (The European Green Deal, COM(2019) 640 final, Brussels, 11.12.2019)

The 'DestinE' initiative will bring together European scientific and industrial excellence to develop a very high precision digital model of the Earth. This ground-breaking initiative will offer a digital modelling platform to visualize, monitor and forecast natural and human activity on the planet in support of sustainable development thus supporting Europe's efforts for a better environment as set out in the Green Deal. The Digital Twin of the Earth will be constructed progressively, starting in 2021. (A European Strategy for Data COM(2020) 66 final).

The overall objective of DestinE (DestinE)[3] is therefore to develop a dynamic, interactive, computing and data intensive **"Digital Twin (DT) of the Earth"**: a digital, multi-dimensional replica of a physical entity, the Earth (system), which would enable different user groups (public, scientific, private) to interact with vast amounts of natural and socio-economic information to:

- continuously **monitor the health of the planet** (e.g. climate change induced effects, state of the oceans, cryosphere, biodiversity, land use, natural resources)
- perform **high precision, dynamic simulations of the natural systems of the Earth** (focusing on thematic domains: e.g. marine, land, coastal, atmosphere and possibly also geographic areas: e.g. Europe, Mediterranean, Africa)
- improve **modelling and predictive capacities:** e.g. to help anticipate and plan measures in case of hurricanes and other extreme weather events (such as storms or floods) or natural disasters (such as volcano eruptions, earthquakes) and contribute to analyses of socio-economic disruptions (e.g. diseases and pandemics)
- support **EU policy making and implementation** (e.g. for assessing the impact and efficiency of proposed solutions, such as legislative measures).

[3] https://ec.europa.eu/digital-single-market/en/destination-earth-destine

- reinforce **Europe's industrial and technology capabilities** in simulation, modelling, predictive data analytics and Artificial Intelligence as well as advanced and high performance computing.

DestinE will build on the **flexible and convergent use of data, infrastructure (incl. high performance computing), software and AI applications/analytics** supported by a strong horizontal framework (incl. all EU data and digital governance provisions) to:

i) offer a **federated, cloud-based core platform** providing users with access to data and infrastructure, enabling them to build applications on top of it and to integrate their own data, thus forming the enabling core of a European earth observation, geospatial data and earth systems' applications ecosystem (**Green Deal Data Space**);

ii) develop a number of **thematic DTs (DTs) in priority EU policy areas** (e.g. environment, climate, urban areas, civil protection) giving users easy access to thematic information, services, models, scenarios, forecasts, visualisations etc.

Thus, DestinE will act as both a (horizontal) enabler of an ecosystem/data space as well as an advanced (vertical) tool for elaborating and monitoring thematic public policy needs.

Scope

The scope of this document is to present, and provide an initial evaluation of use cases received from policy Directorates General (DGs) of the European Commission as contributions to the initial development phase of the DestinE Initiative.

General Methodology

A kick-off workshop with policy DGs and other key stakeholders was originally planned for the 31st March 2020 to start identifying these initial use cases driving the implementation of DestinE but had to be cancelled due to the COVID crisis. As a result, the JRC engaged in a series of bilateral meetings during the months of April and May 2020 to present the DestinE initiative to all the stakeholders and gather from them 1-2 use cases they considered as priority to respond to their policy needs.

Information on the key elements necessary for the development of the priority DTs under DestinE is now available following a series of workshops organized by DG CNECT [4] [5].

Nevertheless, the publication of this JRC report is of value as it shows the initial phases to develop the scopes of the DestinE priority DTs.

To help the policy DGs to express their use cases JRC encouraged them to consider the policy goals and key actors involved, what would make a significant difference if implemented in a DT approach, the science case and some consideration on implementation. These elements respond to four main criteria/viewpoints JRC agreed with CNECT, namely: (1) policy view; (2) digital innovation view; (3) science

[4] https://ec.europa.eu/digital-single-market/en/news/elements-digital-twin-weather-induced-and-geophysical-extremes-workshop-destination-earth

[5] https://ec.europa.eu/digital-single-market/en/news/elements-digital-twin-climate-change-adaptation-workshop-destination-earth-initiative

view; and (4) feasibility view. The use case descriptions received were very variable in extent and structure but JRC has done its best to use them to fill the tables in this report, and to provide a first qualitative evaluation.

The evaluation is based on: (a) the use case description text as provided by the Proposers; (b) the discussions JRC had in bilateral meetings with the Proposers; (c) the knowledge of the JRC group engaged in the DestinE study.

The next step would have been to organise one or more workshops with the stakeholders to fill the gaps in the tables where possible and gather feedback on the use cases and their initial evaluation. For this purpose JRC considered as aid to the discussion and the definition of the relative importance of the different criteria using a structured approach such as the Analytic Hierarchy Process (AHP approach[6]).

This, however, was finally not necessary due to the valuable information gathering and discussion processes in relation to DestinE priority DTs taking place at the above mentioned workshops organized by DG CNCT in October 2020.

Summary

JRC received 30 use case proposals from 6 policy DGs in the European Commission (i.e. DEFIS, CLIMA, RTD, ECHO, ENV, AGRI), EEA, Mercator Océan, and EUMETSAT as well as DG JRC. In addition, ESA, ECMWF, expressed the possible synergy with their work on DTs.

Applying the methodology described above, JRC carried out a preliminary evaluation of the use cases, clustering them according to their maturity level in terms of policy, scientific and anticipatory potentiality. All the submitted use cases would benefit from the scalability and high-performance computing promised to be delivered by the DestinE platform. However, it is noteworthy that use case maturity contributes to determine the actual scalability effectiveness in addressing the policy question that is at the core of the use case itself. Scaling up a mature use case is likely to make a real difference; while, where scientific modeling and intelligence generation process are not yet well developed in the use case, the provision of scalability and high-performance computing would most likely not have as disrupting an effect, at least in the in the short run.

As result of the evaluation, JRC clustered the use cases in three groups:

1. **Mature use cases** – where scalability and high-performance computing provision will make the difference to advance the present state of the art;
2. **Less mature use cases** – where scalability and high-performance computing provision is less likely to make a big difference in a short time because there are still some open issues.
3. **Use cases to be further developed** – where scalability and high-performance computing provision will make the difference only once the process and required resources will be elaborated further.

This evaluation has some limitations, in particular:

- The descriptions of the use cases received were quite heterogenous.

[6] Bhushan, N., & Kanwal, R. (2004). Strategic Decision Making: Applying the Analytic Hierarchy Process. London: Springer-Verlag.

- The “Costs” criterion was not considered because this information was considered premature and was not included in the use case descriptions.
- It is a qualitative evaluation, i.e. the degree of intensity of preference (see the annex) is yet to be discussed.

For these reasons, this preliminary evaluation was verified and refined with the stakeholders in an initial workshop on 2nd July covering the three main evaluation criteria/concerns:

- “Link to Policy”
- “Maturity Level”
- “Anticipatory potentiality”

Many of the use cases have strong linkages to each other: they contribute addressing similar policy needs, serve the same users, and/or engaging analogous stakeholders in their process. Therefore, it is possible to organize the use cases into few high-level DTs exploiting these synergies and creating a systems effect that will be the real benefit of DestinE, i.e. responding to multiple use cases with a shared core platform, core data, and core software /analytics environment. The Annex provides a first hypothesis of this clustering into policy area DTs, for the most mature use cases.

Use Cases description and evaluation

The received use cases were described at different levels of details, stressing diverse viewpoints and opportunities. Therefore, we introduced a set of common features characterizing a general use case contributing to DestinE, which were also utilized as common evaluation criteria —see the ontology and evaluation scheme in the Annex.

This document presents 30 use case proposals. For each proposal, a table is introduced whose fields are the features considered to describe the different characteristics of a use case –for the scope of this study. These elements were used as evaluation criteria (and sub-criteria). The information reported in each table was elicited from: the received use case description, the bilateral meetings with the use case proposers, and the JRC working group knowledge in the specific domain.

Mature use cases

Use Case #1: Accelerating disaster risk management

Abstract

There is growing concern about the sustainability of development efforts in the context of increasing vulnerability and exposure to disaster events which are now costing the global economy between US$250 billion to US$300 billion annually. With climate change, future impacts of weather-related disasters are likely to rise. Recently, in the global risks report published during the last World Economic Forum, extreme weather events were rated the second most likely global risk to the economy and the failure of climate change mitigation and adaptation as the highest global risk in terms of impact on the economy. Efforts at all levels are ongoing to reduce the impact of disasters with the Union Civil Protection Mechanism and the Sendai Framework for Disaster Risk Reduction being the most important policy frameworks at European and global level.

Components

The use case main components are described in Table 1.

Table 1. Components characterizing the “Accelerating Disaster Risk Management” use case

Component	Value	Intensity of preference (1-9)
Goals [activities]	• Improve disaster risk management with timely information on exposure of human settlements and fine scale hazard and risk information: ○ Day and night population distribution, ○ Dynamic modeling of population movements (daily and seasonal), ○ Assessment of characteristics of building assets: heights, typology (residential, commercial, industrial), etc.	

	○ Assessment of changes in built-up areas and modeling or urban expansion ○ High-resolution hazard maps (floods/forest fires/wind storms/etc.) ○ Increased predictability of extreme events on the short to medium range as well as decadal scales (climate change)	
Actors [roles]	• Advanced users (e.g. public authorities involved in data analysis or processing, users working with operational environments, etc.) run analysis on large output datasets produced in this use case. • Expert users (e.g. research institutions) would actually perform developments on this DT making use of all its functionalities. • Policy DGs (e.g. DG CLIMA, DG DEVCO, DG ENV, DG REGIO, DG ECHO) they will not interact directly with the system, however, they would benefit from high level analysis of the outputs produced in this use case.	
Potential contribution to broader DT	• The use case may contribute to a "Disaster Risk Management" DT. • This use case might be linked to the Twins developed by ECMWF, ESA and by other use cases. • It would be recommendable to turn this into a cross-cutting DT. • Connected to several other use cases (as reported in their description).	
Beyond State-of-Art	• Hyper-resolution atmosphere and land process models.	
Science/modeling maturity	• Connected to ECMWF modeling on extreme events.	
Data maturity	• Connected to ESA, EUMETSAT, and ECMWF data.	
Development cost	•	
Maintenance cost	•	

Use Case #2: Climate change adaptation in agriculture

Abstract

The evolution of the agricultural system depends on both external factors (e.g. climate, economics, finance and policy) and internal ones (systemic responses) usually occurring on 10-year time scale. The response of the farming sector to both these factors consist of changes in agro-management approaches, land-use, breeding of new varieties, financial and food markets, etc. Therefore, the development of effective climate-change adaptation and sustainability strategies for the agricultural sector should focus on decadal time scale.

Decadal climate predictions (in contrast to projections) have recently emerged and very recently started to be explored as tools in climate change adaptation. The starting point of climate predictions is a realistic description of the current state of the climate system to either initialize model forecasts or identify

available model simulations being in phase with the main large-scale patterns of the climate system. Consequently, decadal predictions combined with innovative coupled modelling approaches as well as data coming from other sources (e.g. farm surveys) can provide novel insights into the design of sustainable and effective adaptation strategies for agriculture.

Components

The use case main components are described in Table 2 *(additional feedback expected from CLIMA)*

Table 2. Components characterizing the "Climate Change Adaptation in Agriculture" use case

Component	Value	Intensity of preference (1-9)
Goals [activities]	• To develop a sustainable and effective adaptation strategies for agriculture, based on decadal predictions combined with innovative coupled modelling approaches as well as data coming from other sources (e.g. farm surveys).	
Actors [roles]	• Providers and Experts (i.e. agro-climatic-economic experts, providers and experts of decadal climate predictions, experts on large-scale agent-based models (ABMs), experts on AI and behavioral modelling) • Policy officers and other Managers	
Potential contribution to broader DT	• Multiple synergies with other use cases proposed n the area of climate and agriculture. • Can contribute to broader DT in the areas of climate adaptation and agriculture/	
Beyond State-of-Art	• Improving the current crop modelling system; • High-resolution multiple ensembles of decadal climate predictions, including improved ingestion of data and better initialization and bias/drift-adjusting procedures. • Development of large-scale ABMs methods trained with AI methods and different data sources. • Testing of the coupled climate-crop-ABM approach.	
Science/modeling maturity	• Builds on Copernicus Land service and CROP modeling from MARS	
Data maturity	• Builds on Copernicus Land service. Data from ECMWF, JRC, etc.	
Development cost	•	
Maintenance cost	•	

Use Case #3: Climate modeling

Abstract

Global Climate Models (GCMs) continue to be extended in their process realism, through the inclusion of new and/or more advanced representation of key biogeochemical processes. Such models are commonly referred to as Earth system models (ESMs) and are the primary tools available for making future projections of global climate change, linking such projected changes to allowable carbon emissions commensurate with staying below a given warming target. ESMs allow an assessment of the potential response of the full global environment (including biological and chemical components) to future climate change.

Components

The use case main components are described in Table 3

Table 3. Components characterizing the "Climate Modeling (by RTD)" use case

Component	Value	Intensity of preference (1-9)
Goals [activities]	• Generation of advanced and well-evaluated high-resolution global climate models (GCM), capable of simulating and predicting regional climate with unprecedented fidelity. • Generation of advanced and well-evaluated high-resolution Earth System Models (ESM), which are the primary tools available for making future projections of global climate change, linking such projected changes to allowable carbon emissions commensurate with staying below a given warming target.	
Actors [roles]	• Scientific community (e.g. ECMWF)	
Potential contribution to broader DT	• Moving from process to further data driven modeling.	
Beyond State-of-Art	• Undertaking modelling requiring significant computational power. • Improving uncertainty in climate predictions and projections, regional downscaling, and evaluation against observations. • reducing inter-model spread and produce robust projections, forming the European contribution to a CMIP6 High-resolution Model Inter-comparison project (HIRESMIP).	
Science/modeling maturity	• Good: connects to the "Extreme Earth DT" by ECMWF and ESA.	
Data maturity	• Good: connects to the "Extreme Earth DT" by ECMWF and ESA.	
Development cost	•	
Maintenance cost	•	

Use Case #4: Rapid analysis of risks in climate adaptation options

Abstract

Use of DestinE to develop rapid analysis responding to requests on risks and adaptation options. Could build on the work done to date, such as fast creation of maps of forest fire risk under different climate and land use scenarios; fast creation of maps of heat stress risk under different climate scenarios; fast creation of maps of heat stress risk; fast creation of coastal flood risk maps from JRC data; drought risk for agriculture and ecosystems, PESETA etc.

Components

The use case main components are described in Table 4.

Table 4. Components characterizing the "Rapid analysis in CLIMA responding to requests on risks and adaptation" use case

Component	Value	Intensity of preference (1-9)
Goals [activities]	• Develop rapid analysis responding to requests on risks and adaptation options ○ fast creation of maps of forest fire risk under different climate and land use scenarios; ○ fast creation of maps of heat stress risk under different climate scenarios; ○ fast creation of maps of heat stress risk; ○ fast creation of coastal flood risk maps from JRC data; drought risk for agriculture and ecosystems	
Actors [roles]	• DG CLIMA and national/European Civil Protection	
Potential contribution to broader DT	• Connection to the Accelerating Disaster Risk Management use case and potential DT in this area as well as and the Climate Modeling use cases. • Possible contributions from the use cases: Real Time Evolution of Forest Fires, Detailed Medium-Term Seasonal Forecasts on Hurricanes and Typhoons, Complex Interdependencies and Critical Nodes Affected by Natural or Man-made Disasters, and Natech[7] Events and Nowcast Modelling for Emergency Response Operations.	
Beyond State-of-Art	• Link with the DTs developed by developed by ECMWF, ESA and by the other connected use cases –in particular the cross-cutting "Disaster Risk Management" DT.	
Science/modeling maturity	• Hyper-resolution atmosphere, water, and land process models. • Connected to ECMWF modeling on extreme events.	
Data maturity	• Connected to ESA, EUMETSAT, and ECMWF data.	
Development cost	•	
Maintenance cost	•	

[7] Natural Hazard Triggering Technological Disasters

Use Case #5: Ecosystems monitoring and modelling

Abstract

Healthy ecosystems provide essential goods and services to human societies and are of central importance for meeting the Sustainable Development Goals (SDGs). However, anthropogenic pressures cause severe threats to ecosystem integrity, functions and processes, potentially leading to the loss of ecosystem services - the benefits ecosystems provide to humankind. Protected Areas, in particular, represent a crucial component of the natural capital and provide ecosystem services that are often unavailable in the surrounding regions. Proper management and conservation actions require the quantitative knowledge of the state and changes taking place in ecosystems. Recent advances in Earth Observation (Remote Sensing and in situ measurements) offer new opportunities to monitor ecosystem functions, processes and services, and the pressures they face.

Components

The use case main components are described in Table 5.

Table 5. Components characterizing the "Ecosystems" use case

Component	Value	Intensity of preference (1-9)
Goals [activities]	• To understand and monitor ongoing changes in ecosystems and support effective management of Protected Areas. ○ [To quantitatively assess the future expected changes in ecosystems and ecosystem services] ○ [to develop climate and ecological models able to generate future ecosystem projections and with the ability to estimate the uncertainties on the projections]	
Actors [roles]	• Scientific community, Policy makers addressing the nexus among climate, Land Use/agriculture, and biodiversity/protected areas.	
Potential contribution to broader DT	• Possible contribution to climate and agriculture DTs, carrying the scientific community on biodiversity and ecosystem services.	
Beyond State-of-Art	• Multi-disciplinary models interconnection in order to operationalize the concept of ecosystem-as-a-service.	
Science/modeling maturity	• Good: builds on ECOPOTENTIAL modeling and community	
Data maturity	• Possibly, to be connected with the Climate and Agriculture use cases.	
Development cost	•	
Maintenance cost	•	

Use Case #6: Global security indices in a natural disaster environment

Abstract

The European Commission's humanitarian and civil protection operations carried out by DG ECHO are the EU response to natural and man-made disasters world-wide. These operations often take place in challenging and sometimes threatening environments for the safety and security of the personnel, assets and infrastructure. In addition, according to various studies, the impact of climate change hazards (heatwaves, storms, tropical cyclones, floods (also floods caused by landslides), drought and forest fires) will likely grow, and consequently humanitarian and civil protection operations will rise.

DG ECHO shall consider these two elements when planning, implementing, and monitoring its deployments and related operations in the field, and particularly in so-called high risk countries or areas (HRCs). Although there are currently means and measures of how this is factored-in, there is nonetheless an increased demand of evidence-driven in-depth security analysis. This demand can be met by leveraging improving technologies for the availability and processing of the data required as well as combing different disciplines.

Components

The use case main components are described in Table 6.

Table 6. Components characterizing the "Global Security Indices in a Natural Disaster Environment" use case

Component	Value	Intensity of preference (1-9)
Goals [activities]	• Improve natural disaster risk management with timely information on exposure of human settlements and fine scale hazard and risk information: ○ day and night population distribution, ○ dynamic modelling of population movements (daily and seasonal), ○ assessment of characteristics of building assets: heights, typology (residential, commercial, industrial), etc. ○ assessment of changes in built-up areas and modelling or urban expansion ○ high-resolution hazard maps (floods/forest fires/wind storms/etc.) ○ Increased predictability of extreme events on the short to medium range as well as decadal scales (climate change) • Improve man-made disaster risk assessment and management with accurate and timely information on	

	exposure of human settlements, critical infrastructure, as well as safety and security risks information that may impact staff, assets, operations and reputation of DG ECHO.	
Actors [roles]	• Civil Protection: Emergency Response Coordination Center requires impact info on disasters for emergency response as well as prevention planning which is provided by the analytical team that will work with the input of the study of the DT. • Humanitarian Aid: The Analytical Team and Security Sector require information for the deployment of ECHO Staff (ECHO Offices worldwide and HQ Staff going on missions) to high-risk countries.	
Potential contribution to broader DT	• Infrastructure data enabling seamless integration of multiple data sources (geospatial data, satellite imagery, census data, crowd-sourced and socio-economic data) and includes the key infrastructure such as roads, communication lines, hospital, etc. • Possible connection to the Accelerating Disaster Risk Management use case –and through it to the Extreme weather events by ECMWF.	
Beyond State-of-Art	• Connect different modeling communities (e.g. weather, land use, operational research) and products, making them operational.	
Science/modeling maturity	• Build on existing Copernicus disaster risk reduction services and the ECMWF and EUMETSAT modeling activities and products.	

Data maturity	• **Hazard risks data**
	• **Hazard related data**
	  o Models outputs
	  o Observed evens
	• **Security-related Data**
	  o Violent events
	    o Armed conflicts
	      ▪ INFORM (Human hazards)
	    o Terrorism
	      ▪ ACLED
	  o Civil unrest (political, social, etc.)
	      ▪ ACLED
	  o Crime
	    o Property crime (robberies, burglaries, thefts)
	      ▪ UNODC
	    o Corruption
	    o Abductions, kidnapping
	  o Humanitarian perception
	• **Safety-related Data**
	  o Health	

	○ Healthcare system (availability, proximity, capacities, etc.) ○ Health advices (required medicines/vaccines, outbreak alerts, ○ Health issues (staff comp ○ Travel ○ Road infrastructure (state, advices) ○ Road traffic (incidents, fatalities)	
Development cost	•	
Maintenance cost	•	

Use Case #7: Agricultural monitoring and the Common Agricultural Policy (CAP)

Abstract

This use case is aimed at:

- Provision of long-term open access to uniform and regularly updated digital reference data at the appropriate scales (e.g. Digital Elevation Models, digital soil maps, topography, hydrology, public thematic data layers on (or relevant to) agriculture)
- Provision of long-term open access to the complete (historic and actualized) full resolution archives of semi-continuous observations on environmental drivers (e.g. weather, remote sensing, public measurement networks), and the derived information product derived thereof (land use dynamics, forecasts, phenology and quality metrics)
- Provision of innovative interfaces and remuneration for the exchange of standardized *in situ* observations, from sensors networks, NGO and voluntary contributions (e.g. farmers, citizen science)
- Facilitation of integrated modeling of physical, chemical and ecological processes that are related to agricultural production and environmental impact, including their integration with monitoring outputs and economic impact analysis and the establishment of machine learning and AI based inference.

Components

The use case main components are described in Table 7.

Table 7. Components characterizing the "Agricultural monitoring" use case

Component	Value	Intensity of preference (1-9)

Goals [activities]	• Establish a collaborative platform for the prioritization of CAP measures that are aimed at improving the environmental and climate footprint of agriculture
	  ○ Provision of long term open access to uniform and regularly updated digital reference data at the appropriate scales.
	  ○ Provision of long term open access to the complete full resolution archives of semi-continuous observations on environmental drivers and derived products
	  ○ Provision of innovative interfaces and remuneration for the exchange of standardized *in situ* observations, from sensors networks, NGO and voluntary contributions
	  ○ Facilitation of integrated modeling of physical, chemical and ecological processes that are related to agricultural production and environmental impact, including their integration with monitoring outputs and economic impact analysis and the establishment of machine learning and AI based inference	

Actors [roles]	• <u>Policy Makers</u>
	  ○ formulation of policy options that require a comprehensive impact analysis in terms of expected policy gains and economic costs. High-level knowledge needed to help define realistic feasibility scenarios and trust in quantitative and qualitative outputs provided.
	• <u>Science users</u>
	  ○ match policy options with the data requirements, modeling efforts and use case processing capacities available in Digital Earth. Develop and adapt new approaches, scientific modeling and compute solutions, knowledge inference. Provide a science based policy review back to policy makers.
	• <u>Policy beneficiaries</u>
	  ○ Integrate feedback from their daily practices with observed impact and participate in adaptation and fine-tuning of the implementation process
	• <u>Data and Solution Providers</u>	

	◦ propose alternative data integration, compute solutions based on review of the open data and open source approaches inside the use case, test new sensor concepts, data acquisition strategies in agricultural domains.	
Potential contribution to broader DT	• This use case can contribute to a DT measuring policy impacts in agriculture by using ecological models that estimate carbon accumulation under specific physical and chemical conditions of regionally diverse soil and physical conditions. • Possible connections with the Ecosystem use cases and the Climate Change Adaptation in Agriculture use case.	
Beyond State-of-Art	• Advanced, high resolution modeling through integration of high end computing solutions and modern machine learning and AI inference techniques	
Science/modeling maturity	• Good: builds on and interconnect several existing modeling communities, including, Land use modeling, crop modeling and Copernicus services	
Data maturity	• Good: builds on the Copernicus Land services.	
Development cost	•	
Maintenance cost	•	

Use Case #8: Real time evolution of forest fires

Abstract

Closely monitoring the evolution of forest fires is an increasingly critical task for DG ECHO, as the events of recent years have shown. The extreme fires in Portugal in 2017, in Greece in 2018, as well as the devastating fires outside the EU such as the ones in the Amazon basin in 2019, in Siberia in the same year and in Australia in 2019-2020 have brought sharply into focus the need for accurate fire behaviour modelling and monitoring. Climate change will probably make this situation even more critical, so increased resources, knowledge and capacities are in order. P'As fire-fighting means become a rescEU asset, DG ECHO needs to have access to a very high capacity to anticipate fire evolution and allocate assets accordingly.

In order to assess fire evolution, the European Forest Fire Information System (EFFIS) has developed a system (called Decision Support System) that uses meteorological data to model the possible evolution of a fire and then ranks the current fires in Europe in decreasing risk order, according to the danger they pose to settlements, infrastructure, protected areas, etc. Obviously, a reliable and accurate forecast of the fire's behaviour is crucial for this system to work.

Components

The use case main components are described in Table 8.

Table 8. Components characterizing the "Real Time Evolution of Forest Fires" use case

Component	Value	Intensity of preference (1-9)
Goals [activities]	• Closely monitoring the evolution of forest fires	
Actors [roles]	• DG ECHO and national/European Civil Protection	
Potential contribution to broader DT	• Connected to the JRC EFIS activity and the Accelerating Disaster Risk Management use case –and through it to the Extreme weather events by ECMWF. • Possibly, contributes to the Rapid Analysis in CLIMA responding to requests on risks and Adaptation use case.	
Beyond State-of-Art	Currently, these models are limited by three very important constraints: 1. Limits in the timeliness of the meteorological information. Conditions change very rapidly, especially since some very large fires create their own localised weather. **Functional requirement:** The models should be able to receive real-time data, and for that a real-time localised weather model has to be kept running. 2. Limits in the resolution of the meteo data. Normal ECMWF data have a resolution of 9 km - enough for usual weather forecast, but hardly enough for a fire front that can be 1km across in a 2-km valley and is threatening a village. **Functional requirement:** Very high resolution and continuous updating is required, and the computing infrastructure to have this on a European or a global scale falls within the scope of DestinE. 3. Limits in the details of the terrain, vegetation, humidity and other parameters that can affect propagation. **Functional requirement:** Modelling these, as well as keeping information and making it instantly available would be a great asset in the fire-control effort. The envisaged computing power behind DestinE would help significantly to reduce significantly these constraints and help DG ECHO as well as all stakeholders to be much more effective in	

	managing the firefighting efforts and resources and ultimately reduce the impact and damage of the ever-increasing forest and landscape fires in Europe and the world.	
Science/modeling maturity	• Connect different modeling communities (e.g. weather, land use, operational research) and products, extending the functionalities of the already operational services.	
Data maturity	• Build on existing Copernicus disaster risk reduction services, EFIS by JRC, and the ECMWF and EUMETSAT modeling activities and products.	
Development cost	•	
Maintenance cost	•	

Use Case #9: Detailed medium-term seasonal forecasts on hurricanes and typhoons

Abstract

The impact of tropical cyclones both on developed and developing countries has always been significant and is getting even more so, aided by two factors:

1. The strengthening of the storms, in terms of their maximum land falling strength, as noticed in reality and as foreseen by the climate change models.

2. The increase in people and infrastructure exposure to the cyclone effects, particularly coastal flooding.

In the past decade, typhoons in the Pacific such as HAIYAN and hurricanes like IRMA, MARIA and IDAI and DORIAN more recently have devastated vulnerable countries. Significant international efforts and DG ECHO-led European help campaigns have been necessary to help countries deal with the aftermath.

Components

The use case main components are described in Table 9.

Table 9. Components characterizing the "Detailed Medium-Term Seasonal Forecasts on Hurricanes and Typhoons" use case

Component	Value	Intensity of preference (1-9)
Goals [activities]	• Detailed Medium-Term Seasonal Forecasts on Hurricanes and Typhoons ○ Much increased resolution in the cyclone tracking models (e.g. down to 500m) would help locate the exact place of impact, which is quite significant for the planning of aid release. A difference of a few km in the track can mean that a tropical nation can either be completely devastated or spared with little damage. ○ Development of full models of medium-term cyclone development potential would help even more in allocating resources beforehand and preparing countries well in advance. Most current models are largely empirical and would benefit a lot from expanded infrastructure on which to run the very demanding global models for medium-term predictions.	
Actors [roles]	• DG ECHO and the national/European Civil Protection	
Potential contribution to broader DT	• Connected to the Accelerating Disaster Risk Management use cases and the Extreme weather DT proposed by ECMWF and ESA. • Possibly, contributes to the Rapid Analysis in CLIMA responding to requests on risks and Adaptation use case.	
Beyond State-of-Art	A number of institutes publishes forecasts at the beginning of each season in each basin. As soon as a tropical cyclone is formed, the responsible Meteorological Centre starts tracking it and issues regular bulletin on intensity and track, based on models. These models (such as the global model of ECMWF and the dedicated HWRF model of NCEP/NOAA) are quite heterogeneous and quite limited in their resolution. Digital Earth computing and modelling infrastructure would help significantly to address these shortcomings.	
Science/modeling maturity	• Good: builds on existing modeling and services activities. • Develop the software platform and services to connect and operationalize the diverse components.	
Data maturity	• Good: builds on existing modeling and services activities	

Development cost	•	
Maintenance cost	•	

Use Case #10: Analysis of the external (global) impacts of climate change adaptation on Europe

Abstract

Use of DestinE to develop an analysis of the External (Global) impacts of Climate Change Adaptation on Europe. Could include topics such as trade and security impacts of climate change, relevant adaptation options and their impacts on Europe.

Components

The use case main components are described in Table 10.

Table 10. Components characterizing the "Analysis of the External (Global) Impacts of Climate Change on Europe and Adaptation" use case.

Component	Value	Intensity of preference (1-9)

Goals [activities]	• Analysis of the External (Global) impacts of Climate Change on Europe and Adaptation
	  ○ trade and security impacts of climate change
	  ○ relevant adaptation options and their impacts on Europe	

Actors [roles]	• DG CLIMA, policy makers, and relevant society communities.	
Potential contribution to broader DT	• Connection to the "Rapid analysis in CLIMA responding to requests on risks and adaptation" use case.	
Beyond State-of-Art	• Hyper-resolution models of Earth natural components. • Integration of socio-economic data streams and modeling.	
Science/modeling maturity	• Builds on ECMWF modeling.	
Data maturity	• Connected to ESA, EUMETSAT, and ECMWF data.	
Development cost	•	
Maintenance cost	•	

Use Case #11: Climate resilient rural and agricultural planning

Abstract

Use of DestinE to support climate resilient rural and agricultural planning. Could build on the work done to date such as water resource models such as RIBASIM and WEAP, as well as possible work on short to medium-term (<10 years) agricultural modelling (see use case 1 above).

Components

The use case main components are described in Table 11.

Table 11. Components characterizing the "Climate resilient rural and agricultural planning" use case.

Component	Value	Intensity of preference (1-9)
Goals [activities]	• Support climate resilient rural and agricultural planning	
Actors [roles]	• Local authorities and policy makers	
Potential contribution to broader DT	• Connection to the "Climate Change Adaptation in Agriculture" use case and to the "Agricultural monitoring & CAP" use case. • Connection to the "Rapid analysis in CLIMA responding to requests on risks and adaptation" use case.	
Beyond State-of-Art	• Utilization of connected use cases –in particular the "Climate Change Adaptation in Agriculture" one.	
Science/modeling maturity	• Build on the work done to date such as water resource models such as RIBASIM and WEAP, as well as possible work on short to medium-term (<10 years) agricultural modelling.	
Data maturity	• Builds on existing data streams developed by the agriculture community.	
Development cost	•	
Maintenance cost	•	

Less Mature Use Cases

Use Case #12: Freshwater and marine modelling framework (FMMF)

Abstract

The FMMF is a suit of interconnected models that conforms a Regional Earth System Model (RESM). Its main aim is to simulate the conditions of marine ecosystems under a set of external stressors. It is comprised by: an atmospheric component (it could be a climate model or reanalysis of atmospheric data), a riverine component (it can also be dataset of river conditions or full hydrological models), a hydro-dynamic-bio-geo-chemical ocean model (to simulate physical and low trophic levels variables in the ocean) and a high trophic level model (to simulate food web conditions in marine ecosystems).

Components

The use case main components are described in Table 12.

Table 12. Components characterizing the "Freshwater and Marine Modelling Framework" use case

Component	Value	Intensity of preference (1-9)

Goals [activities]	• To simulate the conditions of marine ecosystems under a set of external stressors.
	  ○ [develop and applying hydrological (river) models and relevant scenarios].
	  ○ [develop and apply hydro-dynamic bio-geochemical and high trophic (marine) models and relevant scenarios]
	  ○ [provide information on impacts of different management scenarios on physic-chemical variables for the models (e.g., changes in freshwater quality and/quality)]	

Actors [roles]	• Freshwater and scientists
	  ○ [to set-up and run the most accurate models (rivers and sea) being able to translate policy options into models' parameters.
	• Policy officers and other Managers
	  ○ [to ask the right questions and help scientists to put those questions into a virtual 'currency' understandable and relevant for the models];
	  ○ [to pose questions to the framework about the effectiveness of proposed measures in reaching their ecological targets (for example the Good Environmental Status as defined in the MSFD or the Maximum Sustainable Yield as aimed for in the CFP)].
	  ○ [to simulate 'what if' scenarios].	

Potential contribution to broader DT	• This use case can contrite to one or more DT set up to address the following topics: • Hydrology through different models (LISFLOOD, GREEN and SWAT) that can simulate the freshwater quantity (flow) and its quality (chemical composition) in the entire EU. • Atmosphere by using either reanalysis data (for example from ECMWF) or climate models (to make future scenarios in the context of Climate Change). • Hydro-dynamic-bio-geo-chemical nexus simulates the physicochemical conditions in the ocean (using the models GETM and GOTM).	

	• High trophic level (using the EwE model) uses the environmental information created by the hydrodynamic biogeochemical nexus to force the dynamic of the entire marine food webs. • Connections with the Sea Level Rise, Hydrology use case and the Renewable Marine Energy use case.	
Beyond State-of-Art	• Complex system that requires HPC facilities to perform simulations. • It could be expanded or applied to other regions but with a considerable effort and needing ad-hoc analysis and work.	
Science/modeling maturity	• Composed by a variety of models, which are not fully online ('on the go') coupled. • To make the connection between several of the models it is necessary to use one model output as input to the next one with some processing steps in between.	
Data maturity	• Builds on existing data streams developed by the marine and water communities.	
Development cost	•	
Maintenance cost	•	

Use Case #13: Sea level rise, hydrology

Abstract

Present day water management in many sectors has to be able to cope with extreme hydrological conditions. In addition, the impacts of global warming on water resources have become a matter of grave concern to water resource managers and decision-makers. The limited predictability of these extremes at sufficiently long lead times results in considerable social vulnerability, also in light of the imminent increase in frequency and severity of extreme events in the future.

Components

The use case main components are described in Table 13.

Table 13. Components characterizing the "Sea Level Rise, Hydrology" use case

Component	Value	Intensity of preference (1-9)
Goals [activities]	• Improve predictions and management of hydrological extremes. ○ [provides innovative approaches, tools and practical case studies to help improve our ability to anticipate and respond to future hydrological extreme events].	

Actors [roles]	• Scientific community, Civil Protection, and European agencies and Policy DGs.	
Potential contribution to broader DT	• Connected to the Extreme Earth DT by ECMWF and ESA. • Connected to Disaster risk management use case.	
Beyond State-of-Art	• Improve the current state-of-the art of forecasting systems and management procedures.	
Science/modeling maturity	• Good: connected to Copernicus Marine services and Disaster Risk Management.	
Data maturity	• Good: connected to Copernicus Marine services and Disaster Risk Management.	
Development cost	•	
Maintenance cost	•	

Use Case #14: Big data streams for ocean and carbon modelling

Abstract

DTs are ingested by big data streams. These data streams are essential to keep the digital representation synchronized with the physical twin. Besides, those data are utilized to train, first, and feed, then, the learning-based models that characterize DTs. Big data streams are those characterized by one or more of the following challenges: voluminous data, heterogeneous data, data provided by many diverse sources, data to be processed in real and near-real time, data characterized by different quality.

Components

The use case main components are described in Table 14.

Table 14. Components characterizing the "Big Data Streams" use case

Component	Value	Intensity of preference (1-9)
Goals [activities]	• To develop observation and measurement data streams to feed DTs virtualizing Earth system components. ○ To build an efficient integrated Arctic Observation System by extending, improving and unifying existing systems in the different regions of the Arctic. ○ To build an Atlantic Ocean observing system building on heterogeneous international, national and regional in-situ data systems. ○ To build a system to quantify carbon stocks and the fluxes of carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) across the EU and in the US, China and Indonesia based on independent observations.	
Actors [roles]	• Scientific community	

Potential contribution to broader DT	• Bring together several observing (big) data systems to reinforce the data-driven modeling approach. • Potentially, contribute to the DT of the Ocean use case.	
Beyond State-of-Art	• Utilization of HPC capabilities for Big Data management and processing scalability.	
Science/modeling maturity	• There exist several existing models and frameworks. There is the need to further development to interconnect the systems and the diverse use cases.	
Data maturity	• Good effort to bring together disperse networks (in particular in-situ ones), but it needs further development.	
Development cost	•	
Maintenance cost	•	

Use Case #15: Digital models of the ocean

Abstract

This use case aims to deliver interactive virtual tools of the ocean in a unified digital environment. It would empower a shared responsibility to monitor and ensure marine habitat preservation, sustainable marine economic activities and exploitation of ecosystem services (fishing, aquaculture, transport, offshore energy, …). It should allow assessments of ecosystems and habitats, the impact of human activities and forecasts of their short and long-term changes, development of biodiversity conservation strategies, management of sustainable economic activities, assessment of infrastructure vulnerability, development of mitigation, adaptation and replacement plans to deal with climate risks and optimization of emergency responses to severe events such as storm surges.

Components

The use case main components are described in Table 15.

Table 15. Components characterizing the "A DT of the Ocean" use case

Component	Value	Intensity of preference (1-9)

Goals [activities]	• Deliver interactive virtual tools of the ocean in a unified digital environment
	  ○ [Build on the integration of existing EU leading-edge capacities in ocean observation, modelling and data warehousing (Copernicus, Emodnet, ERICs) with innovative IT technology].
	  ○ [Cover the whole knowledge value chain, from data acquisition (from multiple sources: research, monitoring, industrial and citizen data) to user services].	

	○ [Address concrete cases in local or regional sea basins].	
Actors [roles]	• Resource Providers ○ Integration of new automated sensors and autonomous platforms, allowing more to be measured with increased frequency and lower cost; ○ Incorporate unstructured data from unorthodox sources such as citizen science or historic data collected before the digital age and the application of big data and artificial intelligence technologies. • Experts ○ Develop of what-if scenarios and EU-national coupled-modelling capacities to analyse impact of preventive measures to adapt and mitigate climate risks at regional and local scale. ○ Apply co-creation approaches and frameworks (cloud-based, digital, i.e. BlueCloud and Wekeo) with local authorities, scientists, private sector to develop shared applications and support international and EU policies. ○ Deliver information to citizens through new generation reporting of ocean health	
Potential contribution to broader DT	• Development of digital interactive replicas of the oceans. • Possible connection to the “Marine Food” and “Natural Resources and Energy” use cases. • Possible connection to “Freshwater and Marine Modelling Framework” use case.	
Beyond State-of-Art	• To develop a very high precision digital model of the Earth	
Science/modeling maturity	• Building on Copernicus Marine services and the Mercator Océan use cases.	
Data maturity	• Can also leverage the contribution of the Big Data Streams use case.	
Development cost	•	
Maintenance cost	•	

Use Case #16: Marine food modelling

Abstract

Aquaculture is expanding and need to find new locations for new farms. Ocean data is needed to allocate new sustainable locations for growing farmed fishes in the marine environment. Environmental companies or agencies, involved in the monitoring of the environmental impact of aquaculture farms (see here for example: https://marine.copernicus.eu/usecases/finding-sustainable-locations-growing-rainbow-trout-baltic-sea/) want to have a dashboard displaying various KPI among which the past conditions (20 years reanalysis) and future forecast of wave/currents/dissolved oxygen/nutrients/ Chlorophyll-a at the potential farm site locations. Users such as LUKE (Natural Resources Institute Finland) are expert users who are able to understand the complexity of wave and ocean current and biogeochemistry modeling. They need regular, on the shelf, free of charge model outputs at high resolution (less than 1km).

Components

The use case main components are described in Table 16.

Table 16. Components characterizing the "Marine Food" use case

Component	Value	Intensity of preference (1-9)

Goals [activities]	• Aquaculture
	  ○ Monitoring of the environmental impact of aquaculture farms.
	  ○ Find new locations for new farms.	

Actors [roles]	• Environmental companies or agencies
	  ○ Utilize ocean data to allocate new sustainable locations for growing farmed fishes in the marine environment.
	  ○ Have a dashboard displaying various KPI among which the past conditions (20 years reanalysis) and future forecast of wave/currents/dissolved oxygen/nutrients/ Chlorophyll-a at the potential farm site locations.	

Potential contribution to broader DT	• Global or basin-scale wave and ocean currents and biogeochemistry models, refined at the coast. • Connection with the Freshwater and Marine Modelling Framework use case, a DT of the Ocean use case, and the Sea level Rise, Hydrology use case.	
Beyond State-of-Art	• Higher resolution coastal models for wave / ocean currents /biogeochemistry.	
Science/modeling maturity	• Good: builds on the models developed by CMEMS (Copernicus Marine Services) and the Mercator Océan activities.	
Data maturity	• Good: builds on Copernicus and the data streams contributing to CMEMS (Copernicus Marine Services).	
Development cost	•	
Maintenance cost	•	

Use Case #17: Renewable marine energy

Abstract

The planning for testing and calibrating various energy prototype requires knowledge of ocean conditions (mainly waves and ocean currents). Companies running renewable energy test sites (e.g. BIMEP see here: https://marine.copernicus.eu/usecases/met-ocean-conditions-bimep-marine-renewable-energy-test-site/) need to know ocean conditions in order to better plan when tests can be done so that prototype will not get damaged. (could be linked with mechanics model (Twins) of the prototypes). They need to

know the ocean conditions in order to better calibrate the energy prototype and test which ocean conditions (e.g. which wave height) provide the largest electricity production and productivity.

Users such as IH Cantabria are expert users who are able to understand the complexity of wave and ocean current modeling. They need regular, on the shelf, free of charge model outputs. They have a deep knowledge of upstream industry, including infrastructure modelling. They could be the link between a DTE core service and a DTE base application for Marine renewable energy, including possible industry model.

Components

The use case main components are described in Table 17.

Table 17. Components characterizing the "Natural Resources and Energy, and more specifically Renewable Marine Energy" use case

Component	Value	Intensity of preference (1-9)
Goals [activities]	• The planning for testing and calibrating various energy prototype requires knowledge of ocean conditions (mainly waves and ocean currents); ○ provide a dashboard displaying various KPI among which the forecast of wave and currents at the test site locations.	

Actors [roles]	• Companies running renewable energy test sites
	  ○ to know ocean conditions in order to better plan when tests can be done so that prototype will not get damaged. (could be linked with mechanics model (Twins) of the prototypes)
	  ○ to know the ocean conditions in order to better calibrate the energy prototype and test which ocean conditions (e.g. which wave height) provide the largest electricity production and productivity.	

Potential contribution to broader DT	• Global or basin-scale wave and ocean currents models, refined at the coast by higher resolution coastal models for wave and ocean currents.
	  ○ Interaction between land information, meteo information and marine information is keys.
	  ○ Models and ML can also improve resolution in time and space
	• Connection with the Freshwater and Marine Modelling Framework use case, a DT of the Ocean use case, and the Sea level Rise, Hydrology use case.	

Beyond State-of-Art	• Currently dashboards are based on model that runs every day. A DTE of the ocean, could improve the in-situ and space data collection and, based on HPC processing and AI,	

	provide frequent updates of the KPIs, to anticipate productions data and risks for the infrastructure.	
Science/modeling maturity	• Good: builds on the models developed by CMEMS (Copernicus Marine Services) and the Mercator Océan activities.	
Data maturity	• Good: builds on Copernicus and the data streams contributing to CMEMS (Copernicus Marine Services).	
Development cost	•	
Maintenance cost	•	

Use Case #18: Climate resilient integrated river basin management plans

Abstract

Use of DestinE for the development of climate resilient integrated river basin management plans used by water authorities, connecting to the work done by Member States under the Directive 2007/60/EC of the European Parliament and of the Council of 23 October 2007 on the assessment and management of flood risks and the EU Water Framework Directive.

Components

The use case main components are described in Table 18.

Table 18. Components characterizing the "Climate resilient integrated river basin management plans" use case.

Component	Value	Intensity of preference (1-9)
Goals [activities]	• Development of climate resilient integrated river basin management plans ○ connecting to the work done by Member States under the Directive 2007/60/EC of the European Parliament and of the Council of 23 October 2007 on the assessment and management of flood risks and the EU Water Framework Directive	
Actors [roles]	• Water authorities	
Potential contribution to broader DT	• Connection to the "Freshwater and Marine Modelling Framework" use case and to the "Sea Level Rise, Hydrology" use case. • Connection to the "Rapid analysis in CLIMA responding to requests on risks and adaptation" use case.	
Beyond State-of-Art	• Utilization of the DTs introduced by the connected use cases –in particular the "Freshwater and Marine Modelling Framework" one.	
Science/modeling maturity	• The present frameworks developed for the assessment and management of flood risks and for the EU Water Framework Directive.	

	• Utilize the modeling capacity developed by marine and water communities.	
Data maturity	• Builds on existing data streams developed by the marine and water communities.	
Development cost	•	
Maintenance cost	•	

Use Cases to be Further Developed

Use Case #19: Digital Twins of local/urban areas

Abstract

Urban areas are complex ecosystems with very dynamic economic, ecological, and demographic conditions. Besides, urban areas are the ground for interactions of divergent perceptions and interests of citizens and stakeholders. Hence, in the field of urban planning, there is a need for approaches and systems to cope with urban complexity while allowing for participatory and collaborative processes to empower citizens.

Smart urban areas are opening the way for the collection of so-called "big data" (i.e. simply, cheaply, and efficiently created databases or sensor networks (internet of things, IoT)), which collects information from various sources to test and create sophisticated simulations on urban processes and also behavioral aspects of their citizens.

In the realm of urban areas, a DT (DT) is a virtual model of a local district, a replica of the physical world. A DT allows to visualize the pulse of the urban district in real time with layered data sources of buildings, urban infrastructure, mobility networks, utilities, businesses, movement of people and vehicles. A DT of a local area has several objectives: virtual experimentation, test-bedding, decision-making and research & development.

Components

The use case main components are described in Table 19.

Table 19. Components characterizing the "[TITLE]" use case

Component	Value	Intensity of preference (1-9)
Goals [activities]	• **Develop an urban area DT** ○ **[Mobility & Spatial planning]**: help local areas to become more environmentally, economically and socially sustainable. ○ **[Disaster preparedness]**: provide useful information in real-time, like which areas are flooded, which infrastructure will be closed down, which hospitals could be affected and thus allowing city managers to take immediate action. By having real-time information of any emergency, planners could allocate resources, plan for operations and optimize traffic**,** which would improve by itself many other urban systems and improve cities resilience. ○ **[Prediction and control of diseases]:** To combat the outbreak of an infectious disease, virtual societies can be created in cyberspace by combining geographical and transport information with DTs of people mapping their activity and relationship patterns to accurately make predictions of the spread of the infection.	
Actors [roles]	• Local Authorities and local Communities	
Potential contribution to broader DT	• Possibly, to be connected in the future with federation of Urban DTs and Smart Communities data spaces.	
Beyond State-of-Art	• Too early to say	
Science/modeling maturity	• There exists a development on urban DTs, which is gaining momentum, building on gaming environments, that needs scaling up at the European level.	
Data maturity	• There is the challenge of bringing together heterogeneous data from multiple stakeholders.	
Development cost	•	
Maintenance cost	•	

Use Case #20: Bindustrial revolution 4.0: the Internet of bins

Abstract

The range and volume of waste collected, moved, sold, processed or disposed of by the waste management industry generates a tremendous amount and velocity of data. Up until now, this data has not been captured very well, let alone shared. Nor has the wider industry turned to what little data is available to help drive efficiencies, innovations or new business models.

The Waste Shipment Regulation (EC) No 1013/2006 (EC SWD(2020) 26 final) demonstrated to perform well on its environmental objectives. However, several challenges exist, including: the lack of consistent implementations, the administrative burden related to procedures, and the lack of harmonization in enforcement. Therefore, it is recommended to generate good practices and develop a use case (a *DT Nexus use case)* with the following aims in mind:

1. a standardized and coordinated system across Europe would contribute to harmonisation;
2. has the potential to increase efficiency while also reducing the likelihood of administrative errors;
3. allowing for more resources to be redirected into inspections for illegal shipments.

Components

The use case main components are described in Table 20.

Table 20. Components characterizing the "Bindustrial Revolution 4.0: the Internet of Bins" use case

Component	Value	Intensity of preference (1-9)
Goals [activities]	• Develop a digital waste tracking system ○ [Digitally track the many hundreds of millions of waste movements across and out a MS, every year] ○ [Apply a Topolytics approach by using mapping and spatial intelligence] ○ [Ingest and analyze waste data from multiple sources, qualify and check it before applying data science/ML to generate insights]	
Actors [roles]	• Geospatial Experts and Data Providers	
Potential contribution to broader DT	• Develop a DT for waste tracking	
Beyond State-of-Art	• Exploit IoT interconnectivity and modeling of dynamic data stream to support policy enforcement and Green Deal objectives.	
Science/modeling maturity	• Possible connection to smart transport and modeling of connected mobility.	

Data maturity	• Low: data streams to be developed and stakeholders engagement yet to be assured.	
Development cost	•	
Maintenance cost	•	

Use Case #21: Development of city adaptation plans

Abstract

Use of DestinE to support the development of local level / city adaptation plans, including both step 3 and 4 of the policy process. Could build on the work done to date such as the Climate-ADAPT Urban Adaptation Support Tool, the work done of the EU and Global Covenant of Mayors, the demonstration of the RESIN (Climate Resilient Cities and Infrastructure) adaptation options library, and use of atlases to support provincial planning policies.

Components

The use case main components are described in Table 21.

Table 21. Components characterizing the "Development of city adaptation plans" use case.

Component	Value	Intensity of preference (1-9)
Goals [activities]	• Development of local level / city adaptation plans ○ including both step 3 and 4 of the policy process.	
Actors [roles]	• City administrators and related society communities	
Potential contribution to broader DT	• Connection to the "Rapid analysis in CLIMA responding to requests on risks and adaptation" use case. • Possible connection to DT of Local/Urban areas use case and to the Bindustrial Revolution 4.0: the Internet of Bins use case. • Possibly, to be connected in the future with federation of Urban DTs and Smart Communities data spaces	
Beyond State-of-Art	• Hyper-resolution models of Earth natural components. • Exploit IoT interconnectivity and modeling of dynamic data stream to support policy enforcement and Green Deal objectives • Integration of socio-economic data streams and modeling	
Science/modeling maturity	• Build on the work done to date such as the Climate-ADAPT Urban Adaptation Support Tool, the work done of the EU and Global Covenant of Mayors, the demonstration of the RESIN (Climate Resilient Cities and Infrastructure) adaptation options library, and use of atlases to support provincial planning policies. • There exists a development on urban DTs, which is gaining momentum, building on gaming environments, that needs scaling up at the European level.	

Data maturity	• Connected to ESA, EUMETSAT, and ECMWF data. • There is the challenge of bringing together heterogeneous data from multiple stakeholders.	
Development cost	•	
Maintenance cost	•	

Use Case #22: Nowcast modelling for emergency response operations

Abstract

Building on the experience and tools developed by the JRC, the computing power and geophysical data available to DestinE could be used to offer reliable and real-time models and assessments for Natech events. Currently, this work needs to be done by highly trained scientists, and updates are limited to the capabilities available to emergency response organizations at any moment. Under this user case, an ideally global and automatic modelling system could offer complementing analysis regarding the development, impact and safety issues around Natech events.

Components

The use case main components are described in Table 22.

Table 22. Components characterizing the "Natech Events and Nowcast Modelling for Emergency Response Operations" use case

Component	Value	Intensity of preference (1-9)
Goals [activities]	• Emergency Response Operations ○ Nowcast Modelling	
Actors [roles]	• Emergency response organizations; national/European Civil Protection	
Potential contribution to broader DT	• Connected to the Accelerating Disaster Risk Management use cases and the Extreme weather DT proposed by ECMWF and ESA. • Possibly, contribute to the Rapid Analysis in CLIMA responding to requests on risks and Adaptation use case.	
Beyond State-of-Art	• Develop nowcasting and forecasting capabilities.	
Science/modeling maturity	• Builds on existing modeling activities –e.g. ECMWF and EUMETSAT ones.	
Data maturity	• Builds on the Copernicus data services.	
Development cost	•	
Maintenance cost	•	

Use Case #23: Light touch climate risk assessment for adaptation

Abstract

Use of DestinE to develop light touch Climate Risk Assessments for Adaptation for smaller climate proofing projects and more conventional investments such as roads. Could build on the work done to date on applicability of qualitative assessment tools (JASPER/EUFIWACC), landslide susceptibility mapping to select location for refugee camps, and application of the Roadapt quick scan etc.

Components

The use case main components are described in Table 23.

Table 23. Components characterizing the "Light touch Climate Risk Assessment for Adaptation for smaller climate proofing projects and more conventional investments" use case.

Component	Value	Intensity of preference (1-9)
Goals [activities]	• Develop light touch Climate Risk Assessments for Adaptation for smaller climate proofing projects and more conventional investments such as roads	
Actors [roles]	• DG REGIO / DG CLIMA / EIB • Policy makers, and relevant society communities	
Potential contribution to broader DT	• Connection to the "Rapid analysis in CLIMA responding to requests on risks and adaptation" use case	
Beyond State-of-Art	• Hyper-resolution models of Earth natural components. • Integration of socio-economic data streams and modeling.	
Science/modeling maturity	• Builds on ECMWF modeling. • Builds on the work done to date on applicability of qualitative assessment tools (JASPER/EUFIWACC), landslide susceptibility mapping to select location for refugee camps, and application of the Roadapt quick scan etc.	
Data maturity	• Connected to ESA, EUMETSAT, and ECMWF data.	
Development cost	•	
Maintenance cost	•	

Use Case #24: Analysis of Climate Risks for Business

Abstract

Use of DestinE to develop analysis of climate risks for a business, including climate related financial disclosure for physical climate change risk analysis, to assess the climate risk off assets or investments as well as analysis of adaptation options.

Components

The use case main components are described in Table 24.

Table 24. Components characterizing the "Analysis of climate risks for business to assess climate risk of assets or investments, analysis of adaptation options" use case.

Component	Value	Intensity of preference (1-9)
Goals [activities]	• Develop analysis of climate risks for a business ○ climate related financial disclosure for physical climate change risk analysis ○ assess the climate risk off assets or investments ○ analysis of adaptation options	
Actors [roles]	• Business / private sector	
Potential contribution to broader DT	• Connection to the "Rapid analysis in CLIMA responding to requests on risks and adaptation" use case.	
Beyond State-of-Art	• Utilization of the use case introduced by the "Rapid analysis in CLIMA responding to requests on risks and adaptation".	
Science/modeling maturity	• Builds on modeling frameworks developed by the climate and financial communities.	
Data maturity	• Builds on existing data streams developed by climate and financial communities.	
Development cost	•	
Maintenance cost	•	

Use Case #25: Analysis of role of insurance for transferring risks at European scale

Abstract

Use of DestinE to support the analysis of the role of insurance as a risk transferring tool at a European scale and for a wider set of users. Including an analysis of different insurance systems and policy differentiation to enhance adaptation (global as well as national). Could build on the work done to date, including flood risk management through insurance incentives in the EU and demonstration of models at a national level.

Components

The use case main components are described in Table 25.

Table 25. Components characterizing the "Analysis of role of insurance for transferring risks at European scale" use case.

Component	Value	Intensity of preference (1-9)
Goals [activities]	• Support the analysis of the role of insurance as a risk transferring tool at a European scale and for a wider set of users ○ analysis of different insurance systems and policy differentiation to enhance adaptation (global as well as national)	
Actors [roles]	• DG CLIMA / DG ECHO / Private sector	
Potential contribution to broader DT	• Connection to the "Rapid analysis in CLIMA responding to requests on risks and adaptation" use case. • Connection to the "Accelerating Disaster Risk Management" use case.	
Beyond State-of-Art	• Utilization of the connected use cases –in particular the "Accelerating Disaster Risk Management" one.	
Science/modeling maturity	• Builds on the work done to date, including flood risk management through insurance incentives in the EU and demonstration of models at a national level	
Data maturity	• Builds on the existing data streams developed by climate and insurance communities.	
Development cost	•	
Maintenance cost	•	

Use Case #26: Support for Member States national adaptation plan development

Abstract

Use of DestinE to assessing the role of human induced global warming in the definition of hazard occurrence and intensity, and societal CBA for options appraisal under different scenarios supporting National Adaptation Plan development.

Components

The use case main components are described in Table 26.

Table 26. Components characterizing the "Support for Member States National Adaptation Plan development" use case.

Component	Value	Intensity of preference (1-9)
Goals [activities]	• Assess the role of human induced global warming in the definition of hazard occurrence and intensity, and societal CBA for options appraisal under different scenarios supporting National Adaptation Plan development	
Actors [roles]	• Member States and policy makers	
Potential contribution to broader DT	• Contribute to the "Accelerating Disaster Risk Management" use case. • Connection to the "Rapid analysis in CLIMA responding to requests on risks and adaptation" use case.	
Beyond State-of-Art	• Utilizes/contribute to the DTs of the connected use cases.	
Science/modeling maturity	• Connected to ECMWF modeling on extreme events. • Connected to the human settlement modeling frameworks.	
Data maturity	• Connected to ESA, EUMETSAT, and ECMWF data. • Connection with national and European statistical data.	
Development cost	•	
Maintenance cost	•	

Use Case #27: Complex interdependencies affected by natural or man-made disasters

Abstract

In line with the work already started by JRC through the Geospatial Risk and Resilience Assessment Platform (GRRASP) model, a real time and global forecasting and nowcasting platform to assess the impact of natural and man-made events in critical nodes would be extremely useful.

In the face of an upcoming or ongoing natural event, modelling tools offering impact forecasts of critical nodes would be essential to anticipate the impact of that event not only in classical means (area and population affected), but identifying the affected nodes and thus offering a chance to target support and assistance in a way that restores the capabilities of the affected system as soon as possible. This forecasting and nowcasting modelling support can also complement and even anticipate on-the-ground impact assessments, hence supporting the early mobilization of targeted response teams even before classic needs assessment teams reach the affected area.

For man-made hazards, nowcasting elements become even more essential, particularly for technological events. For other man-made events such as those related to health, the forecast element can help decision-makers in the face of complex decisions. The user case is based on complex interdependencies

and the notion that critical nodes, either by standing of failing, determine the resilience of the whole system.

Components

The use case main components are described in Table 27.

Table 27. Components characterizing the "Complex Interdependencies and Critical Nodes Affected by Natural or Man-made Disasters" use case

Component	Value	Intensity of preference (1-9)
Goals [activities]	• Develop modelling tools offering impact forecasts of critical nodes would be essential to anticipate the impact of that event not only in classical means (area and population affected), but identifying the affected nodes and thus offering a chance to target support and assistance in a way that restores the capabilities of the affected system as soon as possible	
Actors [roles]	• DG ECHO and the national/European Civil Protection	
Potential contribution to broader DT	• Connected to the Accelerating Disaster Risk Management use cases and the Extreme weather DT proposed by ECMWF and ESA. • Possibly, contribute to the Rapid Analysis in CLIMA responding to requests on risks and Adaptation use case.	
Beyond State-of-Art	• Develop nowcasting and forecasting capabilities.	
Science/modeling maturity	• Build on existing modeling activities –e.g. ECMWF and EUMETSAT ones.	
Data maturity	• Build on the Copernicus data services.	
Development cost		
Maintenance cost		

Use Case #28: Climate risk assessment and adaptation for major European infrastructure investments

Abstract

Use of DestinE to develop Climate Risk Assessment and Adaptation options for major European infrastructure investments with high climate sensitivity, to enable climate proofing both of existing infrastructure investments, and new projects, Type 1 projects etc. Including decision-making under uncertainty.

Components

The use case main components are described in Table 10.

Table 28. Components characterizing the "Climate Risk Assessment and Adaptation for major European infrastructure investments with high climate sensitivity" use case.

Component	Value	Intensity of preference (1-9)
Goals [activities]	• Develop Climate Risk Assessment and Adaptation options for major European infrastructure investments characterized by high climate sensitivity ○ enable climate proofing both of existing infrastructure investments, and new projects, Type 1 projects etc. ○ decision-making under uncertainty	
Actors [roles]	• DG REGIO / DG CLIMA / EIB • Policy makers, and relevant society communities	
Potential contribution to broader DT	• Connection to the "Rapid analysis in CLIMA responding to requests on risks and adaptation" use case.	
Beyond State-of-Art	• Hyper-resolution models of Earth natural components. • Integration of socio-economic data streams and modeling.	
Science/modeling maturity	• Builds on ECMWF modeling.	
Data maturity	• Connected to ESA, EUMETSAT, and ECMWF data.	
Development cost		
Maintenance cost		

Use Case #29: Agriculture-food- biodiversity-systemic risks

Abstract

The scope of this use case is covering global (beyond the Europe) dimensions, trade and security/risks aspects. The aim is to identify environmental emergences and opportunities for good environment performance, improve anticipated governance, preparedness and build resilience (ecological and societal) taking into account planetary boundaries framework and global aspects across the STEEP framework - Social, Technical, Environmental, Economic, Political dimensions of European-global interactions. DestinE could bring together and integrate the key data needed for informing the above assessments. The data are currently very spread, partially non-accessible and non-harmonised. It could then provide and refine the methodologies and tools to explore the relationships. A valuable reference is the EEA's recent Planetary Boundaries report[8].

[8] https://www.eea.europa.eu/publications/is-europe-living-within-the-planets-limits

Components

The use case main components are described in Table 29.

Table 29. Components characterizing the "Agriculture-food- biodiversity-systemic risks" use case.

Component	Value	Intensity of preference (1-9)
Goals [activities]	• Identify environmental emergences and opportunities for: ○ good environment performance ○ improve anticipated governance ○ preparedness and build resilience (ecological and societal) taking into account planetary boundaries framework and global aspects across the STEEP framework.	
Actors [roles]	• DG ENV, European Parliament, DG RTD/JRC (Foresight part and food safety part), Research Service (GMTs and quite some past work on food), EEA Member Countries.	
Potential contribution to broader DT	• Possible connection with the "Accelerating Disaster Risk Management" use case. • Possible connection with the "Climate Change Adaptation in Agriculture" use case.	
Beyond State-of-Art	• DestinE could bring together and integrate the key data needed for generate the require intelligence and make assessments	
Science/modeling maturity	• Methodologies and tools must be further investigated.	
Data maturity	• The data are currently very spread, partially non-accessible and non-harmonised.	
Development cost	•	
Maintenance cost	•	

Use Case #30: Socio-ecological resilience

Abstract

The future environment and climate impacts of transport and mobility, air pollution and noise to social cohesion, people's health and well-being and ecosystem resilience.

This future-oriented use case would focus primarily on the application of a horizon scanning approach and from there elaborate on possible future benefits as well as systemic risks. It is addressing parts of the zero pollution ambitions of the European Green Deal. DestinE support would provide the opportunity to test how emerging technology and tools can help in horizon scanning and enable access to the ground and accurate information input. It could also test how new sources of data in future assessments can be used and where there are difficulties and strengths of such approaches. At a later phase, the use case has the

potential to be expanded to cover general, regular horizon scanning activities for use by other projects. A valuable reference is EEA's recent TERM report[9].

Components

The use case main components are described in Table 30.

Table 30. Components characterizing the "Socio-Ecological resilience" use case.

Component	Value	Intensity of preference (1-9)
Goals [activities]	• The future environment and climate impacts of transport and mobility, air pollution and noise to social cohesion, people's health and well-being and ecosystem resilience ○ horizon scanning approach and elaboration on possible future benefits as well as systemic risks • Address parts of the zero pollution ambitions of the European Green Deal.	
Actors [roles]	• DG ENV, RTD, JRC (HS and resilience part), KIC Climate, EEA Member Countries through the National Reference Centres for Air Pollution, Transport, Noise, Health and Foresight ○ Some of them are knowledge co-creators but many are also important users	
Potential contribution to broader DT	• Possible connection with the "Accelerating Disaster Risk Management" use case. • Possible connection with the "Climate Modeling" and "Rapid analysis in CLIMA responding to requests on risks and adaptation" use cases.	
Beyond State-of-Art	• DestinE support would provide the opportunity to test how emerging technology and tools can help in horizon scanning and enable access to the ground and accurate information input.	
Science/modeling maturity	• Methodologies and tools must be further investigated.	
Data maturity	• Opportunity to test how new sources of data in future assessments can be used and where there are difficulties and strengths of such approaches.	
Development cost	•	
Maintenance cost	•	

[9] https://www.eea.europa.eu/publications/the-first-and-last-mile

Interviewed Policy DGs and Stakeholders

For the preparation of this document, we engaged with a set of policy DGs and relevant Stakeholders, asking them to help and support us in the collection of information on the role of DTs for addressing the European policy goals and objectives and to submit one or more use scenarios. We are particularly in debt to the colleagues in the European Commission DG CLIMA A3, DG DEFIS C3, DG RTD C3 and C4, DG ENV E4, DG ECHO A3, DG AGRI DDG2.D.3, DG JRC as well as colleagues in the European Environment Agency, European Space Agency, Eumetsat, European Centre For Medium Weather Forecast, and Mercator-Ocean.

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Annex

Evaluation Scheme

The AHP method requires the definition of a hierarchy of *Criteria* (and optionally *sub-Criteria*) to reach a given *Goal*. Once the hierarchy is achieved, it must be evaluated as to the importance of each criterion referred to the others –a normalized weighting approach is largely utilized. Eventually, the available alternatives (i.e. use case proposals) are evaluated giving a score for each *Criterion*/*sub-Criterion*.

To analyses and prioritize the use case proposals, the defined hierarchy is depicted in Figure 1. The hierarchy is characterized by two priorities (i.e. the intensity of importance of each criterion in respect to its sibling), i.e. “Anticipatory potentiality” and “Link to Policy”. The importance intensities can be changed by modifying the weights, which are equals presently.

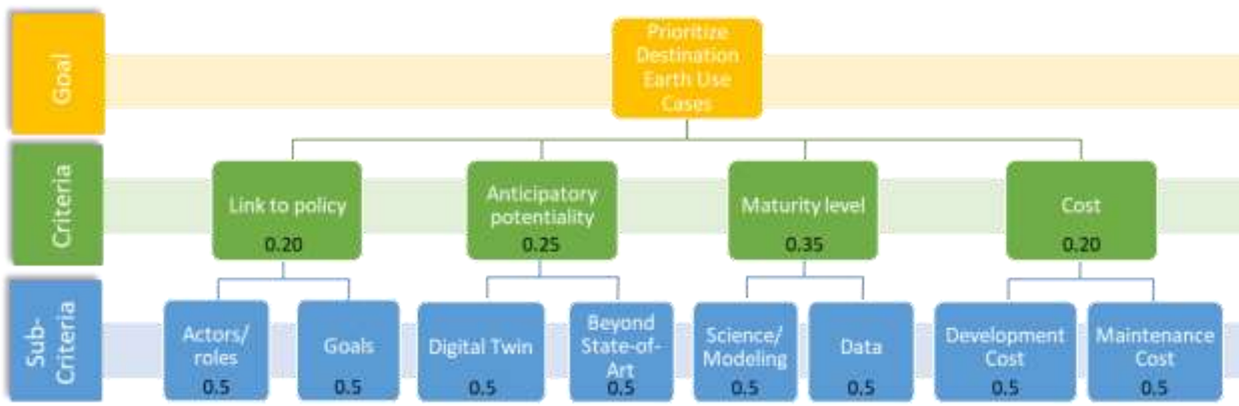

Figure 1. Analysis hierarchy utilized for use case prioritization

Criteria and sub-criteria ontology

Given different values of a (sub-)criterion, there exist several practices to compare them, either singly or pairwise –commonly used with AHP. Considering the number of alternatives and criteria, we analyzed the values singly against a common scale, by assigning a score from 1 to 9 that represents their intensity of preference. Most of the components are describe in the ontology showed in Figure 2.

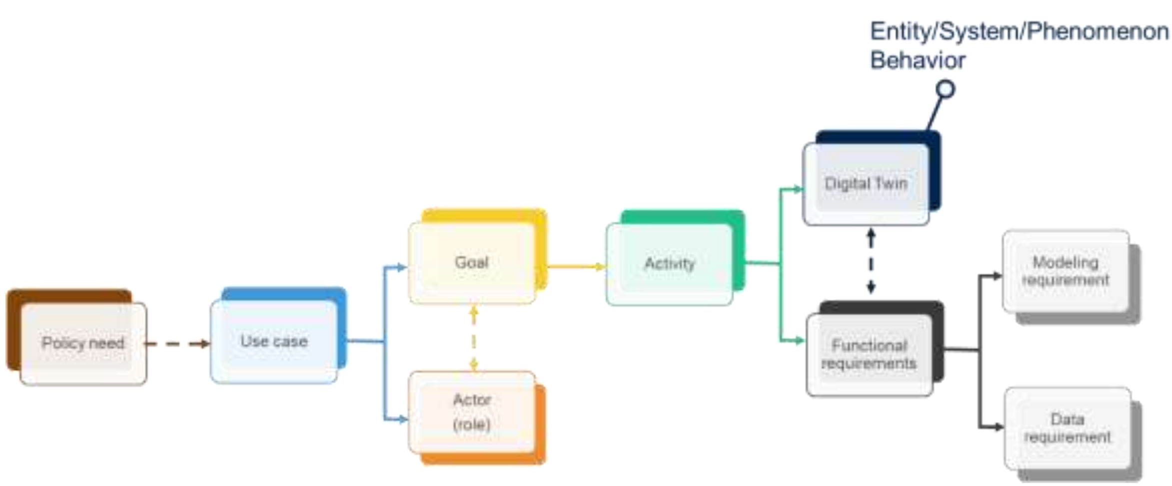

Figure 2. Use case components concepts and relationships.

DTs policy area viewpoint

A policy area DT can address/integrate/cross-fertilize the different use cases, which contribute to similar policy needs, serve the same users, and engage with analogous stakeholders, and raise the game beyond incremental improvements. In this way, policy area DTs can deliver a “system effect”. The recognized DTs are described in Table 31.

Table 31. DestinE DTs

Policy area DT	[Proposer] Use Cases	State-of-Art advancement	Possible Users/ stakeholders

"Extreme Earth" (disaster risk management from extreme weather-induced natural disasters)	• *Accelerating disaster risk management*
	• *Global security indices in a natural disaster environment*
	• *Rapid analysis of risks in climate adaptation options*
	• *Real time evolution of forest fires*
	• *Detailed medium-term seasonal forecasts on hurricanes and typhoons.*
	• *Big Data streams for ocean and carbon modelling*
		• Go beyond the limits in:
		  ○ resolution of meteo data
		  ○ timeliness of meteo information
		  ○ details of terrain, vegetation, humidity and other parameters
		  ○ modelling medium-term cyclone development potential
		  ○ disaster impact modelling of critical nodes
		• Provide timely information on exposure of human settlements and fine scale hazard and risk information.
		• Increased resolution in cyclone tracking models
		• Increased predictability of extreme events on the short to medium range as well as decadal scales.
			• Civil Protection
			• Humanitarian aid organizations
			• Advanced users
			  ○ e.g. public authorities
			• Expert users
			  ○ e.g. research institutions
			• Policy DGs (e.g. DG CLIMA, DG DEVCO, DG ENV, DG REGIO, DG ECHO)
			• ECMWF, ESA, EUMETSAT
			• Members States
			• Business and Private sector

Climate adaptation (food and water supply security).	• *Rapid analysis of risks in climate adaptation options*
	• *Climate change adaptation in agriculture*
	• *Agricultural monitoring & CAP*
	• *Climate modeling*
	• *Ecosystems monitoring and modeling*
	• *Big Data Streams for ocean and carbon modelling*
	• *Climate resilient rural and agricultural planning*
	• *Analysis of the external (global) impacts of climate change adaptation on Europe*
		• Develop modelling requiring significant computational power.
		• Improve uncertainty in climate predictions and projections, regional downscaling, and evaluation against observations.
		• Reduce inter-model spread and produce robust projections, forming the European contribution to a CMIP6 High-resolution Model Inter-comparison project (HIRESMIP).
		• Improve the coupled climate-crop-ABM[10] approach.
		• Improve the current crop modelling systems.
		• Provide high-resolution multiple ensembles of decadal climate predictions
		  ○ improved data ingestion
		  ○ better initialization and bias/drift-adjusting procedures.
		• Development of large-scale ABMs methods
		  ○ training with AI methods and different data sources.
		• Provide advanced, high resolution modeling through integration of
		  ○ high end computing solutions
		  ○ modern ML[11] and AI inference techniques
		• Develop climate and ecological models able to generate future ecosystem projections and estimate projections uncertainties.
		• Quantify carbon stocks and the fluxes of carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O) across the EU and in the US, China and Indonesia based on independent observations.
			• Policy officers and other Managers.
			• Providers and Experts
			  ○ e.g agro-climatic-economic experts
			  ○ experts of decadal climate predictions
			  ○ experts on large-scale ABMs
			  ○ experts on AI and behavioral modelling
			• Data and solution Providers including ECMWF, EUMETSAT
			• Local authorities
			• Policy DGs (e.g. DG CLIMA, DG REGIO)

[10] Agent Based Model
[11] Machine Learning

Digital oceans around food and energy	• *Digital models of the ocean*
	• *Freshwater and marine modelling framework*
	• *Sea level rise, hydrology*
	• *Big data streams for ocean and carbon modelling*
	• *Renewable marine energy*
	• *Marine food modelling*
	• *Climate resilient integrated river basin management plans*
		• Develop digital interactive replicas of the oceans.
		• Deliver interactive virtual tools of the ocean in a unified digital environment.
		• Simulate the conditions of marine ecosystems under a set of external stressors
		  ○ Complex system that requires HPC facilities to perform simulations
		• Improve predictions and management of hydrological extremes.
		  ○ Provides innovative approaches, tools and practical case studies to advance our ability to anticipate and respond to future hydrological extreme events.
		• Develop data streams to feed DTs virtualizing Earth system components.
		  ○ To build an efficient integrated Arctic Observation System by extending, improving and unifying existing systems in the different regions of the Arctic.
		  ○ To build an Atlantic Ocean observing system building on heterogeneous international, national and regional in-situ data systems.
		• Provide more frequent updates of ocean conditions.
		• Provide higher resolution coastal models for wave / ocean currents /biogeochemistry.
		• Integrate new automated sensors and autonomous platforms.
		• Utilize unstructured data from unorthodox sources such as citizen science or historic data.
		• ·Contribute to significantly increase the capacity to observe coastal and marine waters, the sharing, availability, visualisation and use of data.
			• Resource Providers (including Mercator Océan and Citizen Science activities)
			• Experts & scientists
			• Water authorities
			• Policy officers and other Managers
			• Practitioners & Citizens
			• Environmental companies and agencies
			• Companies running renewable energy test sites

Glossary

AI	Artificial Intelligence
ACELD	Armed Conflict Location & Event Data project
CAP	Common Agriculture Policy
CBA	Cost-benefit analysis
CFP	Common Fisheries Policy
CMEM	Copernicus - Marine environment monitoring service
COM	(European) Commission
DT	Digital Twin
DTE	Digital Twin Earth
EC	European Commission
ECMWF	European Centre for Medium-Range Weather Forecasts
ECOPOTENTIAL	H2020 ECOPOTENTIAL project
EEA	European Environmental Agency
EFFIS	Emergency Management Service
ERIC	European Research Infrastructure Consortium
ESA	European Space Agency
ESM	Earth System Models
EwE	Ecopath with Ecosim
FMMF	Freshwater and Marine Modelling Framework
GCM	Global Climate Model
GTEM	General Estuarine Transport Model
GOTM	General Ocean Turbulence Model
HIRESMIP	High-resolution Model Inter-comparison project
HPC	High Performance Computing
HQ	Headquarter
HWRF	Hurricane Weather Research and Forecasting model
INFORM project	a collaboration of the Inter-Agency Standing Committee Reference Group on Risk, Early Warning and Preparedness and the European Commission
KPI	Key Performance Indicator
MARS	Monitoring Agricultural ResourceS project
ML	Machine Learning
MS	(European Union) Member State
MSFD	Marine Strategy Framework Directive
NATECH	Natural Hazard Triggering Technological Disasters
NCEP	US National Centers for Environmental Prediction
NGO	Non-governmental organization
NOAA	US National Oceanic and Atmospheric Administration
RESIN	RESIN project
RESM	Regional Earth System Model
RIBASIM	River Basin Planning and Management
SDG	Sustainable Development Goals
STEEP	Social-Technological-Environmental-Economic-Political analysis framework
SWAT	Soil & Water Assessment Tool
UNODC	United Nations Office on Drugs and Crime

WEAP	Water Evaluation And Planning System

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