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D4.7

Plan for the engagement of Space Agencies and International initiatives in EPOS

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Executive Summary

This deliverable describes the plan for the engagement of the stakeholders for the EPOS TCS Satellite data (TCS SATD). In particular, the deliverable focuses on the relationships with the space agencies and their role within the TCS SATD, the international Earth Observation initiatives that contribute to the enhancement of the satellite Earth Observation sector, and the user communities interested in the exploitation of the services deployed by the TCS SATD. Finally, the deliverable addresses the evolution of the European Cloud Computing infrastructures that may play a key role for the long-term sustainability of the TCS SATD. Indeed, ESA and Copernicus Programme are fostering the development of advanced cloud computing environments and thematic platforms designed to meet the satellite scientific community needs and the TCS SATD may profitably benefit from the large investments that European Commission is doing in this framework.

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1. Introduction

EPOS (European Plate Observing System) is the pan-European research infrastructure aimed at ensuring sustainable and universal use and re-use of multidisciplinary solid Earth science data and products fostering state-of-the-art research and innovation. EPOS has evolved from a simple concept to integrate and distribute digital data into a distributed research infrastructure for European solid Earth science, integrating existing research infrastructures to enable innovative multidisciplinary and cross-disciplinary research. The EPOS Research Infrastructure (EPOS RI) has completed its Implementation Phase (2015-2019) achieving a cornerstone in its lifecycle and it is currently facing the transition from the Implementation to the Operational Phase. Starting from 2020, a particular stage of the lifecycle of the EPOS RI started: the EPOS Pilot Operational Phase" (EPOS POP1). It will last three years (2020-2022) and it will be coordinated by the EPOS ERIC. The EPOS SP project represents an essential contribution to the EPOS POP because it contributes in keeping the communities committed to support the building of the EPOS Delivery Framework.

Among the various communities that contribute to EPOS, the satellite one, represented by the Thematic Core Services (TCS) Satellite Data (SATD), aims at implementing Earth Observation services, based on satellite observations, transverse to the large EPOS community and suitable to be used in several application scenarios. The main goal of the TCS SATD is to contribute with mature satellite services that have already well demonstrated their effectiveness and relevance in investigating the physical processes that control earthquakes, volcanic eruptions and unrest episodes, as well as those driving tectonics and Earth surface dynamics.

The TCS SATD is organized in National Research Infrastructures. Five institutions (CNR, CNRS, CSIC, INGV, University of Leeds) from five different countries (Italy, France, Spain, and UK) are partners of the TCS. CNR, CNRS, CSIC, and University of Leeds are providers of the services EPOSAR (CNR, Italy), GDM (CNRS, France), 3D-Def (CSIC, Spain), and Comet (UoL, UK). Each service is related to a different National Research Infrastructure.

At this stage, two levels of products and services, focused mainly on the determination of the Earth surface displacements through satellite radar and optical data, are foreseen. The first level (**LEVEL-1**) deals with "standard" satellite products/tools (e.g., SAR interferograms, LOS displacements maps and deformation time-series generation). The second level (**LEVEL-2**) concerns value-added satellite products/tools (e.g., modelling analyses, 3D displacement maps, source mechanisms, fault models, strain maps). The TCS services are mainly based on **Copernicus** data (Sentinel-1/2 datasets); in addition, advanced DInSAR web processing services dealing with archived data (ERS-1/2 and ASAR-ENVISAT) are going to be integrated in the EPOS infrastructure and will be soon available.

[1] https://www.epos-ip.org/about/epos-pilot-operational-phase-pop

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The TCS has a unique thematic interface towards the ICS (Integrated Core Services). This interface is represented by the ESA's **Geohazards Exploitation Platform (GEP),** which is able to provide interoperable access to data products, web processing tools and processing facilities. This unique gateway allows the TCS to have a common structure and standards for metadata, API and AAAI.

The future development of the TCS needs to establish effective links with the space agencies and the international initiatives in the Earth Observation field, to engage and involve within the EPOS infrastructure the satellite data owners, service providers and user communities.

The TCS Consortium Agreement establishes two boards, Space Agency Committee and User Committee, through which space agencies and users representatives can collaborate with the service providers and contribute to the TCS enhancement.

2. National Space Agency engagement

The Space Agencies represent a fundamental stakeholder for the TCS SATD, because they are the main data providers and they support several programs to engage the user communities and access the satellite data. The TCS started from the beginning in cooperating with some space agencies to enhance the development of the implementation phase. In order to ease the involvement of the space agencies in the TCS, the Consortium Agreement allows to have in the TCS consortium associated member, with an observer status without voting rights. Such members has to be sign a Memorandum of Understanding (MoU) with the TCS SATD.

European Space Agency (ESA) contributed to the TCS during the implementation phase. In particular, ESA and EPOS signed some support letters during the EPOS implementation phase and ESA collaborated with the TCS SATD by sharing human resources and IT expertise coming from several projects; in particular the TCS benefitted from the IT advancements developed within the Thematic Exploitation Platform (TEP) projects. The TCS SATD and ESA agreed to sign a MoU to formalize the future cooperation once the implementation phase is concluded.

During the implementation phase, the TCS SATD also cooperated with the French Space Agency (CNES). CNES followed and contributed to the activities carried out to implement the TCS. Similarly to ESA, CNES agreed to sign a MoU with the TCS.

Other national space agencies, such as German, Italian and Spanish, will be engaged in the next months to consider their involvement in the EPOS activities.

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Table I shows the plan to engage the space agencies.

Table I

Space Agency	Country	Engaged	Role	Status
ESA	Europe	Yes	MoU	Drafting MoU
CNES	France	Yes	Mou/TCS partner	In progress
ASI	Italy	No	TBD	-
DLR	Germany	No	TBD	-
INTA	Spain	No	TBD	-

3. International initiative engagement

EPOS is interested in collaborating with the international initiatives acting in the field of the Solid Earth Science. In this context, the TCS SATD is working to engage those activities that can benefit from the services deployed by the TCS or can actively contribute to enhance the TCS partnership by providing mature services for the EPOS community. In this context, the TCS has identified several initiatives or projects, described in the following, that are successfully contributing to the satellite Earth Observation domain and can be stakeholders of the EPOS RI.

NextGEOSS is a centralised European Earth Observation data hub and platform. The concept revolves around providing the data and ICT resources needed, together with cloud services, seamlessly connected to provide an integrated ecosystem to support the deployment of Earth observation-based applications and services. The NextGEOSS project aim was to implement a federated data hub to access and exploit Earth Observation data, including user-friendly tools for data mining, discovery, access and exploitation. The main general objectives for NextGEOSS are to:

1. Deliver the next generation data hub and Earth Observation exploitation for innovation and business;
2. Engage communities, promoting innovative GEOSS powered applications from Europe;
3. Advocate GEOSS as a sustainable European approach for Earth Observation data distribution and exploitation.

NextGEOSS focuses on a fundamental change to facilitate the connectivity to the European and global data centres with new discovery and processing methods. It leverages web and Cloud technologies, offering seamless access to all the relevant data repositories, as well as providing efficient operations for search, processing/re-processing, visualization, analysis of products from federated sources. NextGEOSS includes a set of demonstrative pilot activities, which showcase the system capabilities, and a number of initiatives devoted to engagement of GEO and other EO-related communities.

Within the NextGEOSS project, CNR-IREA, leader of the EPOS TCS satellite community activities, acted as point of contact for the integration of the EPOS TCS satellite community products in the

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data hub (see Fig. 1). The interest for the EPOS community in NextGEOSS was the possibility to promote and enlarge the data accessibility and the EPOS visibility. Data integration was successful and straightforward. Presently, 80 EPOS data sets are available in the NextGEOSS hub and much more will be available when the EPOS Pilot Operational Phase will end.

European Ground Motion Service (EGMS) aims to provide consistent, regular, standardised, harmonised and reliable information regarding natural and anthropogenic ground motion phenomena over Europe and across national borders.

The main objective of the EGMS is to measure ground displacements, including landslides and subsidence, as well as deformation of infrastructure. The ground motion will be derived from time series analyses of Copernicus Sentinel-1 data using Persistent Scatterers and Distributed Scatterers radar interferometry approach. This will be complementary to Global Navigation Satellite Systems (GNSS) and other in situ observations.

EGMS will complement national existing and emerging initiatives, and serve as a foundation for more in-depth national and regional ground motion studies and collaborations. EGMS will provide a wider context and will reduce the cost for access to ground motion data through economies of scale.

Several Copernicus Participating States have already or are in the process of implementing national ground motion services. Germany, Italy, Norway, Spain, Denmark, and France have begun to implement or operate services. The Netherlands and Poland are in the planning process with other

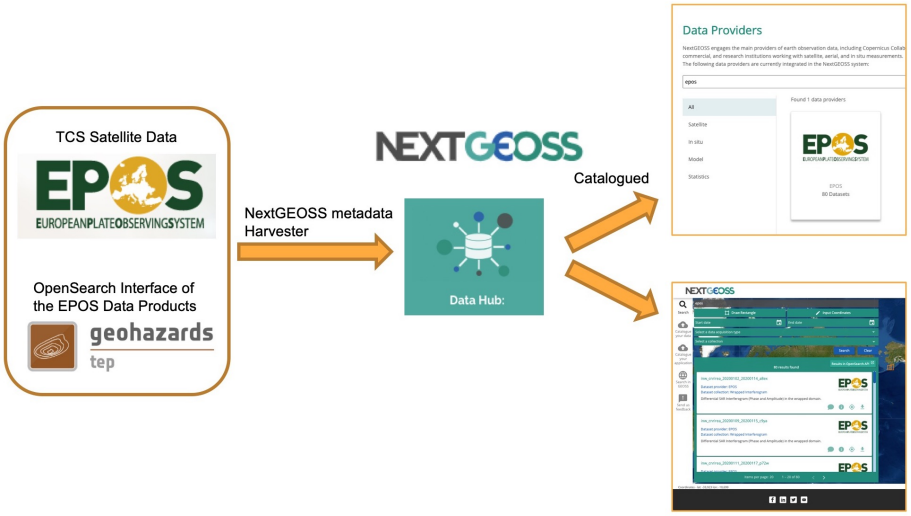

Figure 1: Synoptic block diagram of the connections between the EPOS TCS SATD and the NextGEOSS data hub.

nations expected to follow. All these services will both benefit from and complement the EGMS with it being able to provide a baseline deformation map, and lead an effort to establish norms and

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standardise national service components as much as possible. It can foster the use of the deformation data by both public users and commercial downstream service providers.

The EGMS partnership has been recently defined and the project is starting in the first months of 2021. In the future, TCS SATD and EGMS partnership may profitably interact and collaborate.

The **Geohazard Supersites and Natural Laboratory** initiative (**GSNL**) is a voluntary international partnership established in 2010 within the Group on Earth Observation (GEO), aiming to improve, through an Open Science approach, geophysical scientific research and geohazard assessment in support of Disaster Risk Reduction.

The GSNL goal is pursued to promote broad international scientific collaboration and open access to a variety of space- and ground-based data, focusing on areas with important scientific challenges and high seismic/volcanic risk levels: the Supersites and the Natural Laboratories.

Over these special focus areas a joint effort is carried out: several space agencies grouped under the Committee for Earth Observation Satellites (CEOS) provide satellite imagery at no cost for scientific use, the local geohazard monitoring agencies provide open access to ground-based data, and the global scientific community exploits these data to generate state of the art scientific results, which are openly shared in digital format.

TCS SATD and GSNL partners have already interacted and collaborated, but a formal link between TCS and GSNL has not been still established, mainly because the TCS governance was not appointed, yet.

The **Geohazards Lab** (**GeoLab**) is an initiative within the CEOS WG Disasters to enable greater use of observation data and derived products to assess geohazards and their impact. The CEOS WG Disasters activities are focusing on Disaster Risk Management (DRM), i.e., both Disaster Risk Reduction (DRR) and emergency response, with primary focus on DRR. The Geohazards Lab is a new initiative from space agencies following on and collaborating with Pilots in relevant themes (e.g., in the Seismic, Volcano and Landslides Pilots) and the Recovery Observatory. It is initiated in the context of CEOS with contributions from space agencies and Pilot partners from the geohazards community, primarily geoscience centres engaged in hazard and risk applications based on terrain motion mapping. The Geohazards Lab aims to continue to provide hosted processing as already demonstrated with the Seismic Hazards and Volcano pilots, as well the newly initiated Landslide pilot. It will fully articulate with on- going Pilots and the Recovery Observatory (RO) in particular concerning data delivery and will develop synergies with them.

The initiative is focusing on the sharing of resources to provide a scientific environment for EO data processing and e-collaboration for DRR purposes and for advanced scientific products used in the context of disaster response. It is originated by space agencies with a long-term vision about

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supporting geoscience centres so they can exploit EO data, share results and compare measurements in space and time thanks to a geospatial infrastructure guaranteeing the persistency of measurements and known quality levels of the processing. The Geohazards Lab aims to articulate in an orderly fashion with global, regional and national EO based disaster response capabilities. As an example, it is building on the agreement in place since July 2015 between the International Charter Space & Major Disasters and the CEOS WG Disasters.

TCS SATD partners and GeoLab started some discussions during the EPOS IP project to find a common layer of cooperation. The link between the two initiatives will be established during 2021 when the TCS governance will be fully working and operative.

4. Sustainability study and engagement of European e-infrastructure

An important aim of the EPOS-SP project is to address the sustainability framework of the TCS SATD. In particular the activities will evaluate the capability of the recent European cloud computing initiatives to provide a clear and robust sustainability framework for the TCS SATD services. Indeed, in the last years the European Community is fostering the creation of federating environments with the involvement of new or existing research data infrastructures, to support different EU scientific disciplines for storing, sharing, processing purposes. These initiatives bring together institutional,

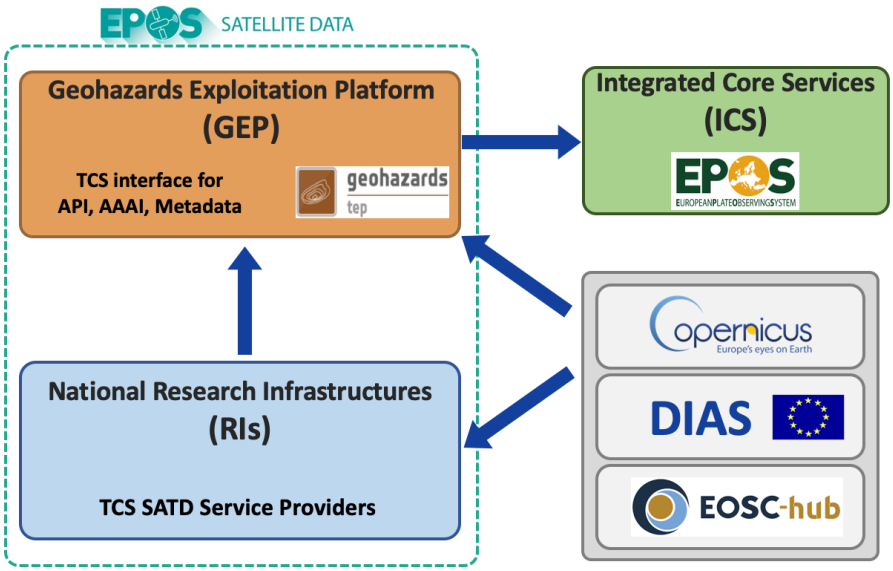

Figure 2: Synoptic block diagram of the connections between the TCS SATD and the European initiatives in the Earth Observation field to support the EPOS scientific community for the study of solid Earth.

national and European stakeholders, initiatives, data infrastructures and scientific platforms to increase the research productivity, to standardize the access to data and improve the reproducibility in science. In this context several initiatives provide facilities and instruments, particularly suitable

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for supporting the needs of the EPOS satellite scientific communities. The European Open Science Cloud (EOSC), the Data and Information Access Services (DIAS) and Geohazards Exploitation Platform (GEP) are the most important European initiatives that the TCS SATD is engaging within the EPOS platform to offer access to satellite data, computing resources and environments to develop and deploy operative EO services. Figure 2 depicts the connections between the TCS SATD and the recent European initiatives to support the research community in the Earth Observation field.

European Open Science Cloud (EOSC)

The European Open Science Cloud (EOSC) is an environment for hosting and processing research data to support EU science. The process to create the EOSC was initiated by the Commission in 2015. It aimed to develop a trusted, virtual, federated environment that cuts across borders and scientific disciplines to store, share, process and re-use research digital objects (like publications, data, and software) following FAIR principles.

The EOSC brings together institutional, national and European stakeholders, initiatives and data infrastructures to develop an inclusive open science ecosystem in Europe. This can lead new insights and innovations, higher research productivity and improved reproducibility in science.

In the last years, the TCS SATD partners have contributed to the EOSC development through several H2020 projects. To implement a sustainability framework, the TCS intends to fully benefit from the potentialities offered by the EOSC galaxy.

Data and Information Access Services (DIAS):

To facilitate and standardise access to data, the European Commission has funded the deployment of five cloud-based platforms with the aim to provide full access to Copernicus data as well as processing facilities. The DIAS engagement within the EPOS platform is nowadays at an advanced status, due to a productive collaboration with the TCS SATD. Various experiments based on exploiting the ONDA and CreoDIAS cloud providers have been developing to evaluate their technical performance and financial effort, by performing use cases based on the exploitation of these environments for the creation of operational services in the Earth Observation field. In this context, A performance assessment to evaluate the suitability of DIAS environment for TCS SATD purposes is essentially based on the analysis of fundamental needs for the EO users community, in particular:

- data archives in close proximity to processing resources, with no need to move large data volumes through external networks;
- access to the data catalogues;

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- on-demand processing services;
- “nearly unlimited” storage and computing resources;
- sizeable, scalable, secure, and reliable infrastructures;
- cost of cloud resources.

The exploitation of advanced environments, such as DIAS, based on cloud computing technologies developed to efficiently serve the satellite EO community, in particular when supported to the European level through the Copernicus Programme, fosters the deployment of TCS mature and operational services.

Geohazards Exploitation Platform (GEP):

The GEP platform aims to support the exploitation of satellite Earth Observations for geohazards, with a primary focus on mapping hazard prone land surfaces and monitoring terrain deformation. GEP provides data processing services and support for the community to integrate their own algorithms on the platform. The GEP supports the geohazards community with on-demand processing for specific user needs or systematic processing to address specific area-of-interest analysis.

The GEP processing portfolio includes basic services providing full resolution imagery and change detection imagery for rapid online visualization and advanced services both for Optical & SAR data processing. The GEP processing services have access to the 70+ Terabytes of ERS and ENVISAT archive data and the Copernicus Sentinel-1 catalogue available online. The optical data such as the Copernicus Sentinel-2 and Sentinel-3 and the third party missions SPOT, Pléiades and Landsat 8 complement the data resources. Finally, the scientists can integrate their applications and make them available as-a-service through the GEP geo-browser to other scientists.

The engagement of the GEP platform within the EPOS RI is at an adavanced stage, as it started during the EPOS-IP project. Currently, all the TCS data and products are accessible through the GEP geo-browser and the platform is fully integrated with the ICS-C. Moreover, the users can access GEP with EPOS credentials and *vice versa*, as the AAAI systems have been successfully integrated. Moreover, some TCS processing services, such as EPOSAR, are available for the EPOS users via the GEP platform that transparently offers scalable and parallel processing/analysis tools over pre-loaded satellite big datasets.

More specifically, GEP represents the front-end for all the web services deployed by TCS SATD (see Fig. 2), being the unique interface for TCS metadata, API and AAAI towards the ICS, as well as it supports the EPOS community in the processing of satellite data to perform studies over specific areas of interest.

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Until now, GEP resources have been freely provided within the ESA's support. TCS and GEP management are now discussing about EPOS support for the resources requested by the TCS SATD; the negotiations are at an advanced stage and an agreement/contract will be formalized in the next months.

5. Engagement Channels and Instruments

Unfortunately, the COVID-19 pandemic situation that has seriously injured the globe, has negatively impacted the engagement activities. However, we are confident that as the COVID-19 crisis will subside we may increase the engagement operations by exploiting different communication channels, such as:

- **Workshops and conferences:** Through project-run workshops and scientific conferences, the space agencies and international initiatives representatives may be involved in new collaborations with TCS Satellite Data. Moreover, these events will help to build partnerships, raise awareness about the EPOS environment, and expand the TCS Satellite Data community.

- **Interviews, consultations and individual meetings:** direct interactions will be carried out by the TCS SATD partners, benefitting from their connections in the EO sector, to engage new stakeholders.

- **Pilot studies and use cases:** The TCS SATD could collaborate with research groups and scientific institutions to identify problems and obstacles in using the TCS Satellite Data resources/services through pilot studies. The implemented use cases will also serve as best-practice examples for future studies.

6. Conclusion

The first 12 months of activity permitted to identify the strategy for the engagement of the national space agency and international initiatives. About the involvement of new or existing European research e-infrastructures to support the TCS SATD, the main role is played by GEP, DIAS and EOSC platforms, that in some cases are mature and operational.

TCS SATD partners already started to engage and collaborate with the several players that contribute to the satellite Earth Observation sector. Next steps will focus on:

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- the establishment of an effective and formal link with the space agencies;
- the engagement of international initiatives and their involvement in the TCS activities;
- the operational use of cloud computing resources for the long-term TCS sustainability;
- the enhancement of the communication channels for the engagement purposes.

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