EPOS SP – Grant Agreement n. 871121

EPOS SP_D5.8 Plan for sustainability of EPOS utilising the ICS

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VERSION	DATE	CHANGE
1	2021-01-08	initial version
2	2021-01-13	Improvement with comments from WP5 leader
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4	2021-01-23	Reviewer comments actioned

Contents

THE EPOS SP PROJECT HAS RECEIVED FUNDING FROM THE EUROPEAN UNION'S HORIZON 2020 RESEARCH AND INNOVATION PROGRAMME UNDER GRANT AGREEMENT N° 871121

1. Executive Summary

This deliverable provides the plan to contribute to the sustainability of EPOS using the Integrated Core Services (ICS) – or more accurately - the assets provided by the TCS (Thematic Core Services) and the access to the assets through the ICS.

Section 2 outlines WP5 of EPOS-SP and the positioning of T5.4 (and hence D5.8) within it and indicates the dependencies on – and hence interactions with - other WP5 tasks and other WPs. The current state of EPOS and the assets is outlined (Sections 3-6) since this is the basis for the offer to industrial and commercial organisations which needs to be understood to appreciate the plan. Section 7 provides the plan, with the Key Performance Indicators (KPIs) to be achieved, the elements of the plan (i.e., what is to be achieved) and the steps of the plan. ANNEX 1 (Section 8) provides the current list of partners and modes of engagement.

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2. Introduction

EPOS-SP WP5 is concerned with strengthening links with the private sector. Task 5.4 is concerned with EPOS services (implemented with the ICS) for research and innovation . The concept is that the services provided through the ICS – as well as being useful for the research/academic community – should also be useful for the commercial/industrial community. This deliverable, D5.8, reviews the available and planned EPOS assets, considers the engagement with the industrial/commercial partners and potential partners, and outlines the plan to make EPOS attractive to industrial/commercial users.

Moreover, as well as industry utilising existing EPOS services, it is intended that industry-produced and owned services could be included in the EPOS-ICS-C catalog and made available (subject to appropriate conditions) to the community (both academic and commercial).

Finally, it is expected that new or improved services should be developed jointly by academia and industry to increase the EPOS services portfolio in the ICS-C catalog and accessed through ICS-C.

All these activities should provide new users and services/assets to EPOS (under certain conditions) thus expanding the use of EPOS, increasing its reach and success, and stimulating further investment for the sustainability of EPOS. This provision of assets (services) will be stimulated by events and training activities advertised and promoted by EPOS Coordination Office (ECO) using the EPOS website.

The achievement of the objectives of T5.4 depends on many factors, most of which are covered by activity in other WPs ad Tasks:

1. Identification of ICS services to support Pilot areas for EPOS collaboration with the private sector (T5.1)
2. Identification of appropriate additional commercial/industrial partners (T5.2);
3. Engagement of the partners identified (T5.2, T5.3);
4. Understanding their requirements and the match to existing EPOS services (T5.2);
5. Understanding their offerings and their relevance to the academic as well as industrial EPOS community (T5.2, T5.3);
6. Understanding their requirements and the need for different EPOS services leading to their development by industry or jointly within an EPOS context;
7. Ensuring services for users are of increased value with appropriate quality, tested and trusted (WP4);
8. Aligning as appropriate industrial stakeholders with the new TCS communities and their services (WP4);
9. Consideration of access to ICS services globally (WP3);

Thus T5.4 supports with services the pilots of T5.1; it supports the interactions leading to engagement with industry of T5.2; it does all this within the financial, legal, governance conditions of T5.3 and supports with the ICS system those aspects; it provides the asset base for discussions and cooperation with other organisations in WP3; and depends on joint work with WP4 activities to ensure user value through tested, robust, trusted services and additional services from additional user communities joining EPOS.

T5.4 also interacts with WP7 for outreach (especially to new communities in industry) and training, support WP6 (Value to Society) and inputs to WP8 Impact on Long-term sustainability.

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3. EPOS Governance and Structure

3.1. Introduction

A brief overview of the EPOS structure and governance is provided since it provides the framework for T5.4 activities with opportunities and constraints.

3.2. Assets, Research Infrastructures, Communities

EPOS is all about geoscience assets and making them available, from their asset stores in the Research Infrastructures (RIs) grouped into communities providing Thematic Core Services (TCS) each representing a sub-domain of Geoscience such as volcanology or seismology. There is a n:m relationship between TCS and RIs, and also between RIs and assets.

3.3. A vision for interoperation

The assets themselves reside in the RIs within the TCS. However, metadata describing the assets (in many different formats) is converted to Common European Research Information Format (CERIF) - an EU recommendation to Member States - and stored in a metadata catalog within the Integrated Core Services (ICS). ICS Central (ICS-C) provides the portal functionality based on the catalog, as well as access to the portals of each TCS. Finally, ICS-C assists users in creating workflows to be executed using e-Infrastructure resources external to EPOS (as well as using the e-Infrastructures at RIs holding the assets within EPOS) - these are instances of ICS Distributed (ICS-D). This is illustrated in (Figure 1). A simplified view of the architecture is presented in (

Figure 2).

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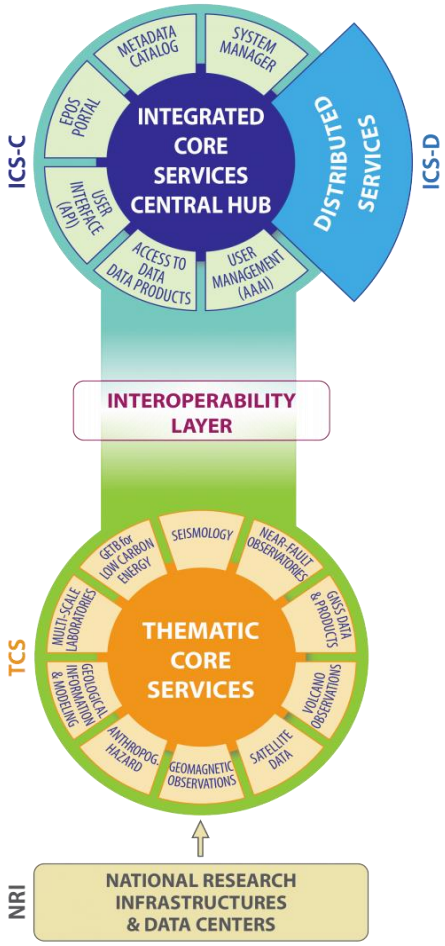

Figure 1: ICS, TCS and RIs

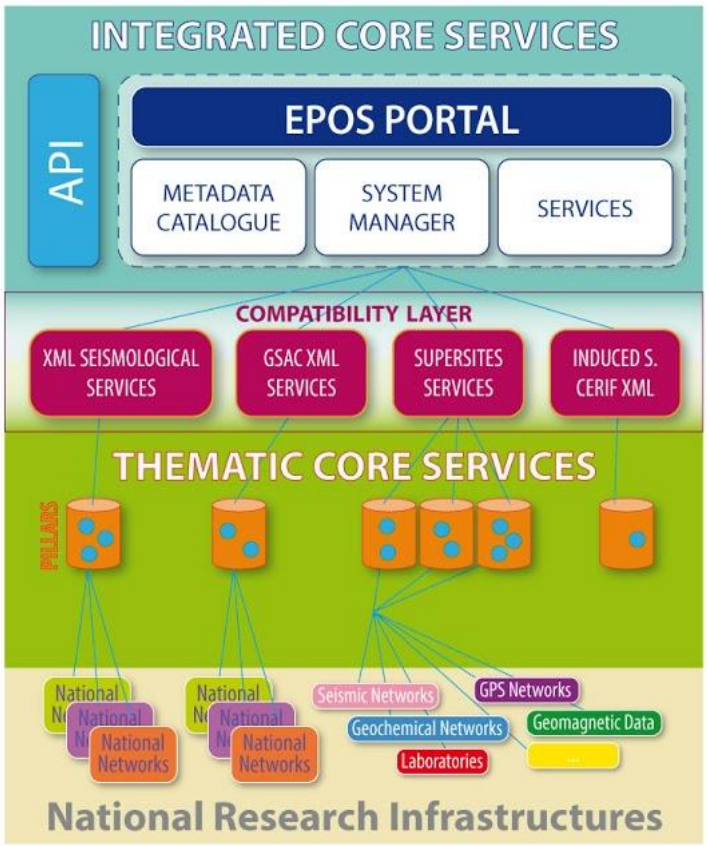

Figure 2: ICS-TCS Architecture

3.4. Governance and Structure

The EPOS-ERIC Governance structure is represented in (Figure 4). Under control of the Executive Committee (and ultimately reporting to the General Assembly) the Services Coordinating Committee represents the TCS and the IT team working together. The more detailed governance of the IT aspects is represented in (Figure 4). The area of the diagram in green represents the systems development activity, while the area in orange represents the hosting of ICS-C on the e-Infrastructure.

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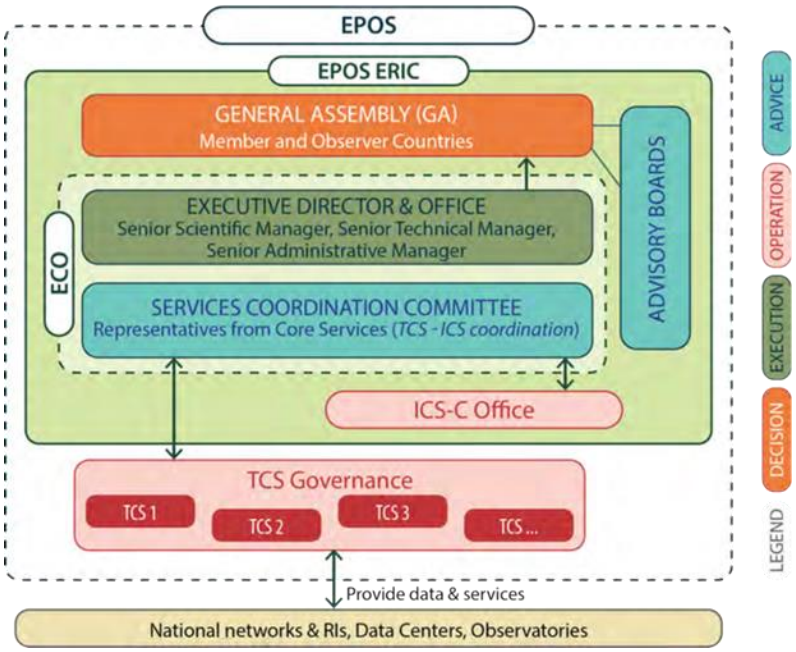

Figure 3: EPOS Governance Structure

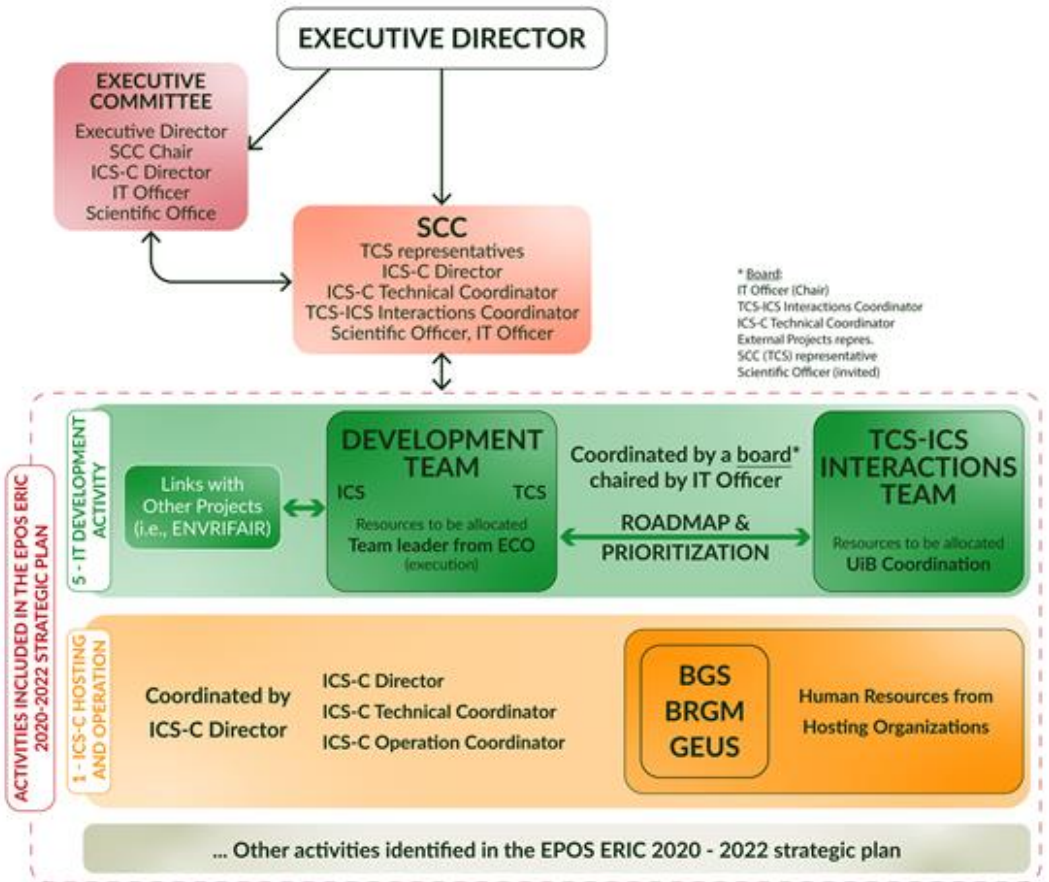

*Figure 4: Interactions between the TCS-ICS Interactions, Development and Operational activities related to the EPOS ICS System as well as their relevant links to coordination and governance bodies. Please note that the IT-Board is referred as " * Board "*

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3.5. A Governance and Technical Framework for Delivery

The above frameworks provide the basis for engaging with industry. In the following, we describe – in general terms – the asset base provided by the TCS and the access provided through the ICS.

4. TCS

4.1. Introduction

The term TCS is used in two ways:

(a) communities each representing a domain of geoscience (e.g., seismology, volcanology) where individual RIs offer relevant assets;

(b) services provided by that community to EPOS and recorded as metadata in the ICS-C catalog to be accessed via ICS-C;

4.2. TCS Assets

The TCS assets are Data, Data products, Software and Services (DDSS). It was decided to initiate EPOS with services (in the sense of web services providing access to datasets with or without some processing and visualisation), in line with other clusters of research domains in Europe and the European Open Science Cloud (EOSC).

4.3. Services

The TCS offered services act on other assets in RIs of the TCS (and sometimes other TCS). The services usually concern access to datasets, management of datasets and operations (e.g., analytics, visualisation) of those datasets. However, additionally, Trans-National Access (TNA) services are being developed to provide remote access to equipment in a laboratory or sensors in the field. This also involves requesting time using the equipment, authorisation of access and protocols for equipment control and data curation.

4.4. Metadata

The assets are described by metadata. The various RIs have their own metadata standards, currently 17 different standards are recognised. Clearly, in order to provide user access to a homogeneous view over this heterogeneity harmonisation is required.

4.5. Harmonisation

Introduction

This subsection is elaborated based on the result of joint work with WP4. The objective of harmonisation in the context of EPOS-SP is to provide end-users with an improved set of services for geoscience supporting their work. The improvements concern (a) increased standardised metadata descriptions for services and other assets as recorded in the catalog; (b) standardisation of service APIs for use by developers; (c) standardisation of nomenclature for input parameters (that also occur in the APIs); (d) standardisation of output types to allow integration of outputs from different services or other assets into a homogeneous form. While the harmonisation is dominantly for the purposes of EPOS including EPOS-SP (improving EPOS sustainability by improved services), it has to be achieved within a broader context involving also the ENVRI cluster. This is mainly for permitting harmonisation and interoperation across multiple environmental research infrastructures and European Open Science Cloud (EOSC), which in return permitting harmonisation and interoperation across the full range of publicly available services and assets.

A key aspect of harmonisation is to ensure that EPOS assets are FAIR (Findable, Accessible, Interoperable and Re-usable). The main method of achievement is rich metadata, assisted by appropriate API structures and

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an appropriate interface for users. A recent survey of EPOS within the ENVRI-FAIR project indicated that EPOS was FAIR although there is always room for improvement.
The ongoing work on harmonisation is described below.

Metadata

EPOS uses CERIF for the catalog. CERIF has a rich and expressive format based on base entities and linking entities with a semantic layer for ontologies all within a coherent structure. CERIF is a superset of commonly-used metadata schemes and is a data model designed to make it easy to interoperate (through convertor software) with other metadata standards thus providing maximum flexibility. CERIF is extensible, and has indeed been extended by EPOS to cover entities not in the original model.

However, with the richness comes complexity. To facilitate collection of metadata from the TCS - with their (currently 17) different metadata standards an intermediate metadata scheme is used. It is a much-extended version of DCAT namely EPOS-DCAT-AP. Thus, metadata in the standard appropriate to each TCS is converted to EPOS-DCAT-AP and then to CERIF. The gold coloured-entities in (Figure 5) indicate clearly the large extension to DCAT necessary to accommodate the metadata standards used by the various RIs within the TCS.

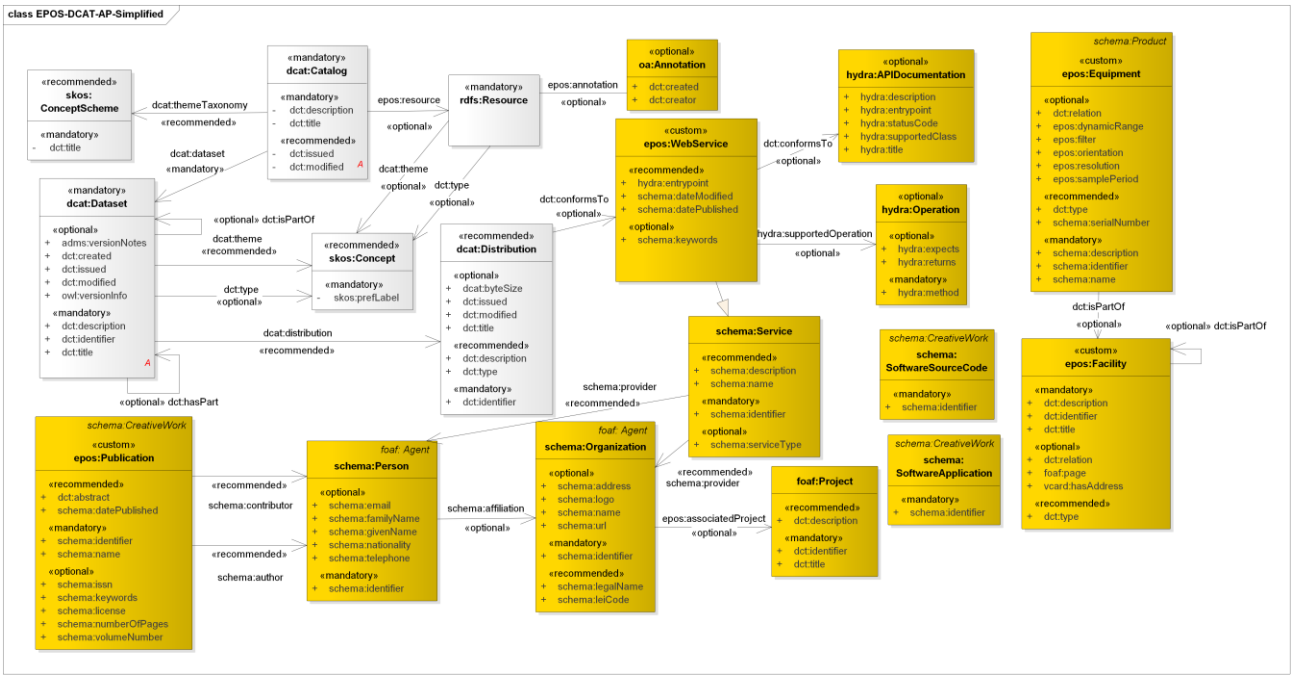

Figure 5: EPOS-DCAT-AP

Improving the metadata ingestion, conversion and editing facilitates the inclusion of further services and other assets into the EPOS catalog thus providing end-users with more assets to use. Furthermore, the provision of a wider range of assets encourages new groups of users to utilise EPOS.

APIs

Standardisation of APIs ensures that additional services can be developed quickly and easily and that developers creating more complex services (e.g., for ICS-D) can do so more easily. The standardisation of the

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parameter names in APIs, corresponding with metadata attributes in CERIF, ensures that ICS-C is consistent. Changes in the metadata - for example additional entities or attributes to encompass new requirements from end-users - require changes to the APIs through a controlled process. It is planned that this could be semi-automated thus assisting in rapid deployment of an increased range of services to encourage greater use of EPOS by existing users and use of EPOS by new user groups.

Input Parameters

Although defined in the metadata and the APIs, input parameter values may be input by an end-user to configure the execution of a particular service. Name standardisation - according with the metadata and API - reduces the chance of error and thus provides the end-user with a more robust and reliable service leading to greater satisfaction and increased usage with confidence.

Output Types

In many ways, this is the most difficult part of harmonisation. Historically, individual TCS have chosen output types to suit their particular requirements without considering the requirements of other domains of geoscience (or wider). Thus, we have a plethora of output types for download (or transmission to another service on the same or different computer system) or display.

Efforts are being made to understand the requirements of the TCS communities and to work towards a reduced list of approved output types. This will reduce the number of convertors needed between output types communicated between services (e.g., data file formats), and also reduce the number of services needed for displaying output results of the execution of one or more services. At present most services manage their own output but once services are composed into a workflow, and the end-user wishes to display the results together (e.g., overlays of a map) the display services become more complex. In an ideal world, the TCS services would be structured with separate microservices for input collection and validation, for the actual processing, and for output communication or display - then the interoperation of services would be improved. However, EPOS is not yet at that stage of development.

Vocabularies

Once the previous parameters have been well established, we will have precise API, INPUT format and OUPUT format. However, those are IT languages, protocols, file format, this is still not covering the scientists' language. How can we be sure that the "Fe" element in the Trans National Access (TNA) to a piece of equipment, is equivalent to the "iron" found while drilling a borehole? Is it described the same way? Is it named the same "iron" vs "Fe"? Should it be written the same way? In summary, how can we have a common scientific language amongst different communities, vast debate?

During the EPOS IP project, a Vocabulary Task Force was set up, but the results were mitigated. On one hand the communities have been convinced that harmonization must be made, but on the other hand the huge number of communities made it a difficult process. There were two comments: a) lack of guidance, b) no tools to support the guidance. While ENVRI-FAIR is supporting the enhancement of the tools and procedures, EPOS-SP (WP4) should work on filling the tools with harmonized vocabularies to increase the value for users.

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Activities

The ICS-TCS team has now built a solid experience on integrating TCS. This experience provides robustness. To sustain that robustness, the ICS needs to be careful of not spreading too thinly, lessening its maintainability. Therefore, we identified the following key WP4 activities to improve value for users (and especially industrial users) of EPOS:

- Ensure the services are robust, secure, performant, well-documented;
- Ensure the services match requirements of end-users – especially in industry;
- Enhance the service catalog with new users meeting the needs of (especially industrial) end-users;
- Energise the Vocabulary Task Force to provide a harmonised vocabulary within CERIF;

4.6. Accepting the TCS Assets

A quality assurance (QA) process has been constructed to ingest TCS assets into the EPOS system (Figure 6) including ingesting metadata into the catalog (Figure 7). Such a process is essential for end-user (especially industrial end-user) confidence in the EPOS system.

Figure 6: QA Process

5. ICS-C

5.1. Introduction

ICS-C is the portal system providing access to the EPOS assets through the metadata catalog. It also provides access to the TCS portals directly.

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5.2. The Metadata Catalog

The metadata catalog is stored using CERIF. General information on CERIF may be found at the euroCRIS website[1]; the detailed datamodel (in TOAD modeller) can be accessed directly[2].

CERIF consists of base entities (e.g., person, project, organisational unit, research product, equipment…) and link entities which express relationships (role and temporal interval) between base entities (e.g., <Person P><manager of><Equipment E><2019-01-31:09:00><2019-10-31:17:00>). It thus provides a fully connected labelled graph with a rich syntax. The roles are not coded directly in the syntactic layer but are represented by persistent unique identifiers which point to the relevant term in the semantic layer (thus ensuring integrity of terminology) which has the same structure as the syntactic layer so terms (in base entities of the semantic layer) can be related to each other (link entities of the semantic layer) providing a full ontological structure.

The metadata catalog is populated from the heterogeneous metadata formats used within the TCS via EPOS-DCAT-AP in an ingestion pipeline (Figure 7) but work is underway for dynamic update by specified TCS managers within a secure environment.

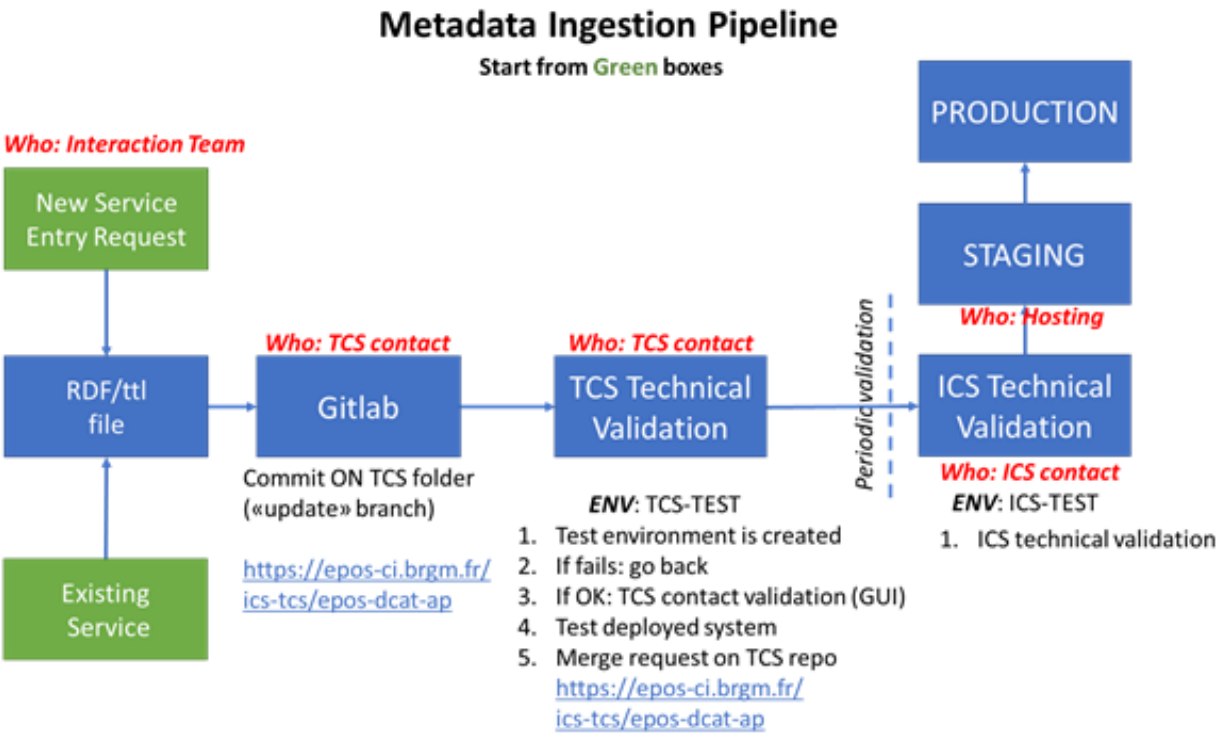

Figure 7: Metadata Ingestion Pipeline for new services or for updating existing services.

5.3. ICS-C System

Introduction

The purpose of the ICS-C system is to provide user access to the EPOS assets.

[1] https://www.eurocris.org/services/main-features-cerif

[2] https://cdn.rawgit.com/EuroCRIS/CERIF-DataModel/8743066b/documentation/MInfo.html

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Functionality

The ICS-C functionality is developing continually. The overall expected functionality is as follows:

(a) discover, contextualise services (and possibly other assets);
(b) configure servics with parameters;
(c) compose those services (and other assets) into a workflow - including conditionalities and hints on parallel/sequential and localised/distributed execution;
(d) convert the workflow to CWL (Common Workflow Language) ready for deployment;
(e) manage deployment which could be manual or automated with optimisation, and including appropriate AAAI, curation and provenance aspects.
(f) Monitor and modify deployment from the ICS-C console allowing tracking of progress and/or halting to change parameters at appropriate break-points;
(g) Receive the results of the deployment and produce/record appropriate metadata for the generated assets.

And may be represented (Figure 8).

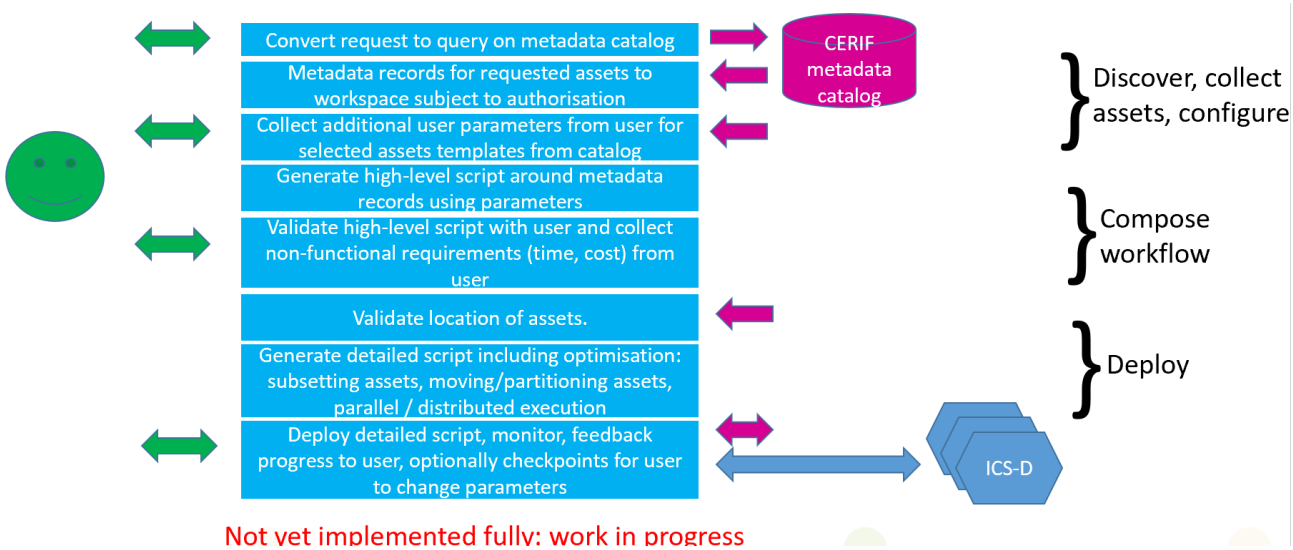

Figure 8: ICS-C Functionality

User Interface

The user interface (Figure 9) has several areas or panes:

Top banner: feedback form, help and login;

Top: spatial and temporal coordinates;

Left: assets, with an advanced search, browsing and asset selection to workspace;

Middle: display for pre-visualisation of asset(s); map, graph, table;

Bottom: providing either details (metadata) of the asset, configuration parameters (for user to override defaults) or the console which provides the logging of the activity.

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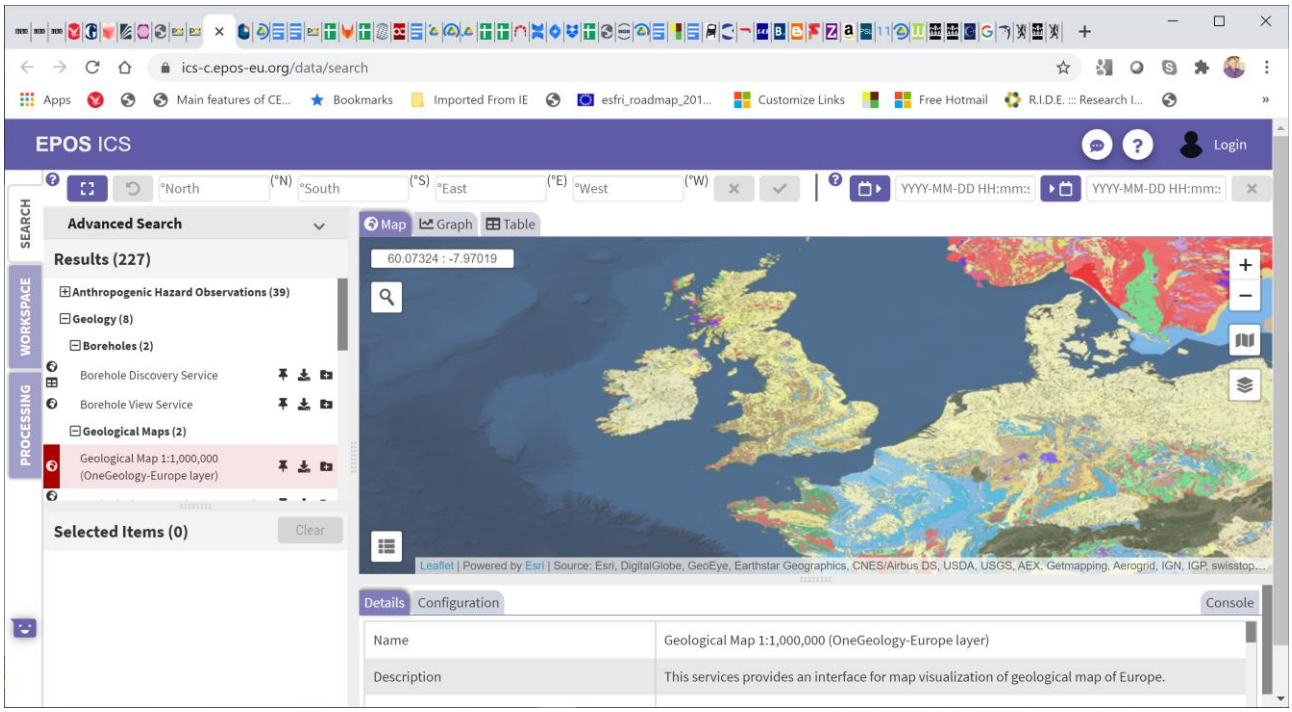

Figure 9: Screenshot EPOS ICS-C User Interface

6. ICS-D

6.1. Context

ICS-D is a class of specialised EPOS services that require access to external e-Infrastructure and are more complex than typical TCS-supplied services in that they need a workflow of steps of processing (Figure 8). The workflow is generated (at present manually) from the ICS-C workspace of selected assets once they are configured. Current activity is investigating use cases and prototypes of ICS-D to provide the requirements for the final design of a generic ICS-D system.

7. The Plan

7.1. Introduction

Having described what EPOS offers – and intends to offer - through the TCS, ICS-C and ICS-D we can now consider the plan to engage with industry. The plan has the following elements:

1. Identify industrial and commercial partners already engaged with EPOS participant organisations;
2. Identify other potential industrial and commercial partners;
3. For existing industrial/commercial partners, document requirements and current joint activity (including any joint developments or offerings from the partners);
4. Engage with potential industrial/commercial partners to understand their requirements and potential joint activity (including any joint developments or offerings from the partners);
5. Produce an integrated plan of engagement with existing and potential industrial/commercial partners relating partners to existing or potential ICS services;
6. From the plan identify ICS services to be improved with (a) increased resilience, robustness and performance; (b) better documentation/training;

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7. From the plan identify ICS services that are required and do not yet exist and add them to the development schedule based on strength of requirement and available resources;
8. Produce an integrated plan for development activity to engage, support and provision existing and potential industrial/commercial partners with appropriate ICS services;

We thus have two classes of partners: existing and potential. Some activities relate to both, but in general existing partners will know more about EPOS and may have already appropriate offerings as assets. Potential partners require introducing to EPOS and understanding of requirements followed by matching to EPOS existing services. Unmatched requirements become candidates for service development by the partner or EPOS or jointly.

7.2. Dashboard

WP5 maintains a dashboard with Key Performance Indicators on ICS services' relevance and performance, aimed at assessing the evolution of usage and visibility and dissemination of ICS services to report the relevance to drive the innovation. This will be used to assess progress by reporting at regular intervals.

WP 5	Strengthening Links with private sector			
KPI n.	**Description**	**Objective (Target)**	**Purpose**	**Measure tools**
5.1	Number of public and commercial institutions/companies interested in pilot services offered	8	To measures the potential of pilots to attract the private and public organizations; to allows to react and improve the pilots during the project	number of commercial organisations visiting EPOS website measured through the AAAI accounting tool and the metadata characterisation of the registered user
5.2	Number of users visiting or using R&I web resources or APIs	100	To measures how is the commercial interest in EPOS assets, and in which areas this interest can be developed)	number of users within commercial organisations through web log statistics and API statistics related to attribution of user to organisation

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5.3	Number of visits of the web resources related to R&I	1000	To measures how is the commercial interest in EPOS assets, and in which areas this interest can be developed)	number of visits to EPOS website by commercial organisations users through web log statistics and API statistics related to attribution of user to organisation
5.4	Number of new assets in the catalog as R&I services	10	To measure how rich R&I service of EPOS is and it will give later on, after some time since the implementation, the information how is the interest of using this service	number of new EPOS assets provided and used by commercial organisations from web and API logs
5.5	Number of EPOS common undertakings with the private sector	6	bi-directional collaboration: it measures how EPOS fosters the collaboration between the science and private sector); target is one per TCS involved in WP%	number of EPOS assets provided by joint work with commercial organisations

7.3. Teaming

The engagement with the communities and individual partners (existing or potential) is crucial to success. The concept of 'teaming' with the partners – proposed by the WP5 leader - to ensure cooperatively the best use of EPOS is made is a very positive way forward. The close engagement of partners to ensure that their requirements or offerings are well-understood ensures their integration into EPOS is facilitated and their potential benefit to EPOS (and to the partners) is maximised. The current Coronavirus pandemic is, of course, restricting severely outreach and engagement since for (a) understanding requirements; (b) discussing solutions and potential offerings; face-to-face meetings – with shared whiteboard, diagrams, system demonstrations etc. – are much more effective than using teleconferencing.

7.4. The Plan in Steps

Identification of Existing Industrial/Commercial Partners

This activity was started already in 2020. See (ANNEX 1 Existing and Potential Industrial/Commercial Partners) jointly with the other tasks in WP5.

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Identification of Potential Industrial/Commercial Partners

This activity was started already in 2020. See (ANNEX 1 Existing and Potential Industrial/Commercial Partners) jointly with the other tasks in WP5.

Requirements and Activity of Existing Industrial/Commercial Partners

Having identified the existing partners working with organisations participating actively in EPOS, the next step is to engage with them, presenting EPOS offerings, and to document the requirements and current/planned activity in order to identify areas of greatest activity where resources might be concentrated to encourage further industrial/commercial participation. There is also the possibility that there is intersection of requirements and activity among existing commercial/industrial partners and that this could be optimised with re-use, sharing, cooperative work. This class of partners may have already suitable offerings (services) to be included (subject to conditions) in the ICS catalog. This step requires active participation from T5.1.

Requirements and Activity of Potential Industrial/Commercial Partners

Having identified the potential partners working with organisations participating actively in EPOS, the next step is to engage with them, presenting EPOS offerings, and to document the requirements and potential activity in order to identify areas where resources might be concentrated to encourage further industrial/commercial participation. There is also the possibility that there is intersection of requirements and activity among potential commercial/industrial partners and that this could be optimised with re-use, sharing, cooperative work. This step requires active participation from T5.2.

Plan for Engagement

Based on the results of the previous steps of the plan, an integration and consolidation provides ordered lists of requirements and industrial/commercial partner offerings, together with appropriate information (such as contacts, any restrictions of use including licensing conditions or costs, rights claims…all dealt with by WP2). The plan for engagement ensures the partners are contacted appropriately. The initial engagement will be with commercial/industrial partners engaged in the activities of T5.1. Longer-term, this step requires active participation from T5.3.

Identification of Services for Improvement

From the above engagement plan, each requirement or offering from existing or potential industrial/commercial partners is matched against the existing services offered by ICS. Depending on the degree of matching, the closely matched existing services are flagged as being appropriate for potential improvement in increased resilience, robustness and performance and documentation/training. Offered services from the industrial/commercial partners are evaluated for inclusion in the ICS catalog. The resources required to achieve this are estimated for each service in this category. This is a major activity of T5.4.

Identification of Services for Development

From the above engagement plan, each unmatched requirement from existing and potential industrial/commercial partners is flagged as being appropriate for development, as a service to be developed

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by EPOS, by the industrial/commercial partner (as an offering) or jointly. The resources required to achieve this is estimated for each service in this category. This is a major activity of T5.4.

Development Plan

The improvements to ICS services and the proposed developments of new services identified in the previous two steps are integrated into a development plan, as part of the overall EPOS IT development plan managed by IT Board. The criteria for prioritisation are yet to be agreed, but are likely to include (1) benefit of this service to maximum number of EPOS users; (2) benefit to EPOS (financial, reach to the community, benefit for society…) from engagement of the industrial/commercial partner(s) with the requirement or offering. This is a major activity of T5.4.

The timescale is – because of Coronavirus – flexible and certainly delayed with respect to the original ambitions. T5.1 is experiencing difficulties in working closely with the partners engaged in the pilots, and the experience from that work was intended to inform T5.2 including working with potential partners. The Pre-Operational Testing (POT) phase of EPOS-ERIC – to prove that the system is operational, robust and fit for purpose - is underway and should provide assurances to industrial/commercial partners (actual or potential) sufficient to encourage engagement.

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8. ANNEX 1 Existing and Potential Industrial/Commercial Partners

WP5 T5.4 Industry Contact Worksheet_2

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EPOS-SP **WP5 T5.4 Industry Involvement**
Commercial In Confidence **intent: Yes, No, Possibly**

Industry Name	Use EPOS	Consultant	Joint Dev	Contact name	Contact email	www	*	contact from:
EDF France - French Nuclear power station (seismic) safety	P	N	P	Paola Traversa	paola.traversa@edf.fr	https://www.edf.fr/en/meta-home		J.R. Grasso
Green Gas DPB - Mine seismology, Czech Rep	P	N	P			https://www.dpb.cz		Jan Sileny
gas company Innogy - Underground gas storage near Pribram, Czech Rep	P	N	P			https://www.innogy-gasstorage.cz/en/about-us/our-storages/haje/		Jan Sileny
KGHM Polska Miedz SA - Copper ore extraction and enrichment	Y	N	Y*			https://kghm.com/en	Supervising the monitoring of seismic impact due to mining exploitation on the OUOW "Żelazny most" repository embankment seismic network and the stations monitoring the western foreland of OUOW Supervising the monitoring of seismic impact due to mining exploitation on the OUOW "Żelazny Most" repository embankment seismic network and the stations monitoring the western foreland of OUOW has been carried out in line with the contract concluded by and between KGHM Polska Miedź S.A. Hydrotechnical Division, Rudna, and Institute of Geophysics Polish Academy of Sciences in Warsaw.	Stan Lasocki
ZEW NIEDZICA SA - Niedzica hydropower plant	N	N	Y*			http://www.zzw-niedzica.com.pl/	Monitoring activities by Departmntt of Seismology IG PAS	Stan Lasocki
PGE Capital Group	N	N	Y*			https://www.ekpge.pl/inyestor-relations/PGE-Group	Department of Seismology IG PAS in cooperation with Technical Support Department is involved in seismic monitoring of potential nuclear power plant (NPP) site in northern Poland since 2015.	Stan Lasocki
Polish Coal Mine Lubelski Wegiel "Bogdanka" S.A.	N	Y TCS AH IAC**	Y*	Łukasz Herezy	lherezy@lw.com.pl	https://lw.com.pl/en,2,start,s119.html	Department of Seismology IG PAS started a new collaboration with one of Polish coal mine Lubelski Wegiel "Bogdanka" S.A. The main aim of the collaboration is focused on seismological observation of seismic activity induced in the vicinity of the mine.	Stan Lasocki
LKAB (Sweden)	P	Y TCS AH IAC**	N	Christina Dahner-Lindqvist	christina.dahner.lindqvist@lkab.com	https://www.lkab.com/en/		Savka Dineva
Balya Mine, Eczacıbaşı Esan (Turkey) - Mine seismology	P	N	P			https://www.emxroyalty.com/royalties/turkey/balya/		Savka Dineva
Ente Nazionale Idrocarburi (ENI) - Oil & Gas company. Operator of the Val d'Agri oil field Italy).	Y	N	P			https://www.eni.com/en-IT/home.html		Alex Garcia
Polish Mining Group	Y	Y TCS AH IAC**	Y*	Aleksandra Pierzyna	a.pierzyna@pgg.pl	https://www.pgg.pl/en	Cooperation with IG PAS in projects: EPOS PL	Stan Lasocki
Haelixa	P	N	Y S4CE			www.haelixa.com		Stan Lasocki
Mirico Ltd	P	N	Y S4CE			www.mirico.co.uk		Stan Lasocki
GEL Geothermal Engineering Ltd	P	N	Y S4CE			www.geothermalengineering.co.uk		Stan Lasocki
TWI Ltd	P	N	Y S4CE			https://www.twi-global.com/		Stan Lasocki
geomecon	P	N	Y S4CE			http://www.geomecon.de		Stan Lasocki
SCM Software for Chemistry & Materials	P	N	Y S4CE			https://www.scm.com/		Stan Lasocki
Reykjavik Energy	P	N	Y S4CE			www.or.is/english/		Stan Lasocki
NIS	P	N	Y S4CE			https://www.nis.eu/en/		Stan Lasocki
GeoThermal Engineering GmbH	P	N	Y S4CE			http://www.geo-t.de/en/		Stan Lasocki
GAGAT	Y	Y TCS AH UC***	Y*	Janusz Mirek	Janusz.Mirek@seisnet.eu	http://seisnet.eu/index.html	IG PAS former employee, (worked in IS EPOS Platfrom team), now private sector, monitoring activities	Stan Lasocki

** TCS AH Innovation Advisory Committee
*** TCS AH User Committee