

D3.3a

Architecture and Interoperability Guidelines for Operational Services of the EOSC-Core

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Abstract

This deliverable describes the architecture of the EOSC-Core Technical Platform (in short EOSC Platform), a set of internal services that allow EOSC to operate and with which the researcher-facing services and research products in the EOSC-Exchange can be integrated as desired to take advantage of their capabilities.

The document highlights the interactions between EOSC-Core services and details the architecture for the operational services of the platform, including the EOSC Resource Catalogue, Helpdesk, Monitoring, Accounting and Order Management.

It also introduces the concept of EOSC-Core Interoperability Guidelines, that facilitate the implementation of different information exchanges between EOSC-Core functions and EOSC-Exchange resources. EOSC Profiles and interfaces/API have been identified as the building blocks of the EOSC-Core Interoperability Guidelines.

Finally, it details the Interoperability Guidelines for the operational services of the EOSC-Core.

The revised version of this deliverable has been enriched with two appendixes that presents respectively the architecture diagrams of the EOSC Platform, developed according to the [C4 methodology](https://c4model.com/)¹, and the project overall technical roadmap.

¹ <https://c4model.com/>

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Glossary

EOSC Future project Glossary is incorporated by reference: <https://wiki.eoscfuture.eu/x/JQCK>

List of Abbreviations

Acronym	Definition
AAI	Authentication and Authorisation Infrastructure
AARC	Authentication and Authorisation for Research and Collaboration
AI	Artificial Intelligence
API	Application Programming Interface
A/R	Availability/Reliability
CESSDA	Consortium of European Social Science Data Archives
CMS	Configuration Management System
CMT	Configuration Management Tool
CRIS	Current Research Information System
DIH	Digital Innovation Hub
DMP	Data Management Plan
DOI	Digital Object Identifier
EGI.eu	European Grid Infrastructure Foundation
eIDAS	Electronic Identification, Authentication and Trust Services
EIF	EOSC Interoperability Framework
EMSO	European Multidisciplinary Seafloor and Water Column Observatory
EO	Earth Observation
EODC	Earth Observation Data Centre
EOSC	European Open Science Cloud
EPOT	EOSC Portal Onboarding Team
HPC	High-Performance Computing
IdP	Identity Provider
I/O	Input/Output
JNP	JNP Strategy Management Consulting
ML	Machine Learning
MVE	Minimal Viable EOSC
N/A	Not Applicable
OMS	Order Management System
PaaS	Platform as a Service
PID	Persistent Identifier
PSNC	Poznan Supercomputing and Networking Center
RDA	Research Data Alliance
RO	Research Object
RoP	Rules of Participation
SMS	Service Management System

SOMBO	Service Order Management Back Office
TBD	To Be Determined
TF	Task Force
TGB	Technopolis Group Belgium
WeNMR	Worldwide e-Infrastructure for Nuclear Magnetic Resonance
WG	Working Group

1 Executive Summary

This deliverable describes the architecture of the EOSC-Core Technical Platform (in short EOSC Platform), that is set of internal services that allow EOSC to operate and with which the researcher-facing services and research products in the EOSC-Exchange can be integrated as desired to take advantage of their capabilities.

The document highlights the interactions between EOSC-Core services and details the architecture for the operational services of the platform, including the EOSC Resource Catalogue, Helpdesk, Monitoring, Accounting and Order Management.

It also introduces the concept of EOSC-Core Interoperability Guidelines, that facilitate the implementation of different information exchanges between EOSC-Core functions and EOSC-Exchange resources. The guidelines define the interfaces that enable the communication between components in the EOSC-Core, and external to the EOSC-Core to allow EOSC providers to (i) onboard (aka register) resources (services and research products) in the EOSC Resource Catalogue, and (ii) integrate resources with the EOSC-Core added-value services. EOSC-Core Interoperability Guidelines comprises interfaces/APIs and profiles, that specify the data and the related format that should be used to interact with the EOSC-Core services. These guidelines are combined with the EOSC-Exchange Interoperability Guidelines, which describe standards, API, and procedures to facilitate interoperation among EOSC-Exchange services, to make up the EOSC Interoperability Framework.

The relationships among the data models of the EOSC-Core services are also presented. The union of these data models forms the EOSC Platform Virtual Data Model, a common conceptual data model that describes the EOSC entities, the information about these entities, and the relationships between them, all of which are needed by EOSC-Core services and other services interacting with those EOSC-Core services. This Virtual Data Model is a key architectural tool for defining the relationships between logical entities of importance to EOSC, their role in different use cases, and their implementation.

EOSC Profiles are further defined in the document, and their current status and plans for evolution and extension are depicted.

Finally, details are provided regarding the Interoperability Guidelines for each operational service of the EOSC Platform. These include the description of the integration options offered to EOSC-Exchange providers and the information that should be exchanged with the EOSC-Core services to enable this integration. The availability of multiple integration options per EOSC-Core service allows providers to select the integration type that best fits their requirements, taking into account benefits in terms of capabilities and integration costs.

The extension of the EOSC Platform has been planned for the near future with the addition of new functions and components. One example is the AI/ML for discovery component or Recommender system that is under development and will enrich the Marketplace/Front-End Platform with instruments to facilitate the users' navigation over the EOSC Resource Catalogue. Other functions will be identified later according to the use cases that will emerge. Each new function to be added to the platform will adopt the architecture guidelines and tools introduced in this document, specifying its own data model, the interactions with the data models of the other services and the required profiles, which, together with the interfaces, will compose the Interoperability Guidelines for this new EOSC-Core function.

The revised version of this deliverable has been enriched with two appendixes that present respectively the architecture diagrams of the EOSC Platform, developed according to the C4 methodology, and the project overall technical roadmap.

2 Introduction

The aim of this deliverable is to provide an overview of the EOSC Platform and to establish a clear framework and guidance that define the information to be exchanged, together with necessary procedures, to enable interoperation with each function of the EOSC-Core.

This document is directed towards organisations and individuals involved in the implementation and expansion of EOSC:

- **Partners implementing EOSC-Core functions.** The document presents the guidelines required to develop the overall information architecture of the Minimum Viable EOSC (MVE) and aims at providing the framework for implementation and interoperability of EOSC-Core functions.
- **EOSC-Exchange service and research product providers.** The document provides essential information for these providers to plan and use the EOSC-Core functions in a dynamic and evolving environment.
- **Stakeholders.** The deliverable presents important aspects of the EOSC Information architecture that must be considered when integrating service and research product catalogues and building the EOSC Federation. This document signals community-wide agreement on the architecture of the implementation within EOSC and therefore, sets an important milestone in the overall evolution of EOSC.

The document is structured as follows:

- Section 3 presents the EOSC-Core platform and positions it in the overall EOSC Architecture. It introduces the EOSC-Core Architecture Specifications and Interoperability Guidelines, defining the types of information that they should describe, and explains how the data models behind each EOSC-Core function together form a unified, EOSC Platform Virtual Data Model that describes interactions between EOSC-Core functions.
- Section 4 introduces the EOSC Profiles, describes their current implementation and depicts their evolution.
- Section 5 details the operational services of the EOSC-Core describing their high-level architecture and interoperability guidelines.
- Section 6 draws conclusions and outlines future work.

The following table introduces and defines key terms used in the deliverable. It is the output of a process to (1) harmonise the terminology that was adopted by past EOSC projects and (2) align it to the latest advancements on the EOSC Architecture being implemented by EOSC Future. Some old terms were replaced with new terms that better reflect the current implementation. All the project documentation is being updated to adopt the new terminology; this brief glossary can also help to map old terms to new ones until the changes are propagated among all the project documents.

Table 2-1: Main terms used in the document

Terms	Definitions
EOSC Resources	All types of EOSC entities. Today these include Services and Research Products, but other types will be added in the future.
EOSC Providers	Organizations responsible for operating and/or offering access to one or more EOSC Resources.
EOSC Services	Services onboarded in EOSC as part of the EOSC-Exchange.
EOSC Data Sources	Catalogue or container of Research Products. It is a special type (extension/subclass) of EOSC Service. Data sources are EOSC Resources and a subclass of EOSC Services whose specific purpose is to offer deposition, preservation, curation, discovery, access, and usage statistics functionalities of collections of EOSC Research Products from a thematic or cross-discipline perspective.
EOSC Research Products	Datasets, publications, software and other types of scientific artefacts

	onboarded in EOSC.
EOSC Resource Catalogue	A catalogue of all EOSC Resources, the result of integrating the EOSC Service Catalogue and the EOSC Research Product Catalogue.
EOSC Service Catalogue	A catalogue containing all the Services onboarded in EOSC, together with their Providers. Previously referred to as EOSC Service Registry or EOSC Resource Catalogue.
EOSC Research Product Catalogue	A catalogue containing all the Research Products (datasets, software, etc.) onboarded in EOSC, together with their context in the scholarly communication infrastructure, e.g. creators, organisations, funders, projects. Previously referred to as the Research Graph or OpenAIRE EXPLORE.
EOSC Marketplace/Front-end platform	The Marketplace provides the user interface for the EOSC Resource Catalogue (both Services, Data Sources, Catalogues and Research Products).
EOSC Service Profile²	Profile to describe an EOSC Service. Previously referred to as the EOSC Resource Profile.
EOSC Data Source Profile³	Profile to describe an EOSC Data Source.
EOSC Research Product Profiles⁴	Profiles to describe EOSC Data Sources. Research Product Profiles are well-established metadata schemas, endorsed by the research communities' guidelines. Currently supported profiles: • OpenAIRE interop guidelines • Bioschemas.org (under integration)
EOSC Provider Profile⁵	Profile to describe an EOSC Provider.
EOSC Service Provider Portal	Tools used by Providers to register themselves to the EOSC and onboard their Services. Previously referred to as EOSC Provider Portal.
EOSC Research Product Provider Portal	Tools used by Providers to register to the EOSC and onboard their Research Products

² <https://wiki.eoscfuture.eu/display/PUBLIC/v4.00+EOSC+Resource+Profile>

³ <https://wiki.eoscfuture.eu/display/PUBLIC/v4.00+EOSC+Data+Source+Profile>

⁴ <https://wiki.eoscfuture.eu/display/PUBLIC/v4.00+EOSC+Research+Product+Profile>

⁵ <https://wiki.eoscfuture.eu/display/PUBLIC/v4.00+EOSC+Provider+Profile>

3 EOSC Platform Architecture

This section presents the overall architecture of the EOSC Platform. It is followed by sections describing the operational EOSC-Core services, including the EOSC Resource Catalogue, Helpdesk, Monitoring, Accounting and Order Management. The architecture of each of these EOSC-Core services is detailed together with their interfaces with other EOSC-Core services and the resources in the EOSC-Exchange.

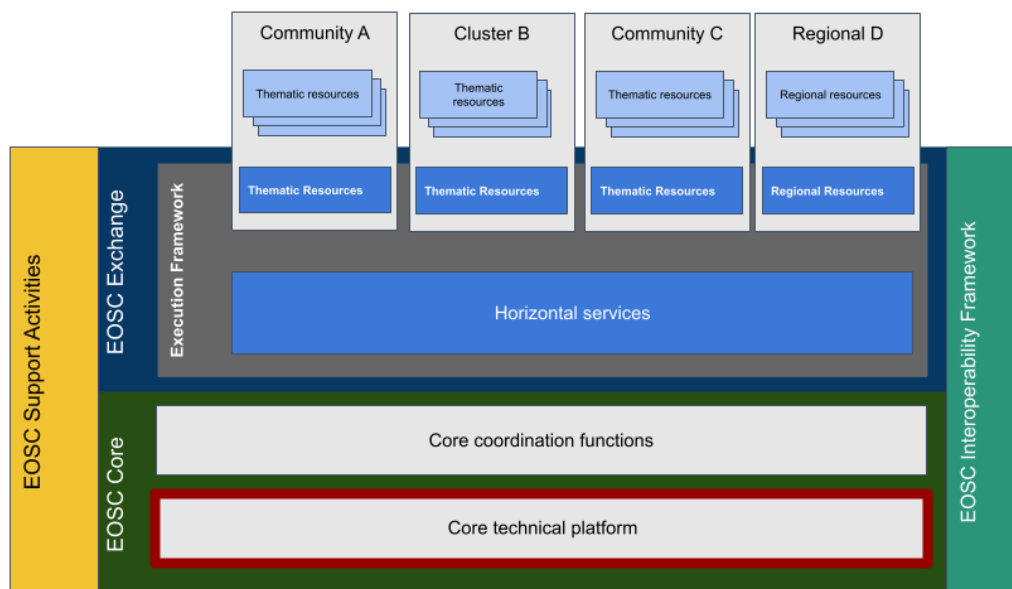


Figure 3.1: EOSC-Core technical platform (in short EOSC Platform) in the EOSC Architecture

3.1 Overall Architecture

The EOSC Platform is the engine that enables the EOSC operations. It consists of services such as the comprehensive Resource Catalogues, the Marketplace, the Infrastructure Proxy for the EOSC Core services, the AAI Registry supporting the AAI Federation, the Helpdesk, the Monitoring, the Accounting, and the Order Management. EOSC Future *D2.9 Co-Designed Architecture Description* details the capabilities of the EOSC Platform, identifying the IT tools and the coordination and support activities needed to deliver each EOSC-Core service, together with the requirements with which they have to comply.

The EOSC Platform and the EOSC-Core Coordination Functions together comprise the EOSC-Core. The EOSC-Core Coordination Functions ensure a harmonised delivery of the EOSC-Core (e.g. procedures and policies to support the management of Core Services) and support the interactions with EOSC Providers (e.g. the onboarding process to manage the registration and validation of service onboarding request, the coordination of security incident response activities, etc.).

Services provided by the EOSC Platform can be adopted by EOSC Providers to ensure a consistent user experience for researchers using resources through EOSC. For example, the AAI Federation enables single-sign-on to gain access to multiple EOSC Resources, Helpdesk delivers common support channels in EOSC regardless of the user access point, and Accounting provides an integrated view of resource consumption, service usage, and other metrics.

Figure 3.2 shows the overall architecture of the EOSC Platform and its interactions with the EOSC-Core Coordination Functions, EOSC users (resource consumers), EOSC Providers and other relevant stakeholders (e.g. funding agencies).

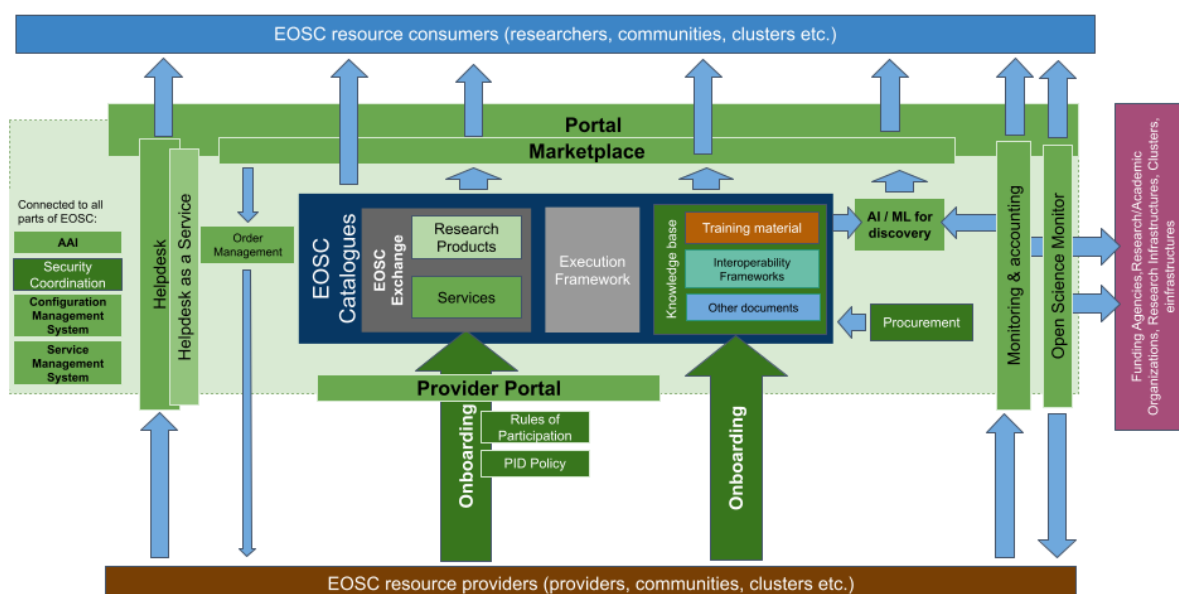


Figure 3.2: EOSC-Core Technical Platform Architecture

On the left side of the diagram there are several common functions that interact with all others, such as AAI, Service Management and Security Coordination, mixing both technical components of the EOSC Platform and EOSC-Core coordination activities. Other services of the EOSC Platform are loosely coupled, and currently the primary interactions are between the EOSC Resource Catalogue in the centre, providing information about Services and Research Products, and the other EOSC-Core services. Direct connections between EOSC-Core services and the Marketplace also enable a rich set of information to be delivered to the users (e.g. create a helpdesk ticket from the Marketplace, or display monitoring information in the page presenting a Service to end-users). The number of interactions between EOSC-Core services is expected to grow as new use cases are supported. For example, Figure 3.2 illustrates a component of the EOSC Marketplace that is currently under development, the AI/ML for discovery or Recommender System, that extracts data from other EOSC-Core services (the Resource Catalogue, the Accounting, etc) to facilitate user navigation in the Marketplace. All the services of the EOSC Platform expose interfaces towards the EOSC Providers and users that are key elements of the EOSC Interoperability Framework, as described in the EOSC Future *D3.2 EOSC Architecture and Interoperability Framework* and are detailed in this deliverable as Interoperability Guidelines for the EOSC-Core.

The EOSC Platform is being shaped by EOSC Future, integrating, and evolving a series of services, already available when the project started and currently in operation, which were delivered by past EOSC Projects (EOSC-hub, EOSC Enhance and OpenAIRE Advance). EOSC Future is working to deliver a full production release of the EOSC Platform that will be professionally managed according to the EOSC Service Management System (SMS). In particular EOSC Future's effort is focused on:

- Integrating into a single platform all the services developed by previous parallel and independent initiatives, guaranteeing their coordinated behaviour and a uniform user experience;
- Further evolving these services according to EOSC Future's High-level Technical Roadmap⁶ and in response to additional requirements being gathered by the project.

Some of the key capabilities of the EOSC Platform, planned over the course of 2022, whose development will be guided by this deliverable, are:

- Connections between the EOSC Resource Catalogue and other thematic and regional catalogues encompassed in the overall EOSC Architecture. WP3 is collaborating with relevant WPs and representatives of these other catalogues to define the uses cases to be supported and the information

⁶ See Appendix A

required, and to make architectural decisions about how these connections will be supported by enhanced EOSC Profiles (defined later in the document), EOSC components such as the Resource Catalogue, and interactions with the other catalogues.

- Integration of EOSC-Core Services (Accounting, Monitoring, etc.) with other EOSC services such as Marketplace, in order to support more than just “findability of resources” and extend seamlessly to accessing, ordering, getting support, and tracking the use and quality of services and resources that today can essentially only be “found” through EOSC. This will particularly include information about how the Resources are funded (e.g. EC funded) and their access model, in order to support the Order Management service.
- Introduction of the “Horizontal Services” concept in the EOSC Resource Catalogue. Services that deliver functions useful to multiple scientific domains will be marked as “Horizontal Services” and highlighted in the Marketplace for their easy identification. Horizontal Services can be associated with metadata, data storage and processing, scientific publishing and discovery, and a number of other functions relevant to many scientific processes.
- Enabling the combination and composition of resources in the EOSC-Exchange by introducing tools to describe and associate resources to the Interoperability Frameworks with which they comply.

3.2 Architecture specifications and Interoperability guidelines of the EOSC-Core Platform

The Architecture specifications and Interoperability guidelines of the EOSC Platform services describe (1) the high-level architecture of the EOSC-Core services and (2) their Interoperability Guidelines. The high-level architecture depicts the main components and their interactions with each EOSC-Core service. The Interoperability Guidelines detail the interfaces that enable communication between components in the EOSC-Core, and communications external to the EOSC-Core that allow EOSC Providers to (i) onboard (aka register) Services and Research Products in the EOSC Resource Catalogue, and (ii) integrate Resources with the EOSC-Core added-value services. For example, the integration with EOSC-Core services can allow providers to benefit from monitoring tools, report usage statistics about services and products, exploit helpdesk functions out-of-the-box, and exchange service ordering information. These interfaces will, as much as possible, take advantage of existing standards and well-known best-practises in order to facilitate the integration process.

The Interoperability Guidelines of the EOSC-Core are key elements of the EOSC Interoperability Framework. They are combined with the EOSC-Exchange Interoperability Guidelines, which describes standards, API, and procedures to facilitate interoperation among EOSC-Exchange services, to make up the EOSC Interoperability Framework.

Referring to the EOSC Interoperability and Composability model described in Figure 3.3, the EOSC-Core Interoperability Guidelines enable the interoperability of type A that allows the integration of EOSC-Core services of the EOSC Platform with research/horizontal services and with the Research Products in Data Source services from research/e-Infrastructures.

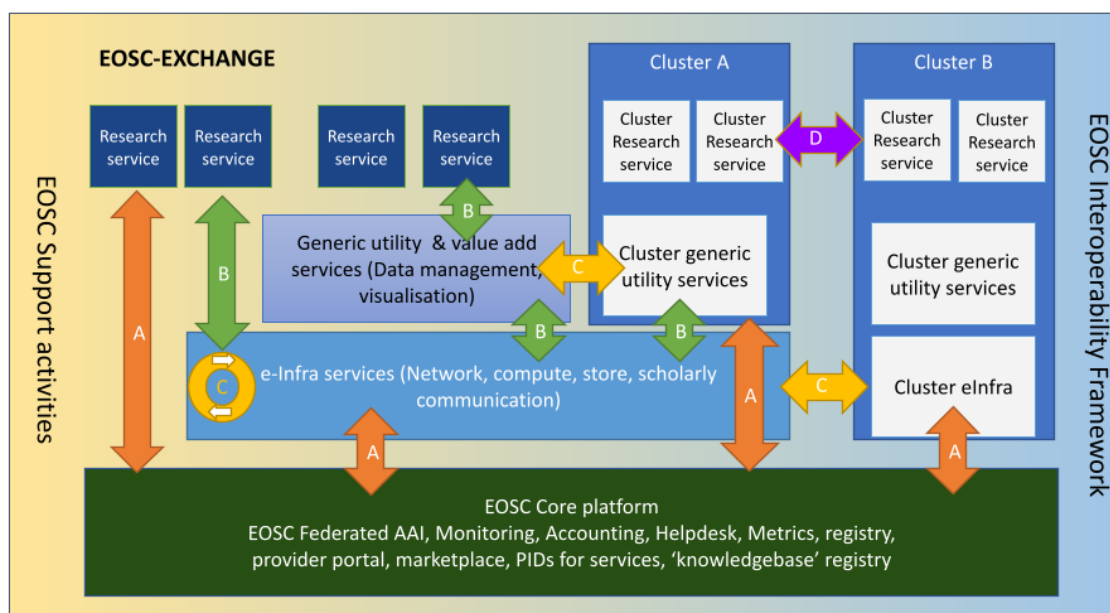


Figure 3.3: EOSC Interoperability and Composability model

Figure 3.4 shows examples of interoperations enabled by the EOSC-Core Interoperability Guidelines in the EOSC Architecture diagram. The green arrows represent the integration between thematic and horizontal resources with the EOSC Platform services.

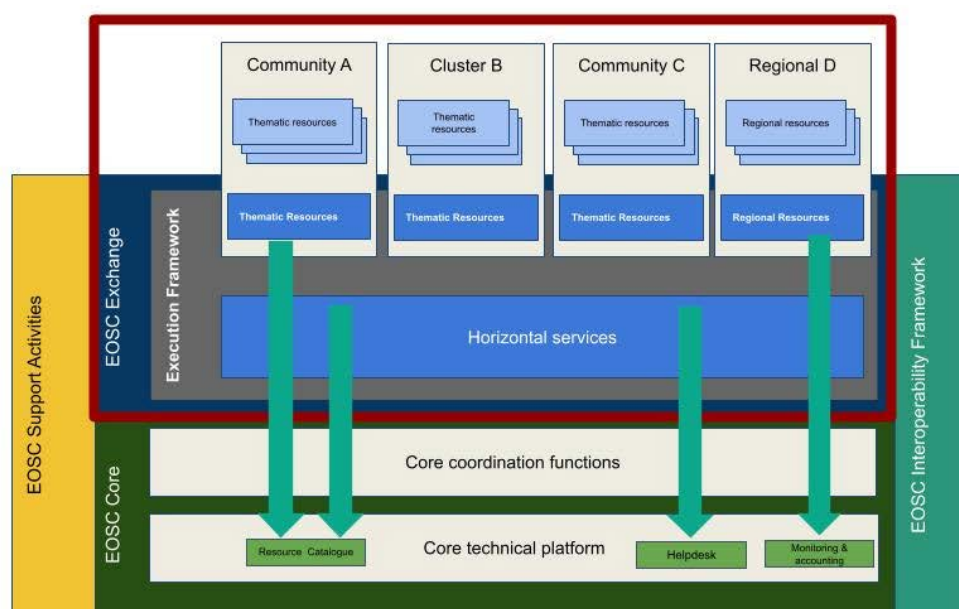


Figure 3.4: Examples of integrations of Thematic & Horizontal resources with EOSC Platform services.

The Interoperability Guidelines of the EOSC-Core services include two main types of information, the description of the interfaces/APIs that should be used by other services to interact with the EOSC-Core services, and the profiles that specify the data and the related format that should be used to interact with the EOSC-Core services via the APIs. Figure 3.5 lists the profiles and the APIs for some EOSC-Core services that a service in the EOSC-Exchange should use to take advantage of these EOSC Platform capabilities. These are detailed in section

4 per each operational core service. The diagram also shows the relationship between the EOSC Resource Catalogue and its main components, the Research Product Catalogue and the Service Catalogue, with the EOSC Interoperability Framework Registry. Resources in the Research Product Catalogue and services in the Service Catalogue can declare, as part of their metadata, that are compliant with certain EOSC-Core service Interoperability Guidelines.

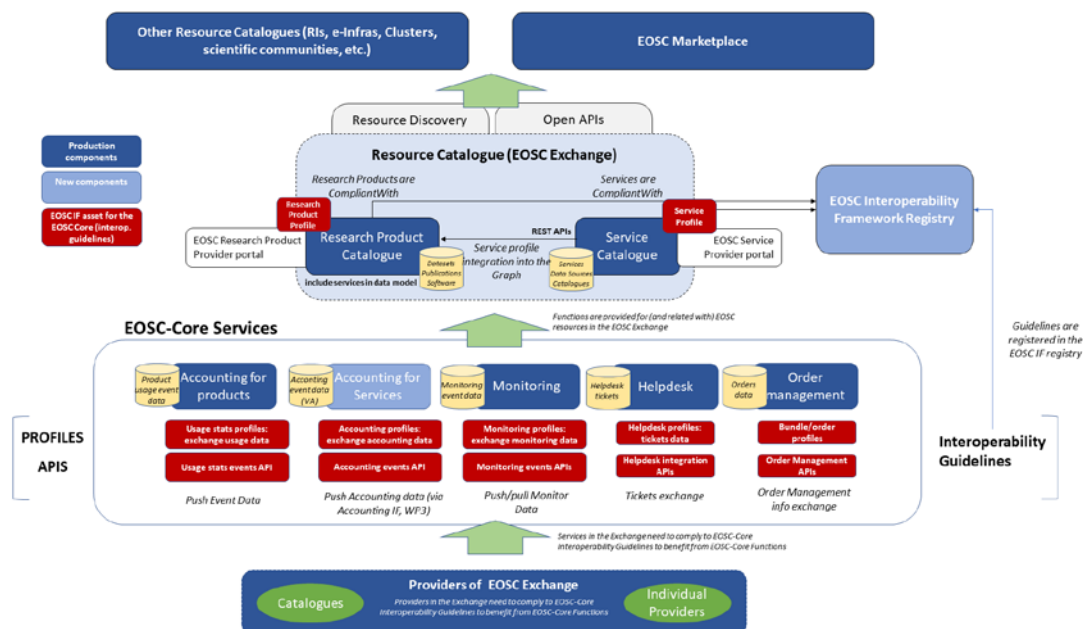


Figure 3.5: Interoperability guidelines include two main types of information, the description of the interfaces/APIs and the Profiles.

These Interoperability Guidelines do not define a single interface for interoperation but varying levels of integration, the integration options, from which a provider (seeking to onboard services or research products in EOSC) can select the option that best fits its needs. Integration options can specify various ways to integrate resources to an EOSC-Core service, from the tightest option, which allows providers to benefit from a greater number of EOSC-Core service features but requires more integration effort, to the loosest option, which enables a more limited feature set but with a lower cost in terms of integration. This approach leaves each provider free to benefit from the added value functions delivered by EOSC Platform at the level it prefers without raising the cost of the basic integration with EOSC and, without creating a barrier that may hinder some providers to onboard their resources.

As an example, a Provider onboarding Services into EOSC can decide to be integrated with the EOSC central Helpdesk choosing one of the following options: (a) full integration - the Provider decides to use the EOSC central Helpdesk as its own helpdesk, (b) integration through the helpdesk API - the Provider programmatically connects its helpdesk to the EOSC central Helpdesk so that a ticket created in the EOSC central Helpdesk is automatically forwarded to its own helpdesk, (c) integration through e-mail - the Provider is notified by the EOSC central Helpdesk via e-mail when a ticket for its Services is created in the EOSC central Helpdesk, (d) no integration - the Provider decides to not integrate its Services with the EOSC Helpdesk.

Similarly, for a Provider onboarding Research Products multiple options are available. When a Provider has onboarded its Data Source, it may choose to onboard the related Research Products according to a selection of metadata profiles, i.e. OpenAIRE guidelines for data archives, institutional and thematic repositories, CRIS systems, and bioschema.org. Providers can also verify the compliance of the metadata of these Research Products, hence the compliance of the Data Source as a whole, to RDA FAIR (data) maturity guidelines.

EOSC Future is focused on defining a well-accepted and flexible architecture, along with companion Interoperability Guidelines, for all the EOSC Platform services. In particular, the project is working on evolving

the guidelines for federation services developed in EOSC-hub⁷ to enable a well-defined and fully integrated EOSC Platform, satisfying the requirements that emerged from relevant research communities and aligning them with the latest enhancement of the EOSC Architecture and Interoperability Framework (IF). The guidelines will be officially published in the EOSC IF during the project lifetime to encourage broad adoption by the main European research communities.

3.3 EOSC Platform Data Models

Figure 3.5 illustrates the various functional components of the EOSC-Core Services in the EOSC Platform as well as the various sets of data that are needed for each EOSC-Core Service to operate. The EOSC-Core Services are loosely coupled, and each of them has its own data model, however they are expected to interact and exchange data to, for example, avoid data duplication. Considering the interrelations between them, we envisage a common **virtual data model for the EOSC-Core Services in the EOSC Platform** as a union of each EOSC-Core service data model. This is currently a star model with the EOSC Resource Catalogue in the centre, but it is expected to evolve in the near future as more interactions among multiple EOSC-Core services will be needed to support emerging use cases.

This virtual Data Model is a unified conceptual data model that describes the logical entities (EOSC Entities), the information about these entities, and the relationships between the entities, needed by EOSC-Core services and other services interacting with those EOSC-Core services. The EOSC Platform Data Model is an important component of the EOSC Interoperability Framework (IF) and a key architectural tool for defining the relationships between logical entities of importance to EOSC, their role in different use cases, and their implementation (through Profiles and software components). Profiles are further discussed in section 4 below.

The Data Model has been defined in detail for the EOSC Resource Catalogue. The EOSC Resource Catalogue data model (see Figure 3.6) defines properties that are relevant for EOSC Providers and EOSC Resources (Services, Data Sources, Research Products). It defines how EOSC Resources are described and the links between them, in order to facilitate discovery, monitoring, and access to them. The Resource Catalogue data model captures descriptive metadata commonalities across different systems, without losing information, and without being overly descriptive, by relying on standards in the domains to capitalise on existing systems and platforms.

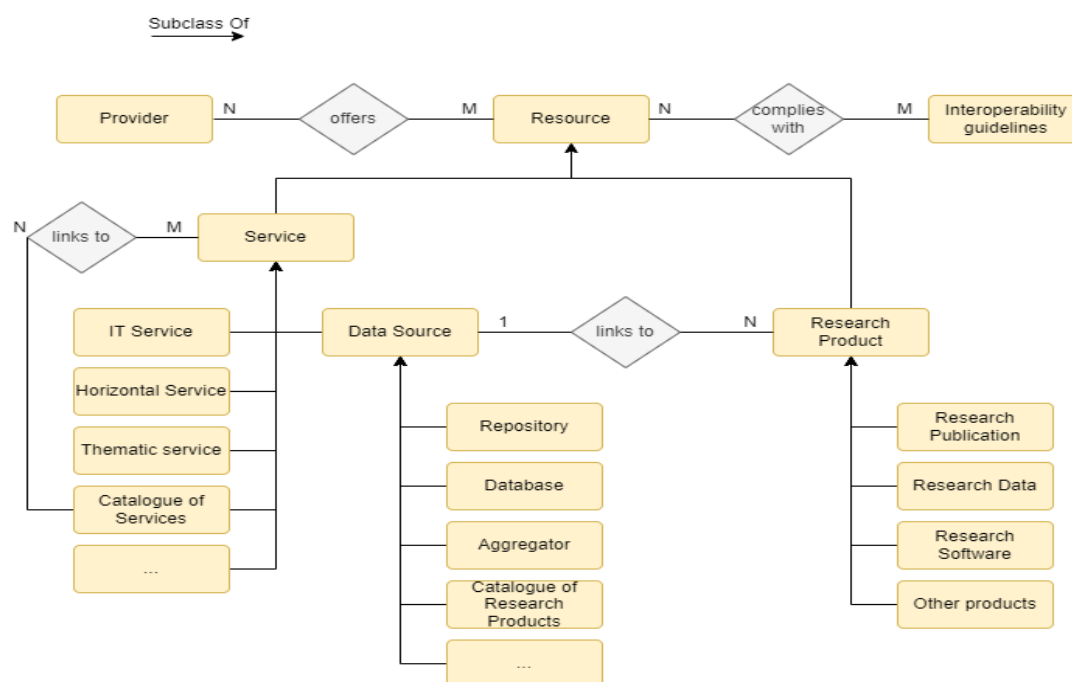


Figure 3.6: EOSC Resource Catalogue data model

⁷ <https://wiki.eosc-hub.eu/display/EOSCDOC/Federation+services>

The EOSC Resource Catalogue forms a knowledge graph, representing the relationship between EOSC Resources, namely catalogues, services, data sources, research products, and providers, which in turn are related to EOSC Interoperability Framework to claim their compatibility to standards, protocols, formats, etc. Figure 3.7 illustrates the application of this information model to one use case, updating and synchronisation between different catalogues and repositories of data resources.

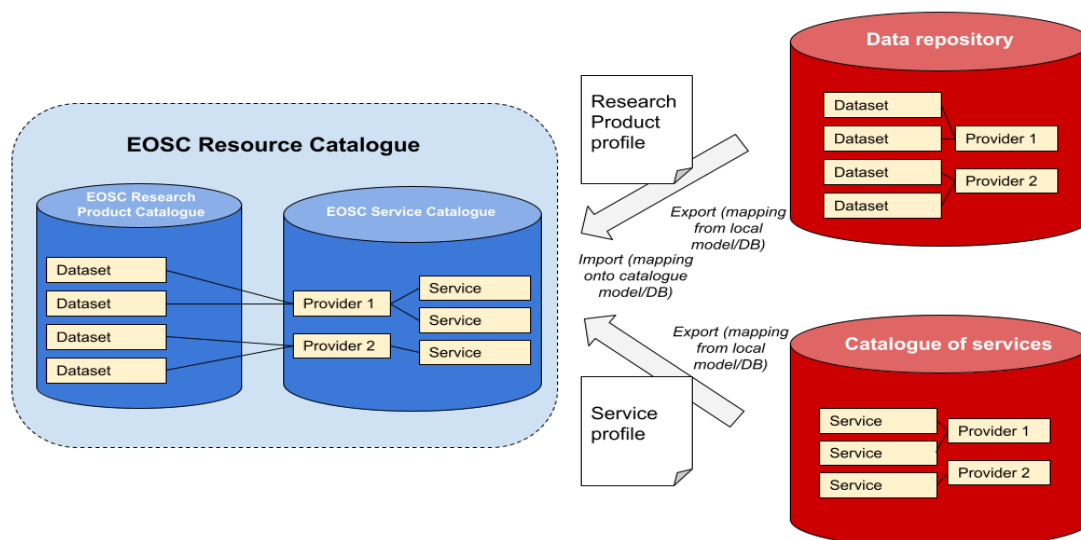


Figure 3.7: Application of the Resource Catalogue data model to catalogue updates and synchronisation

Work is underway, started in EOSC Enhance, to document the EOSC Platform Virtual Data Model, beginning with the Resource Catalogue Data Model, using the XSD format.

Data models required for the operation of other EOSC-Core services are under development, and the intent is to extend the XSD representation of the virtual Data Model to encompass all of the models, highlighting the interactions between and providing an overall virtual view that embeds all the EOSC-Core services data models. EOSC Future will define processes for the evolution of the EOSC-Core services data models, maintenance of virtual Data Model documentation, and related formal change management activities to ensure ongoing architectural alignment and interoperability of EOSC-Core services.

3.4 Common Template for the EOSC-Core Interoperability Guidelines

Although the services in the EOSC-Core Services have different scope, their architecture specification and Interoperability Guidelines need to offer similar information to the Providers, such as details on the specific EOSC-Core service architecture, adopted standards and best practises, integration options and related procedures. This common information is captured in Table 3-1. The template enables easy verification of the completeness of the information and provides standard documentation for EOSC Providers wishing to integrate with the service.

Table 3-1: Template for EOSC-Core Service Interoperability Guidelines

Interoperability guideline section	Description
Description and main features	Short description of the EOSC-Core service highlighting its main features
High-level Service Architecture	Architecture (commented diagram) of the EOSC-Core service that highlights the interfaces with other services (Core and Exchange). List and description of the integration options.

Adopted API, protocols, formats, EOSC-Exchange Interoperability Guidelines etc. (standards and best practice)	List with references to adopted API, protocols, format, EOSC-Exchange Interoperability Guidelines supported by this EOSC-Core service.
Interoperability Guidelines	Describe the procedures services in the EOSC-Exchange need to implement to interoperate with this EOSC-Core service (e.g. integrate a provider's helpdesk with the EOSC Core Helpdesk, integrate a regional catalogue with the EOSC Resource Catalogue, etc.). A procedure is defined for each integration option defined in the High-level Service Architecture section.

In addition to the adoption of this common template, T3.2 is working to ensure that the same level of detail is provided in all the guidelines, in order to achieve homogeneity of document structure, as well as consistency in the amount and type of information included.

4 EOSC Profiles: Metadata schemas for entities in the EOSC Data Model

The EOSC Platform Data Model provides a conceptual definition of the logical entities and their relationships that are important to the proper functioning of EOSC. An EOSC Profile is a concrete representation of selected entities and information required to ensure consistent communications and data exchange among EOSC-Core Services and with linked EOSC-Exchange services. Each EOSC Profile defines a metadata schema (and format) to ensure consistent information about EOSC entities across different systems including the EOSC Resource Catalogue and other EOSC-Core services. As such, EOSC Profiles are driven by the EOSC Platform Virtual Data Model, i.e. can be mapped onto the data model of a core service and are defined as: *A record structure including mandatory and optional elements, singular or multiple elements, and the use of pre-defined vocabularies for specific elements.*

For example, the EOSC Service Profile establishes how e-Infrastructure/RI/cluster service catalogues can exchange metadata records about their services and the relationship with their providers with the EOSC Service Catalogue (and across them). The EOSC Research Product Profiles define how EOSC Data Sources can expose metadata about publications, data and software to the EOSC Research Product Catalogue, together with links to providers, authors, etc. The EOSC Profiles for Services and Research Products, together with the format and APIs to be used to exchange resource record information with the EOSC Resource Catalogue services, compose the EOSC Interoperability Guidelines for the Resource Catalogue that are detailed in section 4.1.

EOSC Profiles also provide recommendations about the expected quality and completeness of the information and about the criteria of inclusion that EOSC Resources must meet to satisfy the EOSC Rules of Participation, as well as the agreed Operating procedures for EOSC-Core and EOSC-Exchange service providers. The Operating procedures complement the Profiles to ensure the consistency of information (e.g. catalogue updates and synchronisation, use of the Profiles as the “payload” of APIs for specific components, etc.).

EOSC Profiles are used by the EOSC Provider Portals and the EOSC Resource Catalogue. These components and the Profiles themselves are used by the EOSC Portal Onboarding Team (EPOT) to review the applications for registering resources submitted by Providers before they are approved for inclusion in the EOSC Resource Catalogue.

4.1 Current EOSC Profiles

Version 3.0 of the EOSC Profiles specification^{8,9} was finalised in January 2021 by EOSC Enhance and is now in production in the EOSC Service Catalogue (formerly referred to as the EOSC Resource Catalogue as well as the Service Registry). Version 3.0 defines a profile specification for two entities: Providers and Resources (only services). Version 3.0 has been used to onboard **237 (209 approved)** providers and **364 (352 approved)** Resource (Service) profiles as of January 2022. Current usage and statistics for Providers and Resources respectively can be found in the EOSC Provider Portal¹⁰, the EOSC Metrics Portal¹¹, as well as the EOSC Portal Statistics Monitoring Tool (requires authorised access).

Version 4.0 of the EOSC Profiles specification¹² was developed by EOSC Enhance to, among other objectives, include in the data model the new entity *Research Products* and to include specific subclasses of services, namely *Data Sources*, which are services that host and provide access to Research Products. The extension is required to integrate Research Products from the EOSC Research Product Catalogue (which will be integrated into the EOSC Resource Catalogue based on the OpenAIRE Research Graph/EXPLORE), and to facilitate inclusion of a wider range of users and a wider range of services through interactions with service catalogues developed by

⁸ <https://wiki.eoscfuture.eu/display/PUBLIC/v3.00+EOSC+Resource+Profile>

⁹ <https://wiki.eoscfuture.eu/display/PUBLIC/v3.00+EOSC+Provider+Profile>

¹⁰ <https://providers.eosc-portal.eu/stats/providers> and <https://providers.eosc-portal.eu/stats/resources>

¹¹ <https://opsportal.eosc-portal.eu/metricsEOSC/ECReport>

¹² <https://wiki.eoscfuture.eu/display/PUBLIC/v4.00+EOSC+Resource+Profile>

INFRAEOSC-04 (thematic), -05 (regional), and -07 (horizontal) projects. Version 4.0 also reflects changes responding to 11 issues raised by stakeholders in testing.

Version 4.0 positions the Profiles to support:

- Linking to the Research Product Catalogue that required specification of “Data Source” and “Research Product” Profiles.
- Interconnection with other catalogues that required specification of a profile for a “Catalogue” entity, and addition of a Catalogue field to existing Profiles.

The new version was finalised by EOSC Enhance in November 2021 and handed over to EOSC Future in December 2021. Most changes from version 3.0 to version 4.0 have been implemented by affected EOSC components and are ready to move to production. Some final actions are needed to populate new data fields and validate existing data fields that are now mandatory and should be completed by March 2022. Additional work will be conducted in the coming months to validate three additional fields that will become mandatory on release in July 2022 (Related Platforms, Terms of Use, Privacy Policy). The July date was selected in order to give currently registered Providers sufficient time to prepare updates to their own API endpoints.

Components affected by this update are:

- EOSC Resource Catalogue is the result of logically joining the EOSC Service Catalogue and the EOSC Research Product Catalogue. The Resource Catalogue will act as a back-end data source for user interactions through the EOSC Marketplace, and direct access to the data will be offered via REST APIs and file transfers.
- Provider Portal (forms used for onboarding providers and services, data sources etc): Service Provider Portal (currently served by the EOSC Portal Provider Portal, and to be rebranded as the EOSC Service Provider Portal) and Research Products Provider Portal (currently served by OpenAIRE Provide, federated to the EOSC Portal, and to be rebranded EOSC Research Product Portal).

The last remaining aspects of the Version 4.0 implementation will require communication with affected stakeholders across the EOSC community. The T3.2.1 profile team will develop a communication plan to explain the planned changes, the benefits to the community, and the actions needed to enable those changes. WP3 will work with WP10 to execute an appropriate outreach plan and support dialog with affected and/or concerned stakeholders. In general, WP3 strives to communicate with the community as early as possible, ideally six months, in advance of major revisions to the Profiles that require action on the part of stakeholders, so this effort will begin soon in order to support full cutover to v4.0 by July 2022.

4.2 Enabling EOSC Profile Evolution

With the handover of EOSC Profile maintenance to EOSC Future in December 2021, WP3’s efforts in connection with the continued evolution of the EOSC Profiles are now both reactive, supporting the general objective of making resources easy to find, access and use, and proactive, supporting delivery of capabilities planned in 2022 for EOSC Future.

To support both of these efforts, WP3 is working to adopt tools and processes to manage the detailed structure and interdependencies of the EOSC Profiles and to support the capture of requirements and an efficient change management process.

Current Tools and Processes:

- The current “repository” for the EOSC Profiles is comprised of a series of Wiki pages¹³ that store the specifications once they are finalised, along with detailed onboarding and change tracking (version to version). This static presentation is complemented by a collection of Jira tickets tracking the implementation of the agreed changes. Public versions of the specifications are available in the EOSC

¹³ <https://wiki.eoscfuture.eu/display/EOSCF/EOSC+Portal+Profiles>

Portal¹⁴ and Zenodo¹⁵. However, these formats are not easy to use – by any stakeholder, nor do they support collaborative processes to record, consider or decide on requests for change.

- The current change management process is detailed in Figure 4.1.

¹⁴ <https://eosc-portal.eu/providers-documentation>

¹⁵ <https://doi.org/10.5281/zenodo.5726890>

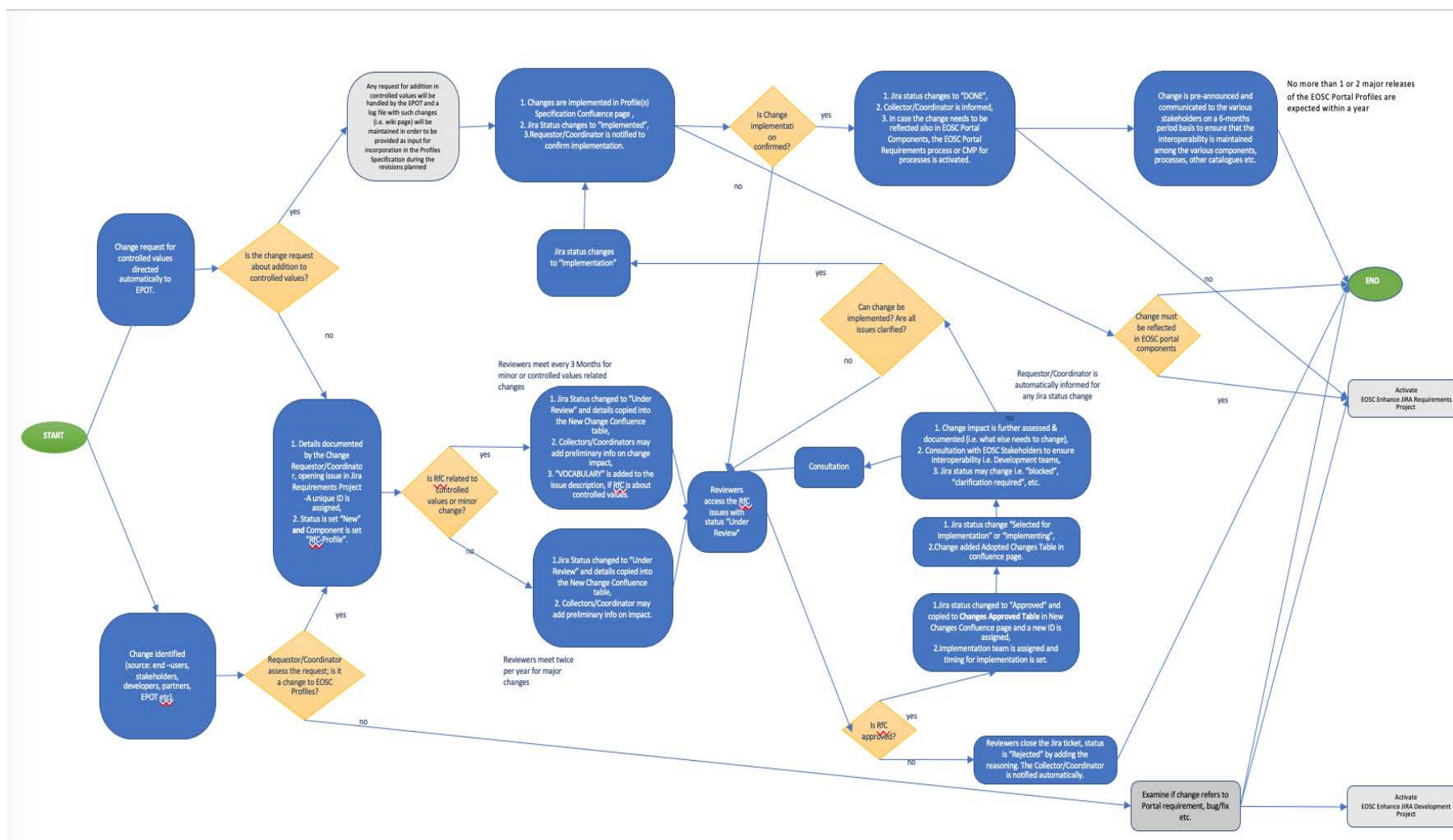


Figure 4.1: Illustration of Current Change Management Process for EOSC Profiles

Future tools and processes to be considered and implemented:

- **Repository and representations.**
 - As noted above, effort is underway to create a machine-readable representation of the EOSC Platform Virtual Data Model using XSD. WP3 will explore compliant tools that can generate both documentation and “textual”, machine-readable representations of the data model (such as XML and JSON).
 - WP3 will examine the value of such structured formats themselves, perhaps held in a Gitlab or Github repository, as a basis for capturing new requirements and issues as well as detailed management and tracking of the change and release process.
- **Change management process.** WP3 intends to split the change management process into two streams and to simplify both streams as much as possible:
 - **Virtual Data Model Change Management:** Working with the XSD representation, proposed changes to the overall Data Model will be handled by a new process to be defined, allowing tracking, management and alignment of changes required to support planned additional EOSC Future capabilities, as well as changes triggered by operational experience. In particular, provisional changes to the Data Model can be modelled to support agile pilot/alpha/beta service enhancements, which, after testing and validation, can be formalised in the Data Model. New capabilities will be explored through agile service development without requiring immediate changes to the EOSC Profiles. The Change Management Process for these changes may incorporate many features of the current process for EOSC Profile changes.
 - **Profile Change Management:** When new feature designs are stable, any data exchanges between EOSC components would be formalised through creation of new Profiles and/or updates to existing Profiles. Such changes would represent the final step of the development process, allowing service integrations and enhancements to be transitioned to production in a controlled way. The Profile Change Management process itself might be simplified to enable a more streamlined approach.

The change management process for both the Data Model and the EOSC Profiles will be aligned with Change Management Processes being implemented through the Service Management System (SMS) being operated in WP7. They will also be tracked and registered through the EOSC Interoperability Framework.

The change management process illustrated in Figure 4.1 partially addresses the communication and stakeholder engagement process required. This process will be further defined, paying greater attention to the consultation/communication process – ensuring that all affected stakeholders, from users to software developers, are appropriately involved in issue and requirements gathering, decision making about new features, and management of the resulting implementation/adoption process. These consultation steps will also be handled differently for Data Model and Profile changes.

The proposed two-tier Change Management Process will provide a natural division of labour for handling change requests triggered by operational experience. Simple changes can be accommodated with “smaller” changes to EOSC Profiles, while requested changes with broader ramifications can be referred to the Data Model Change Management Process for more detailed evaluation and planning.

A communication process will be designed and implemented in order to recognise the need to be sensitive to the impact of change on the participating Providers, ensuring they are given the opportunity to plan for the implementation of Provider-side changes in order to comply with Data Model and Profile changes, as well as the need to recognise the positive impact it would have on managing the development pipeline.

As a final point, WP3 will consider the treatment of “Profile Extensions”, which are supplementary metadata schemas used to increase the descriptive power of EOSC Profiles, without triggering disruptive changes to stable entity Profiles. (See further discussion of Profile Extensions below.)

- **KPIs.** The T3.2.1 activity will examine sub-indicators (to existing high-level KPIs 2¹⁶ and 3¹⁷) that can be used to manage the efficiency and efficacy of the EOSC Profile Maintenance process. Candidates might include:
 - New Provider/Resource records onboarded per period;
 - # of incidents or defects encountered (by providers, by EPOT, by users);
 - Time to evaluate change requests;
 - Time to implement approved changes.

4.3 Enhancing EOSC Profiles to support specific classes of resource, e.g. compute, storage, etc

One potential opportunity for improvement is the use of **Profile Extensions**, such as used to define the “Data Source” profile – which is an “extension” to the Service profile, e.g. modifying a Service to become a Data Source entity by defining the Data Source extension for that entity. This approach creates a structured format for capturing metadata about specific categories of resource without complicating metadata for all resources. This approach may also be useful to integrate Services with other EOSC-Core services, essentially extending the “provides” relationship (between a Provider and a Service) to define additional relationships such as “Supports”, “Offers for Access”, “Accepts Orders for”, “Accounts for”, “Monitors” between Providers and Services.

The EOSC will naturally expand to include new types of resources, to meet the demands of its user base. Accordingly, the EOSC Resource Catalogue and the Marketplace will adapt to ensure sharing, discovery, and access of such resources. Similarly, in some cases new profiles will be required to ensure information can be exchanged between EOSC-Exchange services and the EOSC Platform.

Currently, the EOSC Future WG on the Computing Continuum¹⁸ is working on the definition of an EOSC Profile for computing services, which will enable Compute Services (e.g. Cloud) in the EOSC-Exchange to expose specific kinds of computing services accessible via the Marketplace, thereby simplify the request workflows that such services require. Such profiles will describe the current status of the computing services that are pre-authorized and available from a cloud service, together with their current occupation and release times.

Additional enhancements planned for the EOSC Platform will be supported by modifications to the EOSC Profiles:

- Inter-catalogue connections, updates and synchronisation. Specific use cases are being defined by a dedicated strategy task force, to be followed by agreement on implementation and support through EOSC Profiles. Required modifications could include refinement of the existing “Catalogue” field, addition of “Update Timestamp” and “Inactive” fields, and agreement on guidelines to recognize or create service PIDs to enable cross-referencing and avoid duplication.
- Identification of horizontal services, possibly through addition of a “Horizontal Service” field.
- Modification or extension of existing profiles to support integration with other Core Services.
- Enhancement of existing profiles to reflect EC-funding as well as other aspects of funding and authorization to enable ordering and use.

All enhancements will be governed by the change management and release management process to ensure that new functions are introduced without disrupting existing capabilities and that affected communities understand the value of the planned changes and are given adequate time to take advantage of them.

¹⁶ KPI-2 Resource providers/resources in the Exchange

¹⁷ KPI-3 Connecting major Thematic and Regional Catalogues to the EOSC Exchange

¹⁸ <https://wiki.eoscfuture.eu/display/PUBLIC/Compute+Continuum+Working+Group>

5 Architecture Specifications and Interoperability Guidelines for Operational Services of the EOSC-Core

This section details the Architecture Specifications and Interoperability Guidelines for the operational services of the EOSC Platform. For each EOSC-Core service, the following information is provided:

- A concise description of the EOSC-Core service and its main features;
- A commented diagram of the high-level architecture of the service that highlights the interfaces for integration;
- Description of the offered integration options;
- Description of the EOSC provider and/or service information that should be shared with the EOSC-Core service to enable the integration;
- A brief summary of the plans to evolve the EOSC-Core service and its Interoperability Guidelines.

The Interoperability Guidelines presented in this document are available in the EOSC Future wiki¹⁹ and will be registered in the EOSC Interoperability Framework registry when available. Direct links to each guideline can be found in the following table.

Table 5-1: Interoperability guidelines for operational services of the EOSC-Core platform.

EOSC Core Services	Interoperability guidelines
Resource Catalogue	https://wiki.eoscfuture.eu/display/PUBLIC/Resource+Catalogue+Architecture+and+Interoperability+Guidelines
Helpdesk	https://wiki.eoscfuture.eu/display/PUBLIC/Helpdesk+Architecture+and+Interoperability+Guidelines
Monitoring	https://wiki.eoscfuture.eu/display/PUBLIC/Monitoring+Architecture+and+Interoperability+Guidelines
Accounting	In development
Order Management	https://wiki.eoscfuture.eu/display/PUBLIC/Order+Management+Architecture+and+Interoperability+Guidelines

5.1 EOSC Resource Catalogue

5.1.1 Description

The EOSC provides a “catalogue” that facilitates sharing, discovery, access of EOSC Resources, as provided by EOSC providers, across different RIs, clusters, e-Infrastructures, single researchers, industries, etc. Examples of such resources are services (e.g. computing, storage, scholarly communication, thematic, etc.), data sources (e.g. repositories, data archives, software repositories, libraries, publishers, etc), and research products (e.g. publications, research data, research software, other products) deposited and made available via such data sources. The EOSC Resource Catalogue keeps an up-to-date map of the Resources of the EOSC, by interoperating at the technological and policy level with the local catalogues operated by the scientific communities, clusters, the RIs, and the e-Infrastructures.

The EOSC Resource Catalogue is the result of logically joining the EOSC Service Catalogue (including Data Source services) and the EOSC Research Product Catalogue and includes a related list of EOSC Providers. The Service Catalogue and the Research Product Catalogue are populated independently, as the onboarding process used differs due to the nature of the resources they manage, although these resources may be interrelated. The Service Catalogue and Research Product Catalogue can acquire metadata records from similar catalogues located within RI/clusters/e-Infrastructures other organisations premises or, in the case of research products, directly from the data sources. As a result, the EOSC Resource Catalogue contains metadata about services, data sources, and research products, together with semantic relationships between them, highlighting the nature of the connection between services and products (e.g. hostedBy, generatedBy, etc.).

¹⁹ <https://wiki.eoscfuture.eu/display/PUBLIC/EOSC+Core+services>

Note in the text below, the term “Resource” refers to either a Service or a Research Product.

5.1.2 High-level Architecture

The following figure illustrates the EOSC Resource Catalogue, its main components and the ways they interact with each other and with external components and users. The Service Catalogue contains entries regarding services (onboarded directly or from third party catalogues), external catalogues, and it works together with the Research Product Catalogue to enable Data Source onboarding and management.

The EOSC Resource Catalogue interacts with other EOSC-Core Components via dedicated APIs, exchanging information about Providers and Resources with EOSC Core services and gathering data needed to enable the usage of EOSC-Core services for Providers and/or Resources. It also offers API access for Providers to create and manage catalogue entries, gather usage statistics and guarantee the synchronisation with third party catalogues. Providers can also manage catalogue entries through the Service and Research Product Provider’s Portals (or Providers Dashboards), a web UI that wraps the APIs.

Finally, the EOSC Service Catalogue also exposes an API for the curation and the auditing of the catalogue entries, which is currently used by the EOSC Portal Onboarding Team (EPOT).

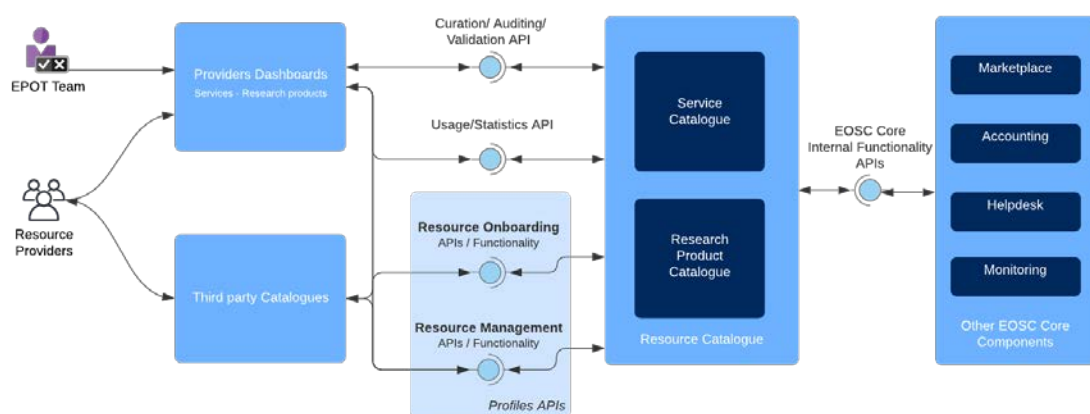


Figure 5.1: High-level Architecture of the EOSC Resource Catalogue.

5.1.3 Interoperability Guidelines

The EOSC Resource Catalogue can onboard both services and research products. The integration paths offered by this component to the providers corresponds to the two onboarding workflows of these two types of resources:

- **EOSC Service onboarding:** register a Provider and then its Services in the Catalogue;
- **EOSC Research Product onboarding:** register Research Products in the Catalogue.

Although the two workflows have independent entry points, they are interrelated. For example, when the onboarding of a Data Source in EOSC is completed, the Provider can trigger the onboarding of all the research products related to the newly registered Data Source. Vice versa, the registration of some datasets through the EOSC Research Product onboarding can trigger the onboarding of their Data Source as a service.

Services and Research Products registered in EOSC will be discoverable by and accessible to the end-users in the EOSC Marketplace.

A high-level description of the two onboarding workflows and their relationships is depicted in Figure 5.2. The remaining part of this section details these workflows.

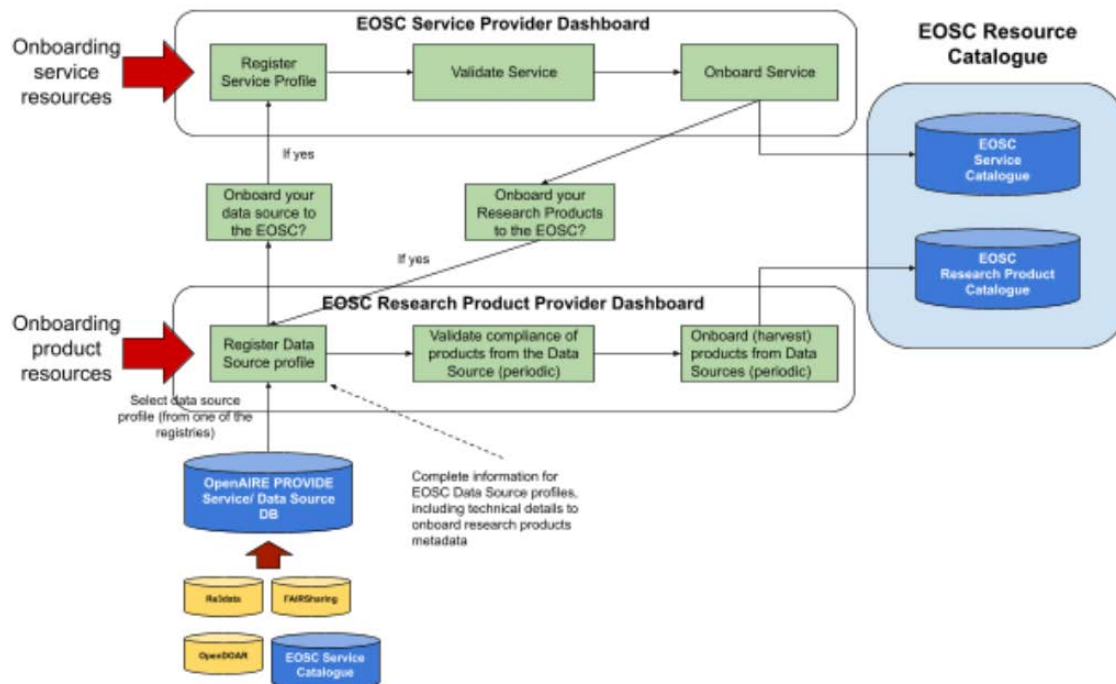


Figure 5.2: EOSC Resource onboarding workflows

EOSC Services onboarding

The EOSC Service Catalogue offers two interfaces to onboard and manage providers and resources:

- the EOSC Service Catalogue REST APIs²⁰;
- the EOSC Service Providers Portal Component²¹: a web portal that offers a simple UI to interact with the Service Catalogue.

These two interfaces enable the following functionalities:

- *Onboarding service*, which implements the EOSC Portal onboarding process for resources, i.e., the registration of a new Provider and the registration of Services or Data Sources managed by the Providers, as well as the registration of Catalogues. Onboarding will target authenticated users who will be able to onboard either via a web-based step wise process or programmatically by using the EOSC Service Catalogue's APIs.
- *Resource Management service*: It offers the functionality for authenticated Providers to manage their resource portfolio in the catalogue, i.e., view the list of Resources associated with their organisation and manage all characteristics of their offerings. Resource management will enable users from onboarded Providers to add, update a Resource, "activate"/"deactivate" a Resource in the EOSC Portal, to assign it to categories or other classification schemes (e.g., scientific domain, TRL, etc), to manage the different versions of a Resource and add new users who will be responsible for managing the offerings of a Provider.
- *Providers Dashboard*: It serves as the UI entry point for Providers. The dashboard offers a Provider-facing overview by way of a list of Resources and their properties including a history of changes applied to each Resource. The dashboard will also give access to a rich set of statistics, which are collected by the EOSC Portal and will be associated with Resources and Providers onboarded in the EOSC Registry.
- *Statistics* over the content of the Service Catalogue, organised by Resources and Providers, such as number of Resources per scientific discipline, Providers per country, etc. These include usage statistics, such as views and visits for Resource, aggregated views and visits for all Resources offered by a provider, search related statistics which are associated with a Provider, orders placed for a Resource,

²⁰ <https://providers.eosc-portal.eu/developers>

²¹ <https://providers.eosc-portal.eu/home>

ratings, recommendations offered to users related to a Resource and finally favourites those users add in the EOSC portal.

- *Validation/Auditing* functionality for recurring quality assurance of Resource data and status and for curation of Provider changes to Resources over time. This functionality is currently used by EOSC Portal Onboarding Team (EPOT) Team members, but it also applies to external catalogue administrators.

Based on the EOSC Resource Catalogue data model, the EOSC Service Catalogue REST APIs cover Services and Data Sources as well as links to third party catalogues that contain additional resources. They are described in the following table together with information on the supported profiles and their implementation status.

Table 5-2: The EOSC Service Catalogue REST APIs

Client	API	Resource Profile	Status
Services	For Service Providers: • Provider/Resource/Controlled Vocabulary REST API • Onboarding workflow (guide, documentation) For EPOT team members: • Auditing and Registry workflow • Email digest and interaction with providers	Service (was Resource) and Provider Profiles (v 3.0, v 4.0)	Ready
Data Sources	For Data Source Providers: • REST APIs for Data Source Providers/Resources/Controlled Vocabularies For EPOT team members • Onboarding/Auditing workflow for Data Sources	Data Source Profiles (v.4.0)	Under development
Catalogues	For third party EOSC Federated Catalogues: • Catalogue Provider/Resource/Controlled Vocabularies REST API For EPOT team members: • Auditing and Registry workflow	Catalogue Profiles (v.4.0)	Under development

The EOSC Service Catalogue REST APIs will be further enhanced during the project lifetime. Plans for their evolution include:

- Workflow alignment with all EOSC Profiles evolution:
 - REST APIs evolution;
 - Providers portal UI updates triggered by new onboarding/management workflows;
- Messaging support through JMS or AMS for EOSC Federated components/partners;
- Support for Resource identification based on PIDs.

EOSC Research Products Onboarding

Research products are EOSC resources resulting from a scientific process, any physical or digital asset produced and shared by users/services for users/services, such as research literature, research data(sets), research

software, and others. Research Products are characterised/described by metadata to be used for citation, attribution, re-use, reproducibility, semantic linking, and findability, made available via EOSC Data Sources, which also host the digital assets when the product is digital.

EOSC Data Sources must comply with the EOSC Research Product interoperability guidelines²² in order to onboard the Research Products that they contain into the EOSC Resource Catalogue. According to the System of Systems approach, EOSC will further extend the set of Research Product guidelines to include other well-established, complete, and community-endorsed standard profiles. The onboarding process (validation and aggregation of metadata), takes place via the EOSC Research Product Onboarding Services, powered by [OpenAIRE PROVIDE](https://provide.openaire.eu/)²³, that is being integrated with the EOSC Service Provider dashboard to harmonise the EOSC Resource onboarding process in a uniform workflow (see fig. 5-2). Onboarded datasets will be published by the EOSC Marketplace, acting as front-end for the EOSC Resource Catalogue.

The EOSC Interoperability Guidelines for research products currently adopted are listed in Table 5-3.

Table 5-3: Interoperability Guidelines for operational services of the EOSC Platform.

EOSC Research Products Interoperability Guidelines	Description
OpenAIRE Guidelines	The OpenAIRE guidelines provide a community-endorsed classification of research products, based on standard metadata formats (DataCite, Dublin Core, JATS) and vocabularies (CASRAI, COAR) in scholarly communication. According to the guidelines, research products are organized into four classes: publications (aka "literature", intended for humans to read), research data (information to be used by programs; human readability is a feature), research software (code for compilation or interpretation), and other research products (products that are not classified as literature, datasets, and software). The model may in the future be extended to include more first-class citizen entities. For example, by identifying into "Other Research Products" other classes of products that are "mature" enough to flank publications, data, and software. For an entity to surface as a first-class entity, the entity must be (i) well recognized across different disciplines of science and (ii) bring a critical mass of products and data sources making such products available. • EOSC Profiles²⁴ for Research Publication/Literature, Research Dataset, Research Software, Other Research Products, limited to OpenAIRE Guidelines for Literature repositories 3.0 and 4.0, Data repositories, and CRIS systems. • Vocabularies for Research Publication²⁵, Research Dataset²⁶, Research Software²⁷, Other Research Product²⁸
Bioschemas.org	As reported at bioschemas.org²⁹, "bioschemas aims to improve the Findability on the Web of life sciences resources such as datasets, software, and training materials. It does this by encouraging people in the life sciences to use Schema.org markup in their websites so that they are indexable by search engines and other services.

²² <https://wiki.eoscfuture.eu/display/EOSCF/v4.00+EOSC+Research+Product+Profile>

²³ <https://provide.openaire.eu/home>

²⁴ <https://guidelines.openaire.eu/en/latest/>

²⁵ http://api.openaire.eu/vocabularies/dnet:result_typologies/publication

²⁶ http://api.openaire.eu/vocabularies/dnet:result_typologies/dataset

²⁷ http://api.openaire.eu/vocabularies/dnet:result_typologies/software

²⁸ http://api.openaire.eu/vocabularies/dnet:result_typologies/other

²⁹ <https://bioschemas.org/>

	Bioschemas encourages the consistent use of markup to ease the consumption of the contained markup across many sites. This structured information then makes it easier to discover, collate, and analyse distributed resources.” Bioschemas defines metadata profiles over the Schema.org types that identify the essential properties to use in describing a resource in the Life Sciences. OpenAIRE PROVIDE is being adapted to accept bioschemas compliant data sources and ensure their onboarding into the EOSC. The adaptation of the system has been promoted in BETA by Autumn 2022, promotion to production is expected by M30.
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5.2 Helpdesk

5.2.1 Description

The EOSC Helpdesk is the entry point and ticketing system/request tracker for issues concerning the available EOSC Services. It implements incident and service request management and provides efficient communication channels between users and providers of the IT resources and services. The EOSC Helpdesk provides several capabilities, identified during requirements analysis, such as self-service, reporting and notifications; it helps ensure the integrity of the IT infrastructure and the quality of the delivered services. The detailed description of all requirements included in the EOSC Helpdesk roadmap in the EOSC Future project is provided by the deliverable *D4.2a Back-Office Requirements Analysis*.

In the EOSC Future project, the Helpdesk is implemented as a distributed multi-tenant system that can be used for efficient support of the EOSC Platform and the EOSC-Exchange services. The EOSC Helpdesk is offered to EOSC Providers as a service to enable dedicated support for users of their services. To achieve this goal, the EOSC Helpdesk supports different levels of integration with Helpdesk components, described in the Section 5.2.2.

5.2.2 High-Level Architecture

Figure 5.3 shows the high-level technical architecture being implemented for EOSC Helpdesk. The main component is the Helpdesk Back Office that implements the core functionality of the service: ticket management, user role management, management of the support groups, etc. The Helpdesk main portal provides the UI for both users and helpdesk agents³⁰, search functionality based on Elasticsearch engine, reporting and statistics dashboards. It also provides self-service functions like a knowledge base and a search engine for common and resolved known issues and problems.

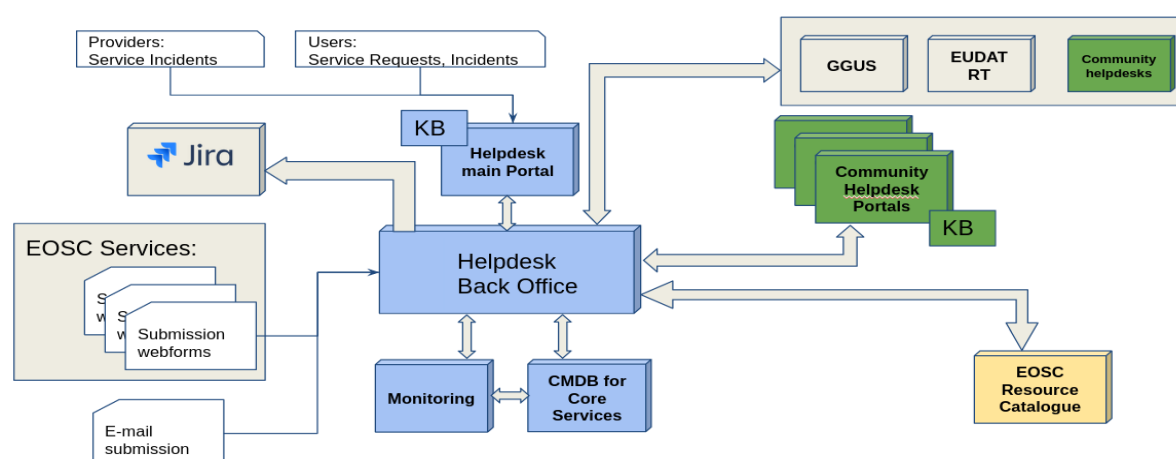


Figure 5.3: High-level architecture and integrations of the EOSC Helpdesk

³⁰ A Helpdesk agent is the person responsible for providing helpdesk support and resolution of the incidents, service requests, queries submitted to the helpdesk, ensuring high level of customer satisfaction.

The Helpdesk Back Office is integrated with multiple components as depicted on Figure 5.3. These include:

- **JIRA:** the integration with JIRA allows the propagation of user requests to specific EOSC internal JIRA projects and support teams. It allows easy conversion of user requests into JIRA tasks or epics for further tracking of the request in JIRA. This integration is one-way, meaning once the helpdesk agent decides to copy the helpdesk ticket to JIRA for further processing, further processing will only happen in JIRA, and the Helpdesk service will not continue to track the status and evolution of the issue, although the Helpdesk will maintain the link to the JIRA issue to assist with follow-up and resolution.
- **EOSC submission webforms:** the integration will provide ready-to-use webforms to be embedded on the dedicated portals of the EOSC Services integrating with the Helpdesk, allowing for easy submission of the request without logging in to the helpdesk. A ready-to-use javascript snippet will be provided upon request for adding it to the web page and enabling webform submission.
- **E-Mail submission:** integration of the Helpdesk with a particular group with a specific mailbox which can be offered for users to submit their requests via e-mail.
- **EGI GGUS, EUDAT RT and community helpdesks:** the integration allows bi-directional synchronisation of user requests created in EOSC Helpdesk with each of these existing helpdesk systems, to enable further processing in those helpdesk systems. The integration for EGI GGUS and EUDAT RT has been achieved in the previous helpdesk adopted in the EOSC-hub project and will be repeated for current helpdesk technology in EOSC Future. Further community helpdesks can be integrated upon community requests according to the specifications provided by the community.
- **Community Helpdesk Portals:** the integration of the multiple user-facing community branded portals under community domains together with dedicated community knowledge bases.
- **Integration with CMDB for EOSC-Core Services:** the integration with the configuration management database which holds the metadata for all EOSC Core Services and their components, which will enable assignment and tracking of the service request for the dedicated EOSC Core service.
- **Integration with the EOSC Monitoring system:** the integration will provide easy access to live information about supported services, their production statuses, availability information and enable the automated creation of helpdesk tickets when alarms are raised (for example when a Monitored Service is not responding to status requests).
- **Integration with EOSC Resource Catalogue:** the integration with EOSC Resource Catalogue service will allow direct submission of issues and requests from the Provider Portals interface to the Helpdesk.

As with all other EOSC-Core services, the EOSC Helpdesk is integrated with the EOSC AAI through the EOSC Core Infrastructure Proxy to enable access to the EOSC Helpdesk for EOSC users and agents. The integration with the Infrastructure Proxy has been performed based on SAML protocol.

The EOSC Helpdesk is based on the open-source helpdesk software Zammad³¹. It provides a powerful REST API and supports multiple REST API clients. The most relevant are listed in Table 5-4.

Table 5-4: Available API clients for EOSC Helpdesk

Client	Description	Main Requirements
Ruby Client	The client is used to access Zammad helpdesk API via Ruby application	This client supports Zammad API version 1.0.
PHP Client	This client can be used to access the Zammad helpdesk API via PHP	Version 3.4.1 and newer. PHP 7.2 and newer
Android Client	Android client library for Zammad, built with Kotlin, Retrofit, Moshi, OkHttp	Kotlin 1.4.0 and newer

³¹ <https://zammad.org/>

5.2.3 Interoperability Guidelines

In this section the main integration scenarios are considered and the Interoperability Guidelines for EOSC Providers for integration of their services, processes and workflows with EOSC Helpdesk are described.

For new EOSC Providers and communities onboarding services, three levels of interoperability with EOSC Helpdesk will be offered, corresponding to the three integration paths:

1. **Full integration:** this path corresponds to the integration of community helpdesks described in the previous section, which implies full synchronisation between EOSC Helpdesk and community helpdesk. This integration can be achieved by application of a set of the EOSC Helpdesk [REST APIs](#)³². The exact integration guidelines will be defined based on the specifications agreed with the community.
2. **Ticket redirection:** in this integration the EOSC Helpdesk is used only as an initial contact point to redirect the initial request to the provider's or community mailing list without further integration.
3. **Direct usage:** in this integration the EOSC Helpdesk can be used by the community as the ticketing system for its onboarded services.

These three options can be chosen during the onboarding process or upon later request created via EOSC Helpdesk.

Ticket redirection is the simplest option and only requires the specification of a mailing list and set of services to trigger the redirection procedure. **Full integration** requires detailed specifications per each integrated helpdesk service and case specific integration tasks.

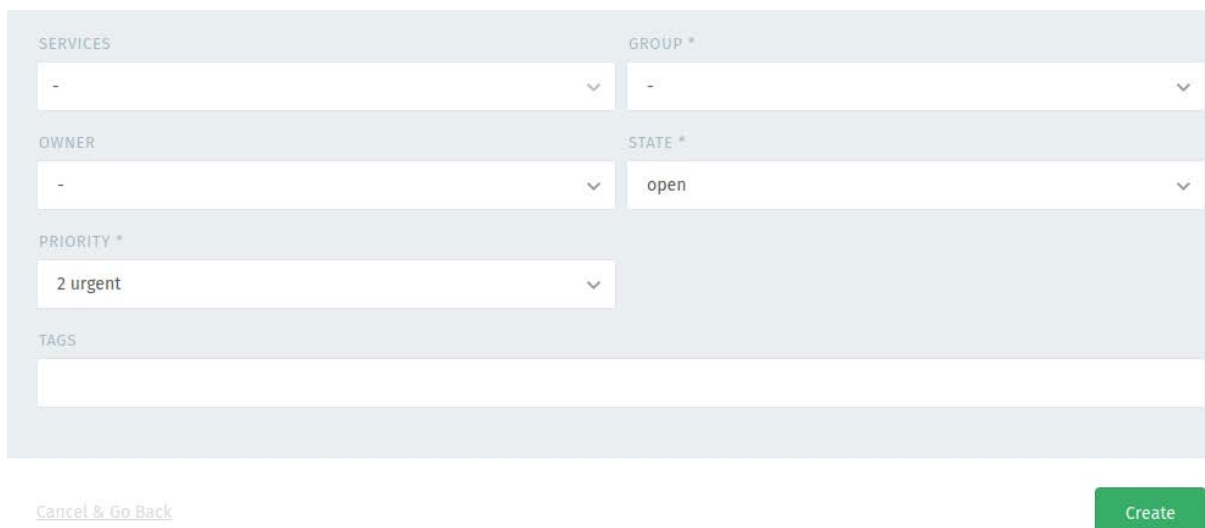
Direct usage requires the Provider or community to provide the information summarised in the Table 5-5.

Table 5-5: Information required to enable Direct Usage of the EOSC Helpdesk as a service.

Attribute Name	Definition	Type	Multiplicity	Required	Example
Service	Name of the resource or service to be shown in the helpdesk fields	String	Multiple	Optional	B2DROP
Group	Support group to be created in the helpdesk for the provider	String	Multiple	Mandatory	CommunityXL1 support
Organisation	Name of organisation	String	1	Optional	CommunityA
E-mail	email associated with support group	String	Multiple	Optional	support@community.eu
Agent	Person involved in ticket management	String	Multiple	Mandatory	Name Surname
Signature	Automatic signature to be used in the answers to the tickets	String	Multiple	Optional	Your support team
Webform	Webform required to generate ticket directly on webpage	Bool	1	Optional	Yes

This minimum set of the attributes is required for the initial setup of the EOSC Helpdesk support groups for the new provider or community. Some of these attributes will be used in the ticket form for assignment of service, group and owner as shown in Figure 5.4.

³² <https://github.com/zammad/zammad-documentation/blob/main/api/intro.rst>



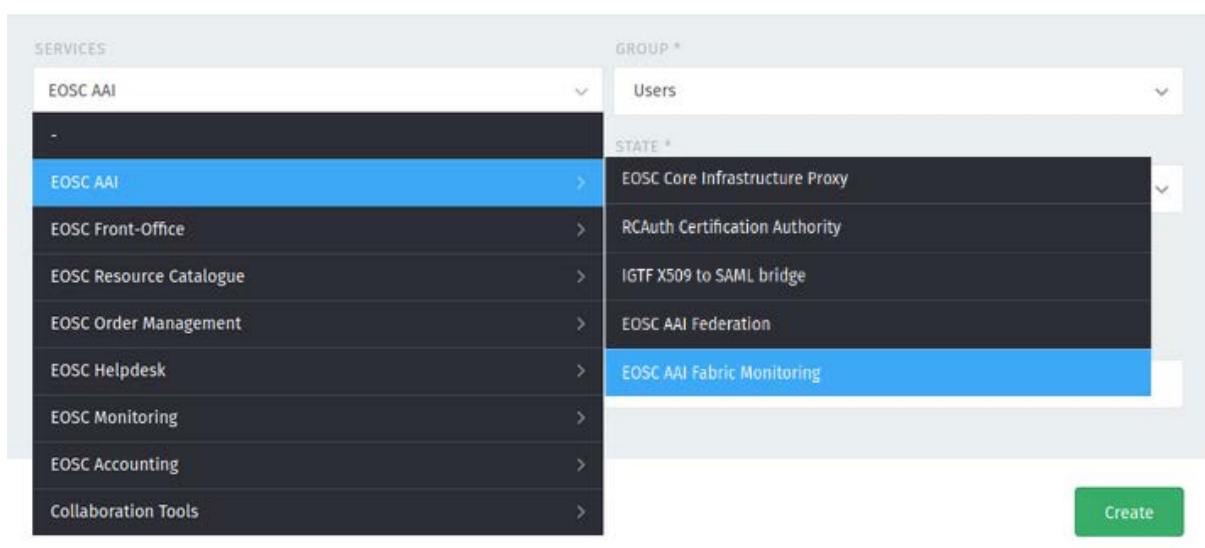
The form contains the following fields:

- SERVICES**: A dropdown menu with a '-' placeholder.
- GROUP ***: A dropdown menu with a '-' placeholder.
- OWNER**: A dropdown menu with a '-' placeholder.
- STATE ***: A dropdown menu with 'open' selected.
- PRIORITY ***: A dropdown menu with '2 urgent' selected.
- TAGS**: A text input field.

At the bottom, there is a [Cancel & Go Back](#) link and a green **Create** button.

Figure 5.4: Ticket form in the EOSC Helpdesk.

Figure 5.5 shows the current implementation of the EOSC Helpdesk for the EOSC-Core Services. As an example, it also shows the major components of the EOSC AAI that are supported through the EOSC Helpdesk.



The form shows the assignment of service components to a ticket. The **SERVICES** dropdown is open, showing a list of services. The **GROUP *** dropdown is set to 'Users'. The **STATE *** dropdown is open, showing a list of service components.

SERVICES	GROUP *	STATE *
EOSC AAI	Users	EOSC Core Infrastructure Proxy
-		RCAuth Certification Authority
EOSC AAI		IGTF X509 to SAML bridge
EOSC Front-Office		EOSC AAI Federation
EOSC Resource Catalogue		EOSC AAI Fabric Monitoring
EOSC Order Management		
EOSC Helpdesk		
EOSC Monitoring		
EOSC Accounting		
Collaboration Tools		

At the bottom right, there is a green **Create** button.

Figure 5.5: EOSC-Core Services and service components assignment in the EOSC Helpdesk.

EOSC Helpdesk enables fine-grained definition of distinct support units, allowing each provider to establish and access support units only for its own services. For example, the list of the support units depicted in Figure 5.5 will be visible to EOSC Helpdesk agents and supporters but not to others that are not involved in the support of these services.

Similarly, a Provider of a Service can define sub-components of that Service, along with different support units for each sub-component, enabling the tracking of the incidents specifically for each sub-component.

Guidelines for further customisation of the EOSC Helpdesk workflows and implementation of custom notification management systems are under development. The guidelines will be enhanced on the dedicated wiki pages.

5.3 EOSC Monitoring

5.3.1 Description

The key functionalities offered by the EOSC Monitoring service are:

- Monitoring of services,
- Reporting availability and reliability,
- Visualisation of the services status,
- Provide dashboard interfaces,
- Sending real-time alerts.

The dashboard design enables easy access to and visualisation of data for end-users. APIs are supported to allow third parties to gather monitoring data from the system.

The EOSC Monitoring service was designed to:

- Support multiple entry points (different types of systems can work together),
- Being easily interoperable with other monitoring systems,
- Operate the different components of the system in High Availability,
- Support Multiple Tenants, Configurations, Metrics and profiles to add flexibility and ease of customisation.

The EOSC Monitoring service combines two operational monitoring services: the EOSC-Core and the EOSC-Exchange Monitoring Services, respectively monitoring the EOSC-Core services (EOSC-Core Monitoring) and the services onboarded to the Marketplace (EOSC-Exchange Monitoring).

The EOSC Monitoring services were implemented adopting the ARGO technology³³.

5.3.2 High-level Architecture

The EOSC Monitoring service collects status (metrics) results from one or more monitoring engine(s) deployed across distributed infrastructure and delivers daily and/or monthly availability (A) and reliability (R) results for monitored services. Status results and A/R metrics are presented through a Web UI, which allows users to drill-down from the availability of a site to the individual test results that contributed to the computed figure.

³³ <https://argoeu.github.io/>

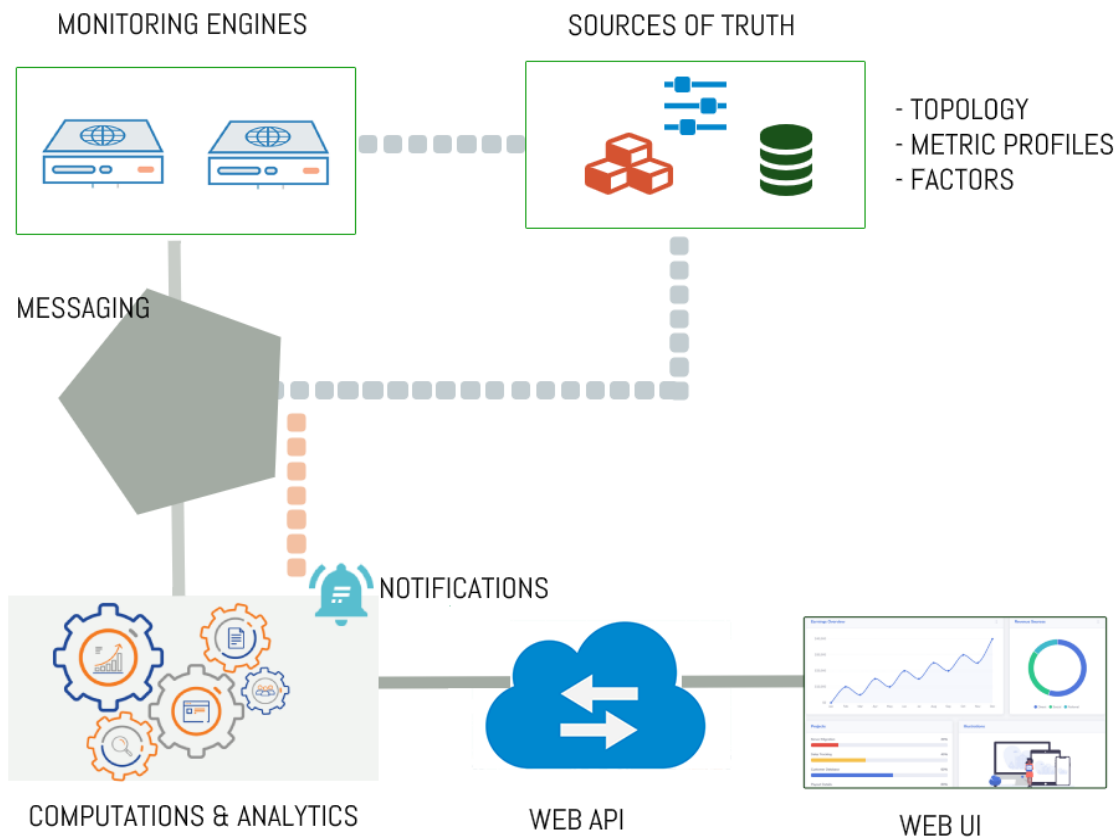


Figure 5.6: High level architecture of the EOSC Monitoring service

The main components of the EOSC Monitoring service are depicted in the high-level architecture diagram and described in Figure 5.6:

- **Monitoring Engine(s):** this component executes the service checks against the distributed infrastructure and delivers the metric data (probe check results) to the Messaging Service.
- **Sources of Truth:** the Monitoring system supports a number of connector plugins that are able to fetch topology, metrics and factors from various sources such as the CMDB³⁴ and the Service Providers Portal. A Metric and Profile Management Component allows checks (probes) to be defined and associated with specific Services. Each combination of checks and service types forms a profile.
- **Messaging:** The monitoring system uses Pub/Sub Messaging to connect its components.
- **Computations & Analytics:** Computational jobs are defined for ingesting data, calculating status and availability/reliability, and a management service automatically configures, deploys and executes those jobs on a distributed processing engine for stateful computations. This component analyses the monitoring results and sends notifications based on a set of rules, to inform the Service Providers about the status of their Services.
- **WEB API:** RESTful HTTP API service provides access to status and availability/reliability results. It supports token-based authentication and authorization with established roles. Results are provided in JSON Format.
- **WEB UI:** The Web UI is the component to present the information about the status of the services. The global information from the primary and heterogeneous data sources is retrieved by means of the different plugins. The collected information is structured and organised within configuration files in the service and, finally, made available to the web application without the need for any further computations. This modular architecture is conceived in order to make it easy to add new data sources

³⁴ Configuration Management Data Base

and to use cached information if a primary source is unavailable. The resulting data is exposed through a [RESTful](#)³⁵ web service interface.

The following table defines key terms that help explain how the EOSC Monitoring service works and the types of information a Provider should supply/define to start to use the service.

Table 5-6: EOSC Monitoring - Definitions.

Definitions	
Tenant	The tenant is an isolated instance of the EOSC Monitoring service that relies on common components and provides the user with its own environment. The EOSC Monitor provides default UI and POEM URLs in following form: • UI: <a href="https://<tenant_name>.ui.argo.grnet.gr">https://<tenant_name>.ui.argo.grnet.gr • POEM: <a href="https://<tenant_name>.poem.argo.grnet.gr">https://<tenant_name>.poem.argo.grnet.gr Custom URLs can be also used, in such cases the customer is responsible for providing valid certificates and DNS aliases.
Topology	EOSC Monitoring service requires the following topology information in order to monitor services: • the services and service endpoints they are running, • the way they are organised (e.g. groups of sites, groups of services), • the service actors (owners, admins, contact points). The topology can be further extended with attributes needed for individual probes (e.g. service port or URL, path to be used in case of storage services, e.g.). The topology sources currently supported are: • EOSC Resource Catalogue: it needs to be extended to hold the following information for Monitoring: – service unique Id – the service endpoints, – the way they are organised (service, service components), – the service actors (owners, admins, contact points). • EGI Configuration Database (GOCDB) • EUDAT DPMT • JSON feed in the predefined format.
Metric	A metric is a small piece of software that checks specific functionality of a given service. For example, a metric such as Portal-WebCheck runs on a site and checks if the HTTP connection responds correctly or not.
Probe	A Probe is a small piece of software that implements single or multiple tests. The probe must comply with the guidelines for monitoring probes³⁶.
Registry of probes and metrics (POEM)	ARGO provides a registry of probes and metrics. New probes and metrics can be added to the registry with the support of the EOSC monitoring team.

³⁵ https://www.ics.uci.edu/~fielding/pubs/dissertation/rest_arch_style.htm

³⁶ <https://argoeu.github.io/argo-monitoring/docs/Monitoring/guidelines/>

Metric Profile	A Metric Profile ³⁷ is used to associate a Service with the corresponding metrics.
Aggregation Profile	An Aggregation Profile ³⁸ defines how to aggregate service statuses into higher hierarchical grouping (i.e. a service_group) status results. They are actually used to define logical rules on how to aggregate individual service status computations into groups.

How the EOSC Monitoring service checks the status of a Service

In order to evaluate the operational state of a Service, all or part of the metrics that check the Service's functionality should be taken into account. The Metrics Profiles encompass, for each Service, all the metrics whose results are included in the calculation of the Service's state. For example, an example Service "WebSite" running on host1.example.com should be considered properly operating if it is accessible and some actions are available such as downloading or uploading material (documents, images etc). In this case three metrics might be used to check the Service's functionalities:

- *Portal-WebCheck* is a metric to check if the http service responds;
- *http.download* is a metric to check if download functionality operates well;
- *http.upload* is a metric to check if upload functionality operates well;

The Service is assumed to operate properly if it is accessible and can support downloading material. Uploading material does not affect the state of the service (whether it is working properly or not). So in the Metrics Profile, the metrics Portal-WebCheck and http.download will be identified as metrics to define the status of the service.

5.3.3 Interoperability Guidelines

EOSC Providers can choose one of five approaches to integrate their Services, with the EOSC Monitoring service:

1. **Monitor an Onboarded Service:** monitor a single EOSC Service;
2. **Monitor an Infrastructure:** monitor a complete infrastructure supporting multiple Services and Resources;
3. **Integrate External Monitoring service:** configure the EOSC Monitoring service to accept monitoring data from third-party monitoring engines;
4. **Combine Results of existing ARGO Tenants:** allow to combine the topology and the results of multiple tenants in a number of reports;
5. **Third-party services exploiting EOSC Monitoring data:** a customer retrieves results from the EOSC Monitoring Service to use them in an external service/dashboard.

These are described below. Details are available in the EOSC Future wiki³⁹.

5.3.3.1 Integration option 1: Monitor an Onboarded Service

This option covers the scenario to monitor one EOSC Service. The results of this process will become available via the EOSC-Exchange Monitoring WebUI.

After a service has been successfully onboarded, a provider can enable the EOSC Monitoring service by supplying some extra information. First, the Monitoring service requires the probes and metrics to be associated with the service. Once the service provider decides on the probes/metrics they wish to use, the metrics should be mapped to the service they wish to monitor in EOSC-Exchange Metric Profile. After that, aggregation and thresholds profiles should also be updated.

³⁷ <https://argoeu.github.io/argo-monitoring/docs/Profiles/metrics-profile>

³⁸ <https://argoeu.github.io/argo-monitoring/docs/Profiles/aggregation-profile>

³⁹ <https://wiki.eoscfuture.eu/display/PUBLIC/Monitoring+Architecture+and+Interoperability+Guidelines>

Once all the information has been provided, the monitoring of the service starts and the EOSC Monitoring Computation and Analytics component calculates availability and reliability of the service and creates a report. The Service Provider can review A/R and status results from the EOSC-Exchange Monitoring WebUI.

5.3.3.2 Integration option 2: Monitor an Infrastructure.

This option covers the scenario when an infrastructure (e.g an e-Infrastructures) with multiple services and a custom topology needs to be monitored by the EOSC Monitoring. In this case, the first integration option is not appropriate because the infrastructure provider needs to take additional steps:

- define a custom topology and of the way in which monitored endpoints will be aggregated for reporting purposes;
- select from existing range of probes and adding custom ones;
- manage profiles and metrics for different services.

This integration option requires the following steps:

1. The Provider (typically its infrastructure manager) must request the creation of a dedicated EOSC Monitoring service instance. This can be done by opening a ticket in the EOSC Helpdesk where the following minimum information should be provided:
 - Infrastructure topology;
 - Personnel responsible for managing profiles;
 - URLs for the registry of probes and metrics (POEM) and UI components.
2. The EOSC Monitoring team will use the provided information to create a new instance (tenant) of the Monitoring Service, within the EOSC Monitoring infrastructure, and inform the infrastructure manager that the instance is ready for use.
3. As a next step, the infrastructure manager must define the minimum set of profiles to allow the monitoring to start:
 - Selection of a list of metrics from the metric repository
 - Definition of the Metric Profile;
 - Definition of the Aggregation Profile

Once all the information has been provided, the monitoring of the service starts and the ARGO monitoring Computation and Analytics component calculates availability and reliability of the service and creates a report. The Infrastructure Manager can have a look at the A/R and status results from a dedicated UI.

5.3.3.3 Integration option 3: Integrate External Monitoring service.

In order to be able to scale-out and take advantage of existing Monitoring systems, the EOSC Monitoring service is capable of accepting data from external sources. When referring to external sources we mean other monitoring engines that may wish to connect with the EOSC Monitoring Service.

This integration option covers the case when a service or an infrastructure provider is already operating its own monitoring system and is willing to publish information about the status of its service(s) in EOSC to, for example, demonstrate their reliability.

The connection of a third-party monitoring system with the EOSC Monitoring is mainly based on the necessary data to create the final monitoring report. In this use case an external monitoring system replaces the internal monitoring engine and is thus **reliable for the validity of the monitoring data that is published**.

This integration option can be enabled following steps:

1. The Provider opens a ticket on EOSC Helpdesk requesting to start the process to connect to the EOSC Monitoring Service. They need to prepare their systems to be able to share the following information:
 - The type of system used;
 - Infrastructure topology;
 - Personnel responsible for managing the necessary profiles;

- URLs for the registry of probes and metrics (POEM) and UI components.
2. The monitoring team creates a new instance/tenant in the EOSC Monitoring service and sets up all the necessary configuration on the EOSC Messaging service. As a result, the monitoring team will then send to the Provider the necessary instructions and the access tokens to connect to the EOSC Monitoring service.
 3. The monitoring team assists the Provider to create the necessary profiles:
 - Metric Profile;
 - Aggregation Profile.
 4. The Provider will need to make the necessary configuration on their monitoring engine in order to start publishing metric data via the EOSC messaging service. The EOSC Monitoring Service supports two options:
 - Supported Monitoring Engine and Operating System (Nagios on Centos 7 or Debian 8): if the Providers use Nagios as its monitoring tool, EOSC Monitoring offers the argo-nagios-ams-publisher⁴⁰ tool⁴¹. argo-nagios-ams-publisher is a component acting as a bridge from Nagios to the EOSC Messaging system and finally to the EOSC Monitoring Engine. The detailed procedure to use this option is described in the Monitoring interoperability guidelines in the project wiki
 - Other Monitoring Engine and Operating System: in this case the external monitoring system should send the monitoring data (metric data) to the EOSC Monitoring in a predefined format. Details on the data format are available in the Monitoring interoperability guidelines in the project wiki.
 5. After the previous steps are completed, the monitoring of the service starts and the EOSC monitoring Computation and Analytics component calculates availability and reliability of the service and creates the monitoring report. The Infrastructure Manager can have a look at the A/R and status results from a dedicated UI.

5.3.3.4 Integration option 4: Combine Results of existing ARGO Tenants.

This integration option covers the scenarios where the topology and the results of multiple monitoring instances/tenants need to be combined in a number of reports. It allows the creation of a monitoring report including services coming from multiple infrastructures like, for example, when a research community is using services from more e-infrastructures. Through this option, a research community is able to create a unique monitoring report including all the services it is using regardless of who is operating them.

As a prerequisite, in order to combine monitoring results from tenants e.g. A and B, those tenants should be already monitored by the EOSC Monitoring service:

- **Latest Data available:** Each tenant should be checked that has an active stream of incoming monitoring data.
- **Topology:** Each tenant should already have a well-defined source of topology that includes lists of groups, endpoints and services.
- **Metric Profile:** In simple terms, a list of all services to be checked along with all relevant metrics per service.

This integration option can be enabled by following these steps:

1. The customer should submit a request in the EOSC Helpdesk describing:
 - Tenants to be used in the combined report;
 - Services and metrics;
 - Aggregation profile.

⁴⁰ <https://github.com/ARGOeu/argo-nagios-ams-publisher>

⁴¹ <https://wiki.eoscfuture.eu/display/PUBLIC/Monitoring+Architecture+and+Interoperability+Guidelines>

2. The monitoring team creates a new tenant that will host the combined report. This tenant acts as a host tenant for the combined results and will rely on the data of the other tenants as input for the computations of the availability, reliability and status results.
3. After the previous steps are completed, the monitoring of the service starts and the EOSC Monitoring Computation and Analytics component calculates availability and reliability of the services and creates a report. The User can have a look at the A/R and status results from the combined reports from the UI.

5.3.3.5 Integration option 5: Third-party services exploiting EOSC Monitoring data

This option covers the scenario according to which the customer needs to use the results of the EOSC Monitoring Service in an external service/dashboard.

The customer can access the following information via an API:

- A/R information about the service and its service components;
- Status information about the service and its service components;
- The topology and grouping of the service;

This integration option can be enabled by following these steps:

1. The user who wants to gain access to this type of monitoring information will get a token with read-only access to the A/R and status results. The user via the EOSC Helpdesk sends a request to the monitoring team including:
 - The name of the service that requires the information;
 - An email to create the user able to access to the monitoring information;
 - The type of information (A/R results, status results or both);
2. The monitoring team will provide the required token and information, guidance on how to retrieve the information. Examples are available at <https://argoeu.github.io/argo-monitoring/>.

5.4 Accounting

EOSC Accounting is composed of two independent services, Service Accounting and Research Product Accounting. They are able to aggregate (push and pull) usage indicators for different types of EOSC Resources. Both offer a number of integration options and will be integrated with the EOSC Resource Catalogue to expose their data in the next months.

The Service Accounting is currently under development while the Research Product Accounting integration with the EOSC Resource Catalogue is ongoing. For this reason, although integration options have been already identified for each of these services, official Interoperability Guidelines have not been released yet.

5.4.1 Service Accounting

5.4.1.1 Description

EOSC Service Accounting collects, stores, aggregates, and displays usage information of Services. This usage data is collected from the Providers operating EOSC Services.

The main features of the EOSC Service Accounting can be grouped by two target groups.

Main features offered to the users are:

- Aggregated views of their service usage wherever that usage occurred.
- Views that allow service usage to be checked against allocation.

Features for Providers:

- Provider-centric views of service usage by users.

- Views that allow comparisons to be made between Providers within and between regions and communities.

Service Accounting data will be also published in the service entries of the EOSC Marketplace to provide information about usage to the users.

5.4.1.2 High-level Architecture

Accounting information is gathered from distributed sensors into a central Accounting Repository where it is processed to generate summaries that are made available through an Accounting Portal. Depending on the use case, the data may go via intermediate repositories that collate accounting data for particular regions, infrastructures or communities. The overall architecture is depicted in Figure 5.7.

The Accounting Repository has a database backend and needs to ensure the exchange of accounting information with peer infrastructures. The Accounting Portal receives and stores accounting information/data from the EOSC-Exchange services. For example, EOSC services providing computing and storage may report resource consumption by users and user groups (e.g. Virtual Organisation/VO). The accounting repository may then generate aggregated summaries and show views via a web portal. By grouping resource centres in a country on specific time intervals, a customised view can be generated and displayed. The databases are organised into resource record databases (e.g. CPU, VM, storage, etc.), a user record database, and a topology database.

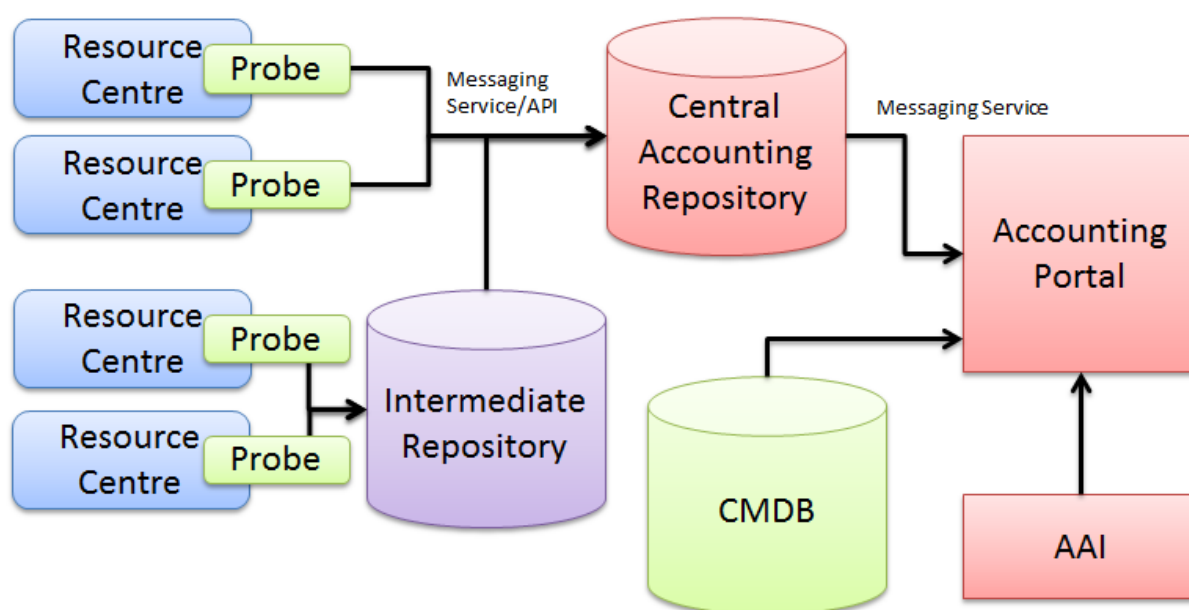


Figure 5.7: EOSC Service Accounting high-level architecture.

5.4.1.3 Interoperability Guidelines

The following picture identifies and maps to the Service Accounting architecture the integration options offered to the EOSC providers:

1. **Direct usage of the EOSC Service Accounting:** a research community adopts the EOSC Service Accounting as its own accounting system. Its resource centres are directly connected to the central accounting repository and accounting information is transferred in push or pull mode. Custom views for the research community are created in the Accounting Portal. The accounting data of the research community can be used to create EOSC accounting views with data gathered by multiple research communities.
2. **Integration of a Regional or Thematic accounting repository:** a research community has its own accounting system but rely on the EOSC Service Accounting for advanced visualisation tools. The

accounting repository of the research community exchanges accounting information with the EOSC accounting repository and custom views for the community are created in the Accounting Portal. The accounting data of the research community can be used to create EOSC accounting views with data gathered by multiple research communities.

3. **Integration of a Regional or Thematic accounting infrastructure:** a research community has its own complete accounting infrastructure with adequate visualisation tools. The research community connects its accounting repository to the EOSC one to transfer accounting information to EOSC and enables the possibility to create EOSC accounting views with data gathered by multiple research communities.

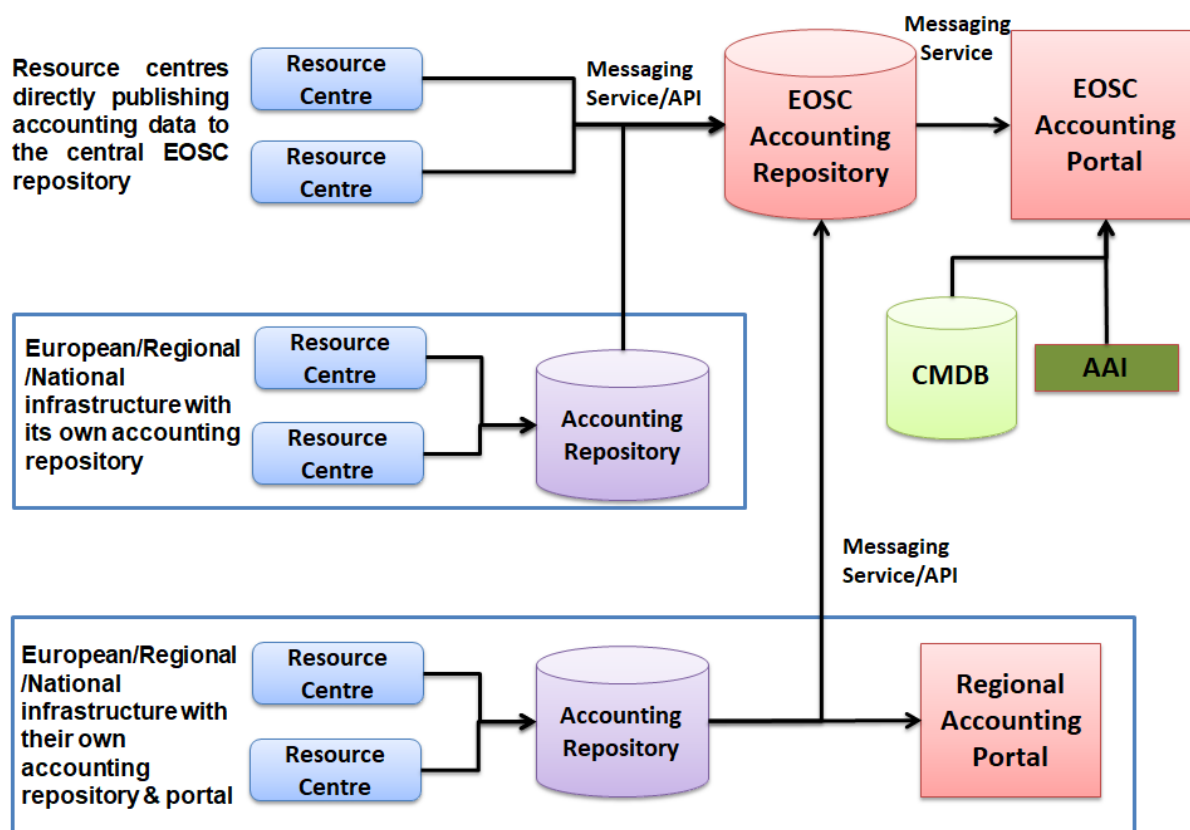


Figure 5.8: EOSC Service Accounting integration options

5.4.2 Research Products Accounting

5.4.2.1 Description

Research Product Accounting is supported by the UsageCounts service⁴². The service collects usage activity from events related to research products, like articles, datasets, etc. of the EOSC Research Product catalogue and creates and deploys aggregated statistics for these products.

5.4.2.2 High-level Architecture

Service architecture comprises two approaches or workflows:

- A PUSH Workflow which allows server-side real-time tracking using tracking software which implements Matomo's Analytics Platform API or using a generic log file parser based on Python that parses log files and sends the usage events to the Matomo Analytics platform (not in real time). The PUSH workflow supports anonymization of IPs.

⁴² <https://usagecounts.openaire.eu/>

- A PULL Workflow which is employed to collect from aggregation services, consolidated usage statistics reports for research products. These reports are compliant to the COUNTER Code of Practice⁴³ and are collected using protocols such as SUSHI-Lite.

A pictorial view of the UsageCounts's service architecture is depicted in the following figure:

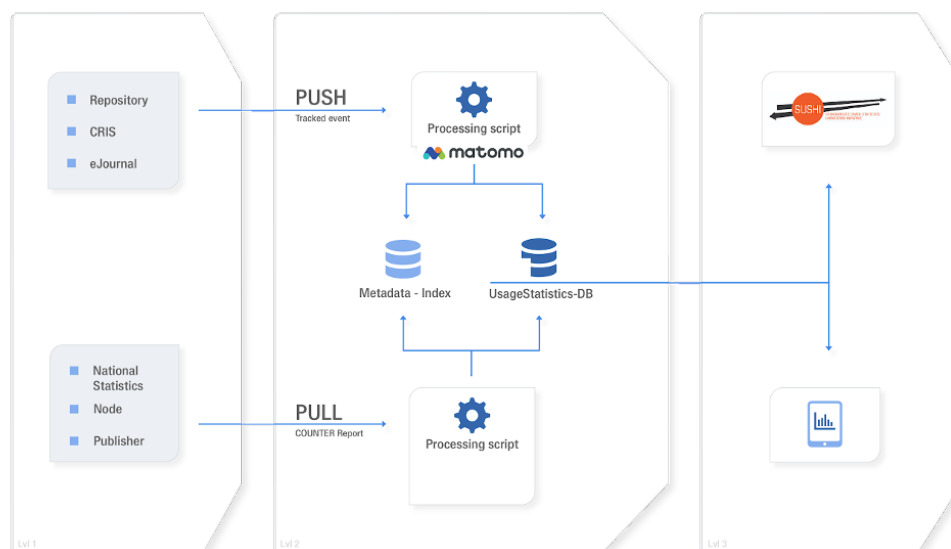


Figure 5.9: EOSC Research Product Accounting high-level architecture.

The UsageCounts service calculates and publishes statistics about the collected research products' usage events. These statistics are also compliant with the COUNTER Code of Practice and deployed using the SUSHILite protocol.

5.4.2.3 Interoperability Guidelines

To participate in Research Product Accounting, research products from content providers or services should be incorporated in the EOSC Research Product catalogue. The next step is to select which UsageCounts service workflow would be adopted, i.e. PUSH or PULL. In case of the PUSH approach, content providers are required to install the tracking software on their platforms. If they follow the PULL workflow, content providers should implement the COUNTER Code of Practice and publish the reports using SUSHILite API endpoints.

5.4.3 Further Development

The release of the Service Accounting and the integration of both Service and Research Product Accounting with the EOSC Marketplace are expected for September 2022.

The first release of the Service Accounting will enable usage accounting of the services that are currently funded through the Virtual Access mechanism. Information on the usage of these EC funded resources like percentage of consumed resources, allocation per scientific disciplines/research communities, etc. will be provided. In the meantime, the integration of other services from research infrastructures and e-infrastructure will start.

The interoperability guidelines for accounting that are being developed will include the following:

- Virtual Access to cover the EOSC resources funded through the EC Virtual Access model.
- Order Management to describe the connection between project items and EOSC Service Accounting.
- Alignment between Service and Research Product Accounting as compatibility between the two types of accounting develops.

⁴³ <https://cop5.projectcounter.org/en/5.0.2/>

5.5 Order Management

5.5.1 Description

A key EOSC Portal's feature is enabling EOSC Providers to offer EOSC Services and Research Products to EOSC end-users. The EOSC Order Management empowers this functionality allowing providers to integrate their ordering and provisioning processes with EOSC in a federated system of systems architecture and, consequently, facilitating the access to their services.

The EOSC Order Management enables added value for providers in the following areas:

1. **Flexible Offering management.** The EOSC Marketplace UI & Offering API allows the easy definition and management of the offerings for each EOSC service. In this way, EOSC users can better understand the overall offering behind each service and select the service configuration (the offer) that best fits with their requirements.
2. **Mapping provider's internal order management workflow.** The EOSC Marketplace Ordering API allows providers to use their internal order management workflows, while mapping them to a consistent workflow for users.
3. **Improved composability between EOSC Resources.** The EOSC Marketplace supports the creation of projects⁴⁴ to allow users to organise their EOSC Research Products and Services into logical blocks to solve scientific challenges. The EOSC Order Management delivers an inter-provider communication platform in scope of a user's project, which, with assistance from the EOSC technical experts, will facilitate the setup of advanced interoperability scenarios enabling the collaboration between the involved providers.

It also improves end-users experience in the following areas:

1. **Consistent experience to access EOSC Resources.** Users will have a consistent journey from the resource discovery for a research project, through ordering, and ending in access, instead of having to navigate through different portals (e.g. when users have to access resources from multiple providers). Furthermore, users can expect all the EOSC Resources' Offerings to follow a common and well-known ordering workflow.
2. **Support from EOSC technical experts and resource providers to compose EOSC Resources.** Users that need to integrate resources from multiple providers can leverage the coordinated technical support from EOSC technical experts and resource providers enabled by EOSC Order Management inter-provider communication platform.

5.5.2 High-level architecture

The overall architecture of the Order Management is depicted in Figure 5.10.

The central component of the architecture is the EOSC Marketplace, which users visit in order to search and discover resources from the EOSC Resource Catalogue. It also holds EOSC Resource offering configurations (both ordering configuration and technical parameters) and a User Space where the user's marketplace projects are stored.

⁴⁴ Projects in the EOSC Marketplace: https://marketplace.eosc-portal.eu/about_projects

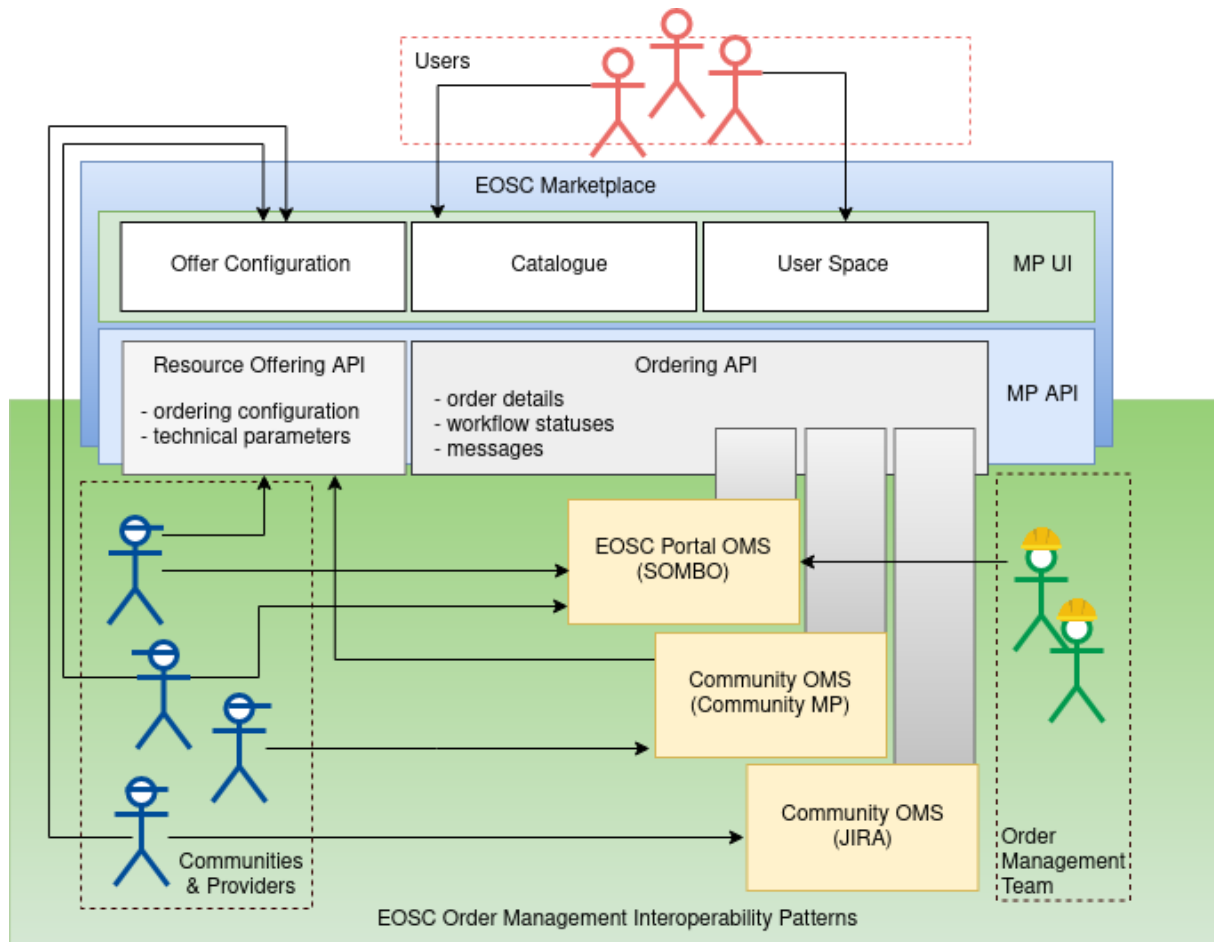


Figure 5.10: EOSC Order Management high-level architecture.

The EOSC Marketplace exposes two APIs to enable interoperation in the scope of the ordering:

- **Resource Offering API:** exposes ordering configuration and technical parameters of EOSC Resources' Offerings. Providers can also manage their resource's offering configurations through a UI built on top of the Resource Offering API.
- **Ordering API:** exposes EOSC Marketplace users' projects and project items, as well as associated communication (messages with different access levels, e.g. between support team and users or between providers). It also enables inter-provider composability patterns and support from EOSC technical experts. Providers can retrieve information about orders and manage them through the API. Orders can be managed through an ordering management system (OMS) connected to the EOSC Marketplace via the Ordering API or using the catch-all order management system SOMBO⁴⁵.

Figure 5.11 shows how different OMSes can be connected to the EOSC Order Management via the Ordering API. SOMBO is the catch-all OMS used by the EOSC order management team to handle requests involving multiple providers. EOSC Providers can integrate their own community OMS with the Order Management or, alternatively, adopt SOMBO to deal with their orders. Regardless of the OMS adopted, the users can check the status of their orders directly in the EOSC Marketplace.

Logically, Ordering API provides a message bus for conversations to take place in scope of users' projects and their project items.

⁴⁵ <https://opsportal.eosc-portal.eu/>

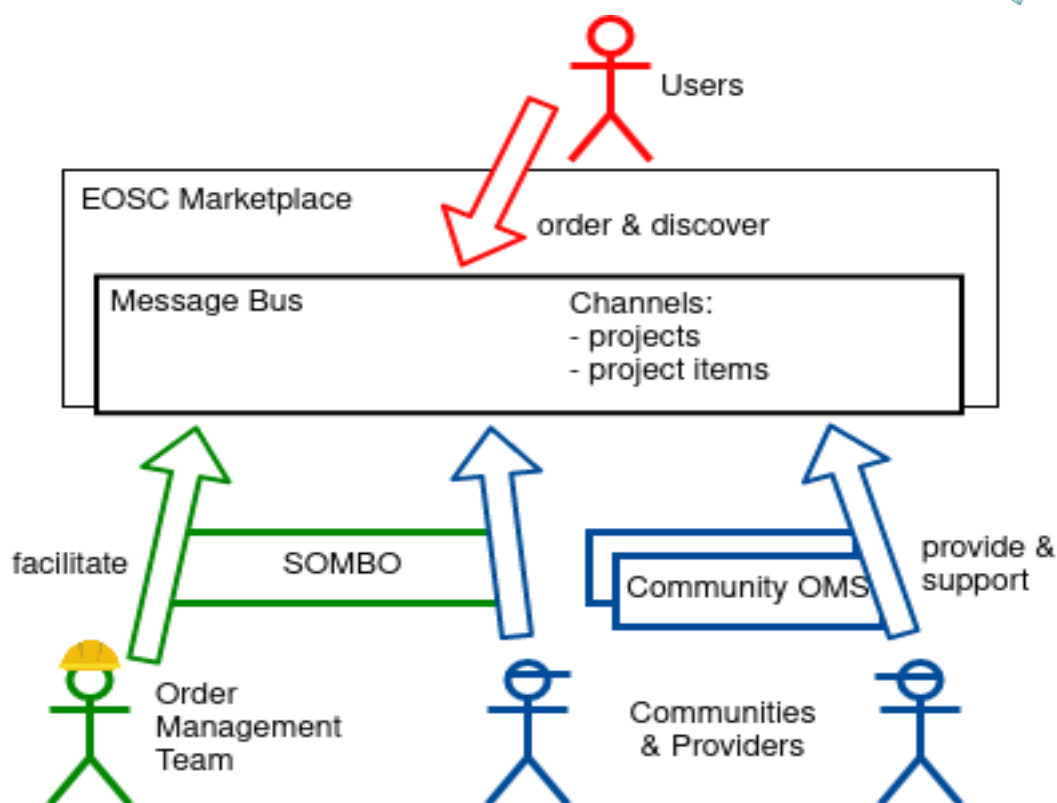


Figure 5.11: Integration of community order management system with the EOSC order management via the Ordering API. SOMBO is a catch-all order management system offered to all the service providers.

5.5.3 Interoperability Guidelines

As mentioned above, there are two areas of integration: **Offering** and **Ordering**. Details on the APIs are available in the EOSC Marketplace documentation⁴⁶.

For the **Offering** management, a provider can only decide to define or not its custom offerings in EOSC. The offering can be specified via UI or API. The providers choosing to utilise UI to configure their Offerings can use the EOSC Marketplace site directly to modify their Offerings. Alternatively, they can use an API for the same operations, enabling direct integration with existing systems.

Ordering API can also be utilised at differing integration levels:

1. Adopt the catch-all OMS SOMBO: providers can use the available-to-all SOMBO system to manage their orders, which itself integrates with the Ordering API;
2. Adopt an exemplar OMS adapter implementation (e.g. a Jira adapter);
3. Use the provider's OMS: providers can have their OMSes connected to the EOSC Order Management directly via the Ordering API.

⁴⁶ https://marketplace.eosc-portal.eu/api_docs

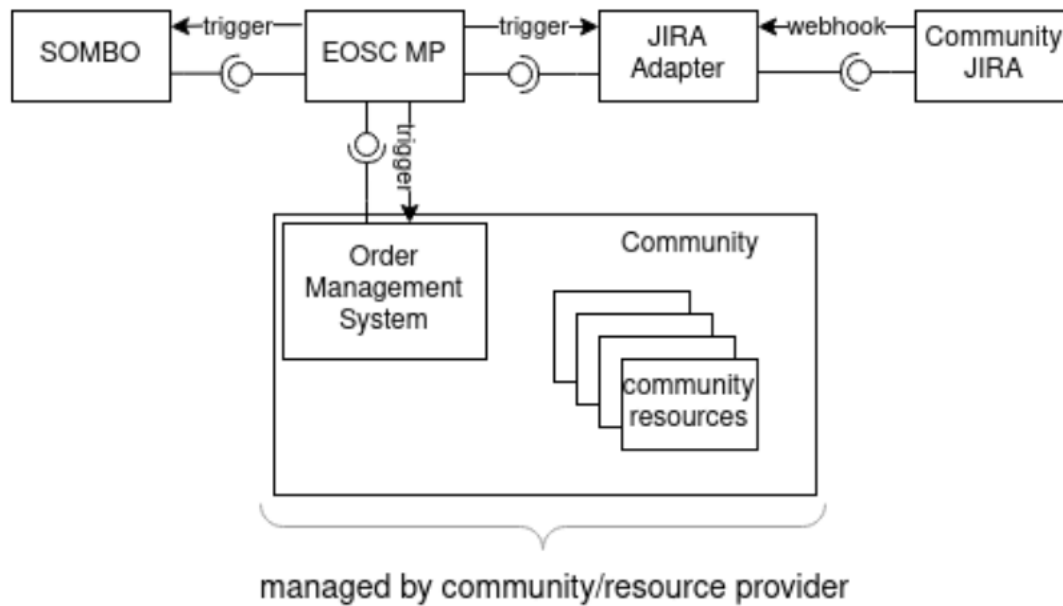


Figure 5.12: Ordering integration options.

5.5.4 Further development

The Order Management Interoperability Guidelines will evolve to incorporate the following areas of interest in the next future:

- **Virtual Access and other procurement models support:** extend the guidelines to encompass the EOSC Resources funded through the EC Virtual Access model.
- **EOSC Service Accounting integration:** guidelines for enabling the connection between project items and EOSC Accounting.
- **Secure authority exchange:** define a process for securely mapping user authority between EOSC Marketplace and external OMSes.
- **Integrate other messaging options for EOSC Marketplace Ordering API:** add support for other means of communication apart from the HTTP API, especially for asynchronous communication.

6 Conclusions

This deliverable presented the overall architecture of the EOSC Platform and detailed the high-level architecture of the operational EOSC-Core services: Resource Catalogue, Helpdesk, Monitoring, Accounting and Order Management. The document also introduced the concept of EOSC-Core interoperability guidelines that have been defined as a set of EOSC profiles and interfaces that enable the interoperation between an EOSC-Core service and EOSC-Exchange services or other Core services. Interoperability guidelines for the operational EOSC-Core services were detailed.

The EOSC-Core interoperability guidelines will contribute to the establishment of the EOSC Interoperability Framework. They will drive cases to validate the onboarding procedure of the EOSC IF defined in the *D3.2 EOSC Architecture and Interoperability Framework*.

These guidelines will also be used by the T6.2 *Integration of EOSC-Core Services into European Research Practice* support team to ensure the integration of EOSC-Core services and external providers services who need to connect to the EOSC platform.

The EOSC-Core interoperability guidelines will evolve during the project lifetime to take under consideration emerging requirements. EOSC Profiles will be extended to support new types of resources.

The deliverable also specified the architecture guidelines and tools that steer the addition of a new function to the EOSC Platform. These consist of (1) specifying the core function data model, (2) identifying the interactions with the data models of the other services and (3) defining the core function profile that together with the interfaces towards EOSC-Exchange services compose the interoperability guidelines for this new core function.

These steps will be followed to integrate new functions in the platform in the coming months. The AI/ML for discovery component or Recommender system that is currently under development will be the first case that will be managed through this procedure. The Recommender system is a new component that will enrich the Front-end platform/Marketplace with instruments to facilitate the users' navigation over the EOSC Resource Catalogue. It will allow interconnections with EOSC-Core and EOSC-Exchange services including:

- The marketplace on which the recommendations will be presented;
- The provider portal or external provider systems where we can serve statistics about the performance of their services on the recommender system;
- Other external catalogues.

In its second version, the deliverable has been improved with the addition of two appendixes that describe, respectively, the work to represent the EOSC Platform architecture with the C4 methodology and the overall technical roadmap of the project.

7 Appendix A – EOSC Future High-Level Technical Roadmap

Area	By Month 6	By Month 18	By Month 30
EOSC Platform	EOSC Marketplace - Shows all data collected from provider and resource profiles. Allows for scoring and rating Provider Portal & Resource Registry - Allows direct onboarding (web + API) but as transfer of provider and resource records from other registries and vice-versa EOSC AAI - EOSC AAI Federation operational Monitoring & Accounting - Allows checking of services based on availability of their web pages/endpoints. Can support better integration via specific metrics. Accounting supports usage tracking to support virtual access reimbursement by the EC Helpdesk - Helpdesk covers core services. Customisation based on new/updated technology and connected to the Service Management System Order Processing - Order management is set up and includes integration of providers. Already used for services inherited from EOSC-hub and others that previously enabled it EOSC Portal Metrics Dashboard - The dashboard provides statistics about services and requests of access and is fully integrated with the EOSC Portal	EOSC Marketplace - Connected to monitoring to be able to enrich feedback with availability data. Includes AI/ML-based suggestion engine interfaces to automatically pull in resources from other catalogues in the EOSC central registry Provider Portal & Resource Registry - Increased automatic validation tools and automatic flagging of resources which are likely to require review EOSC AAI - e-Infrastructure SP-proxies and cluster community AAls fully integrated to EOSC AAI Federation. Community AAls can integrate Monitoring & Accounting - Automated/self-service integration of monitoring probes and metrics offered to providers. Monitoring can track availability and reliability and accounting of usage based on parameters in provider and resource profiles (location, sector, organisation type) Helpdesk - Helpdesk covers core services and can redirect tickets to providers who have their own helpdesk. Helpdesk can be tested by providers who wish to use it Order Processing - Order management can deploy and provision resources from selected providers, including from 07 projects EOSC Portal Metrics Dashboard - The dashboard is enriched with additional information on EOSC resource providers and on	EOSC Marketplace - Describe supported interfaces, standards, workflow languages, and metadata supported by EOSC resources. An advanced user dashboard is available Provider Portal & Resource Registry - Inbuilt or integrated management/workflow engine to support management of applications, review of records, auditing and quality control as well as automatic provider communication EOSC AAI - Community AAls seamless integration with EOSC AAI federation through self-service onboarding Monitoring & Accounting - Automated monitoring includes automated thresholds, raising issues, or alarms in the Service Management System based on results. Accounting is related to capacity data offered by providers Helpdesk - Helpdesk-as-a-service available as optional add-on during onboarding. Integrated with central helpdesk functions Order Processing - Order processing for thematic services can bundle orders for horizontal or basic services needed to deliver the thematic service and include deployment and provisioning EOSC Portal Metrics Dashboard - The dashboard provides statistics related to the combined/integrated usage of EOSC resources

		activities of researchers in EOSC	
EOSC-Exchange	- Resources onboarded through prior projects (e.g. EOSC-hub, EOSC Enhance, elnraCentral) remain available - All horizontal resources from 07 projects are onboarded - A selection of resources from prior projects and 07 projects are integrated with functions from EOSC-Core - Initial cluster services have been onboarded and are listed in the Resource registry in the EOSC portal and accessible through the EOSC Marketplace - Horizontal services (publishing workflows, data transfer, data packaging, container deployment) are demonstrated through 07 service instances - Resource requests are passed to the provider	- First release of EOSC File Transfer Service as first service arising from the clusters to become a horizontal service - Majority of cluster resources (services, data) are available through the central resource registry and EOSC Marketplace - All main 07 horizontal services are integrated with EOSC-Core functionalities - Numerous other horizontal services (publishing workflows, data transfer, data packaging, VM/container deployment and orchestration) are integrated with EOSC-Core functionalities - EOSC-Exchange offers AI/ML-enabled suggestion functions for using the portal(s) - EOSC-Exchange highlights which services can be easily integrated or composed - The onboarding process is extended to include validation of data sources to align to community (FAIR) metadata guidelines - The onboarding process for resources is extended to not only list them but also to include optional integration steps in the same workflow - Resource requests can lead to automatic provisioning of resources	- Production release of EOSC File Transfer Service - First releases of other horizontal services arising from clusters and communities - Ability to create thematic execution environments/VREs based on integration of compliant thematic, horizontal, and core resources - The onboarding process allows for automated/self-service integration with some EOSC-Core functionalities - The onboarding process for resources is extended to include more optional integration steps in the same workflow - Resource requests integrated with procurement as well as provisioning functions - EOSC-Exchange includes numerous services from communities other than those represented by the clusters
EOSC Interoperability Framework	Resource Description Framework - Provider and resource description framework v3.2 including data sources Identifiers - Initial overview of available PID frameworks and guidelines for selecting PID types AAI - Initial technical guidelines for Research Infrastructures and e-Infrastructures to connect AARC-compliant AAI	Resource Description Framework - Provider and resource description framework v3.5 including research products and interoperability guidelines/best practices for horizontal services in EOSC-Exchange Identifiers - Initial guidelines for new PID types (e.g. instruments, services, software, organisations) and standards to connect PID frameworks to PID Graphs. Draft guidelines	Resource Description Framework - Provider and resource description stable release v4.0 incorporating new features requested by the user and provider communities Identifiers - Draft interoperability framework for a PID meta-resolver and guidelines for PID service providers for minimum Kernel Type Information AAI

	Proxies to the EOSC Federated AAI. EOSC AAI Federation guidelines accepted by the cluster communities and e-Infrastructures Metadata and Ontologies - Initial guidelines for metadata discovery and exchange on the basis of existing generic guidelines (e.g. OpenAIRE, DataCite, EUDAT, DCAT) Accounting - Initial guidelines for reporting accounting metrics for virtual access by INFRAEOSC-07 projects Monitoring - Initial guidelines for monitoring service URLs registered in the EOSC Catalogue Order management - Initial guidelines for managing orders specifying interfaces to forward orders to providers Helpdesk - Initial guidelines for handling user requests for services registered in the EOSC Catalogue Data Platforms for Processing - Initial guidelines for data ingesting and movement for processing in hybrid cloud environment Data Publishing and Open Data - Initial guidelines for data repository Cloud Compute Containerisation and Orchestration - Initial guidelines for VM/container management and orchestration HTC-HPC Compute	for PID service providers for minimum Kernel Type Information AAI - Initial technical guidelines to connect AAI proxies from public and private sector service providers to the EOSC Federated AAI should become technical guidelines for cross-infrastructure credential delegation and verification for supporting multi-step agent-driven workflows Metadata and Ontologies - Initial guidelines for communities to publish community-specific metadata and ontologies in EOSC Accounting - Initial interoperability framework for service providers for automated reporting of accounting metrics for VA Monitoring - Initial interoperability framework for service providers for monitoring service availability Order Management - Initial interoperability framework for service providers for automatic dispatching of the orders for services registered in the EOSC Catalogue Helpdesk - Initial interoperability framework for service providers for automatic dispatching and handling of user requests for services registered in the EOSC Catalogue Data Platforms for Processing - Guidelines for data ingesting and movement for processing in hybrid cloud environment improved according to user communities' feedback	- Technical interoperability guidelines for supporting cross-sector access to the EOSC Federated AAI Metadata and Ontologies - Guidelines for minimum metadata to support the discovery, metadata exchange, and cross-walks of research products across communities Accounting - Extended interoperability framework for service providers for automated reporting of accounting and usage metrics Monitoring - Extended interoperability framework for service providers for monitoring service availability of services registered in the EOSC Catalogue Order Management - Extended interoperability framework for service providers for automatic dispatching of orders for services registered in the EOSC Catalogue Helpdesk - Extended interoperability framework for service providers for automatic dispatching and handling of user requests for services registered in the EOSC Catalogue Data Platforms for Processing - EOSC-endorsed guidelines for data ingesting and movement for processing in hybrid cloud environment adopted by one or more horizontal services Data Publishing and Open Data - EOSC-endorsed guidelines for data repository adopted by one or more horizontal services
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	- Initial guidelines for HPC/HTC clusters on demand and multi-tenant containerised job submission Machine Learning - Initial Interoperability guidelines for Machine Learning and review of existing interoperability guidelines (e.g. from EOSC-hub, OpenAIRE Advance, FAIRsFAIR)	Data Publishing and Open Data - Guidelines for data repository improved according to user communities' feedback Cloud Compute Containerisation and Orchestration - Guidelines for VM/container management and orchestration improved according to user communities' feedback HTC-HPC Compute - Guidelines for HPC/HTC clusters on demand and multi-tenant containerised job submission improved according to user communities' feedback Machine Learning - Guidelines for Machine Learning/Deep Learning data analytics services improved according to user communities' feedback	Cloud Compute Containerisation and Orchestration - EOSC-endorsed guidelines for VM/container management and orchestration adopted by one or more horizontal services HTC-HPC Compute - EOSC-endorsed guidelines for HPC/HTC clusters on demand and multi-tenant containerised job submission adopted by one or more horizontal services Machine Learning - EOSC-endorsed interoperability guidelines for Machine Learning
Clusters and Science Projects	SP Deployment - Preparation phase of SPs: cluster SPs started integration and adaptation of cluster/Research Infrastructure tools and services into the broader EOSC framework, including integration with AAI, data sources moved into EOSC (FAIR) data stores, and catalogued, software development and exchange platforms available, workflow deployment mechanisms adapted Clusters' Input to EOSC Horizontal Services - List of candidate services from clusters which can be generalised to be EOSC-wide offerings, with several already being developed to be EOSC-ified	SP Deployment - Initial deployment of SPs done: Most of the SPs have fully operational workflows using integrated EOSC services and tools, make use of EOSC Interoperability Framework, provide feedback from the science communities to the service deployment and operation, and can use resources made available through the Science Clusters/Research Infrastructures Clusters' Input to EOSC Horizontal Services - EOSC software catalogue/repository populated with identified cluster-provided services and tools	SP Deployment - Full scale operation of SPs to the point where many have full scientific analyses ready or close to publication as full demonstrations of open cross-disciplinary science. Demonstrations of the full lifecycle of data processing, storage, analysis and publishing supported by resources available and transparently integrated through EOSC. Workflows deployed across cluster/Research Infrastructure resources and where appropriate on commercial cloud and/or European HPC resources Clusters' Input to EOSC Horizontal Services - General availability of Research Infrastructure-originated horizontal services (as appropriate) visible through EOSC Portal and catalogues

User Experience - Resource Sharing and Discovery	• Researchers can see and reach all thematic and regional portals from the EOSC Portal • Researchers can see services from the thematic clusters through EOSC • A researcher from PaNOSC can seamlessly use compute and/or storage resources provided by the e-Infrastructures to analyse data from the PaNOSC Research Infrastructure using the PaNOSC (UmbrellaID) identity and without having to re-register across infrastructures • A researcher from a new community not involved in EOSC can get a 'virtual tour' of available resources	• A researcher searching on EOSC Portal sees a comprehensive set of resources from multiple communities and clusters • Usage statistics for datasets (views, downloads) will be collected and made available • Researchers using resources through EOSC will have common elements such as AAI, support, monitoring, and accounting • A researcher from PaNOSC can access an ESCAPE resource with the PaNOSC (UmbrellaID) identity. • Researchers using a thematic portal see resources (services,data) pulled in from the central EOSC registry • A richer set of horizontal services to support science is offered to researchers	• A researcher can do the full lifecycle of data processing, storage, analysis, and publishing supported by resources available and transparently integrated through EOSC • EOSC allows research communities to build cross-disciplinary portals • Researchers can gauge the quality and suitability of resources based on usage statistics and feedback from other services
User Experience - Resource Allocation	• A researcher can request resources offered by INFRAEOSC-07 projects through the EOSC Marketplace	• A researcher requesting resources through the EOSC Marketplace portal can request access to EC-funded resources	• Requesting resources through EOSC includes the possibility to access commercial or centrally funded resources • Researchers can request HPC resources (e.g from EuroHPC) directly through the EOSC Marketplace
User Experience - Resource Composability	• Researchers can see example cases of complex workflows using multiple resource providers • Researchers can access and use EOSC computing and storage resources • Researchers can see a rich range of horizontal resources and request access to them	• Researchers can orchestrate data analysis on computing resources provided by multiple e-Infrastructure resource providers and transfer back the output to his/her storage system	• Researchers can compare and select resources based on how easy they are to compose and connect to. • Communities can offer their users fully integrated (end-to-end) workflows and a number of these are available for various research topics

8 Appendix B – EOSC Platform Architecture

EOSC Future is working on ensuring the realisation of EOSC-Core and EOSC-Exchange through the creation of an integrated and professionally operated EOSC platform. To achieve this aim, the project has integrated and evolved a series of services delivered by past EOSC Projects (EOSC-hub, EOSC Enhance and OpenAIRE Advance) and other initiatives in a single and homogenous platform ensuring coordinated behaviour and a uniform user experience.

The creation and integration of the EOSC Platform required extensive work to design its architecture - work that is still on-going. This activity included the definition of the interactions and interfaces between components and towards the external world to implement the use cases that the platform should support, as described in the project High Level Roadmap (HLR). User communities have been directly involved in this effort in line with the co-design principles.

After the M12 review, the project received a recommendation⁴⁷ to rigorously describe the architecture of the EOSC Platform, adopting an architectural view model such as the "4+1"⁴⁸ or others. The EOSC Future Technical Coordination Board (TCB) has acknowledged this recommendation, considered the currently available architectural methodologies and related tools, and selected the C4 methodology to create a consistent, integrated architectural model that would also enable visualisation of the software architecture⁴⁹.

The C4 model is an "abstraction-first" approach to diagramming software architecture, based upon abstractions that reflect how software architects and developers think about and build software. Based on the C4 methodology, a software system is made up of one or more containers (web applications, mobile apps, desktop applications, databases, file systems, etc), each of which contains one or more components, which in turn are implemented by one or more code elements (e.g. classes, interfaces, objects, functions, etc). The C4 model foresees four types of *Core Diagram*:

- **System Context diagram:** it shows a system as a box in the centre, surrounded by its users and the other systems that it interacts with.
- **Container diagram:** it shows the high-level structure of the software architecture and how responsibilities are distributed across it. It also shows the major technology choices and how the containers communicate with one another.
- **Component diagram:** it shows how a container is made up of a number of "components", what each of those components are, their responsibilities and the technology/implementation details.
- **Code:** it shows how each component is implemented as code (e.g. using UML class diagrams).

According to the methodology, it is not mandatory using all diagram types. The System Context and Container diagrams are sufficient in many cases.

The work to describe the EOSC Platform Architecture with the C4 Model started during summer 2022. The EOSC Future TCB agreed to use System Context, Container and Component diagram types in this activity and selected IcePanel⁵⁰ as the project tool to develop the diagrams. The IcePanel tool is more than a diagramming tool -it creates an integrated model for the architecture being described and allows diagrams to be enriched with descriptions and annotations to facilitate their understanding.

⁴⁷ M12 Review Report - Recommendation 12 (Architecture with Implementation Detail, update from previous review): "The consortium must produce more detailed architecture views of the EOSC Future platform. Specifically: (1) The logical view of the architecture must illustrate all the modules that must be implemented or integrated, including the interactions and interfaces between them. (2) Process views for some of the main use cases must be provided (e.g., the user journeys listed in D5.2, the backoffice functionalities of D4.2, the service provider on-boarding process, AAI interactions), including information flows between the main components, as well as the APIs specifications. (3) Implementation and deployment views must be also provided for different parts of the platform (e.g., EOSC Core, EOSC Exchange)."

⁴⁸ https://en.wikipedia.org/wiki/4%2B1_architectural_view_model

⁴⁹ <https://c4model.com/>

⁵⁰ <https://icepanel.io/>

The rest of this appendix presents the current status of this work, including:

- Two system context diagrams of the EOSC Platform.
- One container diagram showing the overall architecture of the EOSC Platform. It also includes views that highlight logical connections between components and standards/interfaces adopted to enable the components communication.
- A component diagram for the “Catalogue and Marketplace” container, illustrating its contained components and the interactions with external systems.

As next steps, the TCB in collaboration with WP leaders and product teams will:

- further refine the logical and standards/interfaces views of the EOSC Platform.
- develop a component diagram for each of the EOSC Platform containers (e.g. all diagrams presented in this deliverable will be re-drawn with C4).
- develop process view diagrams to show how the different components of the platform work together to implement a use case (e.g. the service provider on-boarding process, AAI interactions, etc.).
- enrich descriptions in all the diagrams.

A first rich set of diagrams is expected to be ready by end of November.

8.1 System Context Diagrams

The System Context Diagrams that have been developed present the interactions of the EOSC Platform with external actors from two different point of views.

The *EOSC Overview* diagram (see Figure 8.1) shows the actors according to their interactions with the platform. In that case we have identified three main actors:

- Users: they use the EOSC Platform to search/discovery/order/access/use EOSC resources.
- Service and Research Product providers: they register (aka *onboard*) respectively services and research products in the platform.

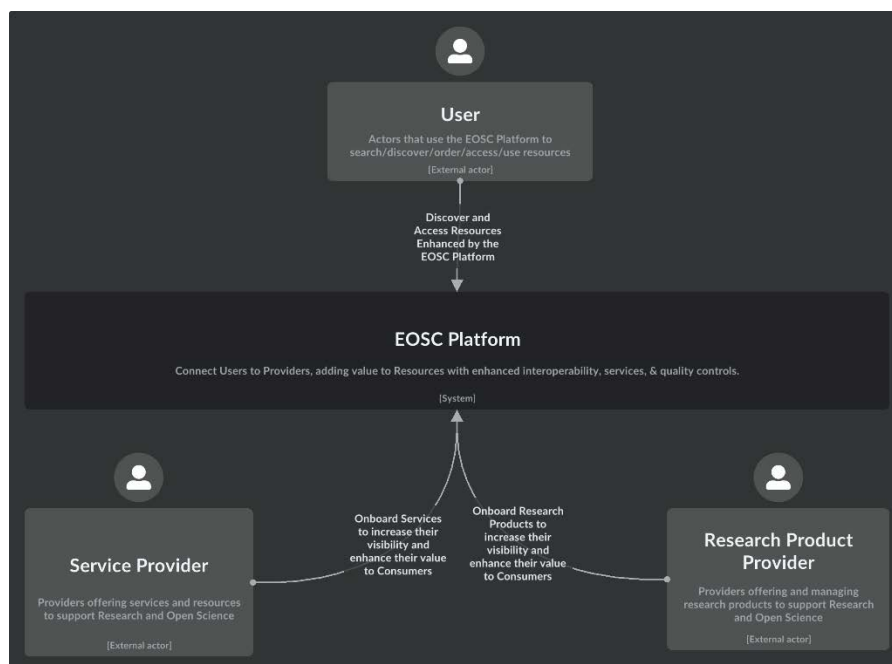


Figure 8.1: EOSC Overview

The *EOSC Stakeholders* diagram (see Figure 8.2) illustrates the main stakeholders that the three “abstract” external actors presented in the *EOSC Overview* diagram:

- Users: including research communities, research infrastructures and single researchers from the long tail of science.
- Service and Research Product providers: including e-Infrastructures, research communities, research infrastructures, commercial companies operating under the OCRE framework and individual providers delivering services and research products for the research.

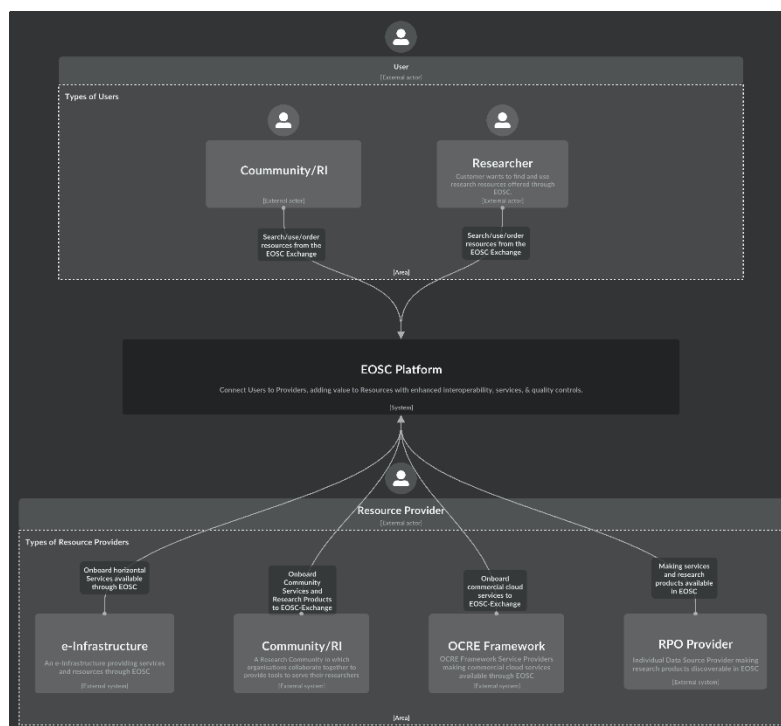


Figure 8.2: EOSC Stakeholders

8.2 EOSC Platform Container Diagram

The *EOSC Platform Container* diagram (see Figure 8.3) details all the main elements of the platform and their internal and external interactions. As a convention, the direction of the arrows shows which element has started the interaction with another element. Due to the number of interactions, it is a complex diagram. To facilitate its understanding, we are developing additional process view diagrams to highlight only the elements and the interactions that happen to enable a given use case (e.g. onboarding of a resource in EOSC).

From the diagram it is worth to notice:

- Users have different entry points to the platform. This reflects how different user communities can decide to exploit different capabilities according to their requirements. A large community might decide to interact with a subset of elements (e.g. the monitoring and the helpdesk) to complement the capabilities of its community platform with capabilities available from EOSC. By contrast, a single researcher can interact with the platform via the *Catalogue and Marketplace* and benefit from a more integrated user experience.
- All the possible interactions between EOSC Platform elements have been identified.
- The diagram shows how a community/RI/e-infrastructure service/research product is selected as part of the EOSC Exchange after onboarding in EOSC.

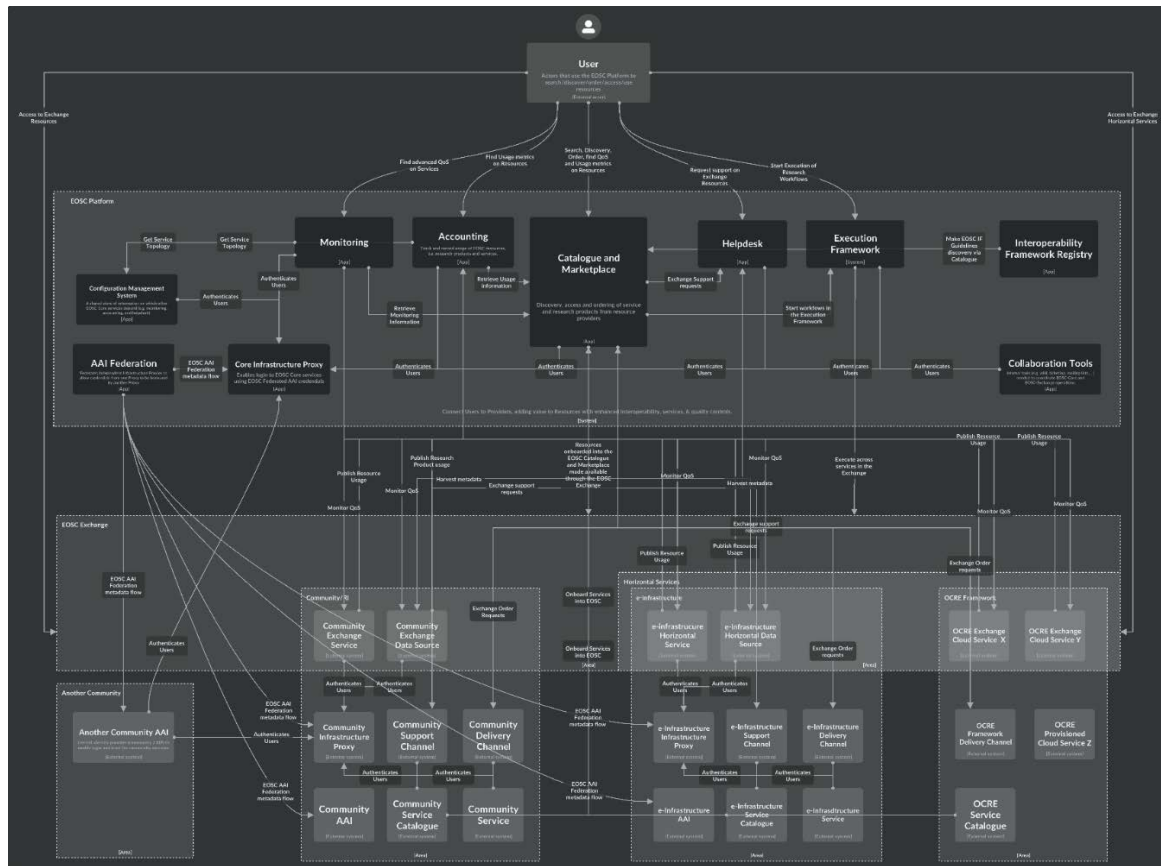


Figure 8.3: EOSC Platform Architecture

The *EOSC Platform Container* diagram has been annotated (tagged) to differentiate the interactions according to the functionality each interaction helps to implement (onboarding, monitoring, accounting, AAI, etc.). This results in the logical view of the platform presented in Figure 8.4. Each functionality has been represented with a colour described in the legend below (accounting/yellow, ordering/red, etc.).

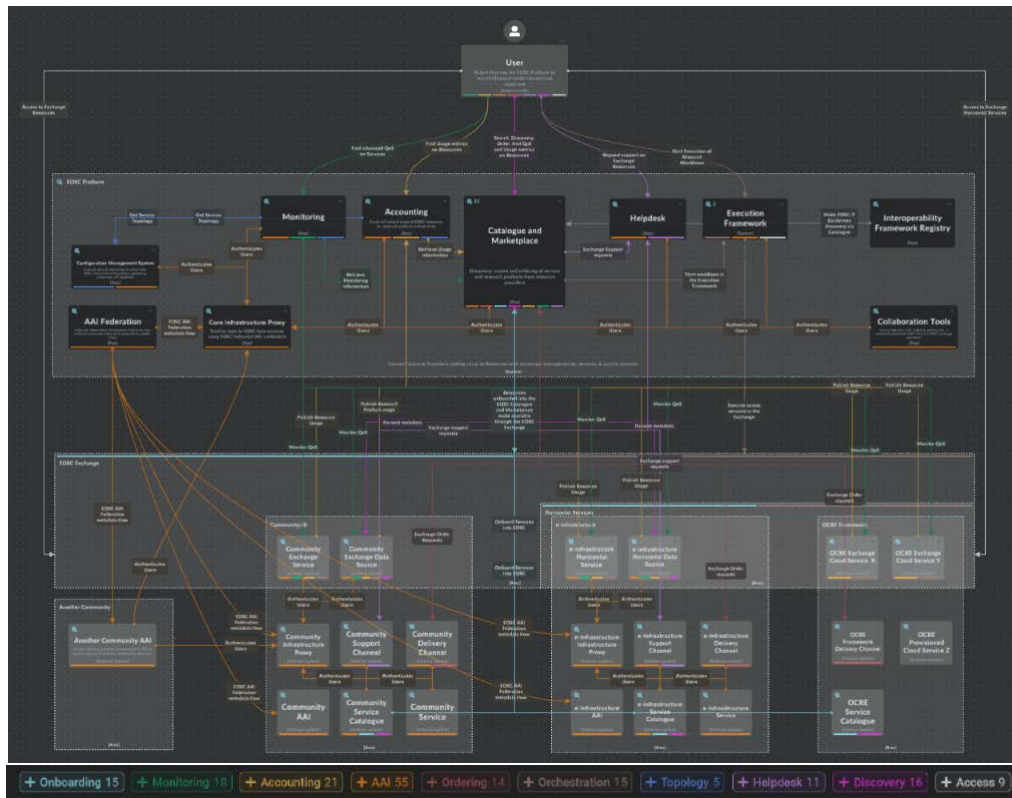
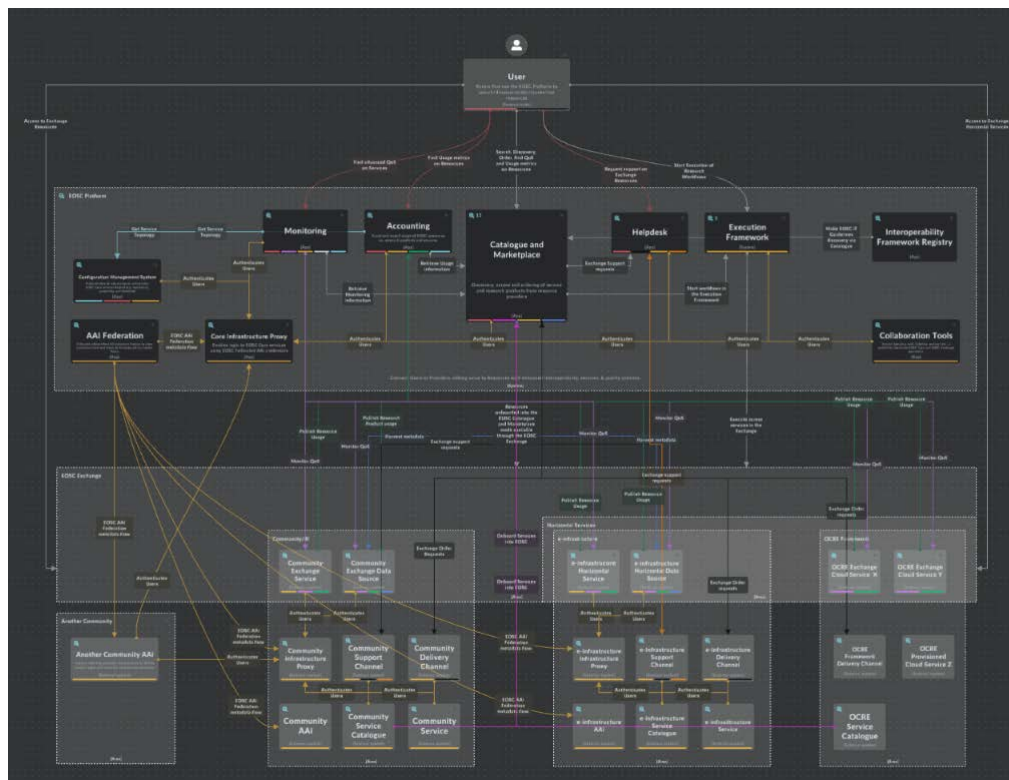


Figure 8.4: EOSC Platform Architecture – Logical view

Similarly, the diagram has been annotated to describe the standards/interfaces adopted to implement each interaction. The result is shown in the Figure 8.5 where, for example, interactions implemented with the *Provider Portal API* are in purple and those using the *SAML* or *OIDC* protocols are in yellow.



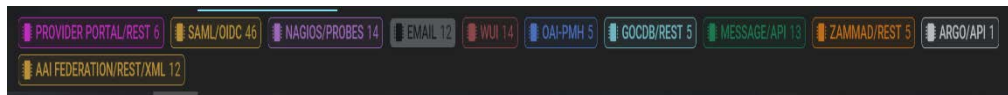


Figure 8.5: EOSC Platform Architecture – Standard view

Both the logical and standard views presented above are being refined by the TCB and are expected to be finalized by November 2022.

8.3 EOSC Catalogue and Marketplace Component Diagram

The last diagram shows the internal components of the EOSC Catalogue and Marketplace container (using the terminology of the C4 model), which is the most complex single element of the EOSC Platform.

The diagram below only shows interactions with external systems (see Figure 8.6). Additional views are being developed, for example, describing all internal interactions within the components that make up the Catalogue and Marketplace container.

The current diagram is included to better support the technical roadmap presented in the next appendix that refers to many of the components of the EOSC Catalogue and Marketplace.

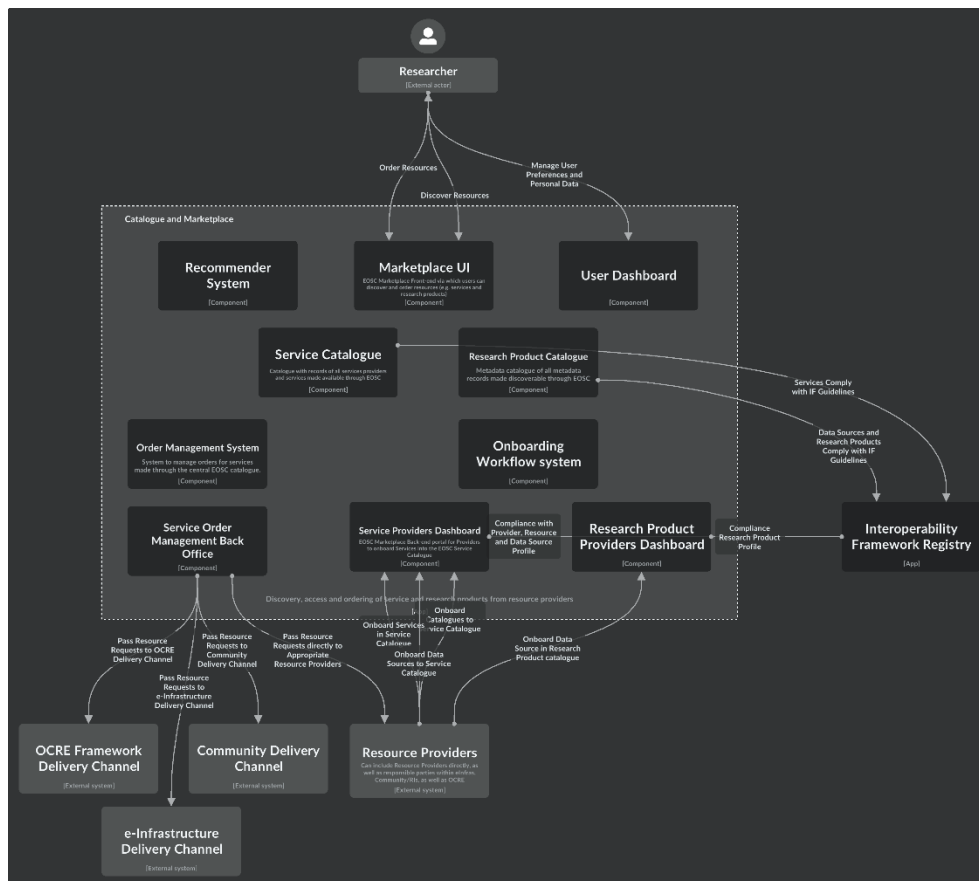


Figure 8.6: EOSC Catalogue & Marketplace

9 Appendix C – Detailed EOSC Future Technical Roadmap

In the following table the detailed EOSC Future Technical Roadmap is presented. For each component, it includes the capabilities to be implemented and their evolution from the project start till the project completion expressed in TRL levels⁵¹. The table lists the relevant Jira Epics to which the capability will contribute. These Epics represents the use cases, described in the project High Level Roadmap, that are being enabled in the EOSC platform by the project by releasing these capabilities. The table also includes information about the responsible partner and the list of other partners involved in the development of each capability.

The following rules have been adopted to represent the implementation status of each capability in TRL levels⁵²:

- A capability that has not been demonstrated yet in the EOSC Platform operational environment has a TRL lower than TRL7. It is considered Not Available (N.A. in the roadmap) for EOSC users.
- A capability that has been successfully validated in the EOSC Platform operational environment, but it is not available to the general public (all the EOSC users). has TRL7.
- A new capability successfully integrated with the EOSC Platform operational environment and made available to the general public (all the EOSC users) has a TRL8.
- A capability that has been successfully delivered in the EOSC Platform operational environment for at least 6 months has a TRL9.

The EOSC Future Technical Roadmap is presented per Container (each paragraph below) and Component according to the C4 model⁵³ adopted by the project to describe the EOSC Platform Architecture (see Appendix B for more details).

⁵¹ Technology Readiness Levels (TRLs) definition:

https://ec.europa.eu/research/participants/data/ref/h2020/wp/2014_2015/annexes/h2020-wp1415-annex-g-trl_en.pdf

⁵² <https://eosc-portal.eu/providers-documentation/eosc-provider-portal-resource-maturity-classification>

⁵³ <https://c4model.com/>

9.1 Catalogue and Marketplace

Capabilities	Description	Enabled EPICS (Use cases)	Resp/ble	Involved	M6	M12	M15	M18	M22	M25	M28	M30
A. Resource Catalogue, Research Product Catalogue, Service Providers Dashboard, Research Product Provider Dashboard, Onboarding Workflow System												
Integration of service catalogues through the EOSC Provider Dashboard (push & pull)	Third-party catalogues can use the EOSC Resource Catalogue APIs to pull selected resource records from the EOSC catalogue into their own catalogues. (No onboarding of the external catalogue by EOSC is necessary.) Third-party catalogues can, once they are onboarded to EOSC, use the EOSC Resource Catalogue APIs to push selected resource records from their own catalogue into the EOSC Catalogue.	A1-M18. A researcher searching on EOSC Portal sees a comprehensive set of resources from multiple communities and clusters. A5-M18. Researchers using a thematic portal can see resources (services, data) pulled in from the central EOSC registry E2-M30. EOSC Resource Catalogue	ATHENA		N.A.	N.A.	TRL7	TRL8	TRL8	TRL9	TRL9	TRL9
Support to data sources and related research product onboarding	Onboarding capabilities are extended to support data sources and related research products in EOSC (similar to service onboarding already available) Update of the data model of the research products knowledge graph to combine research products, services, and data sources Set up of aggregation workflows to ensure service profile collection in the knowledge graph	A1-M18. A researcher searching on EOSC Portal sees a comprehensive set of resources from multiple communities and clusters. D2-M18. Majority of cluster resources (services, data) are available through the central resource registry and EOSC Marketplace. D7-M18. The onboarding process is extended to include validation of data sources to align to community (FAIR) metadata guidelines. E2-M30. EOSC Resource Catalogue	ATHENA	OpenAIRE	N.A.	N.A.	TRL7	TRL8	TRL8	TRL9	TRL9	TRL9
EOSC Resource Catalogue APIs and dumps	API software enhanced to enable discovery of services and of resources by EOSC IF guidelines Generation of EOSC resource catalogue dumps to serve the EOSC Marketplace	E2-M30. EOSC Resource Catalogue	OpenAIRE		N.A.	N.A.	TRL7	TRL7	TRL7	TRL8	TRL8	TRL9

Information on resource compatibility with IF guidelines is linked to resource catalogue entries	Onboarding capabilities are extended to allow linking (new or existing) resources to Interoperability Framework guideline entries and to identify compatibility relationship types between resources and guidelines. Information on guidelines supported by a resource can be retrieved via the resource catalogue API.	C1-M30. Researchers can compare and select resources based on how easy they are to compose and connect to. D6-M18. EOSC-Exchange highlights which services can be easily integrated or composed. G1-M18. EOSC Interoperability Framework's framework	ATHENA	GEANT, OpenAIRE, CYFRONET	N.A.	N.A.	N.A.	N.A.	TRL7	TRL8	TRL8	TRL9
Mining algorithms to infer links between scientific articles and EOSC services in the Marketplace	Engineering and integration of mining algorithms to identify references to EOSC services from scientific publications to be used to define impact indicators	E2-M30. EOSC Resource Catalogue	OpenAIRE		N.A.	N.A.	N.A.	TRL7	TRL7	TRL8	TRL8	TRL9
FAIRification of data sources	Data sources will be validated to check their overall degree of FAIRness	D7-M18. The onboarding process is extended to include validation of data sources to align to community (FAIR) metadata guidelines. E2-M30. EOSC Resource Catalogue	OpenAIRE	OpenAIRE	N.A.	N.A.	N.A.	TRL7	TRL7	TRL8	TRL8	TRL9
Support of Training Resources onboarding	Resource Catalogue supports onboarding and management of training resources	E2-M30. EOSC Resource Catalogue	OpenAIRE	ATHENA	N.A.	N.A.	N.A.	N.A.	TRL7	TRL8	TRL8	TRL9
B. Front-office Platform/Marketplace (UIs for both Services and Research Products)												
Dataset and research products search engine and access	The EOSC Marketplace is enhanced to allow research products to be found and accessed by users, alongside services and other resources.	A1-M18. A researcher searching on EOSC Portal sees a comprehensive set of resources from multiple communities and clusters. D2-M18. Majority of cluster resources (services, data) are available through the central resource registry and EOSC Marketplace. E1-M18 EOSC Front-Office Platform	CYFRONET	OpenAIRE	N.A.	N.A.	TRL7	TRL8	TRL8	TRL9	TRL9	TRL9

Search and access "solutions", as preconfigured set of resources, in the EOSC Marketplace	A solution/bundle combines preconfigured multiple integrated EOSC resources to solve a problem for users	A1-M30. A researcher can do the full lifecycle of data processing, storage, analysis, and publishing supported by resources available and transparently integrated through EOSC. E1-M30. EOSC Front-Office Platform	CYFRONET		N.A.	N.A.	N.A.	N.A.	TRL8	TRL8	TRL9	TRL9
Information on resource compatibility with IF guidelines is presented to users	The Marketplace exposes to end users the list of Interoperability Framework guideline supported by each resource to identify compatibility relationship types between resources and guidelines	C1-M30. Researchers can compare and select resources based on how easy they are to compose and connect to. D6-M18. EOSC-Exchange highlights which services can be easily integrated or composed. G1-M18. EOSC Interoperability Framework's framework E1-M30. EOSC Front-Office Platform	CYFRONET		N.A.	N.A.	N.A.	N.A.	TRL7	TRL8	TRL8	TRL9
Dedicated views to present groups of services and research products to users	A research community or a scientific collaboration (e.g. involving 2 or more RIs) can create a dedicated view in the Marketplace to expose all its resources to EOSC users	A2-M30. EOSC allows research communities to build cross-disciplinary portals. E1-M30 EOSC Front-Office Platform	CYFRONET		N.A.	N.A.	N.A.	N.A.	TRL7	TRL8	TRL8	TRL9
Research products can be added to a Marketplace project	A users can add research products (e.g. datasets) to a Marketplace project together with services	A1-M30. A researcher can do the full lifecycle of data processing, storage, analysis, and publishing supported by resources available and transparently integrated through EOSC. E1-M30. EOSC Front-Office Platform	CYFRONET		N.A.	N.A.	N.A.	N.A.	N.A.	TRL7	TRL8	TRL8
Training resources search engine and access	Extension of the search engine to look for training resources published in the resource catalogue and in the Learning Platform (WP9)	E1-M18. EOSC Front-Office Platform	CYFRONET		N.A.	N.A.	TRL7	TRL8	TRL8	TRL9	TRL9	TRL9
EOSC Explore	EOSC Explore is a web gateway that offers search and navigation functionality over a knowledge graph that interlinks EOSC resources with services, projects, funders, organization, researchers, and other products worldwide	A1-M18. A researcher searching on EOSC Portal sees a comprehensive set of resources from multiple communities and clusters A2-M18. Usage statistics for datasets (views, downloads) will be collected and made available. E1-M18 EOSC Front-Office Platform	OpenAIRE		N.A.	N.A.	TRL7	TRL8	TRL8	TRL9	TRL9	TRL9

C. User Dashboard powered by the Recommender System												
User Dashboard powered by the Recommender System	The User dashboard (previously known as the User panel) is a component of the EOSC Portal that is responsible for managing the interaction with the user and providing them with access to the services offered by the EOSC Portal. It also allows the user to set personal preferences relating to the Recommender System.	D5-M18. Front-Office offers AI/ML-enabled suggestion functions for discovery/accessing the EOSC Exchange portal(s)/services. E1-M18. EOSC Front-Office Platform	CYFRONET	ATHENA	N.A.	N.A.	N.A.	TRL7	TRL8	TRL8	TRL9	TRL9
Deliver recommendations of resources based on user profiles and actions	Logged in user is presented with profiled suggestions for services and research products.	D5-M18. Front-Office offers AI/ML-enabled suggestion functions for discovery/accessing the EOSC Exchange portal(s)/services. E1-M18. EOSC Front-Office Platform	CYFRONET	PSNC, ATHENA	N.A.	N.A.	N.A.	TRL7	TRL8	TRL8	TRL9	TRL9
Integrated user profile visible in the User Dashboard	A richer researcher profile is associated with the User Dashboard so the recommendations for the user might be better matched by the AI recommender system.	D5-M18. Front-Office offers AI/ML-enabled suggestion functions for discovery/accessing the EOSC Exchange portal(s)/services. E1-M18. EOSC Front-Office Platform	CYFRONET	ATHENA	N.A.	N.A.	N.A.	N.A.	N.A.	TRL 7	TRL 8	TRL8
Deliver recommendations to providers to facilitate the onboarding process based on provider profiles and EOSC resources	Accelerate the on-boarding procedure by providing auto-completion recommendations for specific fields (such as tags, scientific domains, categories)	D5-M18. Front-Office offers AI/ML-enabled suggestion functions for discovery/accessing the EOSC Exchange portal(s)/services. E1-M18. EOSC Front-Office Platform	ATHENA		N.A.	N.A.	N.A.	N.A.	N.A.	TRL7	TRL8	TRL8
D. Recommender System												
Personalised recommendations for research products, trainings and services are available for users	The user receives recommendations concerning individual EOSC items, based on the information EOSC Portal and EOSC Marketplace have about the user. Recommendations are delivered separately for each data source used for creating them, e.g., items previously ordered, items previously viewed, items that are currently popular, items that are popular in the same domain, items	D5-M18. Front-Office offers AI/ML-enabled suggestion functions for discovery/accessing the EOSC Exchange portal(s)/services. E1-M18. EOSC Front-Office Platform	PSNC	CYFRONET , ATHENA	N.A.	N.A.	N.A.	TRL7	TRL8	TRL8	TRL9	TRL9

	recommended by users with similar interests/background etc											
Monitoring and recommendation evaluation	An independent metrics framework as a service is being introduced to support the evaluation and adaptation of recommendation mechanisms. The use of diagnostic metrics (such as User Coverage), KPIs (such as Click-Through Rate) and visualizations offers deeper and sometimes surprising insights into a model's performance. The evaluation is quantitatively being performed by processing information such as resources, user actions, ratings, and recommendations in order to measure the impact of the AI-enhanced services and user satisfaction as well as to incorporate this feedback and improve the services provided, via a user-friendly API and dashboard UI.	D5-M18. Front-Office offers AI/ML-enabled suggestion functions for discovery/accessing the EOSC Exchange portal(s)/services. E1-M18. EOSC Front-Office Platform	GRNET	PSNC	N.A.	N.A.	N.A.	TRL7	TRL8	TRL8	TRL9	TRL9
Enabling the providers deeper insight into their services	A set of recommending tools that will better aid providers to understand the impact that the Recommender System has concerning their services (such as number of ratings over time)	D5-M18. Front-Office offers AI/ML-enabled suggestion functions for discovery/accessing the EOSC Exchange portal(s)/services. E1-M18. EOSC Front-Office Platform	ATHENA		N.A.	N.A.	N.A.	N.A.	N.A.	TRL7	TRL8	TRL8
Support for smart search capabilities	The support for personalized search across data, services and software available in EOSC is introduced. The information provided by the user explicitly in a typical search query is usually incomplete or imprecise, and the responses are not properly ordered. The smart search function will address the issue by ordering the search results in accordance with the user preferences.	D5-M18. Front-Office offers AI/ML-enabled suggestion functions for discovery/accessing the EOSC Exchange portal(s)/services. E1-M18. EOSC Front-Office Platform	PSNC	CYFRONET	N.A.	N.A.	N.A.	N.A.	TRL7	TRL8	TRL8	TRL9

9.2 Order Management

Capabilities	Description	Enabled EPICS (Use cases)	Resp/ble	Involved	M6	M12	M15	M18	M22	M25	M28	M30
E. Order Management (OMS in Front Office, Order Workflow Systems, SOMBO)												
Enhanced service offer definition for providers	Graphical interface allowing to define parameters connected with the offer (and ordering if applicable). Any type of parameter is available to the providers and a business logic behind it allows to better express technical capabilities of the service.	A3-M18. Researchers using resources through EOSC will have common elements such as AAI, support, monitoring, and accounting. B1-M18. A researcher requesting resources through the EOSC Marketplace portal can request access to EC-funded resources. E3-M18 EOSC Order Management	CYFRONET		TRL8	TRL8	TRL9	TRL9	TRL9	TRL9	TRL9	TRL9
Integration on demand in the EOSC Provider Portal & Marketplace	Possibility to connect provider's Order Management System (OMS) with EOSC OMS. Possibility to forward provider's offers to EOSC OMS.	A3-M18. Researchers using resources through EOSC will have common elements such as AAI, support, monitoring, and accounting. B1-M18. A researcher requesting resources through the EOSC Marketplace portal can request access to EC-funded resources. E3-M18. EOSC Order Management	CYFRONET		TRL7	TRL8	TRL8	TRL9	TRL9	TRL9	TRL9	TRL9
Solutions/Bundles can be ordered/accessed in one shot	Order management process supports resource solutions/bundles and allows to order or access them as a package. It's consistent with EOSC solutions/bundles definition.	C1-M18. Researchers can orchestrate data analysis on computing resources provided by multiple e-Infrastructure resource providers and transfer back the output to his/her storage system. A1-M30. A researcher can do the full lifecycle of data processing, storage, analysis, and publishing supported by resources available and transparently integrated through EOSC. C2-M30. Communities can offer their users fully integrated (end-to-end) workflows and a number of these are available for various research topics.	CYFRONET	ATHENA	TRL7	TRL7	TRL7	TRL7	TRL8	TRL8	TRL9	TRL9

		E3-M30. EOSC Order Management										
Enhanced order management process to support new emerging use cases	Order management capabilities are extended to capture new information collected via the requirement analysis process and support new use cases.	B1-M30. Requesting resources through EOSC includes the possibility to access commercial or centrally funded resources. B2-M30. Researchers can request HPC resources (e.g from EuroHPC) directly through the EOSC Marketplace. D6-M30. Resource requests integrated with procurement as well as provisioning functions. E3-M30. EOSC Order Management	CYFRONET		N.A.	N.A.	N.A.	N.A.	N.A.	TRL7	TRL8	TRL8
Basic support for workflow management	Order management is extended to include features supporting workflow management.	A1-M30. A researcher can do the full lifecycle of data processing, storage, analysis, and publishing supported by resources available and transparently integrated through EOSC. C2-M30. Communities can offer their users fully integrated (end-to-end) workflows and a number of these are available for various research topics. E3-M30. EOSC Order Management	CYFRONET		N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	TRL7	TRL8

9.3 Monitoring

Capabilities	Description	Enabled EPICS (Use cases)	Resp/ble	Involved	M6	M12	M15	M18	M22	M25	M28	M30
F. Monitoring												
Monitoring dashboard for the EOSC Core	Dashboard to monitor the A/R of the Core services over the time. The monitoring team is constantly assisting the Core providers to develop adequate probes so that all EOSC Core Services are properly monitored.	A3-M18. Researchers using resources through EOSC will have common elements such as AAI, support, monitoring, and accounting. E4-M18. EOSC Monitoring	GRNET	SRCE	TRL9	TRL9	TRL9	TRL9	TRL9	TRL9	TRL9	TRL9
Monitoring dashboard for	Dashboard to monitor the A/R of the Exchange services over the time. Assist EOSC Exchange providers to develop	A3-M18. Researchers using resources through EOSC will have common elements such as AAI,	GRNET	SRCE	TRL9	TRL9	TRL9	TRL9	TRL9	TRL9	TRL9	TRL9

the EOSC Exchange	probes so that their services are properly monitored.	support, monitoring, and accounting. E4-M18. EOSC Monitoring										
Monitoring dashboard Horizontal Services report	Add a new report on EOSC Exchange monitoring dashboard about Horizontal Services	A3-M18. Researchers using resources through EOSC will have common elements such as AAI, support, monitoring, and accounting. E4-M18. EOSC Monitoring	GRNET		N.A.	N.A.	TRL7	TRL7	TRL8	TRL8	TRL9	TRL9
Integration of the EOSC Provider Portal with the Monitoring Service	EOSC Exchange providers can request integration with the EOSC Monitoring via the Provider Portal	A3-M18. Researchers using resources through EOSC will have common elements such as AAI, support, monitoring, and accounting. D3-M18. All main 07 horizontal services are integrated with EOSC-Core functionalities. D4-M18. Numerous other horizontal services (publishing workflows, data transfer, data packaging, VM/container deployment, and orchestration) are integrated with EOSC-Core functionalities. D8-M18. The onboarding process for EOSC service resources is extended to not only register them into the EOSC registry but also to include optional EOSC Core integration steps in the same workflow such as AAI, monitoring, accounting, helpdesk, order management., onboarding of research products (for data sources), etc. E4-M18. EOSC Monitoring	GRNET	ATHENA	N.A.	N.A.	TRL7	TRL7	TRL8	TRL8	TRL9	TRL9
Enhanced integration of the EOSC Provider Portal with the Monitoring Service	The integration of EOSC Exchange services with the EOSC Monitoring via the Provider Portal is simplified and automated as much as possible	D4-M30. The onboarding process allows for automated/self-service integration with some EOSC-Core functionalities. D5-M30. The onboarding process for resources is extended to include more optional integration steps in the same workflow. E4-M30 EOSC Monitoring	GRNET	ATHENA	N.A.	N.A.	N.A.	N.A.	N.A.	TRL7	TRL8	TRL8

Integration of the EOSC Resource Catalogue and Marketplace with the Monitoring Service	The Marketplace and the Provider Portal will include Monitoring Data (status, A/R) in the resource entries	A3-M18. Researchers using resources through EOSC will have common elements such as AAI, support, monitoring, and accounting. A3-M30. Researchers can gauge the quality and suitability of resources based on usage statistics and feedback from other services. E4-M30. EOSC Monitoring	GRNET	CYFRONET	N.A.	N.A.	TRL7	TRL7	TRL8	TRL8	TRL9	TRL9
Status Pages about Core Services	A service to display the latest status about the EOSC Core services	E4-M30. EOSC Monitoring	GRNET		N.A.	N.A.	TRL7	TRL7	TRL8	TRL8	TRL9	TRL9
Automated/self-service integration of monitoring probes and metrics offered to EOSC-Exchange providers	The EOSC Exchange dashboard will offer to the providers the possibility to integrate new monitoring probes and metrics. In that way, providers will be able to customise the monitoring of their services according to their features.	D4-M30. The onboarding process allows for automated/self-service integration with some EOSC-Core functionalities. D5-M30. The onboarding process for resources is extended to include more optional integration steps in the same workflow. E4-M30. EOSC Monitoring	GRNET		N.A.	N.A.	N.A.	N.A.	N.A.	TRL7	TRL8	TRL8

9.4 Accounting

Capabilities	Description	Enabled EPICS (Use cases)	Resp/ble	Involved	M6	M12	M15	M18	M22	M25	M28	M30
G. Accounting												
New accounting system for EOSC services	The new accounting system for services will allow to gather and retrieve information about custom metrics defined by service providers. Documentation and interoperability guidelines will be released contextually with the first release.	A3-M18. Researchers using resources through EOSC will have common elements such as AAI, support, monitoring, and accounting.	GRNET	CNRS, STFC	N.A.	N.A.	TRL7	TRL7	TRL8	TRL9	TRL9	TRL9
Integration of accounting in the EOSC Provider Portal	EOSC Exchange providers can request integration with the EOSC Accounting for services via the Provider Portal	A3-M18. Researchers using resources through EOSC will have common elements such as AAI, support, monitoring, and accounting. D3-M18. All main 07 horizontal services are integrated with EOSC-Core functionalities.	GRNET		N.A.	N.A.	N.A.	N.A.	N.A.	TRL7	TRL8	TRL8

		D4-M18. Numerous other horizontal services (publishing workflows, data transfer, data packaging, VM/container deployment and orchestration) are integrated with EOSC-Core functionalities. D8-M18. The onboarding process for EOSC service resources is extended to not only register them into the EOSC registry but also to include optional EOSC Core integration steps in the same workflow such as AAI, monitoring, accounting, helpdesk, order management., onboarding of research products (for data sources), etc. E5-M18. EOSC Accounting D4-M30. The onboarding process allows for automated/self-service integration with some EOSC-Core functionalities. D5-M30. The onboarding process for resources is extended to include more optional integration steps in the same workflow.										
Integration of accounting for services in the EOSC Marketplace	The Marketplace will include Accounting Data in the service entries	A3-M18. Researchers using resources through EOSC will have common elements such as AAI, support, monitoring, and accounting. A3-M30. Researchers can gauge the quality and suitability of resources based on usage statistics and feedback from other services.	GRNET	CYFRONET	N.A.	N.A.	N.A.	N.A.	N.A.	TRL7	TRL8	TRL8
Accounting system for Research Products	Data Sources can push notifications of usage events (views, downloads) to the service to enable aggregation of usage stats at the level of research product PIDs	A2-M18. Usage statistics for datasets (views, downloads) will be collected and made available A3-M18. Researchers using resources through EOSC will have common elements such as AAI, support, monitoring, and accounting.	OpenAIRE		TRL9	TRL9	TRL9	TRL9	TRL9	TRL9	TRL9	TRL9

Integration of research products accounting in the EOSC Provider Portal	EOSC Exchange providers can request integration with the EOSC Accounting for research products via the Provider Portal	A2-M18. Usage statistics for datasets (views, downloads) will be collected and made available A3-M18. Researchers using resources through EOSC will have common elements such as AAI, support, monitoring, and accounting. D3-M18. All main 07 horizontal services are integrated with EOSC-Core functionalities. D4-M18. Numerous other horizontal services (publishing workflows, data transfer, data packaging, VM/container deployment and orchestration) are integrated with EOSC-Core functionalities. D8-M18. The onboarding process for EOSC service resources is extended to not only register them into the EOSC registry but also to include optional EOSC Core integration steps in the same workflow such as AAI, monitoring, accounting, helpdesk, order management., onboarding of research products (for data sources), etc. E5-M18 EOSC Accounting D4-M30. The onboarding process allows for automated/self-service integration with some EOSC-Core functionalities. D5-M30. The onboarding process for resources is extended to include more optional integration steps in the same workflow.	OpenAIRE	CYFRONET	N.A.	N.A.	N.A.	TRL7	TRL8	TRL8	TRL9	TRL9
Usage statistics of the research products are available into the EOSC Marketplace	Usage statistics are embedded into the EOSC Resource Catalogue and exposed in the Marketplace. Usage statistics can be also retrieved via API.	A2-M18. Usage statistics for datasets (views, downloads) will be collected and made available A3-M18. Researchers using resources through EOSC will have common elements such as AAI, support, monitoring, and accounting.	OpenAIRE	CYFRONET	N.A.	N.A.	N.A.	TRL7	TRL8	TRL8	TRL9	TRL9

		A3-M30. Researchers can gauge the quality and suitability of resources based on usage statistics and feedback from other services.											
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9.5 AAI

Capabilities	Description	Enabled EPICS (Use cases)	Resp/ble	Involved	M6	M12	M15	M18	M22	M25	M28	M30
H. AAI												
Infrastructure proxy for EOSC Core Services	The infrastructure proxy is responsible for connecting the EOSC Core service to the EOSC AAI through the EOSC AAI Federation.	A3-M18. Researchers using resources through EOSC will have common elements such as AAI, support, monitoring, and accounting. G4-M18 AAI: Interoperability guidelines are available as part of the EOSC Interoperability Framework	GEANT	EGI/GRNET	TRL9	TRL9	TRL9	TRL9	TRL9	TRL9	TRL9	TRL9
IGTF to eduGAIN Proxy	The IGTF to eduGAIN Proxy enables users to use their IGTF certificates in order to identify themselves on EOSC services.	-	GEANT	GRNET	TRL9	TRL9	TRL9	TRL9	TRL9	TRL9	TRL9	TRL9
Geographical High Availability for RCAuth CA	The RCAuth.eu service provides PKIX certificates for end-users only through pre-validated credential management services (Master Portals or Token Translation Services). With the geographical HA setup, the RCAuth CA has 3 instances running in GR, NL and UK in active – active mode.	-	GEANT	GRNET/NI KHEF/STFC	N.A.	N.A.	TRL7	TRL7	TRL8	TRL8	TRL9	TRL9
Fabric monitoring the AAI services in EOSC Core	The Fabric monitoring for the AAI services in EOSC core, is responsible for monitoring all the AAI components available in EOSC Core.	-	GEANT	GRNET	N.A.	N.A.	TRL7	TRL7	TRL8	TRL8	TRL9	TRL9
AAI Federation	The EOSC AAI Federation is a full mesh AAI federation that provides the AAI trust anchors from all Research Infrastructures and e-Infrastructures. The EOSC AAI Federation connects the infrastructure proxies and community AAI that are available in EOSC.	A3-M18. Researchers using resources through EOSC will have common elements such as AAI, support, monitoring, and accounting. A4-M18. A researcher from PaNOSC can access an ESCAPE	GEANT	GEANT	N.A.	TRL7	TRL7	TRL7	TRL8	TRL8	TRL9	TRL9

		resource with the PaNOSC (UmbrellaID) identity.											
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9.6 Helpdesk

Capabilities	Description	Enabled EPICS (Use cases)	Resp/ble	Involved	M6	M12	M15	M18	M22	M25	M28	M30
I. Helpdesk												
New Helpdesk based on the Zammad Technology	The helpdesk is deployed and integrated with AAI to enable access for EOSC users and agents.	A3-M18. Researchers using resources through EOSC will have common elements such as AAI, support, monitoring, and accounting.	KIT		N.A.	TRL8	TRL8	TRL9	TRL9	TRL9	TRL9	TRL9
Availability of support units for all Core services (AAI, monitoring, marketplace, etc.)	Helpdesk customisation and Implementation of a support structure consisting of support units for all EOSC Core services and governance support units.	A3-M18. Researchers using resources through EOSC will have common elements such as AAI, support, monitoring, and accounting.	KIT		N.A.	TRL8	TRL8	TRL9	TRL9	TRL9	TRL9	TRL9
Integration on demand in the EOSC Provider Portal & Marketplace	EOSC Exchange service providers can request integrations with the EOSC Helpdesk from the EOSC Provider Portal. Service providers can decide to adopt the EOSC Helpdesk to take advantage of scalable support and helpdesk tools to manage service requests, interact with users. As an alternative, service providers can decide to integrate their helpdesk with the EOSC one.	A3-M18. Researchers using resources through EOSC will have common elements such as AAI, support, monitoring, and accounting. D3-M18. All main 07 horizontal services are integrated with EOSC-Core functionalities. D4-M18. Numerous other horizontal services (publishing workflows, data transfer, data packaging, VM/container deployment and orchestration) are integrated with EOSC-Core functionalities. D8-M18. The onboarding process for EOSC service resources is extended to not only register them into the EOSC registry but also to include optional EOSC Core integration steps in the same workflow such as AAI, monitoring, accounting, helpdesk, order management, onboarding of	KIT	ATHENA, CYFRONET	N.A.	TRL7	TRL7	TRL8	TRL8	TRL9	TRL9	TRL9

		research products (for data sources), etc.										
Helpdesk as-a-service is available for communities	Any community or service provider could get a dedicated management area, including multiple support groups, connected with separate email/webform to support users.	A3-M18. Researchers using resources through EOSC will have common elements such as AAI, support, monitoring, and accounting.	KIT		N.A.	TRL7	TRL7	TRL8	TRL8	TRL8	TRL9	TRL9
EOSC users can request support for EGI and EUDAT services through the EOSC Helpdesk	Full integration with EGI Helpdesk (GGUS) allows to keep all tickets in both helpdesk systems in sync. Redirection option is implemented based on EUDAT requirement for integration with EUDAT helpdesk.	A3-M18. Researchers using resources through EOSC will have common elements such as AAI, support, monitoring, and accounting.	KIT	EGI, EUDAT	N.A.	N.A.	TRL8	TRL8	TRL9	TRL9	TRL9	TRL9
Implementation of multiple webforms, webforms customisation	Capability to add multiple webforms to multiple support units.	A3-M18. Researchers using resources through EOSC will have common elements such as AAI, support, monitoring, and accounting.	KIT		N.A.	N.A.	TRL7	TRL8	TRL8	TRL9	TRL9	TRL9
Helpdesk secure account linking	Capability to link local user accounts in Zammad with SAML account provided by EOSC AAI	A1-M30. A researcher can do the full lifecycle of data processing, storage, analysis, and publishing supported by resources available and transparently integrated through EOSC.	KIT		N.A.	N.A.	N.A.	N.A.	TRL8	TRL8	TRL9	TRL9
Enhanced integration of the EOSC Provider Portal & Marketplace with the Helpdesk Service	The integration of EOSC Exchange services with the EOSC Helpdesk via the Provider Portal and Marketplace is simplified and automated as much as possible	D4-M30. The onboarding process allows for automated/self-service integration with some EOSC-Core functionalities. D5-M30. The onboarding process for resources is extended to include more optional integration steps in the same workflow. E7-M30 Helpdesk	KIT	ATHENA, CYFRONET	N.A.	N.A.	N.A.	N.A.	N.A.	TRL7	TRL8	TRL8
Community branded Multiportals for users with standalone customisation options	Each community or service provider could request a separate subdomain for a customised helpdesk community branded portal. The community also gets more rights to manage their agents, grant and revoke roles for agents in support groups managed by the community.	A1-M30. A researcher can do the full lifecycle of data processing, storage, analysis, and publishing supported by resources available and transparently integrated through EOSC. E7-M30 Helpdesk	KIT		N.A.	N.A.	N.A.	N.A.	N.A.	TRL7	TRL8	TRL8
Multiple Community branded Knowledge bases	Any community or service provider, in addition to dedicated community branded portal, could request knowledge base to organize self-service	A1-M30. A researcher can do the full lifecycle of data processing, storage, analysis, and publishing supported by resources available	KIT		N.A.	N.A.	N.A.	N.A.	N.A.	TRL7	TRL8	TRL8

	for its users. The KB is managed by community support agents and follows FAIR principles, having smart search, integration with helpdesk, connection to the central EOSC Helpdesk.	and transparently integrated through EOSC. A2-M30. EOSC allows research communities to build cross-disciplinary portals. E7-M30 Helpdesk											
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9.7 Interoperability Framework

Capabilities	Description	Enabled EPICS (Use cases)	Resp/ble	Involved	M6	M12	M15	M18	M22	M25	M28	M30
J. Interoperability Framework												
Interoperability Guidelines for EOSC Core services available	Develop initial publish Interoperability Guidelines to the Project's Wiki site	D3-M18. All main 07 horizontal services are integrated with EOSC-Core functionalities. D4-M18. Numerous other horizontal services (publishing workflows, data transfer, data packaging, VM/container deployment and orchestration) are integrated with EOSC-Core functionalities. D8-M18. The onboarding process for EOSC service resources is extended to not only register them into the EOSC registry but also to include optional EOSC Core integration steps in the same workflow such as AAI, monitoring, accounting, helpdesk, order management., onboarding of research products (for data sources), etc. G9-M24. Helpdesk Initial interoperability framework for service providers for automatic dispatching and handling of user requests for services registered in the EOSC Catalogue. G6-M21. Accounting Initial interoperability framework for service providers for automated reporting of accounting metrics for VA	EGI	ATHENA, OpenAIRE, GRNET, KIT, Cyfronet	TRL7	TRL8	TRL8	TRL8	TRL8	TRL9	TRL9	TRL9

		G8-M24. Order Management Initial interoperability framework for service providers for automatic dispatching of the orders for services registered in the EOSC Catalogue. G2-M21. Resource Description Framework										
General availability of the interoperability Guidelines for EOSC Core services in the EOSC Portal	Develop enhanced Interoperability Guidelines for EOSC Core services into finally registered versions to be published formally, and made available via the EOSC-Portal web-site	D3-M18. All main 07 horizontal services are integrated with EOSC-Core functionalities. D4-M18. Numerous other horizontal services (publishing workflows, data transfer, data packaging, VM/container deployment and orchestration) are integrated with EOSC-Core functionalities. D8-M18. The onboarding process for EOSC service resources is extended to not only register them into the EOSC registry but also to include optional EOSC Core integration steps in the same workflow such as AAI, monitoring, accounting, helpdesk, order management., onboarding of research products (for data sources), etc. G9-M24. Helpdesk Initial interoperability framework for service providers for automatic dispatching and handling of user requests for services registered in the EOSC Catalogue. G6-M21. Accounting Initial interoperability framework for service providers for automated reporting of accounting metrics for VA G8-M24. Order Management Initial interoperability framework for service providers for automatic dispatching of the orders for services registered in the EOSC Catalogue.	EGI	ATHENA, OpenAIRE, GRNET, KIT, Cyfronet	N.A.	N.A.	N.A.	TRL7	TRL7	TRL8	TRL9	TRL9

		G2-M21. Resource Description Framework										
Interoperability guidelines for key Horizontal services are available in the EOSC Portal	Interoperability guidelines for EOSC Horizontal services published formally, and made available via the EOSC-Portal web-site	G1-M18. Researchers can orchestrate data analysis on computing resources provided by multiple e-Infrastructure resource providers and transfer back the output to his/her storage system. G10-M30 Data Platforms for Processing Guidelines for data ingesting and movement for processing in hybrid cloud environments improved according to user communities' feedback G12-M21. Cloud Compute Containerisation and Orchestration Guidelines for VM/container management and orchestration improved according to user communities' feedback (task TECHDMP-136) G14-M27. Machine Learning Guidelines for Machine Learning/Deep Learning data analytics services improved according to user communities' feedback. G11-M21. Data Publishing Guidelines for data repository improved according to user communities' feedback. G13-M27. HTC-HPC Compute Guidelines for HPC/HTC clusters on demand and multi-tenant containerised job submission improved according to user communities' feedback. G3-M21. Identifiers: interoperability guidelines in the EOSC IF G10-M30. Data Platforms for Processing Guidelines for data ingesting and movement for processing in hybrid cloud environments improved according to user communities' feedback	EMBL	ATHENA, EGI, OpenAIRE, GRNET, KIT, Cyfronet	N.A.	N.A.	N.A.	N.A.	N.A.	TRL7	TRL7	TRL8

[illegible]

Procedure to onboard new IF guidelines is ready	To facilitate process to publish Interoperability guidelines for EOSC-Core services	EOSC-IF G1-M18-3. Setting up the EOSC IF governance	GEANT	ATHENA, Arctik, Trust-IT	N.A.	TRL7	TRL7	TRL7	TRL7	TRL8	TRL8	TRL9
Research communities can start to register horizontal or thematic Interoperability Guidelines in the EOSC IF	To facilitate process to publish Interoperability guidelines for EOSC-Exchange	C1-M30. Researchers can compare and select resources based on how easy they are to compose and connect to.	GEANT	ATHENA, EGI (EPOT)	N.A.	N.A.	N.A.	N.A.	TRL7	TRL7	TRL8	TRL8
EOSC IF registry: guidelines IDs and profiles	Implementation of EOSC Interoperability Framework Registry with supporting API, UI forms in the Providers Portal and management of IF Guidelines for the EOSC Core and the EOSC Exchange	EOSC-IF G1-M18-1: Design of EOSC IF model v1.0 and specifications D6-M21. EOSC-Exchange highlights which resources can be easily integrated or composed	ATHENA	OpenAIRE, GEANT, EGI, Cyfronet	N.A.	N.A.	N.A.	N.A.	TRL7	TRL7	TRL8	TRL8
IF registry integrated with the Resource Catalogue, Marketplace, and Explore	Providers can indicate which guidelines each of their services is compliant with and this will be presented in the EOSC Marketplace and available as a possible filter for search and selection. E.g. a service in the marketplace/explore is marked as compliant with the EOSC AAI if it can be accessed through the AAI federation	G5-M24. Extending the EOSC IF to onboard community-specific metadata profiles G1-M21. EOSC Interoperability Framework's framework C1-M30. Researchers can compare and select resources based on how easy they are to compose and connect to. D3-M30. Ability to create thematic execution environments/VREs based on integration of compliant thematic, horizontal, and core resources.	CYFRONET and OpenAIRE		N.A.	N.A.	N.A.	N.A.	TRL7	TRL7	TRL8	TRL8
EOSC IF registry: IF guideline configuration profiles	EOSC IF registry prototype piloting the ability of providing specific configurations for the specific guidelines (e.g. actual API URLs), to enable automated reuse	C1-M30. Researchers can compare and select resources based on how easy they are to compose and connect to.	ATHENA	OpenAIRE, GEANT, EGI, Cyfronet	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	TRL7

9.8 Execution Framework

Capabilities	Description	Enabled EPICS (Use cases)	Resp/ble	Involved	M6	M12	M15	M18	M22	M25	M28	M30
K. Execution Framework												
Users can move datasets registered in the Resource Catalogue via EOSC IF API	The Data Transfer is a component of the EOSC Platform that allows users to easily move datasets. It relays on multiple data transfer services (part of EOSC Exchange) that the providers can connect to it. EOSC Data Transfer Interoperability Guidelines describe the procedure to connect (to plug) a data transfer service to the EOSC Data Transfer and define a standard API that can be used by EOSC users to use any of the plugged data transfer services.	D1-M18. First release of EOSC File Transfer Service as the first service arising from the clusters to become a horizontal service. D1-M30. Production release of EOSC File Transfer Service.	EGI	OpenAIRE, CYFRONET	N.A.	TRL7	TRL7	TRL7	TRL7	TRL8	TRL8	TRL9
Users can move datasets registered in the Resource Catalogue via the Marketplace	The Data Transfer is integrated to the EOSC Marketplace via an easy-to-use GUI. EOSC users landing on a dataset page can trigger the transfer of this dataset via the GUI.	D1-M18. First release of EOSC File Transfer Service as the first service arising from the clusters to become a horizontal service. D1-M30. Production release of EOSC File Transfer Service.	EGI	OpenAIRE, CYFRONET	N.A.	TRL7	TRL7	TRL7	TRL7	TRL8	TRL8	TRL9
User can request free-at-point-of-use IT resources via EOSC IF API	Standard API to access free-at-point-of-use IT resources are defined as EOSC IF interoperability guidelines and offered to EOSC users to easy access compute, storage and other kinds of IT resources.	D9-M18. Resource requests can lead to automatic provisioning of resources. B1-M30. Requesting resources through EOSC includes the possibility to access commercial or centrally funded resources. D6-M30. Resource requests integrated with procurement as well as provisioning functions.	CYFRONET	EGI, EUDAT, OpenAIRE, GEANT	N.A.	N.A.	N.A.	N.A.	N.A.	TRL7	TRL8	TRL8
User can request free-at-point-of-use IT resources via the Marketplace	An easy-to-use GUI is integrated in the Marketplace to request free-at-point-of-use resources	D9-M18. Resource requests can lead to automatic provisioning of resources. B1-M30. Requesting resources through EOSC includes the possibility to access commercial or centrally funded resources. D6-M30. Resource requests integrated with procurement as well as provisioning functions.	CYFRONET	EGI, EUDAT, OpenAIRE, GEANT	N.A.	N.A.	N.A.	N.A.	N.A.	TRL7	TRL8	TRL8

Basic support for workflow management	The EOSC Marketplace implements a basic support to run workflow relying on EOSC-Exchange workflow engines.	C1-M18. Researchers can orchestrate data analysis on computing resources provided by multiple e-Infrastructure resource providers and transfer back the output to his/her storage system. C2-M30. Communities can offer their users fully integrated (end-to-end) workflows and a number of these are available for various research topics.	CYFRONET	EGI, EUDAT, OpenAIRE	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	TRL7	TRL8
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