



IMPACTS

May 2021



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EOSC-hub is the first and one of the major implementation projects of EOSC. It significantly contributed to the shaping of the service portfolio, the technical architecture, the interoperability standards, the modelling of the Minimum Viable EOSC, and the Rules of Participation. It also dedicates significant efforts to support the EOSC demand side focusing on multiple target groups: research communities, industry and SMEs.

EOSC-hub provided the first implementation and demonstration of the EOSC Core functionality, as well as the set of integrated services and an engagement model for the further development of the EOSC Exchange. Via active engagement in relevant working groups and consultation activities it shaped and validated the EOSC vision developed and championed by the EOSC Executive Board and the Working Groups. Thus, the concrete success stories and the technical developments behind them had an impact extending beyond the immediate EOSC-hub stakeholders. The role of the project's services as concrete, tangible entry points to the emerging EOSC ecosystem allowed grounding the governance, policy and sustainability discussions on an operational system (rather than a mere technology demonstration or a test bed).

The project provided concrete examples and success stories, illustrating the possibilities and potential of federated resources in EOSC to support innovation. Its impact as a motivator of the overall EOSC implementation should not be underestimated. Supporting the creation of a community mechanisms to determine the mechanisms organisations and individuals can use the services of and contribute to EOSC is another aspect of the project's contribution that is of foundational importance.

The project concretely contributed to the design and implementation of EOSC through active engagement with four working groups and by capturing the projects main outputs into nine Key Exploitable Results (KERs). Each of these KERs have been taken up by EOSC-related follow-up activities, providing a solid foundation for the future continual development of EOSC. Details of these contributions are presented in the section on "Impact on design and implementation of EOSC.

The project has also made a solid contribution to all the expected impacts the EC has requested. These contributions could be seen as having formed cross-cutting priorities that have guided practically all levels of the design and implementation of the project. The section "Impact on science, economy and digital transformation" presents a very high-level summary of this alignment by putting the KERs into the context of the original expected impacts of the project. The role of the project as a catalyst and support for forming a highly visible, sustainable engagement mechanism - both with the SME and start-up sector and with major scientific ventures like ESFRI projects - will continue to have an impact much beyond the project's lifetime and immediate stakeholder groups.

Establishing a link between several innovation ecosystems - ESFRI projects, other thematic collaborations, European Digital Innovation Hub network and EOSC communities - provides a potential of dramatically increasing the knowledge transfer between sciences as well as sciences and the rest of the society.

Impact on design and implementation of EOSC

EOSC-hub delivered 9 key exploitable results that contribute to the main four EOSC implementation areas: support, interoperability, EOSC Core and EOSC Exchange.

Area 1: Support

EOSC-hub has not only provided key innovations for key EOSC components, but has also ensured the delivery of supporting actions that ensure uptake and effective use of its results.

- › The EOSC Digital Innovation Hub provides a clear interface for commercial innovation that can be supported by EOSC as part of the broader European Digital Innovation Hub landscape (such as free access trials). Additional user support actions include the EOSC Early Adopter Programme which aims at offering integrated consultancy services to enable active use of EOSC services.
- › The Training Courses and Materials encompass a large variety of project results such as common and federated services for supporting the whole research life cycle, domain-specific training to target the needs of data providers and data scientists and advanced training on higher-level composable and PaaS services to consultancy building on training events aiming to stimulate the knowledge transfer, foster the use of digital infrastructures and promote the uptake of Open Science paradigm.
- › The Business and Sustainability models are crucial for long-term planning of EOSC. In addition to grounding the discussions about finances, they also provide foundations for ensuring the trust of users and user communities on the continued delivery of services. EOSC-hub provides a definition for the planned “EOSC Federating Core”, including a cost assessment and a business plan.

Area 2: Interoperability

- › Interoperability and Integration Guidelines¹ piloted the definition of the high-level architecture for basic EOSC technical functions and promoting EOSC standards and APIs. The result, if implemented in the EOSC, will facilitate access to services, lower barriers to integrating and composing services and promote the usage of services between adjacent communities.

Area 3: EOSC Core

As the first major implementation project to contribute to building the EOSC, it provided a number of tangible results that directly pilot a functioning EOSC Core.

- › The EOSC Portal and Marketplace support the service discovery and access in EOSC. This KER includes technical components, intangible assets and contractual arrangements that make it possible to provide the service that facilitates the access and use of the EOSC assets.
- › The Internal Services provide the basic enabling services proposed for accessing and operating the EOSC. Some examples of these internal services include access control or accounting as well as common and standard interfaces to shared tools for basic services that need to be aligned in order to provide consistent user experiences. Internal services in the Hub Portfolio are one of the key elements foreseen for the EOSC federating core.
- › EOSC-hub defined and piloted an IT service management system (ITSM) for EOSC. This system will allow service providers to plan, deliver, operate and control services offered to customers or the future EOSC users.
- › To be able to create a market with providers and users, EOSC-hub developed a comprehensive and coherent set of rules and policies for service providers to onboard services and make them discoverable and accessible through the EOSC Portal.

Area 4: EOSC Exchange

The EOSC Exchange is envisioned to provide services storing and exploiting FAIR data and encouraging its reuse. The first set of services EOSC-hub has onboarded allows the EOSC Exchange to start with a comprehensive selection of services.

- › The EOSC is envisioned to provide a “one-stop-shop” for services and solutions to speed up the research process of the disciplines and enable cross-disciplinary collaboration and reuse of tools and results. To this end, EOSC-hub has gathered a number of diverse services in the EOSC Service Portfolio. Independently of the service characteristics, the EOSC Service Portfolio supports them by making the discovery of the services easier and reducing the effort needed to adopt them.

¹ Interoperability and Integration Guidelines: <https://www.eosc-hub.eu/technical-documentation>

The EGI Federation, EUDAT CDI and INDIGO DataCloud provided compute, storage facilities, federated data and compute management, and federated AAI services as horizontal platforms for the hosting of data and data exploitation services.

EOSC-hub was also proactively supporting the work of the EOSC working groups. To summarise, the project was actively engaging in the work of four of the six working groups:

- › **Architecture:** Defining the technical framework required to enable and sustain an evolving EOSC federation of systems.
- › **Rules of participation:** Designing the Rules of Participation that shall define the rights, obligations governing EOSC transactions between EOSC users, providers, and operators
- › **Sustainability:** Providing a set of recommendations concerning the implementation of an operational, scalable, and sustainable EOSC federation after 2020.
- › **Skills and Training:** Providing a framework for a sustainable training infrastructure to support EOSC in all its phases and ensure its uptake

This engagement has obviously played an important role in the dissemination and exploitation of several of the project Key Exploitable results (KERs), especially Interoperability and Integration guidelines, Rules of Participation, Business models and sustainability models for services and the hub and training courses and material. The KERs, their exploitation and future impact are described in more detail in the deliverable D3.4², but we present a short summary of them here.

 <p>EOSC Portal and Marketplace The EOSC Portal and Marketplace - that have developed into joint efforts with EOSC Enhance project - support the service discovery and access in EOSC.</p>	 <p>EOSC Service Management System (SMS) EOSC hub project defines and implements the EOSC IT service management system (ITSM), i.e. the activities performed by service provider to plan, deliver, operate and control services offered to customers.</p>	 <p>EOSC Rules of Participation (RoP) A comprehensive and coherent set of rules and policies for service providers to onboard services and make them discoverable and accessible through the EOSC Portal.</p>
 <p>Internal Services in the Hub Portfolio The Internal Services provide basic enabling services for EOSC access and operation, such as access control or accounting, and offer common and standard interfaces to shared tools...</p>	 <p>External Services in the EOSC Service Portfolio EOSC provides a "one-stop-shop" for a range of services and solutions to speed up the research process of the disciplines and enable cross-disciplinary collaboration and reuse of tools and results.</p>	 <p>EOSC Digital Innovation Hub (DIH): Platform for Industrial collaborations with EOSC The EOSC DIH provides a clear interface for commercial innovation that can be supported by EOSC as part of the broader European Digital Innovation Hub landscape (such as free access trials).</p>
 <p>Business and sustainability models for services and the Hub Business and Sustainability models are crucial for long-term planning of EOSC. In addition to grounding the discussions about finances, they also provide foundations for ensuring the trust of users and user communities in the continued delivery of services.</p>	 <p>Interoperability and Integration guidelines Interoperability and Integration guidelines, defining the high-level architecture for basic EOSC technical functions and promoting EOSC standards and APIs, will facilitate access to services....</p>	 <p>Training courses and material The training courses and material encompass a large variety of project results. They range all the way from common and federated services for supporting the whole research life cycle...</p>

Nine key exploitable results of EOSC-hub

2 <https://zenodo.org/record/5031333>

KER 1. EOSC Portal and Marketplace

Short description

The EOSC Portal and Marketplace support the resources discovery and access in EOSC. As described in the 2019 EOSC Portal collaboration agreement, this KER includes³ “technical components, intangible assets and contractual arrangements that make it possible to provide the service that facilitates the access and use of the EOSC assets. The contractual arrangements include - but are not limited to - the rights to administer the IP addresses and IT infrastructure making accessing the EOSC Portal possible”.

Key benefits for EOSC

The most visible part of the project’s outcomes and impact is the EOSC Portal, that acts as the primary, pan-European entry point to the EOSC ecosystem. It is also closely linked with the other KERs, acting either as a discovery tool for the service provided by them or being directly or indirectly supported by them. From the point of view of an EOSC user, the positive impact of the KER is based on it making it possible to:

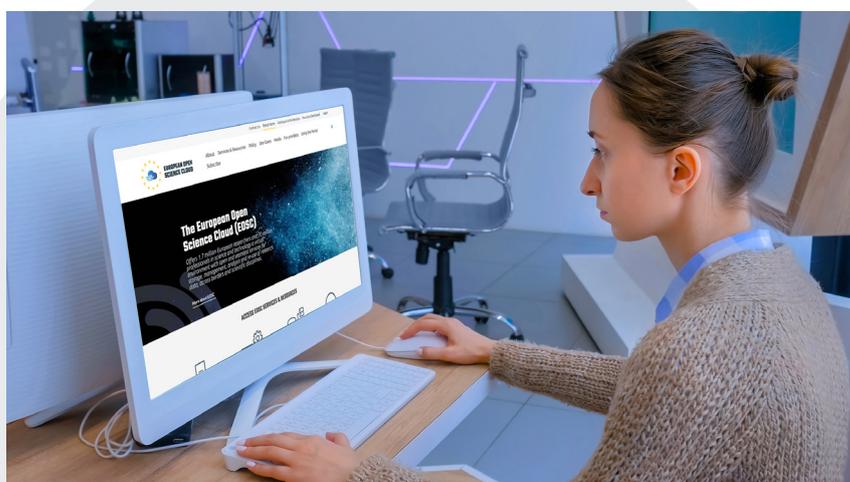
- › Discover⁴ and compare multiple resources and services such as scientific outputs, applications, data management, compute services and thematic services.
- › Order EOSC resources.
- › Find guidance on how to access the resources integrated to EOSC. Access them seamlessly if they incorporate open access policy
- › Organise resources of interest and resource orders into logical blocks in EOSC Marketplace Projects to reflect a common scientific purpose and gain EOSC expert support for the created Marketplace Project.
- › Access services and resources using a common authentication/authorisation process.
- › Pick up on best practices and practical examples featuring research communities, making the most of EOSC.
- › With access to datasets and services from a variety of sources make previously not possible connections and apply new techniques and algorithms to research.
- › Provide feedback about services and information to contribute to building the EOSC service portfolio.

From the service provider point of view, the benefits are based on the ability to:

- › Publish, share and advertise services⁵ and resources to a wider user base.
- › Get statistics about access requests and customer feedback.
- › Get a free online platform where providers can manage service requests, interact with users and provide support to them, and agree on the most suitable service levels.
- › Allow users to authenticate with existing credentials to access services.
- › Demonstrate that the services meet EOSC quality standards.
- › Identify future service offerings.

Use and impact after EOSC-hub

The EOSC Portal will continue to serve EOSC users (researchers / providers / operation team members / founders etc) after the conclusion of the EOSC-hub project, through joint efforts of EOSC Enhance and other EOSC-related projects (including EOSC Future project that will further enhance the technical solution and the services provided through EOSC Core).



3 Concluded in 2019 with the representatives of the EOSC-hub, OpenAIRE-Advance and eInfraCentral project consortia

4 <https://eosc-portal.eu/services-resources>

5 <https://eosc-portal.eu/for-providers>

KER 2. EOSC Service Management System (SMS)

Short description

EOSC-hub defined and implemented the EOSC IT service management system (ITSM) that consists of the activities performed by service providers to plan, deliver, operate and control services offered to customers. These activities are directed by policies and are structured and organised by processes and procedures.

EOSC-hub implements best practices based on the lightweight standard, FitSM, regarding the service planning, delivery, operation and control of the services in the service catalogue. In addition to applying FitSM in practice, it was an area of specific interest in the training activities (KER 9).

Key benefits for EOSC

The key benefits of the SMS are:

- Ensuring robust and resilient service delivery of services within and through EOSC core.
- Facilitating communication between customer and providers by introducing a single point of contact (helpdesk, marketplace etc.).
- Disseminating and sharing best practices related to service delivery among providers.
- Facilitating alignment of service management activities of all of the service providers, supporting different levels of integration with the centralised services.
- Integrating the services provided by the different providers into the common marketplace and monitoring frameworks in a way that provides value for EOSC.

Use and impact after EOSC-hub

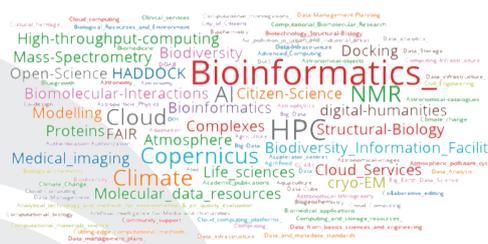
The EOSC Service Management System has already made an impact by creating a prototype SMS for the provision of EOSC core services under a unified management system. It will be further adopted and managed by EOSC Future to provide one of the key functionalities of the EOSC core definition. EOSC SMS can also be used as an example for others how to set up a management system that can support federated service delivery.

Statistics as of 30 April

Onboarded Providers

170

Most Frequent Provider Tags



Onboarded Resources

288

Location of Providers' HQ



KER 3. EOSC Rules of Participation (ROP)

Short description

The KER provides a framework of policies that allow consistent and transparent decision-making process when assessing what kind of resources should be included or integrated in the EOSC. The primary impact channel were the contributions to the EOSC Governance Working Group on Rules of Participation which published its initial RoP at the end of 2020 and has been further developed based on this foundation. The KER provided the foundations of EOSC's ability to provide consistent user experience independent of the exact combination of data, services and service providers a scientific workflow consists of. It could be seen as establishing the governance-level parameters that the SMS system (KER 2) needs to adhere to.

As part of this result, EOSC-hub developed an actionable inclusion criteria that was implemented in onboarding activities. This also resulted in the EOSC Provider and Resource profiles that have been implemented in the EOSC Portal. It also supported the work of the EOSC Portal Onboarding Team which translated the Rules of Participation into operational rules and guided the team on which providers and resources to onboard. Through this activity and making the EOSC Rules of Participation operation through pilot activities, the project managed to gather a community of catalogue operators from various institutions and communities.

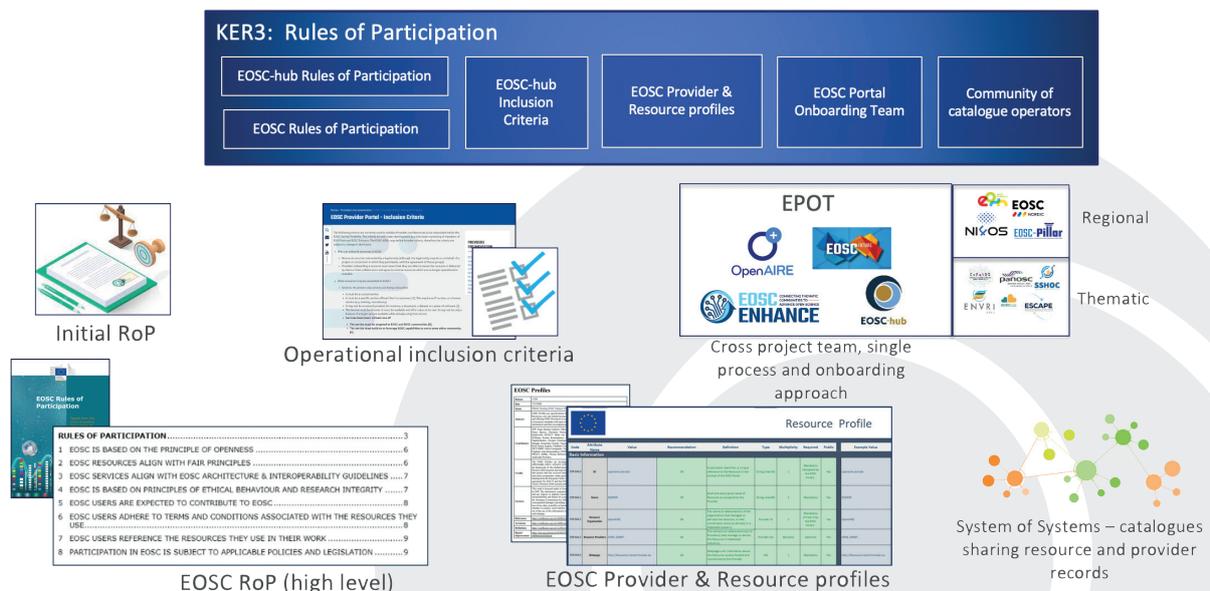
Key benefits for EOSC

RoP makes it as easy as possible to design processes and procedures to new service providers into the EOSC ecosystem while ensuring the quality and compliance of the overall services and building and maintaining the trust of the users and user communities. Practical inclusion criteria translate RoP into actionable procedures which can be used by onboarding teams to repeatedly assess and support applications to join EOSC.

Use and impact after EOSC-hub

The work on RoP from EOSC-hub formed a significant input for the Working Group on Rules of Participation. A set of practical inclusion criteria is adopted and evolved by the EOSC Enhance project and will be further managed by EOSC Future.

KER3: Rules of Participation



KER 4. Internal Services in the Hub Portfolio

Short description

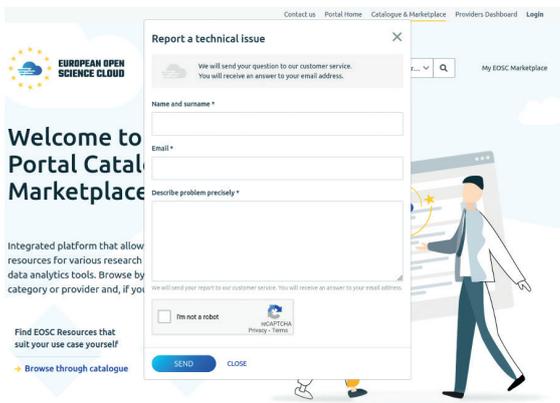
The Internal Services provide basic enabling services for EOSC access and operation, such as access control or accounting. The KER offers common and standard interfaces to shared tools for basic services that need to be aligned in order to provide consistent user experiences. Internal services in the Hub Portfolio are one of the key elements of the EOSC core of the EOSC architecture.

Key benefits for EOSC

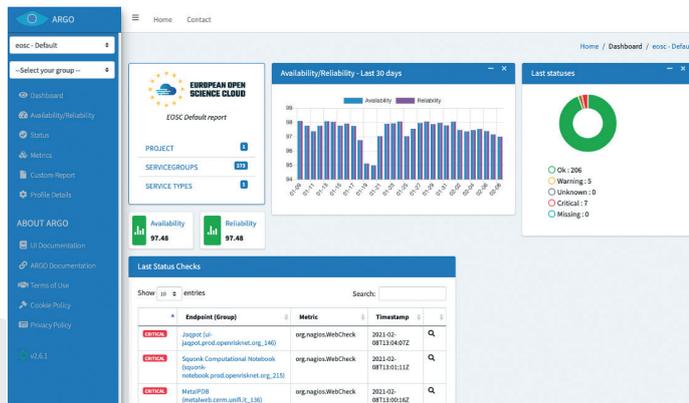
This common toolset enables the integration of services into the EOSC ecosystem, making it easier to benefit from EOSC core services (such as SMS - KER 2). The KER is a prerequisite for the function of the federating core, as a mature implementation of the tools will streamline the processes of the EOSC core and possible other Hub Operators (e.g., ones federating services for a particular thematic community). For the service providers, the KER provides tools to access several user communities through EOSC core by integrating their services into a single service interface (instead of several community-specific ones). The reuse of individual components of the KER by third parties is also possible (and encouraged).

Use and impact after EOSC-hub

The Internal Services components of the KER are used in several projects that continue building the EOSC ecosystem. They will continue playing an important enabling role in the future EOSC Core (EOSC Future project) and Exchange (INFRAEOSC-07) initiatives, paving the way towards the sustainable EOSC in close contact with the EOSC AISBL.



Helpdesk Webform in EOSC Portal



ARGO monitoring dashboard for onboarded services

KER 5. External Services in the EOSC Service Portfolio

Short description

EOSC provides a “one-stop-shop” for a range of services and solutions to speed up the research process of the disciplines and enable cross-disciplinary collaboration and reuse of tools and results. It encourages the sharing of the research tools and data between different research groups - also across disciplines. While the portal and marketplace (KER 1) act as the discovery and access channels, the external services represent the selection of general and thematic resources that can be accessed through EOSC. They demonstrate the value of EOSC, also to individuals with no previous knowledge of (or even interest in) EOSC.

Key benefits for EOSC

As the number of research activities and groups supported by EOSC grows, the possibility to easily search, request and re-use research services will become more and more important. Consistent metadata will be crucial for efficient service discovery (either by the researchers themselves or in collaboration with different helpdesk services). Providing an intuitive interface to the service lifecycle information will be of equal importance, especially when considering the long-term repeatability of EOSC-supported research. The set of services of the KER have acted as a validation and demonstration of these benefits and acts as models and templates for growth of the group of services available through EOSC.

Use and impact after EOSC-hub

Each of the thematic services have their own communities focused on sustainability and further development of the services and their impact within the thematic communities. The trans-disciplinary use supported by EOSC will be further supported by the INFRAEOSC-07 projects.



KER 6. EOSC Digital Innovation Hub (DIH): Platform for Industrial Collaborations with EOSC

Short description

The KER provides a clear interface for commercial innovation that can be supported by EOSC as part of the broader European Digital Innovation Hub landscape. It is a multi-dimensional mechanism that allows research e-Infrastructures to support business organisations to stimulate innovation, as well as helping start-ups, SMEs, and other innovative actors to tap into the academic world both in accessing knowledge as well as technical services. It has also served as a platform for collaboration between SMEs, allowing the SMEs to test and develop collaboration mechanisms before going to market.

Key benefits for EOSC

EOSC DIH allows lowering the initial investments (time and effort) for identifying/accessing services and developing/testing new products and services as well as increasing visibility and networking opportunities at European level. It has created a link between EOSC and the wider network of Digital Innovation Hubs. In the long run, it can provide a formalisation of the knowledge and expertise into procedure descriptions, standardised consulting offerings or certification schemes.

Use and impact after EOSC-hub

The DIH partners have established a framework agreement that ensures that the DIH can continue the basic level of activity independently of project funding. The EOSC DIH will be further developed by the EOSC Future project as the mechanism to centralise the multiple innovation and business collaboration initiatives around the EOSC. The experience and knowledge generated working with companies on the business pilots would be used as input for the EOSC Governance for defining the innovation agenda of the EOSC and how to align it to major European initiatives.

Business Pilots



Finance



Video



AI



Trucking



Furniture



Environment



Compute Credits



FAIR data



Space



Accommodation



Security



Agriculture



Health



Collaboration



Manufacturing



Blockchain



Seaport



Sports

KER 7. Business and sustainability models for services and the hub

Short description

Business and Sustainability models are crucial for long-term planning of EOSC. In addition to grounding the EOSC internal discussions about finances and sustainability, they also provide foundations for ensuring the trust of users and user communities. This KER provides a definition for the planned “EOSC Federating Core”, including a cost assessment, a proposed value proposition for the EOSC, evaluation of procurement and service delivery models applicable to different EOSC scenarios, and consideration of issues related to cross-border service provision and cross-sectoral VAT compliance.

Key benefits for EOSC

By proposing a definition of the EOSC Federating Core, this KER provides a basis for determining the costs and possible business models required to provide the basic EOSC services. It analysed and demonstrated the importance of “Shared Resources” - services and scientific products of pan-European relevance which are developed by a given discipline but used more broadly by external user communities and additional disciplines. By providing recommendations on procurement frameworks and supporting business models, and on ways in which the EOSC can support the delivery of Shared Resources such as cross-border storage and compute services in Europe, this KER points the way towards further business model analysis activities needed for sustained EOSC.

Use and impact after EOSC-hub

Proposals and recommendations from this KER have provided input to:

- › Sustainability Working Group FAIR Lady Report “Solutions for a Sustainable EOSC”⁶
- › Architecture Working Group View on the Minimal Viable EOSC⁷

and have provided crucial input for the planning of the EOSC Future project that is expected to provide the EOSC-Core in the next phase of the implementation of the EOSC. Discussion of Business and Sustainability Models will continue in the EOSC Partnership governance bodies, the EOSC Association, in the EC and member states, and in the service providers themselves.

6 <https://eoscsecretariat.eu/eosc-sustainability-wg-outputs>

7 <https://eoscsecretariat.eu/eosc-architecture-wg-outputs>

KER 8. Interoperability and integration guidelines

Short description

The Interoperability and Integration guidelines define the high-level architecture for basic EOSC technical functions and promote EOSC standards and APIs, they will facilitate access to services, lower barriers to integrating and composing services and encourage sharing of services between adjacent communities.

For a full list of guidelines and links, see Further Reading at the end of the booklet.

Key benefits for EOSC

EOSC services that comply with the interoperability and integration guidelines will offer well-established and documented interfaces for usage and integration, based on well-known standard or APIs, facilitating:

1. Their exploitation from user communities willing to create new scientific services that could rely on well-established and documented interfaces for the integration (e.g., a community creates a new scientific workflow reusing EOSC federation and common services, like AAI, accounting, etc.) and
2. The combined usage of EOSC services, indeed the adoption of well-known standards and interfaces will very likely reduce the cost to integrate services (e.g., two accounting infrastructures can be made easily interoperable if they use the same standard usage record format, in such case accounting data extracted from them can be merged and presented in a unique view).

The well-documented standards will also reduce the perceived technology risk of the integration work needed by the new communities and service providers joining the EOSC ecosystem.

Use and impact after EOSC-hub

The Interoperability and integration guidelines have been used by a large number of related projects that continue beyond the EOSC-hub project itself to make their services EOSC-compatible. This is already happening, for example, in the EOSC regional projects funded under the INFRAEOSC 5b call. Moreover, the interoperability standards will be maintained and further developed by the upcoming EOSC Future project.



KER 9. Training courses and material

Short description

The training courses and material encompass a large variety of project results. They range all the way from common and federated services for supporting the whole research life cycle, domain-specific trainings to target the needs of data providers and data scientists and advanced training on higher-level compo-sable and PaaS services to consultancy building on training events (such as workshops focused on applying the FitSM standard in the specific circumstances in the client organisations or helping research communities to develop a sound Data Management Plans). The KER aims at stimulating knowledge transfer, fostering the use of digital infrastructures and promoting the uptake of the Open Science paradigm.

Key benefits for EOSC

Training and support activities will play a key role in creating awareness of services and resources, augmenting skills and adapting organisational practices needed as prerequisites of full participation in the EOSC ecosystem. In the long run, the demand for training and related services will increase dramatically through the extension of the user base beyond the initial group of early adopters. Future EOSC activities can benefit directly from the training modules themselves, but also - and perhaps more importantly - from the knowledge network spanning several initiatives with a common approach to managing and further enhancing the training material.

Use and impact after EOSC-hub

Most of the KER components are tied to the EOSC portal and its future development, and EOSC-hub has ensured that the future activities have sufficient IPR rights to curate and further develop this resource.



Impact on science, economy and digital transformation

The intended impacts of the projects funded in the European Commission's call for proposals listed the following expected impacts of the funded actions:

- › Optimised access to IT equipment and services
- › No lock-in to particular hardware or software platforms
- › More scientific communities using storage and computing infrastructures
- › More people trained in research and academic sectors
- › Increased incentives for scientific discovery and collaboration across disciplinary and geographical boundaries
- › Establishment of partnerships with industrial & private partners
- › Further development of the European economic innovation capacity

Based on the accomplishments of the project towards its objectives, the project with its KERs made profound contributions to all of these goals. In the following paragraphs we will map the specific outcomes and results to these original impact goals.

The following table illustrates a selection of some of the most significant project metrics that shows how the coordinated efforts of research communities, research infrastructures and e-Infrastructures contributed to the advancement of research excellence and to tackle global societal challenges.

Area	Services and Metric (March 2021)		Trend from beginning	Impact
Social sciences and humanities	CLARIN metadata search portal Visits	1013/month	+138%	Researchers excel thanks to the access digital language data and tools
	Harvested metadata records	> 1.2 Million	+34%	
Environmental Sciences	Earth Observation data available	81 PB data	+235%	Europe leads in addressing the UN sustainable development goals
	Number of data requests served/month	27 Million/month	+23%	
	Users/month	> 123,000	+300%	
Biology	New users registered during the project	+19,700	700 new users/month in the last period	Researchers tackle the COVID-19 pandemic with access to world class digital infrastructures
	Simulation workload produced on the EGI Federation	3.8 Million computational jobs/month	+90%	
	Countries supported worldwide	123	+27 new countries	Open science practices are established through cross-border sharing of scientific applications
All disciplines Computing / EGI Federation	Dynamic On Demand Analysis Service: Computational jobs handled	65,000 jobs/month	+550%	Faster time to publication thanks to federated pan-European digital facilities
	Computing workload produced	5.6 Billion CPU hours/year	+27%	
All disciplines Data Management/ EUDAT CDI	B2SHARE file downloads	1240/month	+147%	
	B2FIND search requests	880/month	120%	
All disciplines Trust and Identity	Number of service providers connected to the EGI and EUDAT community AAI	114	+280%	Federated secure access to data and services

Project contribution to the ERA and societal challenges

Optimised access to IT equipment and services

Supporting KERs:

- › KER 1: EOSC Portal and Marketplace
- › KER 2: EOSC Service Management System (SMS)
- › KER 3: Rules of Participation (RoP)
- › KER 4: Internal Services in the Hub Portfolio
- › KER 5: External Services in the EOSC Service Portfolio
- › KER 8: Interoperability and integration guidelines
- › KER 9: Training courses and material

280%+
More service
providers using AAI
solutions

The project's contributions to the optimisation of access to equipment and services was based on the combined effect of the following contributions:

- › Discoverability, visibility and access of the services integrated to EOSC (KER 1 as platform, KER 5 as builder of the critical mass).
- › Trust in the services made available through EOSC (primarily KERs 2 and 3).
- › Making the integration to EOSC easy and effective (e.g. KER 4), procedurally predictable (KERs 2, 3) and less risky from the provider's perspective (KER 8).

EOSC-hub adopted a service Integration and Management approach to managing suppliers and integrating them to provide a single service catalogue that is now published through the EOSC Portal and Marketplace. There are currently overall **284 horizontal and thematic services** listed on the EOSC marketplace. These services, that initially came from both project partners (EGI, EUDAT, INDIGO-DataCloud and research communities working on WP7 and WP8), now include contributions from external actors (research infrastructures, regional EOSC projects, other EC funded projects, etc.) that registered their services through the Service Providers onboarding process (via the EOSC Portal) and other initiatives (e.g. eInfraCentral project) thanks to the merging of all existing registries in the unique catalogue now behind the EOSC Portal.

The service onboarding is still a live process that does not depend anymore by a single project, but it is shared by different initiatives. All the services in the EOSC Portal and Marketplace are described with a common template, the **EOSC Provider and Resource Profiles 3.0** output of the collaboration with other projects and can be discovered and accessed through common paths. From the launch of the EOSC Portal and Marketplace (November 2018) **407 orders were submitted and 275 of them were fulfilled.**

The harmonisation of service management processes for the operation of EOSC services progressed supported by the FitSM training programme (included in the KER 9 portfolio) that has been delivered to ensure that there was a clear understanding of all the ITSM concepts, terminology and activities to be/being carried out to plan, deliver, operate and control all EOSC-hub services. A total **212 EOSC experts successfully received certification in FitSM** (backed by Certification Authorities ICO-Cert and APMG International) through the 22 training events organised by the project. Thus, the project created a large group of professionals with shared theoretical foundations for systematic mechanisms to ensure optimisation of access and delivery of IT services in the EOSC context. As FitSM is an openly available standard that is not EOSC-specific, this impact will also extend more and more beyond the EOSC core (e.g., through thematic communities with shared resources coming into contact with EOSC and FitSM-trained individuals).

Success story - Increased uptake of the Federated AAI in EOSC

EOSC-hub enhanced AAI solutions for e-infrastructures during its whole lifetime. This was done, from one side, aligning the 4 AAI proxy (EGI Check-in, EUDAT B2ACCESS, INDIGO IAM, GEANT eduTeams), built following the directive of the AARC blueprint⁸, to the latest policy and technical recommendations guidelines⁹ from AARC and AEGIS¹⁰ and, from the other side, collecting requirements from user communities to identify gaps and enhance the services to best fit the needs of researchers. This led to more mature AAI services at the end of the project with an increased interoperability between them. The impact of this work is witnessed by the number of service providers that are currently using the AAI solutions offered by EUDAT or EGI that grew to 114, a growth of 280% from the beginning of the project.

8 <https://aarc-project.eu/architecture/>

9 <https://aarc-project.eu/guidelines/>

10 <https://aarc-project.eu/about/aegis/>

No lock-in to particular hardware or software platforms

Supporting KERs:

- › KER 3: Rules of Participation (RoP)
- › KER 4: Internal Services in the Hub Portfolio
- › KER 5: External Services in the EOSC Service Portfolio
- › KER 8: Interoperability and integration guidelines

120,000 Harvested VLO metadata records
40% Increase in registered VCR collections
94 More processing tools connected to Language Resource Switchboard

EOSC-hub worked on a series of activities to make EOSC an open by default, transparent, trustworthy and community-driven platform fostering Open Science in the European Research Area. Notably the effort to define and promote the EOSC technical interoperability guidelines (KER 8) that allow data and software portability across multiple heterogeneous facilities and foster EOSC uptake, facilitating access to services, lowering barriers to integrate and compose services and promoting the usage of services between adjacent communities.

The vision of sharing and freely combining research data, services and products derived from them can only be realised through common interfaces and consistent behaviour of the components of the ecosystem. While the Interoperability and Integration guidelines (KER 8) address this in the most direct manner, the Rules of Participation (KER 3) provide the foundations for the consistent behaviour. However, the impact of these specifications is greatly increased through the critical mass of services the external (KER 5) and internal services (KER 4) represent. Demonstrating that there is a market adaptation of the interfaces that prevent lock-in shows that targeting the research services market using proprietary hard- or software platform interfaces is considerably less likely to succeed than in the era before EOSC-hub.

18 EOSC technical specifications and interoperability guidelines were defined taking into account existing community practices, well-known standards and interfaces. By involving all relevant EOSC stakeholders (communities, e-infrastructures, service providers, technical experts, etc.) to build them in a collaborative manner, the results have been taken up by several EOSC-related projects in addition to the EOSC Future project.

As a demonstration of the power of EOSC open interfaces and technical support to join the EOSC, 30 thematic services were successfully onboarded into EOSC. These achieved more than 40 technical integrations with 19 different services from e-infrastructures (EGI, EUDAT, INDIGO-DataCloud) exploiting the open and standard interfaces EOSC-hub provides. Furthermore, 26 research communities from Competence Centers (21 different EOSC services were integrated) and Early Adopter Pilots (25 integrations of 9 different services) reached pilot use of the EOSC-hub services and 14 of them moved these integrations in their production setups. In addition, 18 business pilots from the EOSC DIH easily integrated and tested several EOSC services.

EOSC-hub also contributed to the definition and uptake of open interfaces in EOSC, and more in general in the European Research Area, with the participation of its technical experts in the activities of a series of standardisation bodies like the Research Data Alliance (RDA), the Storage Networking Industry Association (SNIA), the HEP Software Foundation (HSF), etc. Relevant results from these standards bodies are reflected in the interoperability guidelines produced by the projects and a technical roadmap for EOSC services was defined. This is expected to be implemented in the follow-up projects, notably those funded under the INFRAEOSC-03 (EOSC Future) and INFRAEOSC-07 call topics (EGI-ACE, DICE, etc.).

Success story - CLARIN

The CLARIN thematic service integrated 3 services into EOSC:

- › The Virtual Language Observatory (VLO): a facet browser for fast navigation and searching in large amounts of metadata. This portal enables the discovery of language data and tools, provided by over 40 CLARIN centres, other language resource providers and Europeans.
- › The Virtual Collection Registry (VCR): a service that allows researchers to create their own citable digital bookmarks.
- › The Language Resource Switchboard: a web application that suggests language analysis tools for specific data sets.

Leveraging the effort of the project on promoting the adoption of standard interfaces and following the integration paths described in the interoperability guidelines, CLARIN achieved integration of its services with several EOSC-hub services. The VLO used B2FIND and computing and storage resources from the EGI Cloud that is now hosting its elasticsearch/kibana stack. The VCR has extended the submission endpoint for third party integrations to facilitate the exploitation of other resources, while the Switchboard was integrated with B2DROP. This allowed the CLARIN services to enrich their feature set and offer a richer user experience to its customers. As a result, the uptake of these 3 CLARIN services grew, the VLO overcame the 1000 visits/month (baseline 425 visits/month) and the number of harvested metadata records reached 120000. The number of virtual collections registered in VCR increased by around 40% and the Language Resource Switchboard is now connected to 154 processing tools (60 at the start of the project). CLARIN also used EGI Cloud resources to support the run of the ReproLang 2020 workshop¹¹.

¹¹ <https://lrec2020.lrec-conf.org/en/reprolang2020/>

More scientific communities using storage and computing infrastructures

Supporting KERs:

- › KER 5: External Services in the EOSC Service Portfolio
- › KER 7: Business and sustainability models for services and the hub
- › KER 9: Training courses and material

550% Growth of EGI Dynamic on Demand Analysis Service jobs

147% Increase in EUDAT file shares

120% Increase in EUDAT searches

In addition to project's dissemination and outreach activities driving awareness and engagement of the scientific communities, the impact in this area has been based on combined impact of several of the projects main results:

- › External services in the service portfolio (KER 5) have brought in new communities directly (through the thematic service user communities) and indirectly (through the EOSC Portal and other project engagement channels) and made EOSC more attractive platform for integration (the horizontal services offer capabilities and capacity that can facilitate the work of the scientific communities).
- › Sustained training efforts and a vast, curated collection of training material (KER 9) have been other means to bring in a large number of scientific communities.
- › Addressing the sustainability and business model issues (KER 7) have demonstrated EOSC-hub's understanding of the importance of long-term sustainability, thus increasing the trust of scientific communities in the long-term vision of EOSC.

As a result, several scientific communities benefited from the EOSC-hub effort on fostering the adoption of advanced IT services provided by the main European e-Infrastructure through EOSC. This was reinforced by the role of the EOSC Portal and Marketplace as mechanisms to expand the access outside the traditional user base. Around 200 unique users ordered services in the EOSC Portal and Marketplace since its launch covering around 100 different scientific disciplines, these orders have been supported by the EOSC-hub service providers and the technical support team.

The 8 Competence Centers of the project experimented integrations with 15 common services and, after successful validation and integration, **10 of the EOSC-hub common services progressed into production setups within the communities.** Furthermore, 3 CCs reached mature integration between common services and their community-specific services and opened up their setups for external users via the EOSC Portal: Argo (ARGO floats data discovery), EISCAT_3D (EISCAT Data Access Portal), Fusion (PROMINENCE). In addition, ELIXIR interfaced the ELIXIR AAI with AAI proxies from EOSC-hub and registered 3 institutional clouds in EOSC Portal (CESNET, CSC, EBI).

Collaborations with the 5 ESFRI-clusters projects (ENVRI-FAIR, EOSC-Life, ESCAPE, PaNOSC, SSHOC), funded in the call INFRAEOSC-04-2018, and the regional EOSC projects, funded in the call INFRAEOSC-05-2018, were also productive. As examples:

- › EOSC-hub set the scene for an active collaboration between e-infrastructures and PaNOSC for adoption and integration of cloud, distributed data management, Jupyter Notebooks and AAI services.
- › ENVRI-FAIR participated in the Early Adopter Programme with its own pilot experimenting integrations with Cloud compute and Notebooks services.
- › EOSC-Synergy achieved several integrations with EOSC-hub services as witnessed by the record score of EGI Federated Cloud utilisation thanks to EOSC-Synergy and deep-Hybrid DataCloud¹² and by the LAGO use case¹³.

Among the **12 pilots supported in the context of the Early Adopter Programme (EAP), 11 integrated their services with cloud resources from EOSC-hub. Overall, in EAP, 24 integrations with horizontal services from e-infrastructure were achieved.** Collaborations between the EAP pilots and e-infrastructures are continuing for almost all pilots in follow-up projects or thanks to direct agreement with the e-infrastructures providing the services and the IT resources.

Success story - Increased uptake of the EGI Federation and EUDAT CDI

At the end of the project, EGI Federation's Dynamic on Demand Analysis Service processed 65,000 analysis jobs per month (550% growth compared to the rate at the beginning of the project), this is also reflected by the increase of the Computing workload produced that reached 5.6 Billion of CPU hours per year. The shares and searches of files hosted on EUDAT infrastructure also grew dramatically (by 147% and 120%, respectively).

12 <https://www.eosc-synergy.eu/record-score-of-egi-federated-cloud-utilisation-thanks-to-eosc-synergy-and-deep-hybrid-datacloud/>

13 <https://www.eosc-synergy.eu/lago-and-eosc-synergy-integrate-cosmic-ray-data-for-the-whole-community/>

More people trained in research and academic sectors

Supporting KERs:

- › KER 5: External Services in the EOSC Service Portfolio
- › KER 6: EOSC Digital Innovation Hub (DIH): Platform for Industrial Collaborations with EOSC
- › KER 9: Training courses and material

DODAS uptake
4 million CPU/hours
20 million GPU/hours

The most obvious impact on this area is through the Training courses and material (KER 9) that provided and coordinated training events as well as self-study and reference material from the project and initiatives it collaborated with. However, the impact of these activities was greatly enhanced by the involvement of the communities behind the External Services in the EOSC Service Portfolio (KER 5). Furthermore, the Digital Innovation Hub (DIH, KER 6) extended this impact also to the commercial sector and created a channel for knowledge exchange with scope that extended beyond solving the initial or immediate challenges that motivated the SMEs or start-ups to get in touch with DIH.

EOSC-hub established a network of training experts including technology providers and service providers within and from outside the consortium that delivers training in different areas: access enabling and federation services, common/horizontal services, data management planning, federated services management, domain-specific training.

WPI1 delivered a total of **203 training events (60 of them in the first reporting period) with 5268 individual training participations by the members of the EOSC community (1512 of them in the first period)**. 36 training about access enabling, federation and common services covered several topics like AAI, IT Security Forensics, Cloud Computing, Cloud PaaS Solutions, data platforms for data processing, solutions for publishing and archiving scientific data and frameworks for the applications on-demand platform tailored for the long tail of science. A joint training programme was defined in collaboration with OpenAIRE Advance and, in this context, **32 DMP trainings** were jointly organised to facilitate and promote the uptake of the services and solutions to support FAIR data and DMPs. Finally, **98 domain-specific training events** (20 in the first reporting period) were organised in different disciplines like life science, structural biology, coastal analysis, climate, high-energy physics, earth observation and arts and humanities.

To strengthen the ability of trainers a **“train the trainers”** webinar was delivered and, as part of the Collaboration Agreement with OpenAIRE-Advance, Community of Practice (CoP) for Training Coordinators was set up. This initiative aims to map out the training activities of various pan-European EOSC-related initiatives and reinforce their training capacity by sharing experiences and good practices and initiating cross-infrastructure training activities.

WPI1 set up an **EOSC online training registry** where members of the project and any other EOSC stakeholder can publish training events and upload training materials. The training registry was completely renewed in the second half of the project and the training material was organised taking into account the different kinds of audience (service providers and researchers/users). It provides EOSC with a huge knowledge base, already containing around **350 training modules**. The training registry is accessible via the EOSC Portal and the EOSC-hub website.

Success story - Dynamic on Demand Analysis Service (DODAS)

DODAS is a cloud enabler for scientists seeking to easily exploit distributed and heterogeneous clouds to process, manipulate or generate data. It aims to guarantee deployment of complex and intricate setup on “any cloud provider” with almost zero effort. As such it implements the paradigm of Infrastructure as code: driven by a templating engine to specify high-level requirements.

To increase researchers' awareness on instantiating on-demand container-based clusters to execute software applications, the DODAS thematic service organised 8 training events and produced several training materials now accessible through the EOSC Portal training registry. Notably, DODAS contributed to the 3rd. edition of the School on Open Science Cloud¹⁴ with two tracks: “Machine Learning Methods and Applications” and “Computing Infrastructure”. The first track provided a comprehensive introduction to basic ML and DL concepts as a way to set a common ground between participants, while the second focused more on providing students both with basic and advanced knowledge on how to build and use cloud-based infrastructures to implement workflows based on technologies and tools such as Hadoop, HDFS and Spark. During the “Big Data Management infrastructures and Analytics”¹⁵ event participants were instructed on how to use cloud-based infrastructure and high-level solutions for big data analytics (e.g.: HDFS, Spark and Kafka), and adopt ML technology to extract valuable insights from datasets. DODAS was also presented during the CODATA-RDA schools in 2019 and 2020 and during the “Multiscale, Machine learning and QSAR (MM-QSAR) Methods applied to biomolecules” schools in 2020 as part of the Elective course Master in Theoretical Chemistry and Computational Modelling (EMTCCM).

This effort on training translated into an increased uptake of the DODAS service that at the end of the project was adopted by 5 large communities (baseline 1) and around 900000 jobs were submitted to DODAS clusters with a usage of more than 4 Million of CPU/hours and 20 Million of GPU/hours in the last period.

14 <https://agenda.infn.it/event/19049/overview>

15 <https://agenda.infn.it/event/20847/overview>

Increased incentives for scientific discovery and collaboration across disciplinary and geographical boundaries

Supporting KERs:

- › KER 1: EOSC Portal and Marketplace
- › KER 2: EOSC Service Management System (SMS)
- › KER 3: Rules of Participation (RoP)
- › KER 4: Internal Services in the Hub Portfolio
- › KER 5: External Services in the EOSC Service Portfolio
- › KER 7: Business and sustainability models for services and the hub

Cross-disciplinary and cross-border collaboration could be seen as a cross-cutting priority that influenced practically all of the project's activities. The Business and Sustainability models (KER 7) provided a framework for analysing and solving many of the issues that arise when the collaborations cross national and organisational boundaries creating a complex network linking numerous governances, funding and incentive structures, often from several organisations, nations and disciplines at the same time. The resources made available through the Virtual Access mechanism played an important role as a "seed", providing the initial incentive to pool solutions, services and user communities around the common hub. However, the mechanisms that made the integration work in a harmonious and consistent way through service management (KER 2), common integration criteria (KER 3), enabling (KER 4) and added value services (KER 5) turned this abstract initiative into tangible services that could be used to make the scientific processes more efficient. In the long term, common tools and working practices, shared discovery platform (KER 1) and - perhaps most importantly - freeing up researchers' time will make cross-disciplinary collaboration more and more attractive and feasible.

The Virtual Access mechanism opened access to EOSC services outside their usual user base from 176 countries. In the second reporting period, access enabling and federation, common and thematic services continued to enlarge their user base as reported in D13.3¹⁶ and D13.4¹⁷ Periodical assessment of the services.

Success story - WeNMR Thematic Service to fight the COVID-19 outbreak

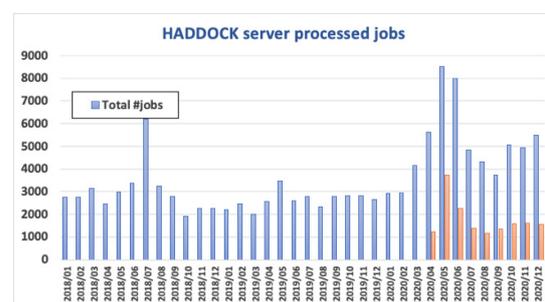
The WeNMR portal has seen an increase of registrations (more than 9000 new users) over the last year with many users indicating they intend to use it for COVID-19 projects, in particular, this was due to the increase of usage of the HADDOCK portal. Indeed, the HADDOCK WeNMR team has been involved in several collaborations ranging from drug screening against the protease to modelling COVID-19 related protein-protein interactions. As a result, the average number of user runs submitted to the portal increased from an average of 30000 to more than 70000 and the HS06 CPU Time/Wall Time hours consumed by jobs submitted to HTC resources moved from around 15 millions of hours to 50 millions. Researchers from additional 13 countries used the WeNMR service suite that reached an overall coverage of 123 countries. By opening access to its tools thanks to virtual access, WeNMR demonstrated the impact of open science practices on the advancement of knowledge to tackle the COVID-19 pandemic.

The success and impact of the WeNMR Thematic service is described in more detail in deliverable D7.5¹⁸. However, the two figures on the side illustrate the dramatic growth that is partly - but not exclusively - driven by the service's relevance to the COVID-19 research.

16 <https://zenodo.org/record/5033485>

17 <https://zenodo.org/record/5027405>

18 <https://zenodo.org/record/5033297>



HADDOCK WeNMR portal user submission per month. Blue bars indicate the total number of submissions and red bars the COVID19-related submissions.



Main WeNMR KPIs over the different reporting periods (9-month periods, P4 finishing 31st December 2020)

Establishment of partnerships with industrial & private partners

Supporting KERs:

- › KER 4: Internal Services in the Hub Portfolio
- › KER 6: EOSC Digital Innovation Hub (DIH): Platform for Industrial Collaborations with EOSC
- › KER 9: Training courses and material

The primary impact on this area is through the KER 6 (EOSC Digital Innovation Hub). However, it relies heavily on other project results, for example internal services on the Service Portfolio (KER 4) and Training Courses and material (KER 9). KER 6 provides a crucial “facilitator and translator” function that makes interaction between EOSC community and SMEs (that typically encounter e-Infrastructures the first time through DIH) fluid and efficient. In addition to the public-private partnerships established, DIH has also shown that it can **stimulate networking between SMEs**. For example, the DataFurn and VAMOS DIH pilots were joint ventures, each bringing together two SMEs. Knowco Collabwith and Kampal Data Solutions started networking activities to explore joint participation in gender data analytics in the upcoming research funding programmes. These kind of success stories will have an indirect effect of encouraging further cross-sectoral collaborations, as they demonstrate the DIH’s role as a platform that allows realising benefits from synergies between companies, in addition to companies and EOSC.

The EOSC Digital Innovation Hub was successfully established at the end of 2018 and is now officially part of the EU Digital Innovation Hub catalogue¹⁹ with a clear, distinct brand that ties it with the whole EOSC (rather than just the project). DIH continues to act as a mechanism for private companies to collaborate with public sector institutions in order to access technical services, research data, and human capital. The services offered are: **(1) pilot and co-design, (2) technical access, (3) training and support, and (4) promotion through the Marketplace**. During the project, **18 pilots with SMEs** were kick-started (12 of them during the second reporting period) and integrated with EOSC-hub services. DIH published two collections of success stories and the details of the pilots and the success factors behind them can be found in the deliverable D9.4²⁰. Altogether, DIH supported 25 SMEs, organised 30 industry events and brought 4 services to EOSC Marketplace.

Partners were active in both event organisation and participation as well as running dedicated webinars on community gathered topics of interest, totaling around 30 events. This included sessions within EOSC flagship events, where business pilots were also present having won best demos and posters. 2 success story publications were produced and technical meetings within pilots transitioned into community wide meetings. The importance of this kind of joint activity as a concrete proof of the relevance of EOSC to actors in the private sector cannot be overstated.

To ensure that EOSC-DIH could maintain the momentum generated in the EOSC-hub and seamlessly build on it in the follow-up activities, the project ensured the long-term sustainability of the EOSC-DIH in a way that is not solely dependent on continued project funding. While externally funded projects will continue to play an important role, the EOSC-DIH partners have secured organisational commitments that secure the continuation of the EOSC-DIH beyond the individual projects. Thus, EOSC-DIH represents a long-term commitment to supporting technology and knowledge transfer between EOSC and the industry. It will continue to serve as a mechanism for business organisations (start-ups, SMEs, large enterprises) to directly engage with EOSC. The initial set of service offers were already expanded via strategic partnerships, such as with DEEP-Hybrid Cloud, and will grow as formal connections made with and through the EOSC Marketplace mature.

Success story - BICcoldTRUCKS Business Pilot

Odin Solutions (OdinS) is a SME founded in August 2014 with a strong background in the R&D fields of Internet of Things, Security and Data Analytics. The main goal of this company was to optimise the cold chain through Big Data analytics and study the characteristics of the trips and products in order to save petrol and reduce food waste. The solution was based in the development of a system that analyses historical data in order to extract existent patterns in the transportation of perishable goods and identify malpractice and analyse real-time data in order to support decision-making in relation to the routes and the grouping of foodstuffs for their transportation. The company managed to provide a solution that shows the following information: Ranking of products according to their demand, Trip Duration, Seasonality and Geographic Representation.

With the pilot the company indexed the data using ElasticSearch and connected the dashboard to it using the elastic search package. The pilot used the Deep Hybrid DataCloud for deploying a Jupyter instance in the DEEP CLOUD tested with a GPU. This served to ease the machine learning models training that were tested for the prediction of the demand of different products.

BigColdTrucks received technical support from the Scientific Data Platforms Department of PSNC in order to fasten up the descriptive analysis that is shown in the Dashboard. Following the EOSC DIH consultancy and support, Odin Solutions decided to use the elastic search solution, that was deployed in one of PSNC machines, for data indexing. The company was able to connect their dashboard to PSNC machines by means of ssh tunnelling and the computing speed of the results was greatly improved.

¹⁹ <https://s3platform.jrc.ec.europa.eu/digital-innovation-hubs-tool/-/dih/6109/view>

²⁰ <https://zenodo.org/record/5033322>

Further Reading

- 📖 EOSC-hub Key Exploitable Results: eosc-hub.eu/results
- 📖 EOSC-DIH: eosc-dih.eu
- 📖 EOSC Portal: eosc-portal.eu
- 📖 Horizon Results Platform: ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/horizon-results-platform/search;keyword=eosc-hub
- 📖 Deliverables: eosc-hub.eu/deliverables

EOSC-hub Technical specifications and interoperability guidelines

Common services

- › Cloud Compute (inc Containerisation and orchestration)
 - 📖 Cloud IaaS Container Management: <https://zenodo.org/record/5040036>
 - 📖 Cloud IaaS VM Management: <https://zenodo.org/record/5040101>
 - 📖 Cloud IaaS VM Orchestration: <https://zenodo.org/record/5040047>
- › HTC/HPC Specification: <https://wiki.eosc-hub.eu/pages/viewpage.action?pageId=63438908>
 - 📖 Multitenant Containerised job submission
 - 📖 Multitenant job submission
 - 📖 Clusters on demand
- › Metadata Management and Data Discovery
 - 📖 Annotation Service: <https://zenodo.org/record/5040026>
 - 📖 Data Discovery and Access: <https://zenodo.org/record/5040105>
 - 📖 Metadata Cataloguing and Indexing: <https://zenodo.org/record/5040142>
- 📖 PaaS Solutions: <https://zenodo.org/record/5040150>
- › Workflow management and user interfaces and Data analytics
 - 📖 Machine Learning/Deep Learning data analytics services: <https://zenodo.org/record/5040126>
 - 📖 Marketplace: <https://zenodo.org/record/5040132>

Federation services

- 📖 Accounting: <https://zenodo.org/record/5040016>
- 📖 Helpdesk: <https://zenodo.org/record/5040118>
- 📖 Monitoring: <https://zenodo.org/record/5040148>
- 📖 Security: <https://zenodo.org/record/5040154>
- 📖 Software Quality Assurance: <https://zenodo.org/record/5040160>
- 📖 AAI service: <https://zenodo.org/record/5040005>





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