



European
Commission

Landscape of EOSC-Related Infrastructures and Initiatives

Report from the
EOSC Executive
Board Working
Group (WG)
Landscape

Independent
Expert
Report

EOSC Executive Board
WG Landscape
August 2020

Research and
Innovation

Landscape of EOSC-Related Infrastructures and Initiatives

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Manuscript completed in August 2020.

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Luxembourg: Publications Office of the European Union, 2020.

PDF

ISBN 978-92-76-21289-8

doi: 10.2777/342650

KI-03-20-541-EN-N

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Report from the EOSC Executive Board Working Group (WG) Landscape

Edited by: the EOSC Executive Board

August 2020



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EXECUTIVE SUMMARY

The Landscape Working Group (WG) of the EOSC Executive Board has surveyed and documented the landscape of infrastructures, initiatives and policies across Europe relating to the development of the European Open Science Cloud (EOSC) system.

This report describes activities in the Member States (MS) and Associated Countries (AC) related to EOSC. Its summaries existing policies and investments based on input from the MS and AC, and using the expert knowledge of the WG members and delegates to the EOSC governing board, is complemented by information from Horizon 2020 research projects and from open sources.

The goal of the EOSC is to make research data and software in Europe open and accessible to all researchers - Findable, Accessible, Interoperable, and Re-usable (FAIR). EOSC will be implemented by joint efforts between the European Commission (EC), the EU MS and AC, research communities, and other stakeholders. EOSC is a federated structure with a central core of standards and services that interlinks with national and institutional resources and research infrastructures providing data and services. It is these resources and infrastructures that the WG has focused on in this report. A flexible and sustainable governance model for EOSC must ensure the long-term sustainability of services regarding data storage, management, analysis and re-use across disciplines, which requires alignment of national policies towards open science. Consequently, the WG has also looked at the landscape of open science policies across Europe.

The work builds on existing surveys and information provided by national authorities, various stakeholder communities and the relevant H2020 projects in close collaboration with the Member States (MS) and Associated countries (AC). Initial reference material includes the recent report of the e-Infrastructure Reflection Group¹ (e-IRG), findings of the Commission expert group on National Points of Reference on Scientific Information², the surveys carried out by the OpenAIRE project, the EOSC-Pillar project, analysis of preliminary mapping of the UK's research and innovation infrastructure landscape, the experience of European Strategy Forum on Research Infrastructures (ESFRI) on cross-disciplinary collaboration of ESFRI Landmarks, other relevant documents identified by the WG members, and outcomes of the survey (country sheets) performed by the Landscape WG itself. The WG has collated input from e-infrastructures, including data and HPC facilities, from European and national research networks (NRENs), pan-European research infrastructures and ESFRI roadmap projects and clusters, and from interest groups such as the Research Data Alliance. At the time of writing, information has been collated on 47 MS and AC.

A virtual Validation Workshop was held online on 27 and 28 April 2020, to validate the provided contributions.

While it has proved difficult to obtain definitive and quantitative data on national levels of investment, it is already clear that the majority of the countries surveyed have made significant investment in national e-infrastructures of one kind or another that could, in principle, either be federated as part of EOSC, or made accessible to users through EOSC. The same applies to many of the data intensive ESFRI landmark infrastructures. Such investment over the past decade now totals billions of Euros, much more than the planned central investment into the EOSC core. This shows that EOSC will only reach its

1 (n.d.). e-IRG. Retrieved 13 July 2020, from <http://e-irg.eu/>

2 (n.d.). Commission expert group on National Points of Reference on Retrieved 13 July 2020, from <https://ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupDetail&groupID=3477>

true potential through effective federation of national and research infrastructure (RI) resources.

The WG has also surveyed the landscape of policy development across Europe regarding open science and EOSC. In keeping with best practice, most countries have research evaluation policies in place. We found that the majority (61%) of the MS and AC respondents have policies in place regarding open access to scholarly publications, but only 34% have a policy in place regarding FAIR data (although encouragingly, 44% have one either in planning or under development). Few countries seem ready to mandate that research data should automatically be made open. Relatively few countries (21%) mention EOSC in their policies, but 38% plan to do so in future; but only three countries so far (BG, DK, RO) include mention of EOSC as part of their funding criteria. More than half of responding countries have nominated contact points for open science (53%) and for EOSC (42%).

Taken together, there has been significant investment across Europe in e-infrastructures and data-oriented research infrastructures. For the EOSC to reach its full potential, such investment needs to be either federated as part of the EOSC or made accessible to users through the EOSC. There has also been a significant, although not yet universal, adoption of policies towards open science and FAIR data. While EOSC has not been very visible up to now as part of national investment strategies, there is evidence that future policies and strategies will increasingly align around the concept.

HOW TO READ THIS REPORT

This report has been produced by the EOSC Executive Board (EB) WG Landscape. It represents a snapshot of the EOSC Landscape at Q1 2020, providing sufficient information, links and references to provide an introduction to the topics. It is intended as a reference tool and entry point for the other EOSC WGs³ defining EOSC architecture, rules for participants, FAIR principles, skills and training and sustainability models, and has sourced background from infrastructures and initiatives that make up the EOSC landscape. The report is structured as follows:

Chapter 1 - Introduction and **Chapter 2 - Background** provide an overview of the EOSC policy development, including the current status of the EOSC implementation and the contribution of EOSC related projects.

Chapter 3 - EOSC relevant infrastructures and initiatives summarises specific information about EOSC-relevant e-infrastructures (Data and Computing infrastructures and Networking), thematic infrastructures from EU MS and AC, and the EOSC-related projects from the Horizon 2020 (H2020) framework programme. The aim is to present an up-to-date overview of the available infrastructures and initiatives in all EU MS and AC (with references). The report builds on information from open sources, contributions from the WG members, participation of the Governance Board members, the active engagement of the EOSC Secretariat and other EOSC-related projects. Results of the INFRAEOSC-5B project- mapping exercise will contribute to this section, once available.

Chapter 4 - National policy and legislation strategies provides an overview of the initial landscaping exercise of EU MS and AC. Moreover, it provides specific information on national policy making bodies, national strategic documents, implementing and funding bodies, as well as national legislation. The aim is to present an up-to-date overview of the available strategies and policies including funding from all EU MS and AC. Additional information may be added to this section as it becomes available. The inputs received from the MS/AC have been aggregated in this report through the country sheets. Results of the INFRAEOSC-5B project-mapping exercise will contribute to this section, once available.

Chapter 5 - Descriptive examples of European, national and regional structures and initiatives describes in detail all the various aspects and the diversity of depicted “typical” cases. The main purpose of this chapter is to provide detailed information on processes.

Members of the Landscape working group are listed at the end of the report, together with the main abbreviations used.

Annex I summarises the information on EOSC-related projects.

3 (n.d.). EOSC Working Groups | EOSC Secretariat. Retrieved from <https://www.eoscsecretariat.eu/eosc-working-groups>

DEFINITIONS OF STAKEHOLDER TYPES IN THE CONTEXT OF THIS REPORT

This section proposes common terminology for stakeholder types used throughout this report. Some terms have built on the definitions provided in the Single Market Glossary⁴, but most are derived by WG members based on EOSCpilot project deliverable D2.1 Draft Stakeholder Map⁵. Whilst an overarching EOSC Glossary⁶ is now available to provide clear and unambiguous understanding of common terminology amongst the EOSC community, it was considered useful to include some specific definitions in this report.

European e-Infrastructures	The comprehensive ICT infrastructure that is needed to enable complex, multi-disciplinary research. It capitalises advances in ICT, integrates hardware for computing, data and networks, observatories and experimental facilities, and provides an interoperable suite of software and middleware services and tools. Such an infrastructure is necessary for researchers to store, analyse and process unprecedented amounts of (heterogeneous in general) data and information, to enable world-scale scientific collaborations and access to, and sharing of, scientific resources and information regardless of their type and location in the world ⁷ . Existing key European e-infrastructures, such as EUDAT, EGI, OpenAIRE, GÉANT and PRACE are the natural starting point for engaging stakeholders. They represent activities that are closely linked to e-infrastructures, including cloud operations. Moreover, they are already organised for further integration.
Data/Research Initiatives	There is a variety of organisations and initiatives, e.g. the Research Data Alliance, interest and working groups that constitute established research communities with a specific stake in cloud services.
Cloud Providers	Cloud services providers (public and private) are key stakeholders by definition. Engaging major companies, e.g. Amazon ⁸ , which provide services to a wide range of research activities is important in order to bring together the needs of the research communities and the offered services, as well as to address data privacy issues.
Research Funders	Funding bodies at both the national and EU level are major stakeholders in EOSC. as they support research in all its stages. Despite variance in funding and organisational structure in different countries, EOSC needs to actively engage them to support the future direction of EU cloud infrastructures.
Cloud Community	The research community working with cloud technologies and participating in EU cloud projects is a valuable ally in designing

4 (n.d.). Glossary | Shaping Europe's digital future. Retrieved from <https://ec.europa.eu/digital-single-market/en/glossary>

5 (2017, May 15). EOSCpilot Deliverable Template. Retrieved from <https://eoscpilot.eu/sites/default/files/eoscpilot-d2.1.pdf>

6 (n.d.). EOSC Glossary | EOSC Portal. Retrieved 10 July 2020, from <https://www.eosc-portal.eu/glossary>

7 (n.d.). Glossary | Shaping Europe's digital future. Retrieved from <https://ec.europa.eu/digital-single-market/en/glossary>

8 (n.d.). Research - About Amazon. Retrieved from <https://www.aboutamazon.com/research>

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	the framework for cloud services in the EU. Identifying key players in this sector is an important challenge.
Research Communities	As main consumers of cloud services, research communities are a basic pillar in EOSC as they define the consumer side of the cloud ecosystem. This is a broad class of consumers and identifying key contact points and the right organisation scheme to engage community members is a complex task. Some of them are already organised at EU scale, such as the HPC Centre of Excellence (CoE).
Research Performing Organisations	There are different types of Research Performing Organisations (RPO), as universities and research institutes, government labs, Research and Technology Organisations (RTOs) and large-scale Research Facilities (LRFs), such as CERN. They are both consumers and providers of data, services and infrastructures. Many are already organised at European level in associations such as the European Universities Association (EUA) or European Association of RTOs (EARTO).
Research Infrastructures	The Research Infrastructure (RI) projects of the EC complement the existing EU RI landscape, by providing thematic (vertical) infrastructures in contrast with the generic (horizontal) e-infrastructure. RIs are the key starting point for engaging communities since they are already organised in an operational structure and use or provide cloud services.
Policy Makers	Policy makers affect cloud infrastructures in profound ways, even when they do not act as funders. For example, the impact of regulatory bodies on data privacy, competition and, of course, on research can shape the future of the EOSC ecosystem in the EU. The EOSCpilot has to identify the most closely related policy makers and investigate the more productive way to engage them ⁹ .

Table 1 Terminology of Stakeholder types

9 (2017, May 15). EOSCpilot Deliverable Template. Retrieved from <https://eoscpilot.eu/sites/default/files/eoscpilot-d2.1.pdf>

1. BACKGROUND

1.1. The Council and the EOSC

Ministers from EU member states responsible for research and innovation (R&I) who met at the Competitiveness Council in Brussels on 29 May 2018, and adopted resolutions on the EOSC^{10,11}, considered the need for an open and trusted environment for managing research data, and confirmed the need to proceed with EOSC implementation along the lines proposed in the EC staff working document *Implementation Roadmap for the European Open Science Cloud*¹². These Council conclusions and the Implementation Roadmap built the foundation for subsequent EOSC development.

Significantly, the Council unambiguously stressed the importance of coordinating activities between the various projects funded by the eighth EU Framework Programme for Research and Innovation (H2020), including transnational initiatives aligning their activities to EOSC.

The Council highlighted the need to respect established practices and existing principles developed by research communities, the European Strategy Forum on Research Infrastructures (ESFRI), the RIs, the e-infrastructures, and the national infrastructures when implementing the EOSC. To this end, the Council agreed on a federated model for the EOSC and encouraged the EU MS to take actions which enable national stakeholders to connect to the EOSC. Existing experiences and knowledge of initiatives, such as ESFRI¹³, the e-Infrastructure Reflection Group (e-IRG)¹⁴, GO FAIR¹⁵ and others should also be considered.

Given the evolutionary character of the EOSC, the Council believed that participation in it should be voluntary and stakeholders should be free to decide which services or data sets are to be shared. The EU MS are invited to identify jointly with the EC national research data infrastructures initiatives, which could be federated. Sound governance and a sustainable business model are considered as key elements for EOSC implementation. In that sense, a two-phase approach is viewed as essential.

1.2. EOSC Governance

In accordance with the agreed implementation, the EC formally launched the EOSC at the University of Vienna¹⁶ in November 2018: the EOSC Portal¹⁷ was inaugurated; the EOSC Executive Board (EB)¹⁸ was established; and the process for forming the EOSC Governing Board (GB)¹⁹, which completes the EOSC governing structure, was initiated. Both governing bodies are now fully operational, have held their first meetings and started to contribute to the implementation of the EOSC roadmap. In addition, the EOSC Stakeholders

10 (2018, May 18). 9029/18 MVG/evt 1 DG G 3 C 1. The European ... - Open Data. Retrieved from <https://data.consilium.europa.eu/doc/document/ST-9029-2018-INIT/en/pdf>

11 (2018, May 29). EOSC. Retrieved from https://www.era.gv.at/object/document/4013/attach/CC_EOSC_final.PDF

12 (2018, March 14). Implementation Roadmap for the European Open Science Retrieved from https://ec.europa.eu/research/openscience/pdf/swd_2018_83_f1_staff_working_paper_en.pdf

13 (n.d.). www.esfri.eu. Retrieved from <https://www.esfri.eu/>

14 (n.d.). e-IRG. Retrieved from <http://e-irg.eu/>

15 (n.d.). GO FAIR. Retrieved from <https://www.go-fair.org/>

16 (2018, November 23). EOSC Vienna Declaration - (EOSC). The launch. Retrieved from <https://eosc-launch.eu/declaration/>

17 (n.d.). EOSC Portal. Retrieved from <https://www.eosc-portal.eu/>

18 (n.d.). EOSC Executive Board | EOSC Portal. Retrieved from <https://www.eosc-portal.eu/governance/executive-board>

19 (n.d.). EOSC Governance Board | EOSC Portal. Retrieved from <https://www.eosc-portal.eu/governance/eosc-board>

Forum²⁰ brings together user communities, research institutions, RIs and e-infrastructures, and specialised EU agencies.

The Strategic Implementation Plan (SIP)^{21,22} has been prepared, approved by both bodies and published on the EC portal. This document, building on the accepted EOSC principles and refining the tasks set-out in the EOSC Implementation Roadmap, defines the six priority areas that were identified by the EB in agreement with the GB, and which have become the target areas of the EB Working Groups. The following Working Groups and their respective role, established during the first phase of the EOSC implementation include the following:

- **WG Landscape:** Mapping of the existing RIs, which are candidates to be part of the EOSC federation.
- **WG FAIR:** Implementing the FAIR data principles by defining the corresponding requirements for the development of EOSC services, in order to foster cross-disciplinary interoperability.
- **WG Architecture:** Defining the technical framework required to enable and sustain an evolving EOSC federation of systems.
- **WG Rules of Participation:** Designing the Rules of Participation that shall define the rights and obligations governing EOSC transactions between EOSC users, providers and operators.
- **WG Sustainability:** Providing a set of recommendations concerning the implementation of an operational, scalable and sustainable EOSC federation after 2020.
- **WG Skills & Training**²³: Building competences and capabilities for the EOSC, agree upon key components for skills development and training, determine how these can be embedded in different levels of EOSC, and identify what structures are needed to make EOSC a viable success.

The SIP also defines a clear timeline for the expected outcomes of these WGs and schematically indicated the connections, links or interdependencies between them.

1.3. EOSC building initiatives and environment

The EOSC is not a new infrastructure or software package, it is a process of making research data in Europe accessible to all researchers under the same terms of use and distribution. The initiative aims to push Europe towards a culture where open research data (including publications, and underlying data) are FAIR²⁴, which will allow all European researchers to expand their use of data-driven science. As stated at the EOSC Summit in June 2017²⁵, 'The EOSC is not a physical space but a diverse ecosystem of connected

20 (n.d.). EOSC Stakeholders Forum | EOSC Portal. Retrieved from <https://www.eosc-portal.eu/governance/stakeholders-forum>

21 (2019, July 24). European Open Science Cloud (EOSC) strategic Retrieved from <https://data.europa.eu/doi/10.2777/202370>

22 (2019, July 24). European Open Science Cloud (EOSC) strategic Retrieved from <https://op.europa.eu/en/publication-detail/-/publication/78ae5276-ae8e-11e9-9d01-01aa75ed71a1/language-en/format-PDF/source-114548231>

23 This WG started in January 2020 and has a 12-month initial duration.

24 Findable, Accessible, Interoperable, Reusable

25 (2017, June 12). European Open Science Cloud Summit | Research and Retrieved from <https://ec.europa.eu/research/index.cfm?eventcode=44D86060-FBA1-1BD1-9355822B162BB0EE&pg=events>

services and infrastructures. Emphasis should shift from project-based development to sustainable collaborative ecosystems.'

The EOSC envisions a European data infrastructure, integrating high-capacity cloud solutions, eventually widening the scope of these services to include the public sector and industry. Efforts focusing on the development of sustainable collaborative ecosystems, as foreseen by the EOSC, are particularly made in the fields of data culture, research data services, federated architecture and co-funding.

The EOSC results from two complementary movements: community-driven and multi-governmental. Therefore, all kinds of national initiatives are invited to link up with existing pan-European initiatives, infrastructures and bodies (ESFRI²⁶, e-IRG²⁷, RDA²⁸, GO FAIR²⁹, EGI³⁰, EUDAT³¹, EOSC-Pilot³², EOSC-Hub³³, OpenAIRE³⁴), as well as expert groups and advisory groups to the EC, such as the High-Level Expert Group on the EOSC³⁵ or the Standing Working Group on Open Science and Innovation of the European Research Area and Innovation Committee (ERAC)³⁶. The overall aim is to encourage EOSC participants to contribute to an Internet of FAIR Data and Services governed by European public interests.

26 (n.d.). European Strategy Forum on Research Infrastructures (ESFRI). Retrieved from https://ec.europa.eu/info/research-and-innovation/strategy/european-research-infrastructures/esfri_en

27 E-IRG: e-IRG is a strategic body to facilitate integration in the area of European e-Infrastructures and connected services, within and between member states, at the European level and globally. The mission of e-IRG is to support both coherent, innovative and strategic European e-Infrastructure policymaking and the development of convergent and sustainable e-Infrastructure services. (n.d.). e-IRG. Retrieved from <http://e-irg.eu/>

28 RDA: In 2013, the Research Data Alliance (RDA) was launched as a community-driven initiative by the European Commission, the United States Government's National Science Foundation and National Institute of Standards and Technology, and the Australian Government's Department of Innovation with the goal of building a social and technical infrastructure that enables open sharing and re-use of data. (2016, March 22). About RDA - Research Data Alliance. Retrieved from <https://www.rd-alliance.org/about-rda>

29 GO FAIR: GO (Global Open) FAIR is a bottom-up initiative that aims at making fragmented and unlinked (research) data findable, accessible, interoperable and thus reusable (FAIR). (n.d.). GO FAIR Initiative - GO FAIR. Retrieved from <https://www.go-fair.org/go-fair-initiative/>

30 EGI: EGI is a federation of 21 cloud providers and hundreds of data centres, spread across Europe and worldwide. EGI delivers advanced computing services to support scientists, multinational projects and research infrastructures. (n.d.). EGI.eu. Retrieved from <https://www.egi.eu/>

31 EUDAT: EUDAT's vision is Data is shared and preserved across borders and disciplines. Achieving this vision means enabling data stewardship within and between European research communities through a Collaborative Data Infrastructure (CDI), a common model and service infrastructure for managing data spanning all European research data centres and community data repositories <https://eudat.eu/what-eudat>

32 EOSC-Pilot: The EOSCpilot project will support the first phase in the development of the European Open Science Cloud (EOSC). (n.d.). About EOSCpilot | eoscpilot.eu. Retrieved from <https://eoscpilot.eu/about-eoscpilot>

33 EOSC-Hub: The EOSC-hub brings together multiple service providers to create the Hub: a single contact point for European researchers and innovators to discover, access, use and reuse a broad spectrum of resources for advanced data-driven research. (n.d.). About us | EOSC Hub. Retrieved from <https://www.eosc-hub.eu/about-us>

34 OpenAIRE: The mission of OpenAIRE is to encourage more openness and transparency in scholarly communication and to facilitate innovative ways to communicate and monitor research. (n.d.). OpenAIRE.eu. Retrieved from <https://www.openaire.eu/>

35 (n.d.). High Level Expert Group on the European Open Science Cloud. Retrieved from <https://ec.europa.eu/research/openscience/index.cfm?pg=open-science-cloud-hleg>

36 (n.d.). WG on Open Science and Innovation - ERA Portal Austria. Retrieved from <https://era.gv.at/directory/243>

1.4. EOSC relevant stakeholders

1.4.1. Policy makers

Numerous policy makers from around the world have articulated a clear and consistent vision of global open science as a driver for enabling a new paradigm of transparent, data-driven science as well as accelerating innovation. In January 2020, Ursula von der Leyen stated in Davos: 'Europe is launching the Europe Open Science Cloud - a trusted space for researchers to store their data - a pool of information leading to a web of insight. We are the first in the world to do so.'³⁷ The EOSC has emerged as a clear policy priority for European R&I. It has been strongly supported by the European scientific community in the EOSC Summit³⁸ and Declaration³⁹, by the Council in Council Conclusions (May 2016)⁴⁰ and by a European Parliament Resolution (January 2017)⁴¹. It also received favourable opinions from the Economic and Social Committee (September 2016)⁴² and from the Committee of the Regions (October 2016)⁴³. At the strategic layer EOSC Governance Board (EOSC GB)⁴⁴, policy makers are involved to combine state-of-the-art expertise on scientific cloud infrastructures. The Board will, therefore, include EU MS and AC representatives in order to make strategic decisions on the development and evolution of the EOSC⁴⁵.

37 (2020, January 22). Keynote by President von der Leyen at the World Economic Forum. Retrieved from https://ec.europa.eu/commission/presscorner/detail/en/speech_20_102

38 (2017, June 12). European Open Science Cloud Summit | Research and Retrieved from <https://ec.europa.eu/research/index.cfm?eventcode=44D86060-FBA1-1BD1-9355822B162BB0EE&pg=events>

39 (n.d.). EOSC Declaration - European Commission. Retrieved from https://ec.europa.eu/research/openscience/pdf/eosc_declaration.pdf

40 (2016, May 27). 9526/16 AFG/evt 1 DG G 3 C Delegations will find ... - Open Data. Retrieved from <https://data.consilium.europa.eu/doc/document/ST-9526-2016-INIT/en/pdf>

41 (n.d.). European Parliament. Retrieved from <https://www.europarl.europa.eu/>

42 (n.d.). European Cloud Initiative - Building a competitive data and knowledge economy in Europe EESC. Retrieved from <https://www.eesc.europa.eu/en/our-work/opinions-information-reports/opinions/european-cloud-initiative-building-competitive-data-and-knowledge-economy-europe>

43 (2020, March 12). European Committee of the Regions. Retrieved from <https://cor.europa.eu/en>

44 <https://www.eosc-portal.eu/governance/eosc-board>

45 (n.d.). Governance | EOSC Portal. Retrieved from <https://www.eosc-portal.eu/governance>

1.4.2. Funders

According to the European Commission staff working document on the Implementation Roadmap for the European Open Science Cloud⁴⁶, Horizon 2020 would be used to support the development of the services for open science. On this basis, the EC is supporting the implementation of the EOSC as a federated model. Horizon 2020 is the financial instrument implementing the core of actions around which the EOSC implementation Roadmap unfolds. Also, other programmes (such as Digital Europe), tools, institutions, businesses or funding bodies contribute to funding EOSC both directly and indirectly through state-of-the-art expertise and investment in national infrastructures. Continuation of funding EOSC activities beyond 2021 is envisaged through Horizon Europe.

1.4.3. Other relevant stakeholders

Other stakeholders are also crucial for a working EOSC ecosystem, such as researchers as the primary target group of data provision and use. Moreover, an expanded range of stakeholders beyond policy makers and funders could benefit from EOSC services, such as RPOs, libraries, universities, business initiatives (e.g. Gaia-X), service providers, institutions, citizens or some ESFRI projects.

1.5. EOSC-in-practice use cases

The following use cases, or success stories, of EOSC-in-practice⁴⁷ highlight how EOSC services and resources can support the daily work of researchers and innovators. For example, the EOSCpilot Science Demonstrators project showed the relevance and usefulness of the EOSC Services to enable the reuse of data as a driver of EOSC development by helping to establish new means of data access, share and reuse for research communities (Photon Neutron Virtual Platform⁴⁸; VisIVO: Data Knowledge Visual Analytics Framework for Astrophysics⁴⁹; LOFAR - Astrophysics Data⁵⁰; eWaterCycle & SWITCH-ON - FAIR data for hydrology⁵¹; EPOS/VERCE - Earthquake Data Environment⁵²; ENVRI – Radiative Force Integration⁵³; Pan-Cancer Analyses: portable federated cloud-

46 (2018, March 14). Implementation Roadmap for the European Open Science Cloud. Retrieved from https://ec.europa.eu/research/openscience/pdf/swd_2018_83_f1_staff_working_paper_en.pdf

47 (n.d.). Use Cases | EOSC Portal. Retrieved from <https://eosc-portal.eu/eosc-in-practice/use-cases>

48 (n.d.). EOSCpilot Science Demonstrator: Photon Neutron Virtual Platform. Retrieved from <https://www.eosc-portal.eu/eoscpilot-science-demonstrator-photon-neutron-virtual-platform>

49 (n.d.). EOSCpilot Science Demonstrator: VisIVO: Data Knowledge Visual Analytics Framework for Astrophysics. Retrieved from <https://eosc-portal.eu/eoscpilot-science-demonstrator-visivo-data-knowledge-visual-analytics-framework-astrophysics>

50 (n.d.). EOSCpilot Science Demonstrator: LOFAR - Astrophysics Data. Retrieved from <https://www.eosc-portal.eu/eoscpilot-science-demonstrator-lofar-astrophysics-data>

51 (n.d.). EOSCpilot Science Demonstrator: eWaterCycle & SWITCH-ON - FAIR data for hydrology. Retrieved from <https://www.eosc-portal.eu/eoscpilot-science-demonstrator-ewatercycle-switch-fair-data-hydrology>

52 (n.d.). EOSCpilot Science Demonstrator: EPOS/VERCE - Earthquake Data Environment. Retrieved from <https://eosc-portal.eu/eoscpilot-science-demonstrator-eposverce-earthquake-data-environment>

53 (n.d.). EOSCpilot Science Demonstrator: ENVRI - Radiative Force Integration. Retrieved from <https://www.eosc-portal.eu/eoscpilot-science-demonstrators-envri-radiative-force-integration>

based solution⁵⁴; EGA - FAIR Genomic datasets⁵⁵; CryoEM - Life Science data workflows⁵⁶; PROMINENCE - HPCAAS for fusion⁵⁷; DPHEP - Data Preservation in High Energy Physics⁵⁸).

Moreover, the EOSC offers scalable computing infrastructures for communities as varied as: Earth Observation⁵⁹; the pufferfish invasion in the Mediterranean Sea – demonstrator⁶⁰; the CLARIN demonstrator⁶¹; ICOS – Integrated Carbon Observation System⁶²; EOSC-hub and OpenAIRE-Advance: Published or Private: How to do both?⁶³ and Advancing research together⁶⁴; EOSCpilot demonstrator: TEXTCROWD⁶⁵.

1.6. EOSC Supporting services

The current offer of services and resources is managed by the EOSC Portal⁶⁶ via the EOSC Catalogue and Marketplace⁶⁷. The EOSC Portal serves as an entry point to EOSC services and resources from various domains by enabling users to access and request e-infrastructure services supplied at institutional, national and regional levels, enabling them to process and analyse data in a distributed computing environment⁶⁸. In order to develop a rich platform offering a wide range of services and resources through the EOSC Portal, EOSC requires the participation of service providers. Services and resources are provided and maintained by different providers under a variety of licences and access requirements (such as: accessible by users outside their original community; described through a common template focused on value proposition and functional capabilities; at least one service instance running in a production environment should be available to the user community; publication of research data is FAIR; release notes and sufficient documentation are available; helpdesk channels are available for support, and bug reporting and requirements gathering must also take place.)⁶⁹ At the moment, the EOSC

54 (n.d.). EOSCpilot Science Demonstrator: Pan-Cancer Analyses: portable federated cloud-based. Retrieved from <https://www.eosc-portal.eu/eosc-pilot-science-demonstrator-pan-cancer-analyses-portable-federated-cloud-based-solution>

55 (n.d.). EOSCpilot Science Demonstrator: EGA - FAIR Genomic datasets. Retrieved from <https://www.eosc-portal.eu/eosc-pilot-science-demonstrator-ega-fair-genomic-datasets>

56 (n.d.). EOSCpilot Science Demonstrator: CryoEM - Life Science data workflows. Retrieved from <https://www.eosc-portal.eu/eosc-pilot-science-demonstrator-cryoem-life-science-data-workflows>

57 (n.d.). EOSCpilot Science Demonstrator: PROMINENCE - HPCAAS for fusion. Retrieved from <https://www.eosc-portal.eu/eosc-pilot-science-demonstrator-prominence-hpcaas-fusion>

58 (n.d.). EOSCpilot Science Demonstrator: DPHEP - Data Preservation in High Energy Physics. Retrieved from <https://www.eosc-portal.eu/eosc-pilot-science-demonstrator-dpheap-data-preservation-high-energy-physics>

59 (n.d.). The EOSC as a scalable computing infrastructure for Earth Observation. Retrieved from <https://eosc-portal.eu/eosc-scalable-computing-infrastructure-earth-observation>

60 (n.d.). The pufferfish invasion in the Mediterranean Sea - EOSC Portal. Retrieved from <https://eosc-portal.eu/pufferfish-invasion-mediterranean-sea-demonstrator>

61 (n.d.). From language data to insight: the CLARIN demonstrator. Retrieved from <https://www.eosc-portal.eu/language-data-insight-clarin-demonstrator>

62 (n.d.). ICOS - Integrated Carbon Observation System | EOSC Portal. Retrieved from <https://www.eosc-portal.eu/icos-integrated-carbon-observation-system>

63 (n.d.). EOSC-hub and OpenAIRE-Advance: Published or Private: How to do both? Retrieved from <https://eosc-portal.eu/eosc-hub-and-openaire-advance-published-or-private-how-do-both>

64 (n.d.). EOSC-hub and OpenAIRE-Advance: Advancing research together. Retrieved from <https://eosc-portal.eu/eosc-hub-and-openaire-advance-advancing-research-together>

65 (n.d.). EOSCpilot demonstrator: TEXTCROWD | EOSC Portal. Retrieved from <https://eosc-portal.eu/eosc-pilot-demonstrator-textcrowd>

66 (n.d.). EOSC Portal. Retrieved from <https://www.eosc-portal.eu/>

67 (n.d.). EOSC Marketplace - EOSC Portal. Retrieved from <https://marketplace.eosc-portal.eu/>

68 (n.d.). Services & Resources | EOSC Portal. Retrieved from <https://www.eosc-portal.eu/services-resources>

69 (n.d.). For providers | EOSC Portal. Retrieved from <https://eosc-portal.eu/for-providers>

Catalogue provides access to: 254 services; 4.4M datasets; 141k software and applications; 34.6M publications; and 3M other research products, offered by 73 service/resource providers and aggregators⁷⁰. The services are grouped in the following 13 categories: Aggregator, Analytics, Application, Compute, Consulting, Data, Networking, Operations, Security, Software, Storage, and Training and Other⁷¹.

1.6.1. Industry Involvement

Through the involvement of industry in EOSC, interaction between research and industry is supported through the use of the data and services Marketplace (accessed via the EOSC Portal). Here, industries can offer value-added services using research data of commercial relevance but may also consume scientific output⁷². The basic value proposition that can be made to the private sector as a service provider/developer, is that EOSC offers a commercialisation channel to promote services via the EOSC Catalogue and Marketplace, a simplified procurement channel for selling to public research sector organisations, and a means of interacting with researchers to improve services. Moreover, the EOSC value proposition to the private sector as consumer is to offer a mechanism to access: publicly funded open access/FAIR datasets; a range of services that can help them exploit open access/FAIR datasets; and a means of interacting with the groups producing the datasets and services.

1.7. EOSC-related EU projects

This report builds heavily on the findings and results of previous EU projects funded by the Directorate-General for Communications Networks, Content and Technology (DG CONNECT) and the Directorate-General for Research and Innovation (DG RTD) from H2020.

1.7.1. EU-funded H2020 projects

As many projects have been and are funded under H2020 and other sources, it was considered useful to gather a list of 50 major projects, which can be found in Annex I. Some project durations overlap with the first phase of EOSC governance implementation, and these projects are very prominent sources of information for this report. In particular: EOSCpilot⁷³, EOSC-Hub⁷⁴, OpenAIRE Advance⁷⁵, FREYA⁷⁶ and eInfraCentral⁷⁷. In addition, the report benefits from the self-co-ordination⁷⁸ of EOSC-related projects, which resulted from the two concentration meetings in Brussels and Budapest in 2019. An ongoing initiative is a dedicated web page published on the EOSCsecretariat.eu website, which will include the public contact information to all the EOSC Projects, and where one can find also the EOSC relevant project outputs (deliverables and milestones, including the delivery date).

70 (n.d.). EOSC Catalogue - EOSC Portal. Retrieved from <https://catalogue.eosc-portal.eu/>

71 (n.d.). Browse service categories - EOSC Catalogue - EOSC Portal. Retrieved from <https://catalogue.eosc-portal.eu/browseCategories>

72 (n.d.). prompting an EOSC in practice - EOSC Portal. Retrieved from https://www.eosc-portal.eu/sites/default/files/KI0318339ENN.en_.pdf

73 (n.d.). eoscpilot.eu. Retrieved from <https://eoscpilot.eu/>

74 (n.d.). EOSC Hub. Retrieved from <https://www.eosc-hub.eu/>

75 (2019, May 2). OpenAIRE Advance project | Projects. Retrieved from <https://www.openaire.eu/openaire-advance-project>

76 (n.d.). The FREYA project — FREYA. Retrieved from <https://www.project-freya.eu/en/about/mission>

77 (n.d.). eInfraCentral Platform. Retrieved from <https://www.einfracentral.eu/>

78 To facilitate information exchange among projects a generic e-mail address was created at allproject@eoscsecretariat.eu

1.7.2. Horizon 2020 INFRAEOSC-5B

In October 2017, as part of its Digital Agenda, the EC made public the *EOSC Declaration*, inviting EU MS, scientific communities and industry to participate in the construction of the EOSC. The EOSC is thus the instrument of Europe to support the paradigm of open science. In this context, the EC launched the *INFRAEOSC-5B* call aimed at providing the support to integrate EOSC-relevant national initiatives across Europe⁷⁹. In view of those projects tackling landscaping activities, synergies between the 5B-projects and the Landscape Working Group exist. Therefore, these projects are briefly described below even though they can be found, together with the other EOSC relevant EU projects, in Annex I.

EOSC-synergy will expand the capacity and capabilities of EOSC by leveraging the experience, effort and resources of national publicly funded digital infrastructures in a coherent way, therefore acting also as an incentive for national resource providers. It bridges the gap between national initiatives and EOSC and expands adoption by developing new capabilities by opening national thematic services to European access, based on a strong human network and advanced training tools. The project partners are from the following EU MS and AC: Czech Republic, France, Germany, Netherlands, Poland, Portugal, Slovakia, Spain, and the United Kingdom⁸⁰.

NI4OS Europe (National Initiatives for Open Science in Europe) exploits and engages a strong human network covering a wide range of stakeholders, as well as the existing infrastructures and services in 15 target countries, to support the overall EOSC vision, architecture and governance. It will federate the existing EOSC-relevant services in the target countries by making them compatible with, and visible in core building blocks of EOSC.

NI4OS-Europe will collaborate directly with the other EOSC-related initiatives to contribute to the common EOSC platform including a set of policies, rules and principles for managing services and research data across the EOSC ecosystem. The project partners are from the following EU MS and AC: Bulgaria, Croatia, Cyprus, Greece, Hungary, Romania, Slovenia, Albania, Bosnia and Herzegovina, North Macedonia, Montenegro, Serbia, Moldova, Georgia and Armenia⁸¹.

ExPaNDS (European Open Science Cloud Photon and Neutron Data Service) is a collaboration between 10 national Photon and Neutron RIs (PaN RIs) as well as EGI. The project aims to deliver standardised, interoperable, and integrated data sources and data analysis services for Photon and Neutron facilities. The project partners are from the following EU MS and AC: Belgium, Czech Republic, Germany, Switzerland, Italy, France, Spain, Sweden and the United Kingdom⁸².

EOSC-Pillar coordinates national open science efforts across Austria, Belgium, France, Germany and Italy, and ensures their contribution and readiness for the implementation of the EOSC. The project partners are from the following EU MS and AC: Austria, Belgium, France, Germany and Italy⁸³.

EOSC-Nordic aims to facilitate the coordination of EOSC relevant initiatives within the Nordic and Baltic countries. The project aims to exploit synergies to achieve greater

79 (2019, February 25). EOSC-synergy – Expanding Capabilities, Building ... - EGI. Retrieved from <https://www.egi.eu/news/eosc-synergy/>

80 (2019, September 1). EOSC-SYNERGY will - EOSC Hub. Retrieved from <https://www.eosc-hub.eu/sites/default/files/EOSC-Synergy.pdf>

81 (n.d.). NI4OS-Europe National Initiatives for Open Science in Europe - EOSC Hub. Retrieved from <https://www.eosc-hub.eu/sites/default/files/NI4OS.pdf>

82 (n.d.). expands.eu. Retrieved May 23, 2020, from <https://expands.eu/>

83 (n.d.). What We Do | EOSC-Pillar. Retrieved from <https://www.eosc-pillar.eu/what-we-do>

harmonisation at policy and service provisioning across these countries, in compliance with EOSC-agreed standards and practices. The project partners are from the following EU MS and AC: Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Netherlands, Sweden, Iceland and Norway⁸⁴.

1.8. Other important EU and global initiatives

1.8.1. EOSC Stakeholders' Forum

The EOSC Stakeholders Forum⁸⁵ is the community actively contributing to and participating in the EOSC. It is composed of organisations, projects and initiatives fully committed in supporting the EOSC vision. The EOSC Stakeholders Forum is a fundamental component of the EOSC governance, as it allows the collection of input and feedback to the other EOSC governance bodies via a series of events organised by the EOSC Secretariat⁸⁶ and various online consultation mechanisms⁸⁷.

1.8.2. Coalition of Doers

The EC shared the EOSC Declaration with all scientific stakeholders for them to provide its endorsement and commitments to the realisation of the EOSC by 2020. The Declaration emerged from the EOSC Summit of 12 June 2017, and is geared towards the implementation of the EOSC. A number of scientific stakeholders, individuals and organisations have also signed up to play a role in the EOSC 'coalition of doers'⁸⁸. The EC strongly encourages more people and organisations to endorse the principles of the Declaration, and to commit to take some of the specific actions forward⁸⁹.

1.8.3. European Countries with Research Data Alliance (RDA) nodes

With a particular focus on data sharing across technologies, disciplines and countries to address the grand challenges of society, RDA⁹⁰ was launched as a community-driven initiative in 2013 by the EC, the United States' National Science Foundation and the National Institute of Standards and Technology as well as the Australian Government's Department of Innovation. The goal is to build the social and technical infrastructure needed to enable open sharing and re-use of data⁹¹. RDA has a grass-roots, inclusive approach covering all data lifecycle stages, engaging data producers, users and stewards, and addressing data exchange, processing, and storage. RDA members collaborate through focused working and interest groups, formed by experts from all around the world – from academia, the private sector and government. It provides a neutral space where its members can come together through focused global working and interest groups (WIG) to develop and adopt infrastructures that promotes data-sharing and data-driven research,

84 (n.d.). About EOSC-Nordic - EOSC-Nordic. Retrieved from <https://www.eosc-nordic.eu/about-eosc-nordic/>

85 (n.d.). EOSC Stakeholders Forum | EOSC Portal. Retrieved from <https://www.eosc-portal.eu/governance/stakeholders-forum>

86 (n.d.). EOSC Secretariat. Retrieved from <https://www.eoscsecretariat.eu/>

87 (n.d.). EOSC Stakeholder Forum | EOSC Secretariat. Retrieved from <https://www.eoscsecretariat.eu/eosc-governance/eosc-stakeholder-forum>

88 (n.d.). The Commissioners - European Commission - Europa EU. Retrieved 10 July 2020, from https://ec.europa.eu/commission/commissioners/2019-2024_en

89 (2017, November 14). EC calls for endorsement of EOSC Declaration - ERA Portal Austria. Retrieved from <https://era.gv.at/object/news/3627>

90 (2017, April 21). RDA Europe - Research Data Alliance. Retrieved from <https://www.rd-alliance.org/rda-europe>

91 (2016, March 22). Get involved | RDA - Research Data Alliance. Retrieved from <https://www.rd-alliance.org/get-involved.html>

and can accelerate the growth of a cohesive data community that integrates contributors across domain, research, national, geographical and generational boundaries⁹². Its outputs include technical and social infrastructure solutions developed by RDA WGs or IGs that enable data sharing, exchange, and interoperability. In August 2019, RDA had more than 8,800 members from 137 countries.

1.8.4. Open Science Policy Platform (OSPP)

The OSPP⁹³ is a high-level advisory group established by the EC to advise on the development and implementation of open science policy in Europe and promote the adoption of agreed-upon best practices among a diverse range of stakeholders, including: universities, funding bodies, research organisations, and libraries. The OSPP has working groups targeting a range of pressing topics in open science such as rewards, altmetrics, new publishing business models, research integrity, Citizen Science and FAIR open data.

1.8.5. Confederation of Open Access Repositories (COAR)

COAR is an international association that brings together individual repositories and repository networks in order to build capacity, align policies and practices, and act as a global voice for the repository community. COAR was launched in 2009, and now has over 150 institutional members from all continents representing libraries, universities, research institutions, government funders and others. Interoperability across repositories is critical to support the development of an international infrastructure for data management. COAR has been working to define the future role of repositories in support of open science (and open access), through an activity called Next Generation Repositories (NGR). NGR defines the behaviours and technologies that need to be adopted by all repository platforms, which will enable the development of value-added services on top of the resources managed across the highly distributed repository network. The Pubfair model, published by COAR in late 2019, builds and expands on NGR recommendations to present an innovative and sustainable vision for open science. In addition, COAR has been working to aggregate the variety of recommended practices, certification schemas, and standards for repositories (related to discovery, access, reuse, preservation and sustainability) and assess their feasibility in different regions, with the aim of developing a multi-factored, international framework that defines the best practices for repositories around the world.

1.8.6. GO FAIR

GO FAIR offers an open and inclusive ecosystem by implementation networks (INs) in order to make data FAIR for stakeholders such as organisations and institutions, as well as individuals. There are three types of IN maintained by GO FAIR: GO CHANGE (focusing on socio-cultural change)⁹⁴; GO TRAIN (raising awareness of FAIR skills and principles in FAIR services and data)⁹⁵; and GO BUILD (coordinating technological matters of FAIR by building technically best practices and components)⁹⁶. While keeping a global perspective, GO FAIR also contributes to the developments in the federated EOSC, which can be seen as the European contribution to the Internet of FAIR Data and services: Europe's virtual

92 (n.d.). Groups - Research Data Alliance. Retrieved from <https://www.rd-alliance.org/groups>

93 (n.d.). Open Science Policy Platform | Open Science - Research and Retrieved 13 July 2020, from <https://ec.europa.eu/research/openscience/index.cfm?pg=open-science-policy-platform>

94 (n.d.). GO CHANGE - GO FAIR. Retrieved from <https://www.go-fair.org/go-fair-initiative/go-change/>

95 (n.d.). GO TRAIN - GO FAIR. Retrieved from <https://www.go-fair.org/go-fair-initiative/go-train/>

96 (n.d.). GO BUILD - GO FAIR. Retrieved from <https://www.go-fair.org/go-fair-initiative/go-build/>

environment for all researchers to access, store, manage, analyse and re-use data for research, innovation and educational purposes⁹⁷.

1.8.7. European data portal

European Data Portal (EDP)⁹⁸ has been the main point of access at the EU level to find public sector information published across Europe. Its objective is to improve access to and re-use of public sector information, foster high-quality open data publication at national, regional and local level, and increase its impact. Within this remit, the European Data Portal has been conducting an annual landscaping exercise⁹⁹ providing the EU MS with an assessment of their maturity level and documenting their year-on-year progress since 2015. The recent *Open Data Maturity Report 2019* describes how open data maturity is measured and provides a detailed assessment of the four open data dimensions: policy, portal, impact, and quality in the EU MS. It offers an overview of open data maturity in the EFTA countries and presents a clustering of the countries in four categories according to their performance¹⁰⁰. In addition, it provides a set of recommendations for the countries depending on the cluster they are associated with, providing indicative guidance for policy-makers, portal owners, and stakeholders in general to push the open data agenda forward.

1.8.8. Big Data Value Association

The Big Data Value Association (BDVA¹⁰¹) is an industry-driven international not-for-profit organisation, with 200 members throughout Europe and a well-balanced composition of large-, small-, and medium-sized industries, as well as research and user organisations. BDVA is the private counterpart to the EU Commission to implement the Big Data Value PPP program. BDVA and the Big Data Value PPP pursue a common shared vision of positioning Europe as a world leader in the creation of Big Data Value (high-volume, variety and verifiable information that enables enhanced decision making). The mission of the BDVA is to develop the Innovation Ecosystem that will enable the data and AI-driven digital transformation in Europe delivering maximum economic and societal benefit, and achieving and sustaining Europe's leadership on Big Data Value creation and Artificial Intelligence. The European Network of (55) National Big Data Centres¹⁰² establishes an open-source friendly environment and collects best practices and key achievements of each centre, defining challenges, meeting on a regular basis, and aligns with other European initiatives, with the ultimate goal of defining the data-driven future of Europe.

97 (n.d.). GO FAIR Initiative - GO FAIR. Retrieved from <https://www.go-fair.org/go-fair-initiative/>

98 (n.d.). European Data Portal. Retrieved from <https://www.europeandataportal.eu/en>

99 (n.d.). Open Data Maturity Report 2019 - European Data Portal. Retrieved from https://www.europeandataportal.eu/sites/default/files/open_data_maturity_report_2019.pdf

100 (n.d.). Open Data Maturity | European Data Portal. Retrieved March 20, 2020, from <http://www.europeandataportal.eu/en/impact-studies/open-data-maturity>

101 (n.d.). BDVA. Retrieved from <http://www.bdva.eu/>

102 (n.d.). Big Data Network Europe. Retrieved from www.big-data-network.eu

2. EOSC RELEVANT INFRASTRUCTURES AND INITIATIVES

The EOSC aims to be a sustainable ecosystem that links research data repositories and interconnect services and infrastructures (Budroni et al., 2019)¹⁰³. While the existing diversity of countries and stakeholders is a strength, it also makes coordination on an European level challenging. This is the reason why the most promising working concept of the EOSC is a federation of existing and relevant infrastructures and initiatives dispersed across countries and disciplines.

This chapter presents an overview of relevant EOSC infrastructures and other initiatives relevant to EOSC. Research infrastructures (RIs) are facilities that provide resources and services for research communities to conduct research and foster innovation. An overall description of the landscape of the relevant European infrastructures and e-infrastructures across different research areas is provided in the following sections, including specific examples of EOSC-relevant initiatives and projects, which are either community-driven or government (nationally) driven.

Inspired by the series of ESFRI strategic roadmap on RIs¹⁰⁴, most countries have developed national roadmaps for RIs, which are valuable sources of information. Taking stock of EOSC-related infrastructures, as recommended in the Council conclusions¹⁰⁵, is still at an early stage, and many countries do not yet have a fully developed countrywide research data repository. Tracking the development of such catch-all repositories and their European integration should be a component of the landscaping activity of EOSC. Sizable efforts have been undertaken by e-IRG to provide service catalogues. By repurposing content from its *Guide to e-infrastructure requirements for European Research Infrastructures*¹⁰⁶ and the Re3Data project¹⁰⁷, a global research data repository registry can be created.

2.1. e-Infrastructures

e-Infrastructures address the needs of European researchers for digital services in terms of networking, computing and data management, and foster the emergence of open science¹⁰⁸ as an essential block of the ERA¹⁰⁹. Federated, national infrastructures and European initiatives will benefit scientific communities by providing trusted and open environments to store, share and re-use scientific data and results, as well as benefit from fast connectivity, high-capacity cloud solutions, and supercomputing capability systems¹¹⁰.

103 (2019, December 14). Architectures of Knowledge: The European Open Science Cloud - de Gruyter. Retrieved from <https://www.degruyter.com/downloadpdf/j/abitech.2019.39.issue-2/abitech-2019-2006/abitech-2019-2006.pdf>

104 (n.d.). www.esfri.eu. Retrieved from <https://www.esfri.eu/>

105 (2018, May 18). 9029/18 MVG/evt 1 DG G 3 C 1. The European ... - Open Data. Retrieved from <https://data.consilium.europa.eu/doc/document/ST-9029-2018-INIT/en/pdf>

106 (n.d.). eirg-1004 - e-Infrastructures Reflection Group - e-IRG. Retrieved from <http://e-irg.eu/catalogue/eirg-1004>

107 (n.d.). Re3data. Retrieved from <http://re3data.org/>

108 (2019, November 5). Open Science | Shaping Europe's digital future. Retrieved from <https://ec.europa.eu/digital-single-market/en/open-science>

109 (2019, November 12). e-Infrastructures | Shaping Europe's digital future - European Retrieved from <https://ec.europa.eu/digital-single-market/en/e-infrastructures>

110 (n.d.). National Nodes - Getting organised; how far are we? - e-IRG. Retrieved from <http://e-irg.eu/documents/10920/238968/NationalNodesGettingorganisedhowfararewe.pdf>

The EC has launched the European Cloud initiative¹¹¹ to strengthen Europe's position in the global data-driven economy by introducing the EOSC and the European Data Infrastructure (EDI)¹¹².

This chapter identifies and lists EOSC target groups, which include data centres; data repositories; data archives; NRENs/computer centres, other institutions that store, operate and distribute data to researchers.

There is information on national e-infrastructures provided through the country sheets. Additional detailed information on how e-infrastructures are governed, operated, financed and accessed at the national level, is also provided in the report from e-IRG from 2019 *National Nodes – Getting organised; how far are we?*¹¹³. For more specific examples on networking and other services, see Section 3.2.

Throughout the MS and AC, there is a large variety of data processing services: from local, regional, and national services to international services. Large, international scientific collaborations have often created their own e-infrastructure ecosystem, for example, the Worldwide LHC Computing Grid (WLCG¹¹⁴), the highly distributed data processing approach for CERN's LHC experiments. Historically, data processing has been provided by two general classes of computation: as high-throughput computing (HTC) and high-performance computing (HPC). HTC systems involve running many independent tasks that require a large amount of computing power and are optimised for large data processing tasks. HPC is commonly used to describe super-computing facilities, which process data in parallel and are optimised for a maximum number of computing operations per second. Although communities and their use cases could be generally assigned to one of the two computing models until around 2010, in recent years, more and more cases of heterogeneous use cases have emerged, which require a mix of both, high-data throughput and large number of computing operations per second, and thus, demand heterogeneous systems.

Examples of separate HTC and HPC infrastructure systems on a national level include France, where national HPC centres are operated by CNRS, CEA, and the universities. Additional, regional HPC centres are usually operated by universities, often in collaboration with CNRS, and HTC services are mainly provided by CC-IN2P3 and Tier-2 centres and are then accessible through EGI.

In Italy, Cineca¹¹⁵ is the largest supercomputing centre dedicated to the academic and research community, and is one of the largest facilities in Europe. Large research performing organisations (RPOs) have developed in-house HPC and HTC infrastructures. INFN has a national infrastructure structured in tiers with a large centre, CNAF, and another 10-medium centre¹¹⁶. ENEAGrid CRESCO¹¹⁷ is coordinating the IBISCO project¹¹⁸ and the GARR Federated Cloud¹¹⁹. Italy will also host one of the three, pre-exascale

111 (2019, November 8). The European Cloud Initiative | Shaping Europe's digital future. Retrieved from <https://ec.europa.eu/digital-single-market/en/%20european-cloud-initiative>

112 (2018, January 31). The European Data Infrastructure (EDI) and the Data Challenge. Retrieved from <https://www.slideshare.net/EUDAT/the-european-data-infrastructure-edi-and-the-data-challenge>

113 <http://e-irg.eu/documents/10920/238968/NationalNodesGettingorganisedhowfararewe.pdf>

114 (n.d.). WLCG: Welcome to the Worldwide LHC Computing Grid. Retrieved from <https://wlcg.web.cern.ch/>

115 (n.d.). Cineca: Home. Retrieved from <http://www.cineca.it/>

116 (n.d.). INFN-CNAF. Retrieved from <https://www.cnaf.infn.it/en/>

117 (n.d.). How to get to Portici - ENEA-Grid. Retrieved from https://www.eneagrid.enea.it/CRESCOportal/howtogetthere_en.php

118 (n.d.). PON - INFN Sezione di Napoli. Retrieved from <https://www.na.infn.it/fondi-esterni/pon>

119 (n.d.). Cloud infrastructure | GARR - Consortium GARR. Retrieved from <https://www.garr.it/en/infrastructures/cloud-infrastructure/cloud-infrastructure>

supercomputers foreseen by the EuroHPC Joint Undertaking¹²⁰, through a consortium led by CINECA, INFN and SISSA. The supercomputer will be hosted at the Technopole in Bologna, which will also host the ECMWF¹²¹ computing centre, due to become operational in 2021.

A similar situation can be found in Germany, where high-performance computing is also organised in a tiered model. The national Tier-1 level is provided by 3 centres through the Gauss Centre for Supercomputing¹²². Several Tier-2 HPC systems can be found at universities like Aachen, Dresden, Göttingen, Darmstadt, Mainz, as well as at the Karlsruhe Institute of Technology (KIT). For HTC services and the management and analysis of large-scale data, KIT is also operating GridKa, the German WLCG Tier-1 data and analysis centre for particle physics (e.g. for the LHC experiments), that manages about 15% of the LHC data.

The separation of HPC and HTC on the national level can also be found in Serbia, where the Academic and Educational Grid Initiative of Serbia (AEGIS) is in charge of the development of High-Throughput Computing (HTC) resources, while the Institute of Physics Belgrade (IPB) coordinates the evolution of national High-Performance Computing (HPC) resources.

Countries, where HPC and HTC services are provided (at least in part) together on the national level, include Austria with the EODC (see above), Finland with the IT Center for Science (CSC – IT CENTER FOR SCIENCE LTD), Sweden via the Swedish National Infrastructure for Computing (SNIC), the Netherlands, where SURF (collaborative organisation for ICT in Dutch education and research), offers several services for research including HPC, data storage and management, Belgium with VSC, CÉCI, Cenaero and Space Pole, and Portugal. In the latter, the Fundação para a Ciência e a Tecnologia (FCT) provides HPC services, and is responsible for the operation of the national advanced computing network, although those functions may be outsourced to universities. The UK also has a federated e-infrastructure involving UKRI facilities (HPC, content and national scientific infrastructure), Jisc services and resources (content, analytics, AAI and network), national subject-specific repositories and university facilities.

Throughout several countries, EGI and EUDAT co-ordinate significant HTC and data services, respectively, at an international level based on a partnership model. Whereas HPC centres join the PRACE partnership initiative and participate in EuroHPC. The separation of the different types of computing e-infrastructure is at least in part due to European funding strategies and organisations. If the EOSC is to overcome this separation, the question of its relation to EuroHPC will need to be addressed.

2.2. Networking and other services

European countries have been developing research and education networks since the 1980s, and have collaborated on pan-European networking for nearly as long. Today, each European country has a National Research and Education Network (NREN), connecting research and higher education institutions with high-performance networks, and offering a range of related services.

120 (n.d.). EuroHPC. Retrieved from <https://eurohpc-ju.europa.eu/>

121 (n.d.). ECMWF. Retrieved from <https://www.ecmwf.int/>

122 (n.d.). Home Gauss Centre for Supercomputing e.V. Retrieved from <https://www.gauss-centre.eu/>

In terms of organisation and funding, the European NRENs are diverse. For example, some are funded directly from government budgets, other are funded by their connected institutions. Some are part of large organisations managing a variety of national e-infrastructures, while others are smaller organisations focussing on just the network. Nevertheless, they have important similarities. All NRENs offer high-performance networks suited to the special needs of research and education, with the headroom required for the bursts in traffic which are unique to research and large instruments, and the capability to serve research collaborations like ESFRI's with specialised network support.

Additionally, all European NRENs offer critical access and identity services such as eduroam and eduGAIN. These trust and identity services make up the foundation of services that allow secure access to research data, authentication to shared resources, and support for mobility and collaboration.

Many NRENs also offer storage services, computing services, and a range of security services.

2.2.1. European networking infrastructures

Together, the NRENs have formed the GÉANT Association, an organisation for European collaboration in research networks and the operator of the pan-European GÉANT network, with connectivity to other world regions. With support from the EC during decades of Framework Partnerships, the GÉANT network has been developed into a world-leading network, ensuring world-class connectivity to all European countries and making Europe a leading actor in global research networking and e-infrastructures.

GÉANT¹²³ is an e-infrastructure delivering the pan-European GÉANT network. Through its integrated catalogue of connectivity, collaboration and identity services, GÉANT provide users with highly reliable, unconstrained access to computing, analysis, storage, applications and other resources, to ensure that Europe remains at the forefront of research. GÉANT interconnects 38 National Research and Education Network (NREN) partners, and it is the largest and most advanced R&E network in the world. GÉANT connects over 50 million users at more than 10,000 institutions across Europe and supports all scientific disciplines. The backbone network operates at speeds of up to 500Gbps and reaches over 100 national networks worldwide. Since its establishment over 20 years ago, the GÉANT network has progressively developed to ensure that European researchers lead international and global collaboration. Over 1000 terabytes of data are transferred via the GÉANT IP backbone every day.

More than just an infrastructure for e-science, it stands as a positive example of European integration and collaboration. GÉANT develops and delivers advanced networks and associated e-infrastructure services. It supports open innovation, collaboration and knowledge-sharing amongst its members, partners and the wider research and education networking community. With more than 40 partners and associates across Europe and a multi-million euro budget, GÉANT has met the challenge of complex international project management. GÉANT also provides consultancy on network-related projects. GÉANT has national members (one per state) and representative members (represent at least two legal entities of different countries), associate (no voting rights) and the possibility of establishing working committees. According to the most recent report: more than 80% of the universities are connected to GÉANT, with 86% of all university-level students serviced in those 40 countries; that is, a total of 25 million university students. The GÉANT network

123 (n.d.). GÉANT. Retrieved from <https://www.geant.org/>

reaches in excess of 50 million users involved in research and education in the region¹²⁴. GÉANT network also offers connectivity to other world regions (AfricaConnect2¹²⁵, CAREN¹²⁶, EUMEDConnect3¹²⁷, EaPConnect¹²⁸, TANDEM¹²⁹ and others).

In the Western Balkans region, SEEREN and SEE-GRID initiatives have established the first SEE regional networking infrastructure and enabled its access to the pan-European GÉANT network. Finally, the GÉANT Compendium¹³⁰ of NRENs offers details on all NRENs across Europe.

2.2.2. National networking infrastructures

In the following sections, we describe, national networking infrastructures, highlighting examples of National Regional Education Networks (NRENs), and illustrating some commonalities and differences in these infrastructures, which are vital for the future EOSC. These examples are based on the information provided in Annex I.

2.2.2.1. Austria

Network services for the scientific community in Austria are provided by ACONet. ACONet¹³¹ is the Austrian National Research and Education Network (NREN) for science, research, education, and culture. It is operated by the Vienna University Computer Center, in cooperation with other universities in Austria. ACONet primarily connects and serves universities, research & education and cultural institutions; other public sector institutions (e.g. public administration, healthcare) are also welcome.

ACONet provides a nation-wide fibre optic backbone¹³² with high-performance access to international academic networks via GÉANT, as well as to the Internet. Furthermore, ACONet offers its members various target-group-specific services¹³³ to support research projects and communities. The legal and operational entity of ACONet is the University of Vienna. Its governance is based on MoU between University of Vienna and the legally independent ACONET Association (members are all universities and some other ACONet participants); the technical advisory group of all participating organisations meets twice/year, with the strategic advisory group, the board of ACONET Association, meeting on at least a quarterly basis.

2.2.2.2. Belgium

Belnet¹³⁴ is the Belgian national research network that provides high-bandwidth internet connection and services to Belgian universities, colleges, schools, research centres and government departments. Furthermore, Belnet also works on the BNIX platform, i.e. the Belgian internet exchange that makes possible high-speed data exchange, among

124 (2017, May 15). D2.1: Draft Stakeholder Map. EOSCpilot Deliverable Template. Retrieved from <https://eoscpilot.eu/sites/default/files/eoscpilot-d2.1.pdf>

125 (n.d.). Français - AfricaConnect2. Retrieved from <https://www.africaconnect2.net/Francais/Pages/Home.aspx>

126 (2017, April 25). CAREN project brings Gigabit-speed connectivity to Central Asia. Retrieved from https://caren.geant.org/Media_Centre/News/Pages/CAREN-project-brings-Gigabit-speed-connectivity-to-Central-Asia.aspx

127 (n.d.). EUMEDCONNECT3 Home. Retrieved from <https://www.eumedconnect3.net/Pages/Home.aspx>

128 (n.d.). EaP Connect - EaP. Retrieved from <https://www.eapconnect.eu/>

129 (n.d.). Project key facts – TANDEM WACREN. Retrieved from <https://www.tandem-wacren.eu/about-tandem/project-key-facts/>

130 (n.d.). GÉANT Compendium of NRENs. Retrieved 30 April 2020, from <https://compendium.geant.org/>

131 (n.d.). ACONet. Retrieved from <https://www.aco.net/>

132 (2018, June 6). ACONet Backbone. Retrieved from <https://www.aco.net/backbone.html?L=1>

133 (2019, October 8). Services & Tools - ACONet. Retrieved from <https://www.aco.net/services.html?L=1>

134 (n.d.). Belnet. Retrieved from <https://belnet.be/en>

others, between Internet service providers and Internet content providers in Belgium. Belnet is a federal government organisation and belongs to the Federal Science Policy. The VON is the physical glass fibre network connecting over a hundred sites of universities, institutes of higher education and research centres in Flanders to Belnet, with a minimum of 1 Gigabit ranging to 10 gigabit and more. The network is currently being upgraded to 100-gigabit readiness for research bandwidth.

2.2.2.3. Finland

Funet¹³⁵ (Finnish University and Research Network) is a high-speed data communications network serving the Finnish research community. It connects about 80 research organisations. CSC – IT CENTER FOR SCIENCE LTD maintains and develops the Funet network. CSC – IT CENTER FOR SCIENCE LTD has an important role as an instrument for helping to implement the policies and development programmes of Finnish Ministry of Education, Science and Culture. CSC – IT CENTER FOR SCIENCE LTD is owned by the Finnish state (70% shareholding) and higher education institutions (30% shareholding).

2.2.2.4. France

Network services for the scientific community in France are provided by RENATER¹³⁶ (Réseau National de télécommunications pour la Technologie, l'Enseignement et la Recherche). RENATER is a public interest group. Its members are major research organisations: CNRS, CPU, CEA, INRIA, CNES, INRA, INSERM, ONERA, CIRAD, IRSTEA, IRD, BRGM, as well as the Ministry of Higher Education, Research and Innovation (MESRI). RENATER also manages the SFINX traffic exchange point, and has research project links with CERN. It provides a network connecting more than 1,300 sites via links with 10 Gbps. Higher bandwidth is available e.g. between centres in Paris and Lyon (100 Gbps), between Lyon and Marseille (80 Gbps), and towards CERN (60 Gbps via Lyon and Grenoble). RENATER is connected to the pan-European GÉANT network. It is also connected to the Internet, in France via an exchange point, the SFINX and to the world via 2 IP Transit links in Paris and Marseille. RENATER's annual budget is about EUR30 M.

2.2.2.5. Germany

Science itself has left the German National Research and Education Network (DFN¹³⁷) organise the communications network for Science and research in Germany. The research and education network X-WiN is the technical platform of DFN. Universities, research institutions and research departments of commercial enterprises are connected with one another in Germany, and are networking with the research and education networks in Europe and on the other continents via X-WiN. Moreover, X-WiN has high-performance peering points with the Internet at its disposal. With a connecting capacity of up to 100 gigabits and a multi-terabit core network, which spans about 60 core locations, X-WiN is one of the most powerful communications networks in the world. In addition, the DFN offers its users a multitude of customised applications for communication. It is constantly being enhanced by new and innovative applications, which are developed and tested in projects and piloting ventures. The association to promote the German education and research network, DFN-Verein, organises DFN and guarantees its further development and use. DFN-Verein is an acknowledged non-profit

135 (n.d.). Funet services - CSC. Retrieved from <https://www.csc.fi/funet-kaikki-palvelut>

136 (n.d.). Accueil | RENATER. Retrieved from <https://www.renater.fr/>

137 (n.d.). DFN-Verein: Welcome to DFN. Retrieved from <https://www.dfn.de/en/>

association. DFN-Verein provides further training to its users conducting conferences and workshops. Moreover, there are contacts in various competence centres available to provide advice and support with important questions concerning the use of the services.

2.2.2.6. Greece

GRNET, National Infrastructures for Research and Technology, is the Greek national research network. GRNET is a state-owned company, operating under the auspices of the Greek Ministry of Digital Governance. GRNET is an integrated e-infrastructure service provider and offers an environment of cutting-edge technologies providing infrastructural and technological support to academic and research institutions, to educational bodies at all levels, and agencies of the public sector. GRNET is the main infrastructure and service enabler for open science in Greece, and leads the coordinated development of e-infrastructures and services in Southeast Europe (SEEREN, SEE-GRID series, HP-SEE, VI-SEEM, NI4OS projects) and the wider region.

GRNET has also been involved in the pan-European and global integration efforts in the full spectrum of e-infrastructure technologies over the past 20 years. This covers the underlying networking technologies within GÉANT, Grid/Cloud/High-Throughput Computing via EGI, data infrastructures via EUDAT, and High-Performance Computing via PRACE and EuroHPC. GRNET operates a backbone network covering the whole national territory: more than 9000 km of dark fibre, operated by GRNET-owned equipment, with several 10Gbps connections to 50 Institutions. GRNET is interconnected with pan-European network GÉANT with 4x10Gbps uplinks, where it has an active role in pan-European network operations, and has linked the Southeast European region to GÉANT through SEEREN projects. GRNET is the leading cloud computer and data infrastructure provider for R&E community in Greece and beyond.

Regarding data storage, GRNET has over 11 Petabytes of raw disk storage and 7 Petabytes of tape archive. Concerning cloud computing, GRNET operates Infrastructure as a Service via large datacentres (135 racks, 1800+ servers, 7000 Virtual Machines active, 5 Petabytes of storage). In the realm of High-Performance Computing (HPC), GRNET is currently operating the Greek national HPC Tier-1 centre – ARIS (Advanced Research Information System). The total theoretical peak performance of the whole system is 434 Tflops.

2.2.2.7. Ireland

HEAnet is Ireland's National Research and Education Network, providing resilient Gigabit network connectivity to all Irish Universities, Technological Universities, Institutes of Technology, other higher education institutions (HEIs), research organisations. HEAnet also connects all primary and post-primary schools across Ireland. HEAnet's extensive portfolio of shared services encompasses Data Centre hosting, Managed Applications, worldwide WiFi roaming, media storage, a multi-platform video collaboration network and more, all secured and supported by experts. HEAnet has particular expertise in the area of federated access and authentication services. HEAnet is a long-standing member of the GÉANT Association and is an active participant in many of GÉANT's EC-funded projects.

From a critical research infrastructure perspective, HEAnet connects:

- **Irish Centre for High-End Computing (ICHEC)**
ICHEC (Irish Centre for High-End Computing) delivers complex compute solutions to Irish HEAs, Enterprises and the Public Sector on behalf of the State. It is Ireland's lead authority in High-Performance Computing (HPC) at a national and international level and manages the national HPC infrastructure, Kay.
- **I-LOFAR (Ireland)**
I-LOFAR is the Irish station in a European-wide network of state-of-the-art radio telescopes, used to observe the Universe at low frequencies (10-240 MHz). This observing facility in Birr Castle¹³⁸, Co. Offaly is located in the midlands of Ireland and connects Ireland to the International LOFAR Telescope¹³⁹, which is one of the most sophisticated and advanced astrophysics research projects in the world.

2.2.2.8. Italy

The GARR network¹⁴⁰ interconnects, at ultra-high capacity, around 1,000 among universities, research centres, libraries, museums, schools and other education, science, culture and innovation facilities. The fibre optic infrastructure is based on leading-edge telecommunication technologies and covers more than 15,000 km of backbone and access links. As of today, the capacity of single backbone links reaches 200 Gbps, while access links can reach 200 Gbps depending on the connected site's bandwidth requirements.

At the physical level, the network is almost completely implemented with dark fibre, connecting the network's Points of Presence with each other and to the numerous user sites (~1000). Only in those cases where fibre links are not available and bandwidth requirements are low, alternative technologies may be used to connect peripheral sites. On top of the physical level, the network has two layers, for transmission and IP/MPLS. In its position of unique national high-performance network provider for research, GARR is involved in INFN's Data Lake project. DL project's overarching objective is to create a distributed data storage on a national scale, from where data could be retrieved irrespective of the physical location of the CPUs where they will be processed. The model foresees to create a relatively small group of distributed large Storage Data Centres, managed and accessed as single entities. This will be done using the Data Centre Interconnection (DCI) technology, that allows high-capacity, low-latency interconnection of geographically separated data centres as if their resources were on the same LAN. DCI was already successfully implemented in several cases, including the single-fibre point-to-point interconnection between CNAF and CINECA that can reach 1.2 Tbps capacity.

2.2.2.9. Norway

Norwegian research institutions have the benefit of cost-effective, coordinated e-infrastructure for research and higher education in many subject areas. UNINETT AS¹⁴¹ develops and operates the Norwegian high-performance network for research and education, connecting over 200 Norwegian institutions and over 300 000 users and linking them to international research networks. UNINETT AS is a non-commercial

138 (n.d.). Welcome to Birr Castle, Gardens & Science Centre | Ireland. Retrieved 30 April 2020, from <https://birrcastle.com/>

139 (n.d.). LOFAR | LOFAR. Retrieved 30 April 2020, from <http://www.lofar.org/>

140 (2019, October 4). Home | GARR - Consortium GARR. Retrieved from <https://www.garr.it/en/>

141 (n.d.). Uninett: Kunnskaps-Norges IKT-infrastrukturselskap. Retrieved from <https://www.uninett.no/>

enterprise owned by the Ministry of Education and Research. Affiliation with the research network is the basis for most other services provided by UNINETT AS. Sigma2 also heads and coordinates Norway's participation in international collaborations on e-infrastructure, such as the Nordic e-Infrastructure Collaboration (NeIC), PRACE and the EUDAT.

2.2.2.10. Poland

The PIONIER¹⁴² network is a nationwide broadband optical network constituting the basis for research and development in the field of information technology and telecommunications, computer sciences (networks, etc.), applications and services for the information society. Built entirely from KBN (Research Committee), it currently connects 21 Centres of the Metropolitan Area Network (MAN) and 5 Centres of High Performance Computing (HPC).

The infrastructure of the PIONIER network is based on its own fibre optic network in Poland and on long-term leased (IRU) fibre connections to Hamburg, Frankfurt/Main and CERN, where the total length of the network exceeds 9000 km. Network services are based on an optical network currently working at 400 Gbps and 100 Gbps lambdas in the backbone of the network, and offers unique services for the scientific community, e.g. quantum key distribution network or time and frequency distribution network.

2.2.2.11. Portugal

RCTS – The Science, Technology and Society Network – is the national education and research network. Managed and operated by FCCN, the RCTS is the unit of the Foundation for Science and Technology (FCT) responsible for national scientific computing, and offers researchers, teachers, and students a high-performance digital infrastructure to support projects on a national and international level. FCT is developing a national advanced computing network, which will integrate resources from the EuroHPC Joint Undertaking. In terms of data infrastructure, 2020 plans include the Portuguese node of EUDAT, as well as Dataverse for the long tail of research data. FCT is also responsible for the infrastructure RCAAP (Scientific Open Access Repositories of Portugal). Among other services, RCAAP offers SaaS hosting services for repositories (based on DSpace) and Open Access journals (based on OJS).

2.2.2.12. Sweden

The Swedish University Computer Network (Sunet)¹⁴³ is the Swedish NREN, providing infrastructure for national and international data communication at universities, colleges and other affiliated organisations. The joint organisation forms a network for research and education and offers a variety of data services. Sunet is part of the Swedish Research Council and is a GÉANT and NORDUnet partner (collaboration among the Nordic NRENS).

2.2.2.13. Switzerland

The private foundation SWITCH¹⁴⁴ offers collaboratively developed ICT solutions for the Swiss academic community. It operates SWITCHlan connecting universities with a data network and offering other network services, as well as the authentication and

142 (n.d.). PIONIER Network - PIONIER online. Retrieved from <http://www.pionier.net.pl/online/en/projects/69/>

143 (n.d.). About Sunet | SUNET. Retrieved from <https://www.sunet.se/about-sunet/>

144 SWITCH: <https://www.switch.ch/>

authorisation infrastructure SWITCHaaI. The latter will be replaced with SWITCH edu-ID, which will additionally provide a lifelong and user-centric identity. SWITCH is a member of GÉANT and posts a delegate to e-IRG.

2.2.2.14. United Kingdom

Janet is the UK's national research and education network, provided by Jisc. It is the network dedicated to the needs of research and education in the UK. It connects the UK's research and education institutions to each other, as well as to the rest of the world through links to the global Internet. In addition, Janet includes a separate network (Aurora) that is available to the community for experimental activities in network development.

The Janet network connects UK universities, FE Colleges, Research Councils, Specialist Colleges and Adult and Community Learning providers. It also provides connections between the Regional Broadband Consortia to facilitate the Department for Education's initiative for a national schools' network. Over 18 million end-users are currently served by the Janet network.

The range of activities facilitated by Janet allows individuals and institutions to push back the traditional boundaries of teaching, learning and research methods. For researchers, the high capacity of the Janet backbone allows the linking of large data storage and high performance computing facilities at a national and international level.

Further information about Jisc can be found at <https://www.jisc.ac.uk/> and the Janet network at <https://www.jisc.ac.uk/connectivity-services>

2.3. Data infrastructures

According to the Open Data Institute definition, 'Data infrastructures consist of data assets supported by people, processes and technology'¹⁴⁵. In the context of this report, we consider data infrastructures the technical and human infrastructures which support management and sharing of research data. The Re3Data project¹⁴⁶ provides a global research data repository registry.

EUDAT¹⁴⁷ is a Collaborative Data Infrastructure (CDI), which manages data spanning from European research data centres and community data repositories. EUDAT aims to support sharing and preserving data across borders and disciplines. European researchers and practitioners from any research discipline can preserve, find, access, and process data in a trusted environment. EUDAT offers heterogeneous research data management services and storage resources, supporting multiple research communities as well as individuals, through a geographically distributed, resilient network distributed across 15 European countries. Data is stored alongside some of Europe's most powerful supercomputers. One of EUDAT's main ambitions is to bridge the gap between RIs and e-infrastructures through an active engagement strategy, using the communities that are in the consortium as EUDAT beacons and integrates others through innovative partnerships. EUDAT offers common data services, supporting multiple research communities as well as individuals.,

145 Data infrastructure - The ODI - <https://theodi.org/topic/data-infrastructure/>

146 (n.d.). Re3data. Retrieved from <http://re3data.org/>

147 (n.d.). EUDAT - Research Data Services, Expertise & Technology Retrieved from <https://eudat.eu/>

through a network of 36 European organisations. Its main services are the following: B2DROP¹⁴⁸, B2SHARE¹⁴⁹, B2SAFE¹⁵⁰, B2STAGE¹⁵¹, B2FIND¹⁵², B2HANDLE¹⁵³, B2ACCESS¹⁵⁴. EUDAT has a dual governance structure. As an EU funded project, it operates through the respective bodies found in most EU projects, i.e. as defined by its Consortium Agreement. As an e-infrastructure that provides a set of common data services, it operates on the basis of the EUDAT CDI. Generic and thematic service providers may join the EUDAT CDI network by signing a specific collaboration agreement.

Scholarly communication initiatives and services are a relevant component of the current landscape, especially for the long tail of science. These initiatives originated from the movement to provide open access to publications, but are now applying open access principles to data (e.g. FAIR data) and other types of research products. OpenAIRE is a key initiative in this area having started as a supporting facility for OA policy of FP7 and H2020, and developing a set of mechanisms to implement and monitor open science in Europe. Services which OpenAIRE can provide within the EOSC are:

- a recognised national network of 35 nodes (National Open Access Desks¹⁵⁵), which are expert organisations offering local support, training and policy alignment on open access and RDM;
- a suite of standards, the OpenAIRE Guidelines for Content providers¹⁵⁶, and services to allow content providers to make publications, data, software to share them in EOSC following open and FAIR principles (more than 1000 already registered);
- a set of services to help researchers do open science:
 - Zenodo¹⁵⁷ – a catch all repository,
 - Argos¹⁵⁸ – an actionable DMP service linked out of the box to EU and national infrastructures,
 - Amnesia¹⁵⁹ – an anonymisation tool,
 - the OpenAIRE Research Graph¹⁶⁰, a global contextual catalogue of research results linked together which is the basis for intelligent, AI-based discovery,
 - the Open Science Observatory¹⁶¹ to monitor different aspects of open science in Europe.

A basic set of data management services for archival, data discovery, and sharing, as well as an open digital repository, are offered to the South-East European researchers through the VI-SEEM initiative. At the moment, these services are managed by the NI4OS-Europe project.

148 (n.d.). B2DROP - EUDAT. Retrieved from <https://www.eudat.eu/services/b2drop>

149 (n.d.). b2share - EUDAT. Retrieved from <https://b2share.eudat.eu/>

150 (n.d.). B2SAFE - EUDAT. Retrieved from <https://www.eudat.eu/b2safe>

151 (n.d.). B2STAGE - EUDAT. Retrieved from <https://www.eudat.eu/b2stage>

152 (n.d.). B2FIND - EUDAT. Retrieved from <https://eudat.eu/services/b2find>

153 (2016, November 7). B2HANDLE - EUDAT. Retrieved from <https://www.eudat.eu/services/userdoc/b2handle>

154 (n.d.). B2ACCESS - EUDAT. Retrieved from <https://eudat.eu/services/b2access>

155 <https://www.openaire.eu/noad-activities>

156 <https://guidelines.openaire.eu/>

157 <https://zenodo.org/>

158 <https://argos.openaire.eu/>

159 <https://amnesia.openaire.eu/>

160 <https://www.openaire.eu/blogs/the-openaire-research-graph>

161 Service release date May 2020. Beta at beta.observatory.openaire.eu

Beyond Europe, the scholarly communication and long-tail data domain are dominated by US initiatives: Open Science Framework¹⁶², The Mendeley Data¹⁶³, National Data Service¹⁶⁴, Dryad digital repository¹⁶⁵ and Harvard Dataverse¹⁶⁶, ScienceOpen¹⁶⁷, Unpaywall¹⁶⁸, CyVerse¹⁶⁹, and Google Dataset Search¹⁷⁰. Other relevant initiatives are the Federated Research Data Repository¹⁷¹ (Canada), the Australian National Data Service¹⁷² hosting the Research Data Australia discovery portal¹⁷³, and the NCI National Research Data Collection¹⁷⁴ (Australia). There are many Chinese repositories with a more focused scope, making good progress in key aspects of open data. A notable example is the Fudan University Social Science Data Repository¹⁷⁵.

As regards big data, several initiatives are being established by developed countries around the world¹⁷⁶, e.g. Japan, which ranks third in the world for the size of the economy and has high-level ICT infrastructure and the world's leading service providers in ICT as Fujitsu, Hitachi, NTT Data and NEC. Big data is one of the main economic priorities for the Japanese government, and a number of strategies have been adopted by the government in this area. The Japanese government adopted Japan Revitalisation Strategy, which outlines the creation of strong infrastructure and facilities to connect to data services market and plans to make Japan the world leader in information technology¹⁷⁷.

2.4. Computing infrastructures

Computing infrastructures typically include high performance computing (HPC) optimised for high memory and CPU intensive tasks and high throughput computing (HTC) optimised for tasks which can be divided into subtasks which distributed across multiple servers; however, infrastructures for more specialised computing architectures also exist (e.g. GPU clusters).

At the European level, there are two significant infrastructures supporting HPC: EuroHPC and PRACE.

EuroHPC will permit the EU and participating countries to coordinate their efforts and share resources with the objective of deploying in Europe a world-class supercomputing infrastructure and a competitive innovation ecosystem in supercomputing technologies,

162 (n.d.). OSF.io. Retrieved from <https://osf.io/>

163 (n.d.). Mendeley Data. Retrieved from <https://data.mendeley.com/>

164 (n.d.). National Data Service: Home. Retrieved from <http://www.nationaldataservice.org/>

165 (n.d.). Data Dryad. Retrieved from <https://datadryad.org/stash>

166 (n.d.). Harvard Dataverse. Retrieved from <https://dataverse.harvard.edu/>

167 (n.d.). ScienceOpen. Retrieved from <https://www.scienceopen.com/>

168 (n.d.). Unpaywall. Retrieved from <https://unpaywall.org/>

169 (n.d.). The Project | CyVerse. Retrieved from <https://cyverse.org/about>

170 (n.d.). Dataset Search - Google. Retrieved from <https://toolbox.google.com/datasetsearch/search?query=10.5064>

171 (n.d.). Data Publication | FRDR-DFDR. Retrieved from <https://www.frdr-dfdr.ca/repo/>

172 (n.d.). Home - ANDS. Retrieved from <https://www.ands.org.au/>

173 (n.d.). Research Data Australia - ANDS. Retrieved from <https://www.ands.org.au/online-services/research-data-australia>

174 (n.d.). Data Collections Management | NCI. Retrieved from <https://nci.org.au/our-services/data-collections-management>

175 (2015, February 12). Featured Dataverse Repository: Fudan University. Retrieved from <https://dataverse.org/blog/featured-dataverse-repository-fudan-university>

176 (2017, June 16). big data initiatives of developed countries - ResearchGate. Retrieved from https://www.researchgate.net/publication/317486245_BIG_DATA_INITIATIVES_OF_DEVELOPED_COUNTRIES

177 (n.d.). Prime Minister of Japan and His Cabinet. Retrieved from <https://japan.kantei.go.jp/>

applications and skills¹⁷⁸. The EuroHPC Joint Undertaking is a legal and funding entity with the aim of developing a pan-European supercomputing infrastructure and supporting research and innovation activities by developing a European supercomputing ecosystem, stimulating a technology supply industry, and making supercomputing resources in many application areas available to a large number of public and private users¹⁷⁹.

The Members of the Joint Undertaking are the following:

- the European Union, represented by the Commission;
- Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Montenegro, the Netherlands, North Macedonia, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and Turkey;
- the European Technology Platform for High-Performance Computing (ETP4HPC) Association and the Big Data Value Association¹⁸⁰.

PRACE (Partnership for Advanced Computing in Europe)¹⁸¹ offers a pan-European supercomputing infrastructure, providing access to computing and data management resources and services for large-scale scientific and engineering applications at the highest performance level. PRACE aims to support all scientific disciplines that need HPC to achieve high impact discovery by offering world-class computing and data management resources and services through a centralised peer review process. The computer systems and operations accessible through PRACE are provided by PRACE members. Four hosting members (BSC¹⁸² representing Spain, CINECA¹⁸³ representing Italy, GCS¹⁸⁴ representing Germany and GENCI¹⁸⁵ representing France) secured funding for the initial period from 2010 to 2016.

PRACE has 26 members, representing European Union Member States and Associated Countries.

The PRACE RI has two forms of members:

- Members – a government organisation or legal entity representing a government. The PRACE RI accepts only one member per Member State of the European Union or an associated country as described in article 217 of the European Union Treaty. Further, to be eligible as a PRACE RI member the legal entity must be responsible for the provisioning of HPC resources and associated services.
- Hosting Members are members who have committed to fund and deliver PRACE RI computing and data management resources. There are 5 Hosting Members: France, Germany, Italy, Spain, and Switzerland¹⁸⁶

178 <https://eurohpc-ju.europa.eu/>

179 <https://ec.europa.eu/digital-single-market/en/eurohpc-joint-undertaking>

180 EUROHPC About members, <https://eurohpc-ju.europa.eu/members.html>

181 (n.d.). PRACE. Retrieved from <https://prace-ri.eu/>

182 (n.d.). BSC-CNS | Barcelona Supercomputing Center - Centro Retrieved from <https://www.bsc.es/>

183 (n.d.). Cineca: Home. Retrieved from <http://www.cineca.it/>

184 (n.d.). Home Gauss Centre for Supercomputing e.V. Retrieved from <https://www.gauss-centre.eu/>

185 (n.d.). Genci. Retrieved from <http://www.genci.fr/fr>

186 (n.d.) PRACE Members from: [.https://prace-ri.eu/about/members/](https://prace-ri.eu/about/members/)

In 2017, PRACE has engaged in the second period of the Partnership, securing the operations of the infrastructure until 2020, and adding a fifth Hosting Member, ETHZ¹⁸⁷ representing Switzerland. During this second phase, PRACE will offer an initial performance above 62 Petaflops in 7 complementary leading-edge systems, offering a total of 4000 million core-hours per year (75 million node hours).

In pace with the needs of the scientific communities and technical developments, systems deployed by PRACE are continuously updated and upgraded to be at the apex of HPC technology. Reducing the lifetime cost of systems and their operations, especially energy consumption and environmental impact, is one of the goals of PRACE. PRACE undertakes similar software and hardware technology initiatives with the goal of preparing for changes in the technologies used in RI and to provide the proper tools, education and training for the user communities to adapt to those changes. PRACE has further initiated the formation of STRATOS (PRACE advisory group for Strategic Technologies) – an organisation for collaboration with industry and other non-PRACE partner organisations. The PRACE leadership systems form the apex of resources for large-scale computing and data management for scientific discovery, engineering research and development for the benefit of Europe and are well integrated into the European HPC ecosystem.

PRACE also offers training services to users, through the PRACE Advanced Training Centre (PATC), PRACE Training Centres (PTC), PRACE seasonal school, and through online training material, including Massive Open Online Courses (MOOCs). Some joint training activities are provided by PRACE and EUDAT¹⁸⁸. PRACE is also using some services of **GÉANT's**¹⁸⁹ network e-infrastructure to provide European users access to Tier-0 systems¹⁹⁰. The PRACE project partners received funding from the EC under the PRACE Preparatory and Implementation Phase Projects¹⁹¹ for a total of €97 million, complemented by the consortium budget of over €60 million.

In the South-East European region, through the HP-SEE and LinkSCEEM initiatives, available HPC resources were unified into the infrastructure, whose capacity includes 45k CPU cores, 1.2M GPU cores (516 GPU cards), 21k Xeon Phi cores (336 Xeon Phi cards), and 18 PB of storage space. Three of these HPC sites (Avitohol, Leo, Aris) were present for some time at the Top500 list of supercomputers. Although these resources are not comparable to the previously listed initiatives, in terms of capacity, in terms of human capacity and capability, these form a strong base that supports European and EOSC aims.

In the field of HPC, the two major US projects (National Strategic Computing Initiative¹⁹² and the Exascale Computing Project¹⁹³) and the Japanese Flagship2020¹⁹⁴ are highlighted by **RISCAPE** in addition to the EuroHPC. The broader global scale includes the

187 (n.d.). ETH Zürich - Homepage | ETH Zürich. Retrieved from <https://ethz.ch/de.html>

188 (n.d.). EUDAT - Research Data Services, Expertise & Technology Retrieved from <https://eudat.eu/>

189 (n.d.). GÉANT. Retrieved from <https://www.geant.org/>

190 (2017, May 15). D2.1: Draft Stakeholder Map. EOSCpilot Deliverable Template. Retrieved from <https://eoscspilot.eu/sites/default/files/eoscspilot-d2.1.pdf>

191 PRACE-PP, 2008-2010, RI-211528; PRACE-1IP, 2010-2012, RI-261557; PRACE-2IP, 2011-2013, RI-283493; PRACE-3IP, 2012-2017, RI-312763; PRACE-4IP, 2015-2017, RI-653838; PRACE-5IP, 2017-2019, RI-730913.

192 (n.d.). The National Strategic Computing Initiative (NSCI) - nitrd. Retrieved from <https://www.nitrd.gov/nsci/>

193 (n.d.). Exascale Computing Project: Home Page. Retrieved from <https://www.exascaleproject.org/>

194 (n.d.). Flagship 2020 Project (Supercomputer Fugaku) | RIKEN Retrieved from <https://www.r-ccs.riken.jp/en/overview/exascalepj>

Supercomputing Consortium of Russian Universities¹⁹⁵ and the South African National Integrated Cyber Infrastructure System¹⁹⁶ (NICIS).

In terms of HTC, at the European level, **EGI**¹⁹⁷ is a federated e-infrastructure initially set up in order to provide advanced computing services for R&I using grid-computing techniques but which now also encompassed cloud computing infrastructures. EGI is publicly funded and comprises over 300 data centres and cloud providers spread across Europe and worldwide. EGI offers a wide range of services for compute, storage, data and support. EGI has been funded by a series of EC research projects such as DataGrid and Enabling Grids for E-science.

EGI creates and delivers open solutions for science and RIs by federating digital capabilities, resources and expertise between communities and across national boundaries. Researchers from all disciplines have easy, integrated and open access to the advanced scientific computing capabilities, resources and expertise needed to collaborate and to carry out data/compute intensive science and innovation.

Regarding the services, EGI delivers advanced computing services to support scientists, multinational projects and RIs. The EGI services are provided by EGI's federated cloud providers and data centres. The services can be requested by anyone involved in academic research and businesses and they can be categorised in the following groups: computing, storage and data, training. EGI provides access to over 700 000 logical CPUs and 500 PB of disk and tape storage.

2.5. Thematic infrastructures

RIs are key elements of modern research. By providing services to a very broad variety of users, they create a shared and collaborative research environment, the so-called RI ecosystem, which has shaped big science for decades. In Europe, this includes the creation of the European Organization for Nuclear Research (**CERN**¹⁹⁸) in the mid-1950s, for particle physics research, and the European Southern Observatory (**ESO**¹⁹⁹) for astronomy in the early 1960s. From their early beginnings, both of this large RIs faced the challenge of managing large amounts of data they produced by developing data technologies and related policies.

RIs also had to develop schemes and processes to overcome challenges raised by the growth of the number of transnational RIs, the increased complexity of scientific problems and societal challenges (often requiring the collaboration of diverse user communities) and the exponential growth of data. Data protocols, quality control and management plans throughout the entire data lifecycle were developed along with the relevant technologies. Thematic RIs are therefore an indispensable and even a driving element of the EOSC data management chain.

The European Strategy Forum on Research Infrastructures (**ESFRI**) was founded in 2002, to coordinate the effort and support the development of a truly European RI policy. ESFRI succeeded in developing a common European approach for the strategic planning and

195 (2009, September 12). Новые издания книг серии IBM Redbooks ... - hpc@cmc. Retrieved from <http://hpc.cmc.msu.ru/node/136>

196 (n.d.). National Integrated Cyber Infrastructure System | CSIR. Retrieved from <https://www.csir.co.za/national-integrated-cyber-infrastructure-system>

197 (n.d.). EGI.eu. Retrieved from <https://www.egi.eu/>

198 (n.d.). CERN: Home. Retrieved from <https://home.cern/>

199 (n.d.). ESO, the European Southern Observatory | ESO. Retrieved from <https://www.eso.org/public/about-eso/esog glance/>

operations of the major RIs throughout their lifecycle²⁰⁰. ESFRI has been particularly successful, not only in coordinating European-wide collaborations of distributed RIs, including e-infrastructures²⁰¹, but also in triggering cooperation with sustained funding and service models of large, single sited RIs, forming vertical RI clusters that are horizontally interlinked to be able to address globally important scientific and technological challenges. The European landscape of RIs extends far beyond the ESFRI roadmaps²⁰² and the corresponding landscape analysis. It is supported by numerous national roadmaps, and embedded into the global environment. To map the entire global RI ecosystem is not trivial. ESFRI is developing strategic approaches to bridge national and European strategies in EOSC-related RI policies²⁰³. An EOSC Taskforce has been created to help ESFRI to tackle the EOSC issues and provide a platform for the exchange of information. One visible action of the EOSC ESFRI task force is the organisation of ESFRI EOSC workshops²⁰⁴.

The **InRoad** project²⁰⁵ has provided some evidence as regards national RI policy making. Scientists in some domains are undertaking efforts to describe their specific landscapes²⁰⁶. Several attempts to map c.1000 smaller facilities in Europe have been undertaken by the MERIL project²⁰⁷. Analysis of the situation has been done by the OECD GSF and the G8 GSO. However, a systematic study at the global scale is now being undertaken by the RISCAPe project²⁰⁸. The RISCAPe landscape report²⁰⁹ is to conduct an analysis of the RI landscape outside of Europe, with a European perspective based on the ESFRI infrastructure framework and with a particular focus on data issues.

The ESFRI *Strategy Report on Research Infrastructures* (ESFRI²¹⁰) includes the Roadmap with ESFRI projects and ESFRI landmarks and the ESFRI vision of the evolution of RIs in Europe, addressing the mandates of the European Council, and identifying strategy goals:

- The first part presents 18 ESFRI Projects and 37 ESFRI Landmarks. It also includes an analysis of the evolving role of the RIs, which reflects the specific mandates from the European Council to address the FAIR data principles and e-infrastructure, the Long-Term Sustainability and the benefits for innovation. The background of ESFRI and its history over the last 16 years complete this part.
- The second part provides the current context of the most relevant RIs that are available to European scientists through a landscape analysis.
- The third part, Projects and Landmarks, describes – through dedicated cards – each ESFRI Project and each ESFRI Landmark. A short description of the RI is given as well as updated information on the legal status, the timeline for construction/operation, and the estimated costs.

ESFRI aims to contribute to an effective and efficient approach to e-infrastructure and services (vertical and horizontal) for European science and its competitiveness in the global

200 (n.d.). e-Infrastructures Group | www.esfri.eu. Retrieved from <https://www.esfri.eu/working-groups/e-infrastructures-group>

201 (n.d.). Data, Computing and Digital Research Infrastructures - ESFRI Retrieved from <https://www.esfri.eu/working-groups/data-computing-and-digital-research-infrastructures>

202 (n.d.). ESFRI Roadmap 2018: Foreword. Retrieved from <http://roadmap2018.esfri.eu/>

203 (n.d.). www.esfri.eu. Retrieved from <https://www.esfri.eu/>

204 (n.d.). ESFRI Workshop on the Future of Research Infrastructures in Retrieved from <https://www.esfri.eu/esfri-events/esfri-workshop-future-research-infrastructures-european-research-area?qt-event=1>

205 (n.d.). InRoad Project. Retrieved from <https://www.inroad.eu/>

206 Neutron scattering landscape or particle physics as examples.

207 (n.d.). MERIL portal. Retrieved from <https://portal.meril.eu/meril/>

208 (n.d.). RISCAPe: We are mapping the research infrastructure Retrieved from <https://riscap.eu/>

209 (n.d.). RISCAPe report - RISCAPe. Retrieved from <https://riscap.eu/riscap-report/>

210 (n.d.). www.esfri.eu. Retrieved from <https://www.esfri.eu/>

scene building on existing research infrastructures and electronic infrastructures. In response to the Conclusions of the Council of the European Union of 29 May 2015 that: 'INVITES ESFRI to explore mechanisms for better coordination of Member States' investment strategies in e-infrastructures, covering also HPC, distributed computing, scientific data and networks', ESFRI created an ad-hoc group and adopted its recommendation in December 2016 in Brussels. Responding to other specific mandates²¹¹, ESFRI is developing a strategy that is based on the requirements and advanced solutions implemented by the RIs. In its report on the long-term sustainability of RIs²¹², ESFRI developed a series of recommendations along with the main recommendation 'Harmonise and integrate the RIs and the e-Is'. ESFRI fosters the definition, implementation and further development of advanced solutions for the effective provision and use of high-quality scientific data, with effective descriptors, ease of access, interoperability and reusability, fully implementing the FAIR principles. It also develops and promotes Data Commons as practised by ESFRI research infrastructures and generic (horizontal) e-infrastructures. These efforts contribute to shaping the EOSC, and in order to better align with the RIs needs and the positions of the individual member states ESFRI is utilising a series of instruments including consultation workshops with the major stakeholders²¹³ and by creating a dedicated ESFRI EOSC Task Force.

2.5.1. ESFRI clusters

RIs have strong links with research communities and projects, manage significant data volumes and develop innovative data analytics tools, ensuring effective research data exploitation. Five ESFRI cluster projects, ENVRI-FAIR, EOSC-Life, PaNOSC, ESCAPE, and SSHOC, have been launched early this year, providing a focus for various ESFRI projects and landmarks to connect to the EOSC. The following projects and consortia are described in more detail in Annex I:

- **ENVRI-FAIR**²¹⁴ collaborates with the entire Environmental Research Infrastructure (ENVRI) community, which include 26 RIs, networks and projects. The aim is to connect ENVRI to EOSC, with the overarching goal that all participating RIs have built a set of FAIR data services.
- **EOSC-life**²¹⁵ consists of 13 Biological and Medical ESFRI RI (BMS RIs). The mission of the projects is to create an open, digital and collaborative space for biological and medical research.
- **PaNOSC**²¹⁶ is a European project with the mission to contribute to the realisation of a data commons for Neutron and Photon science.
- **ESCAPE**²¹⁷ is a collaborative cluster with the aim to implement a functional link between the concerned ESFRI projects and EOSC.

211 (2018, May 18). 9029/18 MVG/evt 1 DG G 3 C 1. The European ... - Open Data. Retrieved from <https://data.consilium.europa.eu/doc/document/ST-9029-2018-INIT/en/pdf>

212 (n.d.). ESFRI Scripta Volume II: 'Long-Term Sustainability of ... Retrieved from <https://www.esfri.eu/latest-esfri-news/esfri-scripta-volume-ii-long-term-sustainability-research-infrastructures-report>

213 (2019, January 30). ESFRI RIs and EOSC Workshop | www.esfri.eu. Retrieved from <https://www.esfri.eu/esfri-events/esfri-ris-eosc-liaison-workshop?qt-event=5>

214 (2019, January 30). ESFRI RIs and EOSC Workshop | www.esfri.eu. Retrieved from <https://www.esfri.eu/esfri-events/esfri-ris-eosc-liaison-workshop?qt-event=5>

215 (n.d.). EOSC Life: Home. Retrieved from <https://www.eosc-life.eu/>

216 (n.d.). The Photon and Neutron Open Science Cloud (PaNOSC Retrieved from <https://www.panosc.eu/>

217 (n.d.). ESCAPE | The European Science Cluster of Astronomy Retrieved from <https://www.escape2020.eu/>

- **SSHOC**²¹⁸ is a cluster project uniting 20 partner organisations and a further 27 associates. SSHOC will create the SSH area of the EOSC and will apply open science practices and FAIR principles to data management.
- **LENS**²¹⁹ (League of advanced European Neutron Sources) is a non-profit consortium promoting collaboration among European-level neutron infrastructure providers that are offering various transnational user programmes for external researchers. The aim is to emphasise improvement of source facilities, the cooperation of various communities and funding organisations. In addition, it enhances resources and aligns policies.
- **LEAPS**²²⁰ (League of European Accelerator-based Photon Sources) is a strategic consortium aimed at promoting the quality and impact of research in its fundamental, applied and industrial fields to ensure greater benefit of European science and society. LENS is initiated by the Directors of the Synchrotron Radiation and Free Electron Laser (FEL) and improves user facilities in Europe.

2.5.1.1. ESFRI Cluster Projects Position Papers

As part of its stakeholder engagement, The EOSCsecretariat.eu project has collected position papers from: ESCAPE²²¹, PaNOSC²²², ENVRI-FAIR²²³, EOSC-Life²²⁴, and SSHOC²²⁵ for EOSC²²⁶. These position papers can be used as tools for cluster projects to contribute to the development process of the EOSC in order to find a way to create synergies among research communities. The future of EOSC will be designed in collaboration between EOSC GB and ESFRI. The aim of collecting position papers from ESFRI Cluster Projects of ESCAPE, PaNOSC, ENVRI-FAIR, EOSC-Life, and SSHOC is to highlight various expectations of the research community, to investigate commitments to EOSC, to determine the added value of EOSC to the research data infrastructures, and to identify issues to be addressed by the EOSC executive board.

In 2019, the ESFRI cluster projects were launched, which will support EOSC as they integrate computer and data management solutions through the EOSC portal. The expectation of EOSC raised in the position papers of ESCAPE, PaNOSC, ENVRI-FAIR, EOSC-Life, and SSHOC, is that EOSC would enable the accessibility and re-use of research data and increase scientific value of research data. An interoperable environment of data infrastructures would enable collaboration within the research community. EOSC would have the added value of easing research data usage and the creation of FAIR data. The virtual research environment will support collaboration of the research community. EOSC is expected to be a trustworthy environment that would enable networking within research communities and ease the creation and storage of content and research data.

218 (n.d.). SSHOPENCLOUD. Retrieved from <https://sshopencloud.eu/>

219 (n.d.). League of advanced European Neutron Sources. Retrieved from <https://www.lens-initiative.org/>

220 (n.d.). LEAPS – League of European Accelerator-based Photon Retrieved from <https://leaps-initiative.eu/>

221 (2020, February 19). ESFRI cluster projects - Position papers on ... - Zenodo. Retrieved from <https://zenodo.org/record/3675081>

222 (2020, February 19). ESFRI cluster projects - Position papers on ... - Zenodo. Retrieved from <https://zenodo.org/record/3675081>

223 (2020, February 19). ESFRI cluster projects - Position papers on ... - Zenodo. Retrieved from <https://zenodo.org/record/3675081>

224 (2020, February 19). ESFRI cluster projects - Position papers on ... - Zenodo. Retrieved from <https://zenodo.org/record/3675081>

225 (2020, February 19). ESFRI cluster projects - Position papers on ... - Zenodo. Retrieved from <https://zenodo.org/record/3675081>

226 (2020, February 19). ESFRI cluster projects - Position papers on ... - Zenodo. Retrieved from <https://zenodo.org/record/3675081>

Guidelines of how to join EOSC and how to access/use services, as well as a cost-benefit analysis is required to be completed by EOSC for the research communities.

In the position papers, the standardisation of FAIR data is seen as a valuable approach towards FAIRification. Projects expect a community-centred approach for EOSC and the value of communication is emphasised. A long-term open data archive and preservation is required to enable a sustainable EOSC and the sustainable use of data. A Minimum Viable Ecosystem is seen as one of the cornerstones of sustainable EOSC. Open data is expected to have its own rights to be published and this would require collaboration with publishers. The Federating Core should be positioned at the national level in order to enable governments to have interest in encouraging open science and defining national policies regarding EOSC and open science.

2.5.2. Environmental research infrastructures

The ESFRI environmental RIs play a key role at a global scale in the UN framework, contributing to the UN Sustainable Development Goals.

Long-term atmospheric observation platforms include:

- the ESFRI Project **ACTRIS**²²⁷ (Aerosols, Clouds and Trace gases Research Infrastructure);
- the ESFRI Landmark **IAGOS**²²⁸ (In-service Aircraft for a Global Observing System) (Airborne, lower atmosphere);
- the ESFRI Landmark **ICOS ERIC**²²⁹ (Integrated Carbon Observation System);
- **ARISE**²³⁰ (Atmospheric dynamics Research Infrastructure in Europe);
- the ESFRI Landmark **EISCAT_3D** (Next generation European Incoherent Scatter radar system) (upper atmosphere);
- **SIOS** (Svalbard Integrated Arctic Earth Observing System);
- the ESFRI Project **DANUBIUS-RI**²³¹ (International Centre for Advanced Studies on River-Sea Systems) which supports interdisciplinary research in river-sea systems;
- ESFRI Landmark **LifeWatch ERIC**²³² (e-infrastructure for Biodiversity and Ecosystem Research) which is the only e-RI, which extends its area of interest to the whole freshwater environment;
- the ESFRI Project **AnaEE**²³³ (Infrastructure for Analysis and Experimentation on Ecosystems).

Marine RIs consist of up to 800 – increasingly networked – distributed facilities in Europe, serving various domains such as ocean – seafloor, subseafloor and water layers above – and coastal sea monitoring, marine biology research, blue biotechnology innovation, research in aquaculture and ocean engineering. These include:

- the ESFRI Landmark **ELIXIR**²³⁴ (a distributed infrastructure for life-science information);

227 (n.d.). actris.eu. Retrieved from <https://www.actris.eu/>

228 (n.d.). IAGOS: In-Service Aircraft for a Global Observing System. Retrieved from <https://www.iagos.org/>

229 (n.d.). ICOS RI. Retrieved from <http://www.icos-ri.eu/>

230 (n.d.). ARISE Project -. Retrieved from <http://arise-project.eu/>

231 (n.d.). Danubius-RI. Retrieved from <https://www.danubius-ri.eu/>

232 (n.d.). LifeWatch-ERIC. Retrieved from <https://www.lifewatch.eu/>

233 (n.d.). AnaEE - Home page. Retrieved from <https://www.anaee.com/>

234 (n.d.). ELIXIR Europe. Retrieved from <https://elixir-europe.org/>

- the ESFRI Landmark **EMBRC ERIC**²³⁵ (European Marine Biological Resource Centre);
- the ESFRI Landmark **LifeWatch ERIC**²³⁶.

The European landscape for terrestrial ecosystem and biodiversity RIs covers the complexity of the research agenda. Among observatories and Monitoring Facilities belong the ESFRI Landmark **ICOS ERIC**²³⁷, the ESFRI Projects **DANUBIUS-RI**²³⁸, and the Long-Term Ecosystem Research in Europe (**eLTER**)²³⁹. The latter is a new distributed research infrastructure which aims at integrating traditional natural sciences and holistic ecosystem research approaches, including studies of the human component, to better understand ecosystems. Through research and monitoring, eLTER seeks to improve our knowledge of the structure and functions of ecosystems and their long-term response to environmental, societal and economic drivers. eLTER comprises: *in situ*, long-term, cross-disciplinary, multiple-use, large-scale coverage of major European socio-ecological systems. The aim is to secure scientific excellence through the highest quality interoperable services in close interaction with related European and global RIs.

There are also several other projects focused on biological collections, data infrastructures and reference data:

- the ESFRI Project **DiSSCo**²⁴⁰ (Distributed System of Scientific Collections);
- the ESFRI Landmark **ELIXIR**²⁴¹;
- the ESFRI Project **MIRRI**²⁴² (Microbial Resource Research Infrastructure).

Progress in Solid Earth science relies on integrating multidisciplinary data acquired through long-term monitoring, new observing systems, and high-level taxonomy data products. It contributes to systemic and highly cross-disciplinary investigations, representing an essential component of the investigation of the Earth system. The solid Earth domain is represented in ESFRI by a single research infrastructure, the ESFRI Landmark **EPOS**²⁴³ (European Plate Observing System).

2.5.3. Health and food research infrastructure

In Europe, the health and food sector include RIs in biological, agrifood and medical sciences. The landscape includes health and food ESFRI research infrastructures (according to the 2018 ESFRI Roadmap there are 7 Landmarks – **BBMRI**²⁴⁴, **EATRIS**²⁴⁵, **ECRIN**²⁴⁶,

235 (n.d.). EMBRC. Retrieved from <https://www.embrc.eu/>

236 (n.d.). LifeWatch-ERIC. Retrieved from <https://www.lifewatch.eu/>

237 (n.d.). ICOS RI. Retrieved from <http://www.icos-ri.eu/>

238 (n.d.). Danubius-RI. Retrieved from <https://www.danubius-ri.eu/>

239 (n.d.). LTER in Europe. Retrieved from <https://www.lter-europe.net/>

240 (n.d.). DiSSCo: Home. Retrieved from <https://www.dissco.eu/>

241 (2016, March 9). ELIXIR presented as Landmark in the 2016 ESFRI roadmap. Retrieved from <https://elixir-europe.org/news/elixir-presented-landmark-2016-esfri-roadmap>

242 (2019, February 10). MIRRI-IS website. Retrieved from <https://www.mirri.org/>

243 (n.d.). European Plate Observing System. Retrieved from <https://www.epos-ip.org/>

244 (n.d.). BBMRI-ERIC. Retrieved from <https://www.bbMRI-eric.eu/>

245 (n.d.). EATRIS. Retrieved from <https://eatris.eu/>

246 (n.d.). ECRIN. Retrieved from <https://www.ecrin.org/>

ELIXIR²⁴⁷, **EU-OPENSREEN**²⁴⁸, **INFRAFRONTIER**²⁴⁹, and **INSTRUCT**²⁵⁰, and six projects: **EMBRC**²⁵¹, **EMPHASIS**²⁵², **ERINHA**²⁵³, **EuBI**²⁵⁴, **ISBE**²⁵⁵, and **MIRRI**²⁵⁶) which differ in scope, focusing on many disciplines (health, marine biology, structural biology, chemical libraries, and animal models, human biobanks, translational research and clinical trials).

ELIXIR is the European Life Science Data Infrastructure that brings together life science resources from across Europe. These resources include databases, software tools, training materials, cloud storage and supercomputers. The goal of ELIXIR is to coordinate these resources so that they form a single infrastructure - accessible across Europe and making it easier for scientists to find and share data, exchange expertise, and agree on best practices. Founded in December 2013, ELIXIR is a distributed organisation with Nodes that organise national resources in its 22 members and a coordinating Hub located at EMBL-EBI (Hinxton, UK).

Thirteen RIs are collaborating in **CORBEL**²⁵⁷, a cluster project, providing shared services for life sciences. These RIs are distributed, with a central facility coordinating the activities of national hubs. They are accessible for users from academic and industry research communities, open to researchers from European countries and providing access to services, data or resources, as well as access to major equipment. In the CORBEL cluster project, a Catalogue of Services provides a list for all 13 biomedical RIs with the objective to help researchers navigate the services. Some of the organisation's RIs found in the appendix of the *RISCAPE* report have broader scientific coverage compared to those based in Europe ones: for instance, Therapeutic Innovation Australia (**TIA**) and Centre for Drug Research and Development – Canada (**CDRD**) cover drug discovery, translational research and to some extent clinical research; in Japan, RIKEN, the largest and most comprehensive organisation for basic and applied sciences, covers several disciplines (among others: translational research, drug discovery, systems biology and mouse models). In comparison with the ESFRI, most of the organisations are distributed (65%) and the remaining one is single-sited (35%). There are no virtual organisations. More than half of the RIs had a peer review-based access policy. Almost 75% of the RIs have or had scientific collaboration or exchanges with European organisations (individual institute or university) but less than half have already established collaboration or have signed a collaboration agreement with a European RI in the same field²⁵⁸.

2.5.4. Physical sciences research infrastructures

In the physics domain, the RIs are mainly single-sited, often large, requiring significant investment for construction. The RIs often allow complementary opportunities for diverse

247 (2016, March 9). ELIXIR presented as Landmark in the 2016 ESFRI roadmap. Retrieved from <https://elixir-europe.org/news/elixir-presented-landmark-2016-esfri-roadmap>

248 (n.d.). EU OPENSREEN - European high-capacity screening network. Retrieved from <https://www.eu-openscreen.eu/>

249 (n.d.). INFRAFRONTIER - The European infrastructure for Retrieved from <https://www.infrafrontier.eu/>

250 (n.d.). Instruct-ERIC - Structural Biology European Research Retrieved from <http://instruct-eric.eu/>

251 (n.d.). EMBRC: Home. Retrieved from <https://www.embrc.eu/>

252 (n.d.). EMPHASIS: Home. Retrieved from <http://www.emphasisproject.eu/>

253 (n.d.). ERINHA. Retrieved from <https://www.erinha.eu/>

254 (n.d.). Euro Bioimaging. Retrieved from <https://www.eurobioimaging.eu/>

255 (n.d.). ISBE Project Website. Retrieved from <https://project.isbe.eu/>

256 (2019, February 10). MIRRI-IS website. Retrieved from <https://www.mirri.org/>

257 (n.d.). Home | CORBEL Project - Coordinated Research Infrastructures Building Enduring Life-science Services. Retrieved from <https://www.corbel-project.eu/>

258 (n.d.). RJH - CEA. Retrieved from <http://www-rjh.cea.fr/fr/index.html>

fields. Therefore, there are sometimes two (or more) facilities on the same site to concentrate more RIs, or they may be there because the facilities are complimentary, or else to create a pool of excellence. The *ESFRI Roadmap 2018* defined seven subdomains:

- 1) Synchrotron Radiation Sources;
- 2) Free Electron Lasers;
- 3) Neutron Sources;
- 4) High Power Lasers;
- 5) High Magnetic Field Facilities;
- 6) Particle Physics; and
- 7) Nuclear Physics.

The report lists 12 ESFRI landmarks and also one ESFRI Project in the field of Physical Sciences and Engineering (Astronomy and Astroparticle Physics, Particle and Nuclear Physics, Analytical Physics). These include the landmarks Cherenkov Telescope Array (**CTA**²⁵⁹), Extreme Light Infrastructure (**ELI**²⁶⁰), Extremely Large Telescope (**ELT**²⁶¹), European Synchrotron Radiation Facility Extremely Brilliant Source (**ESFR EBS**²⁶²), European Spallation Source (**ESS ERIC**²⁶³), European X-Ray Free-Electron Laser Facility (**European XFEL**²⁶⁴), Facility for Antiproton and Ion Research (**FAIR**²⁶⁵), High-Luminosity Large Hadron Collider (**HL-LHC**²⁶⁶), Institut Max von Laue-Paul Langevin (**ILL**²⁶⁷), Square Kilometre Array (**SKA**²⁶⁸), Système de Production d'Ions Radioactifs en Ligne de 2e génération (**SPIRAL2**²⁶⁹), as well as the ESFRI projects European Solar Telescope (**EST**²⁷⁰) and KM3 Neutrino Telescope 2.0 (**KM3NeT2.0**²⁷¹). The *RISCAPE* report considers RIs only in the Physics and Analytical Facilities category, in contrast to the ESFRI Roadmap. For the physics RIs, the categorisation of the RIs pertains to their experimental technique. This is reflected in the description of the sub-domains that first describe the technique, and then in how this is used for various science areas, which are not necessarily physics. MAX IV Laboratory is a Swedish national synchrotron laboratory providing scientists with the most brilliant X-rays for research²⁷²

International RIs (in the respective subfields) differ from European RIs in size, function, organisation, finance, etc. The *RISCAPE* report (Appendix 1) lists all the RIs considered in the landscape exercise for the physics domain. The report recognises the following numbers of RIs – 19 Synchrotron Radiation sources, 11 Free Electron Lasers, 15 Neutron Sources, 6 High Magnetic Field, 11 Particle Physics, 5 Nuclear Physics.

259 (n.d.). Cherenkov Telescope Array. Retrieved from <https://www.cta-observatory.org/>

260 (n.d.). ELI Delivery Consortium | Home. Retrieved from <https://eli-laser.eu/>

261 (n.d.). The European ELT - ESO. Retrieved from <https://www.eso.org/sci/facilities/eelt/>

262 (n.d.). EBS - Extremely Brilliant Source - ESRF. Retrieved from <https://www.esrf.eu/home/UsersAndScience/Accelerators/ebs---extremely-brilliant-source.html>

263 (n.d.). ESS - European Spallation Source. Retrieved from <https://europenspallationsource.se/about>

264 (n.d.). European XFEL. Retrieved from <https://www.xfel.eu/>

265 (n.d.). Facility for Antiproton and Ion Research: About us - FAIR. Retrieved from <https://fair-center.eu/about-us.html>

266 (n.d.). High-Luminosity LHC | CERN. Retrieved from <https://home.cern/science/accelerators/high-luminosity-lhc>

267 (n.d.). Institut Laue-Langevin. Retrieved from <https://www.ill.eu/>

268 (n.d.). Square Kilometre Array. Retrieved from <https://www.skatelescope.org/>

269 (n.d.). GANIL. Retrieved from <https://www.ganil-spiral2.eu/>

270 (n.d.). EST - European Solar Telescope. Retrieved from http://www.est-east.eu/est/index.php?option=com_content&view=article&id=605&Itemid=552&lang=en

271 (n.d.). KM3NeT -. Retrieved from <https://www.km3net.org/>

272 <https://www.maxiv.lu.se/>

The domain of High-Power Lasers is currently led by Europe, with networks of facilities (Laserlab Europe), and a distributed High-Power Laser facility (ELI) underway. Through **Laserlab Europe**²⁷³, many national/university laser facilities in Europe are open to the wider user community. Additionally, the International Committee on Ultra-High intensity lasers (**ICUIL**) promotes collaboration of 107 laser laboratories worldwide. For both European and non-European extreme facilities, which deliver only a very limited number of pulses per year, generally only provide access to general users for a few pulses per year (a few percent), without open peer review-based access.

Data policies are more advanced in North America and Europe than on the other continents. The European Commission is actively supporting the implementation of data policies for European RIs. Responses to the questionnaire show that Open Access initiatives are ongoing and are more frequently implemented in Europe compared to the other continents. This may be linked to the strong support by the European Commission. There are special costs associated with an open data system. First, the RI must put in place a system of access to the data, including validation procedures to protect the data, the RI and the original experimenters. In addition, sophisticated metadata must be available in addition to the data itself, in order to make the data transparent and useful. All of this requires computing capacities and dedicated, expert staff²⁷⁴.

2.5.5. Energy research infrastructures

The 2018 ESFRI Roadmap features two ESFRI Landmarks and four ESFRI projects. In the nuclear research subdomain, ESFRI Landmark Jules Horowitz Reactor (**JHR**)²⁷⁵ is an experimental reactor facility intended to provide scientific breakthroughs on nuclear fuel and materials. European Carbon Dioxide Capture and Storage Laboratory Infrastructure (**ECCSEL**)²⁷⁶ was officially recognised as an ERIC in 2017, and operates a distributed RI on Carbon Capture and Storage. In the renewable energy subdomain, two projects exist on the latest ESFRI Roadmap. European Solar Research Infrastructure for Concentrated Solar Power (**EU-SOLARIS**)²⁷⁷ advances thermal solar power research, while European WindScanner Facility (**WindScanner**)²⁷⁸ is a distributed RI focused on the characterisation of wind fields. In the nuclear energy subdomain, there are also two projects on the 2018 ESFRI Roadmap. Multi-purpose Hybrid Research Reactor for High-tech Applications (**MYRRHA**)²⁷⁹ is a unique first prototype of a multi-purpose hybrid reactor for high-tech applications. Finally, the International Fusion Materials Irradiation Facility-DEMO Oriented NEutron Source (**IFMIF-DONES**)²⁸⁰ entered the roadmap as a new entry²⁸¹.

2.5.6. Astronomy and astroparticle research infrastructures

The large scale of funding required for RIs in astronomy, and specifically, for any space mission, makes it very difficult to compare them with ground-based facilities, and as such, are outside of the ESFRI framework in Europe. The references to RIs in this domain are from both the ESFRI Roadmap, the *Astroparticle Physics European Consortium (APPEC)*

273 (n.d.). Welcome to Laserlab Europe — LASERLAB-EUROPE. Retrieved from <https://www.laserlab-europe.eu/>

274 (n.d.). RJH - CEA. Retrieved from <http://www-rjh.cea.fr/fr/index.html>

275 (n.d.). RJH - CEA. Retrieved from <http://www-rjh.cea.fr/fr/index.html>

276 (n.d.). ECCSEL. Retrieved from <https://www.eccsel.org/>

277 (n.d.). EU-Solaris > Home. Retrieved from <http://www.eusolaris.eu/>

278 (n.d.). WindScanner.eu: Start. Retrieved from <http://www.windscanner.eu/>

279 (n.d.). Myrrha | Home. Retrieved from <https://myrrha.be/>

280 (n.d.). Ciemat. Retrieved from <http://www.ciemat.es/>

281 (n.d.). IFMIF-DONES | ESFRI Roadmap 2018. Retrieved from <http://www.roadmap2018.esfri.eu/projects-and-landmarks/browse-the-catalogue/ifmif-dones/>

*Roadmap*²⁸² (APPEC officially launched the new *European Astroparticle Physics Strategy 2017-2026* at an event in Brussels 2018) and the *ASTRONET Infrastructure Roadmap*²⁸³. Large projects in astronomy require an effort beyond that which a single country can afford, and projects are carried out through a collaboration between multiple countries. Most RIs offer physical, virtual and/or remote access to the provided services. Common requirements include the preservation and management of distributed, digital data archives, access to electronic resources, support of virtual communities, and use of network, grid and computational capacities.

In relation to EOSC, the Virtual Observatory (VO)²⁸⁴, which is the e-science initiative for astronomy, must be highlighted. The VO is not a monolithic system, but relies on a set of standards. The core components of the VO infrastructure are: standards for “publishing” data and services; metadata standards for describing data; interoperability standards for tools; and standards for distributed storage and access to computational and grid resources. The development of VO standards is coordinated by the International Virtual Observatory Alliance (**IVOA**)²⁸⁵.

The geographical distribution of the RIs is very broad and it is driven by specific conditions, such as a dry atmosphere, low interference from human activity, low background emission for neutrino studies, etc. A common feature is a very well developed data policy and a well-established connectivity infrastructure. For example, the Giant Magellan Telescope (**GMT**)²⁸⁶, which is a collaboration between Brazil, US, Australia and Korea, has telescopes in Chile, Headquarters in Pasadena, and its data are instantly transferred over the globe. In fact, the very dry atmosphere and the low light pollution, make the Atacama Desert in Chile one of the preferred locations to install telescopes: for example, **VLT**²⁸⁷, **Gemini South**, **LSST**, **ALMA**²⁸⁸, and in the near future **ELT** and **CTA**, which are both ESFRIs. Sudbury Neutrino Observatory Laboratory (**SNOLAB**)²⁸⁹ is an underground science laboratory specialising in neutrino and dark matter physics. Laser Interferometer Gravitational-Wave Detector (**LIGO**)²⁹⁰ has several interconnected sites which work in close collaboration with **VIRGO**²⁹¹ and The Kamioka Gravitational Wave Detector (**KAGRA**)²⁹² in Japan. The Event Horizon Telescope (**EHT**)²⁹³ is a global enterprise that combines different telescopes around the world to create a virtual Earth-sized telescope in order to capture images of black holes.

282 (n.d.). Roadmap » APPEC - APPEC » Astroparticle Physics Strategy 2017-2026. Retrieved from <https://www.appec.org/roadmap>

283 (n.d.). The ASTRONET Infrastructure Roadmap - ESO. Retrieved from https://www.eso.org/public/archives/books/pdfsm/book_0045.pdf

284 (n.d.). Euro-VO. Retrieved from <http://www.euro-vo.org/>

285 The sixteen members of the International Virtual Observatory Alliance: EURO-VO, China-VO, VO-India, Canadian VO, Spanish VO, Vobs.It (Italy), Armenian VO, French VO, GAVO (Germany), Hungarian VO, Japan VO, Korean VO, US VO, Russian VO, AstroGrid (UK), Australian VO

286 (n.d.). Giant Magellan Telescope (GMT). Retrieved from <https://www.gmto.org/>

287 (n.d.). Very Large Telescope - Encyclopedia Britannica. Retrieved from <https://www.britannica.com/topic/Very-Large-Telescope>

288 (n.d.). ALMA - Atacama Large Millimeter/submillimeter Array | ESO. Retrieved from <https://www.eso.org/public/teles-instr/alma/>

289 (n.d.). SNOLAB. Retrieved from <https://www.snolab.ca/>

290 (n.d.). LIGO Caltech. Retrieved from <https://www.ligo.caltech.edu/>

291 (n.d.). Virgo Website. Retrieved from <http://www.virgo-gw.eu/>

292 (n.d.). Kagra. Retrieved from <https://gwcenter.icrr.u-tokyo.ac.jp/en/>

293 (n.d.). Event Horizon Telescope. Retrieved from <https://eventhorizontelescope.org/>

There is a great deal of similarity in how the RIs work within the different domains: astronomy, astroparticles, gravitational waves. These similarities become very apparent when it comes to needs and data management. Relevant considerations²⁹⁴ include:

- Complex datasets require complex models.
- More powerful computers make such models feasible.
- Producing code that runs on massively parallel, distributed-memory machines requires a different range of skills from those normally acquired by physicists and astronomers.
- Specialist skills are needed to produce graphical user interfaces that make codes easy to use.
- Given the complexity of the datasets, and the power of the models, it is better to resort to forward modelling, i.e. include observational biases in the models rather than correct the data.
- New layers of code are then required for new models to compare them with old datasets.

Huge volumes of data are already produced by current instrumentation and supercomputers, and the size of datasets will continue to increase rapidly. The **GÉANT** European backbone is connected to over 60 R&E networks outside Europe via interconnections with partner networks in North America, Latin America, Africa and Western Asia, Central Asia and Asia-Pacific. In the coming decades, a new generation of survey telescopes, such as **VST, VISTA, LSST, LOFAR**²⁹⁵ and **SKA**²⁹⁶ will each produce petabytes of raw observational data, which will have to be calibrated, processed and archived. Given the complexity and dedication required to calibrate and process this data avalanche, several agencies that operate observatories (e.g., ESO, Astron²⁹⁷) have decided to place this activity in the astronomical community, in order to actively involve the research astronomer in the process.

2.5.7. Social sciences, cultural heritage, digital humanities and languages RIs

The diversity of RIs in social sciences, cultural heritage, digital humanities and language research is particularly large. The European landscape is clearly dominated by the ESFRI infrastructures listed in the recent ESFRI 2018 roadmap update²⁹⁸ (**ESS ERIC, SHARE ERIC, CESSDA ERIC, GGP, E-RIHS, DARIAH, CLARIN, EHRI**). In addition, the ESFRI landscape analysis mentions **EUROPEANA**²⁹⁹ as an “integrating Research Infrastructure”, which provides a gateway to digitised content of archives, libraries and museums across the EU. Similar databases/repositories/surveys are found in other countries across the globe, although no research infrastructures comparable to the collaborative ESFRI RIs exist. Additional European infrastructures are listed in the MERIL database. The European Language Grid initiative³⁰⁰ has a strong and broad network of 32 National Competence Centres (NCCs).

Outside the EU, the RIs are largely replaced by research centres. A comprehensive list can be found in Appendix 8 and 9 of the RISCAPÉ project. The Center for Open Science in Charlottesville provides researchers with shared tools, and space to deposit projects. The Coleridge Initiative aims to use data to transform the way governments access and use data for the social good. The University of Minnesota, IPUMS-International (IPUMSI) is a dedicated project to collect and distribute individual and household level census data from

294 (n.d.). The ASTRONET Infrastructure Roadmap - ESO. Retrieved from https://www.eso.org/public/archives/books/pdfsm/book_0045.pdf

295 (n.d.). LOFAR | Astron. Retrieved from <https://www.astron.nl/telescopes/lofar>

296 (n.d.). Square Kilometre Array. Retrieved from <https://www.skatelescope.org/>

297 (n.d.). Astron: Home. Retrieved from <https://www.astron.nl/>

298 (n.d.). www.esfri.eu - ESFRI Roadmap. Retrieved from <https://www.esfri.eu/esfri-roadmap>

299 (n.d.). Europeana Collections. Retrieved from <https://www.europeana.eu/portal/>

300 (n.d.). NCCs - European Language Grid. Retrieved from <https://www.european-language-grid.eu/ncc/>

around the world. In Japan, the National Diet Library (NDL), the library of the National Congress, is developing such a portal. Its own digital collection comprises 2.7 million digitised or born-digital items. The Australian Data Archive (ADA)³⁰¹ is a Core Trust Seal³⁰² certified repository, based at the Australian National University in the ANU Centre for Social Research and Methods. CLARIN has inspired the South African Centre for Digital Language Resources (SADiLaR)³⁰³.

2.6. EIROforum and other intergovernmental organisations

The eight EIROforum³⁰⁴ organisations (CERN, ILL, ESRF, ESO, ESA, EMBL, European XFEL, EuroFusion) have one common feature inherent to their work: information technology. Large IT infrastructures are not only used for research, but also the development of large-scale structures, such as terrestrial and space telescopes, as well as high-energy physics facilities. Data processing and data handling is an integral part of the IT mandate of these organisations. The coordination of such efforts falls into the following four major categories: licensing of software (ensuring proper pricing schemes); security (IT security shared and implemented); exchange of expertise (in IT domain); and collaboration and cooperation on large projects (e.g. Cloud-Computing).

CERN³⁰⁵ (*Conseil Européen pour la Recherche Nucléaire*), the European Organization for Nuclear Research, is the world's leading laboratory for particle physics. It provides a unique range of particle accelerator facilities, enabling research at the forefront of human knowledge. It concentrates on fundamental physics – finding out what the universe is made of and how it works.

Founded in 1954, CERN is an intergovernmental organisation with 22 EU MS, as well as other nations from around the globe contributing to and participating in its research programmes. The resulting data is stored and analysed using a worldwide computing grid and CERN is the pioneer in data management practices. The CERN computing and data storage infrastructures are challenged by a data deluge from the experiments. Tremendous progress has been made in reducing the number of derived data files written to tape. The CERN Advanced STORAge system (CASTOR) reached the milestone of 400 petabytes of data stored on tape, with 12–13 petabytes written to tape each month.

CERN is a founding member of the Data Preservation in High Energy Physics (DPHEP³⁰⁶) collaboration. A consequence of the greater data volume is increased demand for data transfer and hence, greater network capacities. Three, 100-gigabit-per-second fibre optic circuits are linked to the CERN Data Centre with its remote extension hosted 1200 km away at the Wigner Research Centre for Physics (RCP) in Budapest. The additional bandwidth and redundancy provided by this third link allow CERN to reliably benefit from the computing power and storage at the remote extension.

ESA³⁰⁷ (European Space Agency) is developing Europe's space capability, and ensures that investment in space continues to deliver benefits to the citizens of Europe and the world. It is an intergovernmental organisation of 22 members. ESA's aims to design and

301 (n.d.). Home - ADA. Retrieved from <https://ada.edu.au/>

302 (n.d.). CoreTrustSeal – Core Trustworthy Data Repositories. Retrieved from <https://www.coretrustseal.org/>

303 (n.d.). About - SADiLaR. Retrieved from <https://www.sadilar.org/index.php/en/about>

304 (n.d.). Home | EIROforum - Serving European Science. Retrieved from <https://www.eiroforum.org/>

305 (n.d.). CERN: Home. Retrieved from <https://home.cern/>

306 (n.d.). Data Preservation in High Energy Physics | Collaboration for Retrieved from <https://dphep.org/>

307 (n.d.). European Space Agency. Retrieved from <https://www.esa.int/>

implement the European space programme. ESA's programmes are designed to find out more about Earth, its immediate space environment, our solar system and the universe, as well as to develop satellite-based technologies and services, and to promote European industries. ESA also works closely with space organisations outside of Europe.

ESA generates and collects vast amounts of valuable research data every year. Keeping these records for future generations, as a record of earth and space as we know them, and to leverage them with new technologies, is an important mission for the whole of ESA. To securely manage this data, ESA had to develop its own private cloud, which fulfils all the high security and redundancy standards required by ESA. ESA also expanded into virtualised computing, improving access, efficiency and security for ESA and its MS.

ESO³⁰⁸ (European Center Southern Observatory) is the foremost intergovernmental astronomy organisation in Europe and the world's most productive astronomical observatory. ESO provides state-of-the-art research facilities to astronomers. The annual MS contributions to ESO are approximately 198 million euros and ESO employs around 700 staff members. By building and operating a suite of the world's most powerful ground-based astronomical telescopes enabling important scientific discoveries, ESO offers numerous possibilities for technology spin-off and transfer³⁰⁹, together with high technology contract opportunities and is a dramatic showcase for European industry³¹⁰.

EMBL³¹¹ (European Molecular Biology Laboratory) performs fundamental research in molecular biology, studying the story of life. EMBL offers services to the scientific community; trains the next generation of scientists; and strives to integrate the life sciences across Europe. EMBL is international, innovative and interdisciplinary. 1600 people, from over 80 countries are operating across six sites in Barcelona (Spain), Grenoble (France), Hamburg (Germany), Heidelberg (Germany), Hinxton (UK) and Monterotondo (Italy), and conduct research and offer services in all areas of molecular biology. EMBL-EBI maintains the world's most comprehensive range of freely available and up-to-date molecular data resources.

ESRF³¹² (European Synchrotron Radiation Facility) is the world's most intense X-ray source and a centre of excellence for fundamental and innovation-driven research in condensed and living matter science. Located in Grenoble, France, the ESRF owes its success to the international cooperation of 22 partner nations, of which 13 are Members and 9 are Associates³¹³. The ESRF produces X-rays endowed with exceptional properties, which are produced by the high energy electrons that race around the storage ring, and guided to 44 'beamlines', each equipped with state-of-the-art instrumentation, and managed by highly qualified scientific and technical experts. Computing support, computing resources and services to help accomplish the ESRF's scientific mission. It also supports networking, shared facilities, personal computers and other specialised facilities which do not directly support the scientific programme.

European XFEL³¹⁴ (European XFEL Free-Electron Laser Facility) provides scientists from all over the world with ultrashort X-ray flashes – 27 000 times per second, and with a brilliance that is a billion times higher than that of the best conventional X-ray radiation

308 (n.d.). ESO. Retrieved from <https://www.eso.org/>

309 (n.d.). Technology for Telescopes | ESO. Retrieved July 13, 2020, from <https://www.eso.org/public/teles-instr/technology/>

310 (n.d.). Doing Business with ESO | ESO. Retrieved July 13, 2020, from <https://www.eso.org/public/industry/>

311 (n.d.). European Molecular Biology Laboratory | EMBL.org. Retrieved from <https://www.embl.org/>

312 (n.d.). European Synchrotron Radiation Facility (ESRF). Retrieved from <https://www.esrf.eu/>

313 France, Germany, Italy, United Kingdom, Russia, Spain, Switzerland, Belgium, The Netherlands, Denmark, Finland, Norway, Sweden are member countries. Israel, Austria, Poland, Portugal, Czech Republic, Hungary, Slovakia, India, South Africa are scientific associates.

314 (n.d.). European XFEL. Retrieved from <https://www.xfel.eu/>

sources – that is opening up completely new research opportunities for scientists and industrial users. The construction and operation of the facility have been entrusted to an independent research organisation, the European X-Ray Free-Electron Laser Facility GmbH (European XFEL GmbH), a non-profit limited liability company under German law that has international shareholders. At present, 12 countries are participating in the European XFEL: Denmark, France, Germany, Hungary, Italy, Poland, Russia, Slovakia, Spain, Sweden, Switzerland, and the United Kingdom.

EUROfusion³¹⁵ (European Consortium for the Development of Fusion Energy) consists of two organisations coordinating activities directed towards realising fusion energy generation: EUROfusion and Fusion for Energy (F4E). Both organisations are represented in EIROforum via EUROfusion. EUROfusion coordinates fusion energy research in 28 European countries³¹⁶ through 30 Consortium Members and about 150 universities, laboratories and industry. Its research & development programme combines European and national resources to carry out a coherent programme that is aligned with the European Roadmap to fusion electricity. The research programme involves the collective exploitation of the Joint European Torus (JET), the world's largest operating tokamak. JET attains plasma conditions sufficient for fusion to occur, and is providing invaluable input for the design and operation of ITER, which will begin its experiments in the mid-2020s. A range of national devices in Germany, France, Switzerland, UK, and The Netherlands contribute to the programme, which is further accompanied by a strong theoretical and computational effort. Fusion for Energy is responsible for the European part of the construction of ITER, and for this purpose, works closely with European industry.

ILL³¹⁷ (Institut Laue-Langevin) is the world's leading research centre for research using neutron beams. The ILL also tackles questions relating to the fundamental properties of matter. Situated in Grenoble, France, the ILL is a service laboratory which operates the most intense neutron source in the world. Its suite of 40 high-performance instruments is used to probe the structure and dynamics of existing and newly created materials in the finest detail. The ILL neutron scattering facilities provide an indispensable analytical tool for the analysis of the structure of novel conducting and magnetic materials for future electronic devices, the measurement of stresses in mechanical materials, and investigations into how complex molecular assemblies behave, particularly in a biological environment. The ILL is owned and operated by its three founding countries: France, Germany and the United Kingdom, and ten scientific partners: Spain, Switzerland, Austria, Italy, the Czech Republic, Sweden, Belgium, Slovakia, Denmark and Poland.

ECWM³¹⁸ (European Centre for Medium-Range Weather Forecast), is an intergovernmental organisation offering 24/7 operational services, providing global numerical weather predictions and other data for the MS and cooperating states and other broader communities. The centre has one of the largest supercomputer facilities and meteorological data archives in the world. It operates two services from EU's Copernicus Earth observation programme: the Copernicus Atmosphere Monitoring Service (CAMS³¹⁹); and the Copernicus Climate Change Service (C3S³²⁰). It contributes to Copernicus emergency management service (CEMS³²¹). The ECMWF's supercomputers operate at more than 330

315 (n.d.). EUROfusion. Retrieved from <https://www.euro-fusion.org/>

316 Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, United Kingdom and Ukraine.

317 (n.d.). Institut Laue-Langevin. Retrieved from <https://www.ill.eu/>

318 (n.d.). ECMWF. Retrieved from <https://www.ecmwf.int/>

319 (n.d.). Copernicus Atmosphere Monitoring Service. Retrieved from <https://atmosphere.copernicus.eu/>

320 (n.d.). Copernicus Climate Change Service. Retrieved from <https://climate.copernicus.eu/>

321 (n.d.). Copernicus Emergency Management Service. Retrieved from <https://emergency.copernicus.eu/>

trillion floating-point operations per second, or 330 teraflops, with 25% of that capacity dedicated to operational forecasts and 50% for research. The other 25% is used by its members. The ECMWF's computers process 40 million observations daily, most of which come from about 90 satellite data products. As a result, it is adding about 250TB every day to its MARS meteorological data archive, which the ECMWF describes as the largest in the world. As of December 2018, it contained around 225 petabytes of operational and research data.

2.7. e-infrastructures with identified potential to be federated / accessible to the EOSC

This section highlights selected information which has been provided by the MS/AC through a survey undertaken by the WG. Detailed information were provided through country sheets. Most countries have announced that identification of EOSC-ready infrastructures has begun, so only selected examples from the country sheets are presented below.

2.7.1. Austria

Austria has several organisations that offer national, generic e-infrastructure services: CLARIN; AUSSDA (Austrian Social Science Data Archive), which is a part of CESSDA ERIC; BBMRI ERIC; EODC (Earth Observation Data Centre for Water Resources Monitoring GmbH); VSC (Vienna Scientific Cluster); MACH-2, a cooperation project coordinated by the Univ. of Linz, in the frame of the HRSM programme of the Austrian Federal Ministry of Education, Science and Research (BMBWF); AConet (Austrian NREN); Austrian State Archives; BRZ; IIASA; JKU ePub (University Library Linz); Phaidra – Permanent Hosting, Archiving and Indexing of Digital Resources and Assets (Univ. of Vienna); repositUm (TU Wien); Volare (Land Vorarlberg); IST PubRep (Institute of Science and Technology); Architektur-Informatik; CCCA (Climate Change Center Austria); LBI-HTA – Ludwig Boltzmann Institute of Health Technology Assessment; ePUBWU (Vienna University of Economics and Business); Digital Repository KUG-PHAIDRA (University of Music and Performing Arts Graz – KUG); GAMS, Asset Management System for the Humanities; Statistik Austria Institutional Repository of the University of Art and Design Linz.

As of March 2020, no formal decisions exist in Austria, as to which national e-infrastructures should be federated/accessible to the EOSC. However, there are e-infrastructures that are of potential interest to EOSC. The landscape is rather fragmented. Several Austrian e-infrastructures are also connected to European Research Infrastructures and could be federated / accessible through the ESFRI Clusters. For example, the EODC (Earth Observation Data Centre) for Water Resources Monitoring GmbH³²² is a public-private partnership (PPP).

The mission of the EODC is to work together with its shareholders and multinational partners from science, the public and private sectors in order to foster the use of earth observation (EO) data. The EODC provides a cloud computing environment for the Earth Observation ground segment for deriving geophysical parameters and land cover properties from Sentinel-1 (synthetic aperture radar), Sentinel-2 (high-resolution optical imaging) and other EO missions.

The number of researchers in Austria that can use the available e-infrastructures, is around 36,000 (full-time equivalents). A substantial number of initiatives either directly or indirectly support open and FAIR science practices at present, which would align with EOSC

322 (n.d.). EODC: Collaboration for Earth Observation. Retrieved from <https://www.eodc.eu/>

policies, but coordination is not yet apparent. The project e-Infrastructures Austria Plus (ended 2019) had a WP dedicated to the introduction of RDM Policies at Austrian Universities (according to the FAIR principles) and a WP dedicated to the establishment of FAIR reference points at Austrian Universities. As a result, in 2020 TU Wien will establish a national FAIR Office (planned activity). TU Graz, TU Wien and UNIVIE are planning to set up a FAIR data and services project, which is intended to also serve other universities.

Austrian decision-makers do have a significant amount of structured and refined data concerning the status quo of Austrian research activities at their disposal. This structured information is provided through the project e-Infrastructures Austria. For instance, the 'National survey of Researchers and their data' asked 36,000 researchers about their stance on several issues concerning lifecycle management, the lifecycle of data, and related questions. See the e-Infrastructures Austria report *Researchers and Their Data*³²³, as well as the survey questionnaire *Questionnaire National Research Data Survey*³²⁴.

2.7.2. Belgium

In Belgium, the Federal Research Funding Organisation BELSPO has issued an Open Research Data Mandate, which complies with FAIR principles and is to be considered fully within the EOSC framework. The ERAC Taskforce on Open Data, to which the Belgian Federal Science Policy Department contributed, and the European Community's H2020 RECODE project were instrumental in shaping the mandate. Furthermore, BELSPO has put an Open Access Mandate to Publications³²⁵ in place which states that all BELSPO financed research results have to be deposited in an open access repository, possibly in BELSPO's own central repository (ORFEO³²⁶).

In the Flemish region, the Flanders Research Information Space (FRIS³²⁷) is the regional digital platform containing information on 82 353 researchers and their research (39 021 projects and 419 216 outputs, dated 14-05-2020), funded via public Flemish funds since 2008. All information from the FRIS platform is displayed on a portal website. FRIS has been established as close cooperation between the Department of Economics, Science and Innovation of the Flemish Government and the knowledge institutions³²⁸ in Flanders, i.e. Flemish universities, higher education colleges, strategic research centres, and other scientific institutions.

The platform integrates metadata on different research information objects, using CERIF, the European standard for integrating and exchanging research information in a semantically interoperable manner. In the future, it will also include dataset metadata, and will be used as a monitoring tool for open science. In the FRIS IT architecture, the necessary developments have been made to allow direct, automated and continuous integration between external systems and the FRIS system in both directions. As a result, all FRIS metadata are offered as Open Data, more specifically through web services.

In Belgium, several research organisations offer e-infrastructure services: Alamire Foundation, BeGrid, Bimetra Biobank, CESSDA - SODA, Consortium des Equipements de Calcul Intensif (Céci), DaRWIn, ESO, FRIS, Flanders Make, ILVO, IMEC, INBO, ITG, PRACE

323 (n.d.). o:409318 - University of Vienna Phaidra - Universität Wien. Retrieved from <https://phaidra.univie.ac.at/o:409318>

324 (n.d.). activity report 2014-2016 - Universität Wien. Retrieved from <https://services.phaidra.univie.ac.at/api/object/o:460780/diss/Content/get>

325 (n.d.). BELSPO Open Access Policy. Retrieved from https://www.belspo.be/belspo/openscience/pub_belspo_policy_en.stm

326 (n.d.). ORFEO Home. Retrieved from <https://orfeo.kbr.be/>

327 (n.d.). Welcome to Research Portal | Research Portal. Retrieved from <https://researchportal.be/en>

328 (n.d.). Partners of the FRIS programme | Research Portal. Retrieved 24 May 2020, from <https://researchportal.be/en/who-participates-fris>

(Partnership for Advanced Computing in Europe), Plantentuin Meise, Royal Belgian Institute of Natural Sciences - KBIN-IRNSB, Royal Belgian Institute for Space Aeronomy - BIRA-IASB, Royal Institute for Cultural Heritage - KIK-IRPA, Royal Library Belgium - KBR, Royal Meteorological Institute of Belgium - KMI, Royal Museum for Central Africa, Royal Museums for Art and History, Royal Museums of Fine Arts of Belgium, Royal Observatory of Belgium and the Planetarium - ROB, State Archives of Belgium - AE-RA, The Centre for Historical Research and Documentation on War and Contemporary Society - SOMA-CEGES, VIAA, VIB, VITO, VLIZ, VMM, VSC, Von Karman Institute, War Heritage Institute. Research data repositories and infrastructures that have the potential to be federated / accessible to EOSC, can be found in the country sheets.

In terms of networking infrastructure, Belgium has a national research and education network, Belnet³²⁹ that provides high-bandwidth internet connection and services to Belgian researchers. Furthermore, BEgrid³³⁰ is a grid and cloud infrastructure open to all Belgian researchers, connected to EGI. Finally, HPC infrastructure is available, i.e. Space Pole³³¹ (Tier-2) hosted by federal institutions, Flemish Supercomputer Center³³² (Tier-1 and Tier-2) managed by FWO³³³ in partnership with the five Flemish university associations, and CECI³³⁴ (Tier-2) and Cenaero³³⁵ (Tier-1), supported by the F.R.S-FNRS³³⁶ and the Walloon Region³³⁷, and the Wallonia-Brussels Federation, respectively.

2.7.3. Finland

In Finland, the services and infrastructures required for federation are evolving (especially on HPC-side), so there are currently no usage statistics. The FAIRdata-services³³⁸ cover data lifecycle management services, and Research Information Hub covers metadata about research activities, DL2021 covers storage/disk capacity and HPC services, as does EuroHPC/Finland. The time period for Fairdata Service validation is approximately five years; Research Information Hub approximately 3 years + 2 years to launch; DL2021 approximately 5 years after 2021. A total of 31 national research infrastructures have been selected for Finland's research infrastructure roadmap 2014–20, 18 of which are ESFRI partnerships.

In general, the meaning of the term federation is dependent on the specific infrastructures: a) data infrastructures, which provide capacity, need to be federated on user and project identity. b) the same applies for HPC; and c) repositories need to be federated for data and metadata objects.

329 (n.d.). Belnet. Retrieved from <https://belnet.be/en>

330 (n.d.). BEgrid website – The Belgian Grid for Research. Retrieved from <https://www.begrid.be/>

331 (n.d.). Welcome. Retrieved from <https://spacepole.be/en/>

332 (n.d.). ABOUT VSC | Vlaams Supercomputer Centrum. Retrieved from <https://www.vsc.vlaanderen.be/about>

333 (n.d.). Research Foundation - Flanders. Retrieved from <https://www.fwo.be/en/>

334 (n.d.). Clusters - CECI. Retrieved from <http://www.ceci-hpc.be/clusters.html>

335 (n.d.). High Performance Computing at Cenaero | Operator of the Tier-1 supercomputer of Wallonia Retrieved from <https://tier1.cenaero.be/en/Home>

336 (n.d.). Fonds de la Recherche Scientifique - FNRS - Le FNRS. Retrieved from <https://www.frs-fnrs.be/>

337 (n.d.). DGO6 - Wallonie. Retrieved from <https://recherche-technologie.wallonie.be/>

338 (n.d.). Huolehdi tutkimusaineistosi - Fairdata. Retrieved 13 July 2020, from <https://www.fairdata.fi/en/>

2.7.4. France

There are four, main national computing centres in France: TGCC³³⁹ (CEA), CINES³⁴⁰ (Universities), IDRIS³⁴¹ (CNRS / INS2I), and CC-IN2P3³⁴² (CNRS / IN2P3). The first three provide HPC, while CC-IN2P3 focuses on HTC. Access to the HPC resources is mainly granted through GENCI³⁴³, (*Grand équipement national de calcul intensif*), which is owned by the ministry (49%), CEA (20%), CNRS (20%), and the universities (10%). CC-IN2P3 is the largest data centre (2018: 63 PB tape, 27 Pb disk), while CINES provides data archive services. In addition, about 30 larger regional computing centres provide computing and data storage services. The national grid infrastructure France Grilles provides services (HTC computing on the grid and an academic cloud, data storage) and is providing about 11% of the resources federated by the European Grid Infrastructure (EGI³⁴⁴). The SILECS³⁴⁵ research infrastructure provides computing environments for large-scale experimental computer science, e.g. through the Grid'5000³⁴⁶ testbeds. A number of publicly available repositories are operated in France (see e.g. re3data.org, 151 entries in OpenDOAR³⁴⁷). The infrastructure hosting the HAL national repository for publication is CCSD. The creation of a national data repository is currently under investigation.

2.7.5. Germany

Based on a recommendation of the RfII, the Federal Government and the Länder agreed in the Joint Science Conference GWK to set up a national research data infrastructure (NFDI). The aim of the NFDI is to systematically manage scientific and research data, provide long-term data storage, backup and accessibility, and network the data both nationally and internationally.

From 2020 onwards, in three successive years up to 30 consortia are expected to become a member of the NFDI, with a funding of up to €90 M annually. Besides the NFDI, there are e-infrastructures with potential interest in EOSC. The landscape is rather fragmented. Several German e-infrastructures are also connected to European Research Infrastructures and could be federated / accessible through the ESFRI Clusters. The number of researchers in Germany, which can use the available e-infrastructures, is around 700 000 (full-time equivalents). Concerning salary levels, all publicly funded e-infrastructures follow the remuneration levels of the Tarifvertrag für den Öffentlichen Dienst (TVöD, German civil service pay scale).

2.7.6. Greece

The Greek national roadmap for Research Infrastructures³⁴⁸ is publicly available. The RIs are following the categories of the smart specialisation strategy RIS3. In general, there are 28 RIs (17 ESFRI related and 11 non-ESFRI related), which were summarised in the country sheet, along with the financing scheme for the period 2017-2019. Those national

339 (n.d.). TGCC - CEA - HPC. Retrieved from <http://www-hpc.cea.fr/en/complexe/tgcc.htm>

340 (n.d.). National Computing Center for Higher Education - CINES. Retrieved from <https://www.cines.fr/en/>

341 (n.d.). Institute for Development and Resources in Intensive Scientific Computing - IDRIS. Retrieved from <http://www.idris.fr/eng/>

342 (n.d.). CC-IN2P3. Retrieved from <https://cc.in2p3.fr/en/>

343 (n.d.). Genci. Retrieved from <http://www.genci.fr/en>

344 (n.d.). EGI.eu. Retrieved from <https://www.egi.eu/>

345 (n.d.). SILECS | SILECS Infrastructure for Large-scale Experimental Computer Science ... Retrieved from <https://www.silecs.net/>

346 (2019, December 16). Grid5000: Get an account - Grid5000. Retrieved from https://www.grid5000.fr/w/Grid5000:Get_an_account

347 (n.d.). Directory of Open Access Repositories. Retrieved from <https://v2.sherpa.ac.uk/opensoar>

348 (n.d.). National Roadmap for Research Infrastructures - IMBB-FoRTH. Retrieved 24 May 2020, from <http://www.imbb.forth.gr/news/RoadMap.pdf>

RIs can serve as potential infrastructures that can federated/accessible to EOSC but (most of them) cannot be considered "EOSC ready".

2.7.7. Italy

Data and HPC infrastructures and repositories in Italy are mainly funded from Ministries through research performing organisations (RPOs), and there are both general-purpose allocations as well as dedicated funds for specific national and international initiatives (e.g., ESFRI). Thus, deriving a single figure for the entire national landscape would result in approximated and possibly incorrect results. The ongoing survey from the EOSC Pillar would be likely to provide some more information at RPO level.

2.7.8. Norway

Norway has several organisations that offer national generic e-services: **UNIT**³⁴⁹ offers a wide range of services for research and higher education, within the areas of education and research management, general administration, learning management and support, digital library and archive services. It delivers the national services for reporting of scientific publications (*Current Research Information System in Norway*; Cristin³⁵⁰), the management of research data through the data repository BIRD, and it assists with open access as well as provides the national library services to the education and research sector.

UNINETT³⁵¹ delivers internet and network services to Norwegian universities, colleges and research institutions and handles other national ICT tasks. The network connects all institutes and users on the national level and links them with other international, high-speed networks.

UNINETT Sigma2³⁵² manages the national infrastructure for computational science for research and education in Norway and offers services in high performance computing, data storage (NIRD) and related services for sensitive data (and a list of all services are provided in *Evaluation of UNINETT Sigma2*³⁵³). Sigma2 also coordinates Norway's participation in Nordic and European e-infrastructure collaborations and projects.

NSD, The Norwegian Centre for Research Data³⁵⁴, provides national archiving services for research data and assists researchers with data gathering, data analysis, and issues of methodology, privacy and research ethics.

2.7.9. Poland

The e-infrastructure available in Poland are federated/accessible via PIONIER/MANs infrastructure, which also offers above the net services (e.g. Digital Libraries, Science TV, group communication, PIONIER identity, cloud, archive). **PIONIER**³⁵⁵ is the largest research infrastructure in Poland, which brings together 22 scientific centres. The PIONIER consortium³⁵⁶ is in the process of implementing a large infrastructure for science on the

349 (n.d.). Unit | Direktoratet for IKT og fellestjenester i høyere utdanning og forskning. Retrieved from <https://www.unit.no/>

350 (n.d.). Cristin - University of Tromsø - Uit.no. Retrieved from <https://en.uit.no/go/target/318428>

351 (n.d.). About Uninett | Uninett. Retrieved from <https://www.uninett.no/en/about-uninett>

352 (n.d.). About Sigma2 | Uninett Sigma2. Retrieved from <https://www.sigma2.no/about-sigma2>

353 (n.d.). Evaluation of UNINETT Sigma2 - Norges forskningsråd. Retrieved from <https://www.forskningsradet.no/contentassets/b7dd5e1a046e464abdb1becb51f06484/nfr-evaluation-sigma2.pdf>

354 (n.d.). Norwegian Centre for Research Data | NSD - Norsk ... - NSD. Retrieved from <http://www.nsd.uib.no/nsd/english/index.html>

355 (n.d.). PIONIER online - Strona główna. Retrieved from <http://www.pionier.net.pl/online/>

356 (n.d.). PIONIER Consortium - PIONIER online. Retrieved from <http://www.pionier.net.pl/online/en/entities/>

Polish Roadmap of Research Infrastructures³⁵⁷ - **PIONIER-LAB** (2017-2023). PIONIER-LAB consists of eight research laboratories that are the response of the scientific community to current research challenges in the field of ICT.

2.7.10. Portugal

In Portugal, the Science, Technology and Society Network, **RCTS**³⁵⁸, corresponds to the national education and research network responsible for national scientific computing, managed and operated by the National Scientific Computing Unit (FCCN), a branch of FCT. It offers researchers, teachers and students a high-performance digital infrastructure to support projects on a national and international level. As the Portuguese NREN, FCT is part of the GÉANT network.

The National Distributed Computing Infrastructure, **INCD**³⁵⁹, provides computing and storage services to the scientific and academic community, covering all subject areas. INCD delivers High Performance Computing (HPC), High Throughput Computing (HTC), Cloud Computing, Grid Computing and data-related services to the Portuguese academic and research community. INCD is part of the European Grid Infrastructure (EGI), the Iberian Distributed Computing Infrastructure (IBERGRID), the Worldwide LHC Computing Grid (WLCG) and also EOSC (EOSC-hub and EOSC Synergy). The organisations providing support to INCD activities are as follows: Laboratory of Instrumentation and Experimental Particles Physics (LIP), the National Laboratory for Civil Engineering (LNEC) and FCCN.

2.7.11. Serbia

The Academic and Educational Grid Initiative of Serbia (AEGIS) is in charge of the development of High-Throughput Computing (HTC) resources, while the Institute of Physics Belgrade (IPB) coordinates the evolution of national High-Performance Computing (HPC) resources. In terms of HTC, AEGIS (managed by IPB) provides seamless access to ten computing clusters installed at separate research institutions within the country, while the use of HPC resources at IPB is organised through an open call. The same channels also provide access to the data infrastructures.

The total computing and storage capacity of the HTC infrastructure is around 3,000 CPU-cores and 150 TB of storage space, while the size of the HPC resources reaches 2,500 CPU-cores and 300 TB of storage space. On top of hardware resources, more than 10 generic and more than 100 thematic services have been developed and deployed as production services. Furthermore, AEGIS and IPB host a set of services that enable federation and uniform access to the national e-infrastructure resources. They also organise dissemination and training activities, help the Serbian research community to develop and deploy services, and coordinate related fundraising activities.

2.7.12. Switzerland

For Switzerland, the potential federation of the following infrastructures need to be confirmed: Swiss National Supercomputing Centre (CSCS); SWITCH; Blue Brain³⁶⁰; BMRI CH node: Swiss Biobanking Platform³⁶¹; ELIXIR CH node: Swiss Institute for Bioinformatics

357 (2020, January 14). 20200114 Polska Mapa Infrastruktury Badawczej.pdf. Retrieved 13 July 2020, from http://www.bip.nauka.gov.pl/g2/oryginal/2020_01/3175b4b7b9daae8d0f255b3670d54361.pdf

358 <https://www.fccn.pt/en/institutional/rcts/>

359 <https://www.fccn.pt/en/computing/incd/>

360 (n.d.). Blue Brain Project - EPFL. Retrieved from <https://www.epfl.ch/research/domains/bluebrain/>

361 (n.d.). Swiss Biobanking Platform – National coordination platform. Retrieved from <https://swissbiobanking.ch/>

SIB³⁶²; CESSDA CH node: Swiss Centre of Expertise in the Social Sciences (FORS); SHARE CH node: Institut d'Économie et de Management de la Santé (IEMS); FORS³⁶³; Swiss Data Science Centre (SDSC)³⁶⁴; Data and Service Centre for the Humanities (DASCH)³⁶⁵; The Swiss Personalized Health Network (SPHN)³⁶⁶.

The UK has a federated e-infrastructure involving UKRI facilities (HPC, content and national scientific infrastructure), Jisc services and resources (content and library services, analytics and research information systems, AAI and network), national subject-specific repositories and university facilities. A summary can be found in Chapter 8 of the UK research and innovation landscape analysis³⁶⁷. A full list of over 600 facilities can be found at the UKRI Infrastructure portal³⁶⁸.

All these facilities have the potential to be federated/accessible to EOSC – however, national processes and considerations are ongoing, and the decisions would depend on the identified benefits of this association/federation to the resource and the community, policy issues as regards usage, IPR and branding, and funding and procurement issues; it is difficult to make more precise decisions until EOSC including its nature, sustainability, and principles of participation, is better defined.

2.8. Other EOSC-relevant initiatives and projects

Current research information systems **CRIS**³⁶⁹ or research information management systems (**RIMS**)³⁷⁰ are databases or other information systems used for storing and managing metadata about research, i.e. information on researchers, research organisations, scientific projects, publications, patents, infrastructures, including equipment, facilities, software and research data. A standard has now been developed and recommended by the EU that enables the standardisation, integration and interchange of research information and that can serve as a (semantic) interoperability layer to EOSC, the Common European Research Information Format (CERIF). The **CERIF**³⁷¹, developed and maintained by euroCRIS, has been implemented in many CRIS systems in Europe (and beyond). OpenAire is CERIF-compliant as are many commercial and open-source CRIS systems. An overview of the CRIS systems, as implemented by research institutions, research funders and other bodies in European countries can be found in the Directory of Research Information Systems (**DRIS**)³⁷².

362 (n.d.). SIB Swiss Institute of Bioinformatics: Homepage. Retrieved from <https://www.sib.swiss/>

363 (n.d.). FORS - Swiss Centre of Expertise in the Social Sciences. Retrieved from <https://forscenter.ch/>

364 (n.d.). Swiss Data Science Center. Retrieved from <https://datascience.ch/>

365 (n.d.). Data and Service Center for the Humanities DaSCH. Retrieved from <https://dasch.swiss/>

366 (n.d.). SPHN - Swiss Personalized Health Network (SPHN). Retrieved from <https://sphn.ch/>

367 (n.d.). UKRI Infrastructure Roadmap - Progress report - UK Research and innovation. Retrieved from <https://www.ukri.org/files/infrastructure/landscape-analysis-final-web-version/>

368 https://www.infraportal.org.uk/Search?search_api_fulltext=&sort_by=search_api_relevance&sort_order=DESC&f%5B0%5D=macro_domains%3Ae-infrastructure%20%26%20dat.

369 (n.d.). Current research information system - Wikipedia. Retrieved from https://en.wikipedia.org/wiki/Current_research_information_system

370 (2020, March 17). Research Information Management System (RIMS) : TechWeb. Retrieved from <https://www.bu.edu/tech/services/admin/research-systems/rims/>

371 (n.d.). Main features of CERIF | euroCRIS. Retrieved from <https://www.eurocris.org/cerif/main-features-cerif>

372 (n.d.). DRIS | euroCRIS. Retrieved from <https://dSPACECRIS.eurocris.org/cris/explore/drisc>

The Italian Computing and Data Infrastructure (**ICDI**)³⁷³ is a forum created by representatives of major Italian RIs and e-infrastructures, a bottom-up initiative born from the need, expressed by many scientific communities, with the aim of promoting synergies between national resource and service providers to improve the coordination in national, European, and global initiatives, such as the EOSC, EDI, and the EuroHPC Joint Undertaking.

ICDI has recently mapped the Italian participation in European RI and e-infrastructure programmes, thus co-opting the initial contributors to the initiative. It now involves the main infrastructure providers for the Italian research community (network, storage, computing, cloud services), and research communities characterised by the participation in large national and international research and strong use cases relating to data. The Italian Ministry of Education, Universities and Research has joined ICDI as an observer and expressed an interest in the initiative, as it is a good candidate to represent the national stakeholders and support the Ministry in setting out national strategies in the field of data-driven research. In this respect, ICDI has a dual role, acting both as a resource and service provider, and as a stakeholder for the definition of a national strategy for the participation to the European initiatives.

The EUREF Permanent Network (**EPN**)³⁷⁴ is a voluntary federation of over 100 self-funding agencies, universities, and research institutions in more than 30 European countries. They work together to maintain the European Terrestrial Reference System (**ETRS89**), which is the single, European-wide standard coordinate reference system adopted by the European Commission

While the INSPIRE directive is a legal and technical framework, the European Location Framework (**ELF**) (European Location Framework, 2019) project was a practical implementation of that directive. Building on the experiences of the European Spatial Data Infrastructure Network (**ESDIN**) (European Commission, 2019a) and European Address Infrastructure (**EURADIN**) (European Commission, 2019b) projects, ELF was conceived with the aim of 'developing standards, specifications, tools and technical infrastructure to deliver pan-European geospatial content'.

The Open European Location Services project (**Open ELS**) builds on key ELF project results. Open ELS is a two-year project co-financed by the European Union's Connecting Europe Facility. It is developing pan-European data services using authoritative geospatial information. In doing so, it aims to improve the availability of geospatial information from the public authorities responsible for mapping, cadastre and land registries. The Open ELS project demonstrates the potential of a single access point for international users of harmonised, pan-European, authoritative geospatial information and services. **EuroGeographics**, which represents Europe's national mapping, cadastral and land registration authorities, is coordinating the two-year initiative co-financed by the European Union's Connecting Europe Facility. The international not-for-profit association is working with partners from member organisations in Finland, Germany, Great Britain, Norway, Poland, Spain, Sweden and The Netherlands to deliver this core.

As part of the implementation of the Public Sector Information Re-Use (PSI) Directive, the Malta Information Technology Agency (**MITA**) on behalf of the Government of Malta is

373 (n.d.). home - Italian Computing and Data Infrastructure. Retrieved from <https://www.icdi.it/en/>

374 EUREF Permanent GNSS Network - <http://www.epncb.oma.be/index.php>

currently drafting a National Data Strategy³⁷⁵ that provides a holistic and comprehensive vision for the management of data across the whole Public Administration.

Over the past two decades, there has been a great increase in the volume of survey data collected by the CSO. The Irish Government has embarked on the National Data Infrastructure (**NDI**)³⁷⁶ which concerns itself with the consistent and reliable identification of data that relates to a particular location through the use of an Eircode, a person through the use of a PPSN, and a business through the use of a Unique Business Identifier (UBI). The consistent identification of these core data assets is crucial to successfully link data, connecting with government initiatives, and delivering integrated services³⁷⁷.

The Swiss national data infrastructure (**NDI**) provides data, data-related services and guidelines for the re-use of data to individuals and organisations. It facilitates efficient sharing of data, supports new business models, and as such is a key enabler for the digital economy, open research, and societal benefits.

The Spanish National Geographic Information Centre has developed a platform for the dereferencing of entities through the generation of Persistent Identifiers (PIDs) from its **INSPIRE WFS** services. In addition, a SPARQL endpoint has been created with the aim of generating and storing the RDF triples in Turtle format for these same themes, as well as its link to other Linked Open Data, such as DBpedia and GeoNames.

The Netherlands has a production **Linked Data platform**³⁷⁸ in use for publishing several maintained linked datasets such as Key Register Addresses and Buildings, Key Register Topography and Cadastral Parcels. This production environment consists of a complete stack of tools covering all processes, from creating to publishing linked data.

There have been several prototypes to publish **Linked Open Data** in the National Land Survey of Finland. Geographical Names, Buildings and Administrative Units have been published as demo services.

The Norwegian mapping authority currently has one national dataset available as Linked Open Data (**LOD**) through a production environment, Administrative Units. This is currently being utilised by the national geoportal³⁷⁹ for indirect geocoding of dataset coverage within metadata records. It is also planned that the national data catalogue will begin to use the data and associated services within 2019.

Regarding big data, within the framework of the Horizon 2020 programme, more than 87 projects were supported, including **SoBigData Research Infrastructure**³⁸⁰, Education for Data Intensive Science to Open New Science Frontiers (**EDISON**)³⁸¹, High Performance Computing and Big Storage. The H2020 funded project **RISCAPE**³⁸² makes links to the

375 (n.d.). MITA Home. Retrieved from <https://www.mita.gov.mt/>

376 (2018, April 12). Building the National Data Infrastructure through partnerships. - UNECE. Retrieved from https://www.unece.org/fileadmin/DAM/stats/documents/ece/ces/ge.58/2018/mtg2/Session_2_Ireland.pdf

377 (2020, April 30). Government of Ireland - PUBLIC SERVICE DATA STRATEGY 2019 - 2023. https://data.gov.ie/uploads/page_images/2019-01-03-110200.740673Public-Service-Data-Strategy-2019-2023.pdf

378 (n.d.). PDOK: Home. Retrieved from <https://www.pdok.nl/>

379 (n.d.). Geonorge. Retrieved from <https://www.geonorge.no/>

380 (n.d.). Index-old | SoBigData.eu. Retrieved from <http://www.sobigdata.eu/index>

381 (2019, June 24). EDISON Project - Cordis. Retrieved from <https://cordis.europa.eu/project/id/675419>

382 (n.d.). RISCAPE: We are mapping the research infrastructure landscape. Retrieved from <https://riscape.eu/>

CoreTrustSeal data repository certification³⁸³ and WISE 'information security for IT infrastructures for research' community³⁸⁴.

A questionnaire in the form of country sheets was used to collect the information used in this chapter. The questionnaire was distributed through three channels:

1. EOSC Governance Board (GB) members were required to fill in the questionnaire on behalf of their countries.
2. WG members reached out to other national experts to collect as much information as possible.
3. For 10 countries (without representatives in EOSC-GB and WG) the information was collected using publicly available sources of information, which were validated / completed by the country authorities when possible.

The WG members would like to acknowledge the fruitful collaboration in the data gathering process and thank all national experts for their support. The information extracted from the country sheets will be subsequently amended based on the findings of the INFRAEOSC-5B projects and other sources. This will be particularly important for the analysis of the findings of the landscaping activity. Both the updated country sheets and the analysis of the landscaping activity will be published in a separate report.

The information provided in this document has been subject to validation by the MS/AC (notably during the Validation Workshop (VW), which took place in April 2020) to verify the information provided and to consolidate opinions. The aim of the questionnaire was to not only collect the necessary information to accurately reflect national positions at this stage, but to also form a foundation of information that could monitor progress. More than 60% of the participants, who were a broader audience than the survey respondents, at the Validation Workshop indicated that the results accurately depict the situation in their countries, about 30% indicated that the results did not reflect the current situation in their countries, and 5% did not know.

Information was collected for 47 countries (EU MS, AC and border countries) listed in Section 4.4. Some of the questionnaires were only partially completed. The collected information extracted both from fully and partially completed questionnaires is included in the maps and the data presented in this section. There were no mandatory questions, due to which the aggregated information may be biased where countries have omitted particular questions. The following approach was applied in data processing and generalisation:

1. if "Planning" and any of "Yes" or "No" were checked in the same question, we assumed that the correct answer should be "Planning".
2. if both "Yes" and "No" were checked in the same question, we tried to find more information in the narrative part of the answer (in each question it was possible to provide a narrative answer, i.e. to explain the situation in greater detail).

Moreover, in order to fairly balance the complexity of the landscape in some countries, we did not distinguish between country-wide or regional-, local-wide policies in the aggregated information reported in the country sheets.

383 (n.d.). CoreTrustSeal – Core Trustworthy Data Repositories. Retrieved from <https://www.coretrustseal.org/>

384 (n.d.). WISE Community – Wise Information Security for Retrieved from <https://wise-community.org/>

2.9. Current policy on open science and FAIR data

As far as the adopted policies on open science and FAIR data are concerned, 34.04% (16) of the responding countries claimed to have a respective policy in place (see Figure 1). The other countries indicated that they either did not have a current policy in place or that a policy was in the planning phase (65.96%) (31).

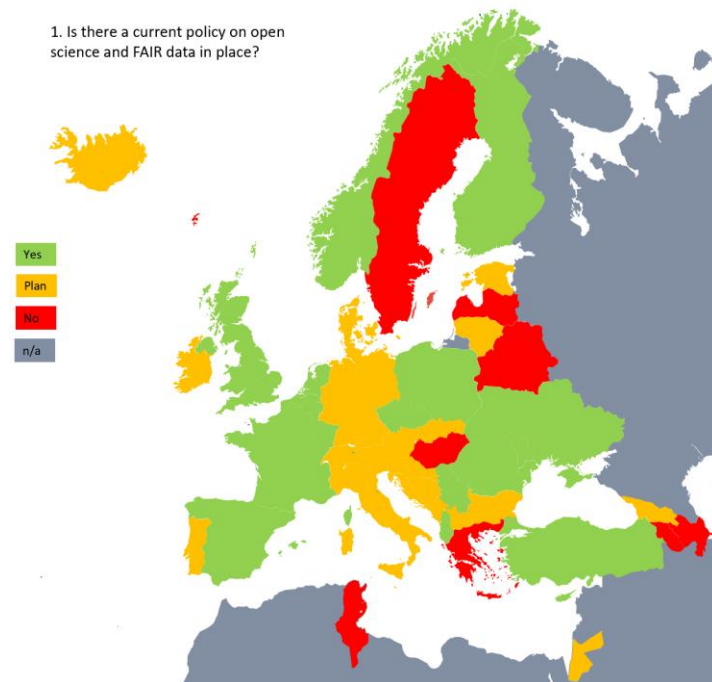


Figure 1: Policy on open science and FAIR data

The results indicate that the majority of responding countries either adopted an open science/FAIR data policy or were getting ready to adopt relevant regulations in this area, which is certainly encouraging. On the other hand, countries can move forward to OS in different areas, in different regions or different institutions. There are examples that show that policies exist and are put into practice at institutional level, and the main policies on the national level came from research funding agencies. Some of the countries that have already adopted policies have also defined the target year when the policy should be fully implemented, which indicates that they have also defined detailed action plans.

Some of the countries ([Austria](#), [Belgium](#), [France](#), [Norway](#), [Serbia](#), and [Slovenia](#)) now have dedicated portals for open science.

In order to align policies and activities of national initiatives fostering open science in Europe, the Council of National Open Science Coordination (CoNOSC) was established in October 2019³⁸⁵.

2.9.1. Policy regarding publications

Figure 2 shows the countries that have already adopted a policy regarding publications. More than 64% (30) of countries claimed to have such a policy in place. Moreover, in all countries that have adopted a policy regarding publications, this either includes (25) open

385 (n.d.). CoNOSC – Council for National Open Science Coordination. Retrieved May 24, 2020, from <https://conosc.org/>

access to publications or an indication that such a requirement is planned (2). The countries planning to adopt a policy regarding publications (15) intend to include an open access mandate in their policies.

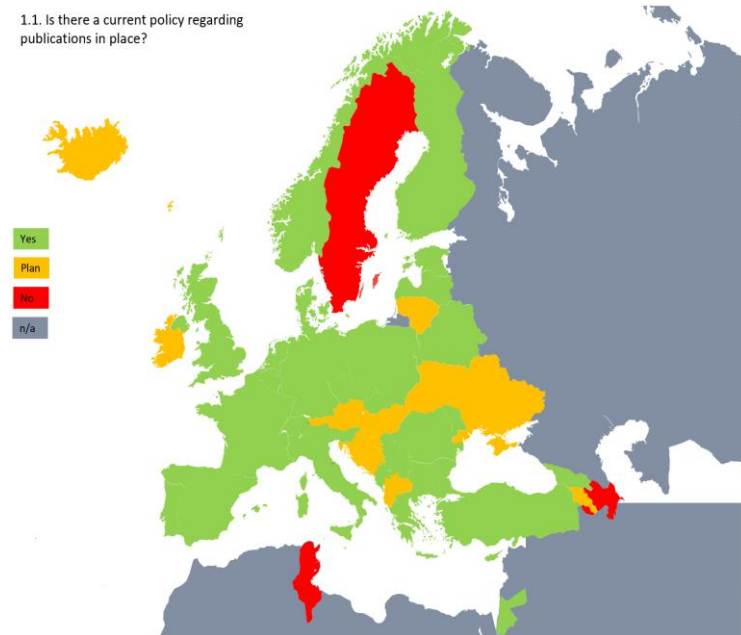


Figure 2: Policy regarding publications

Along with the European Commission, which regularly maintains the [Monitor](#)³⁸⁶ (relying on data from Scopus, i.e. covering only journal articles), some countries maintain applications that monitor the openness of publication (e.g. [Denmark](#)³⁸⁷, [France](#)³⁸⁸, and the [Netherlands](#)³⁸⁹).

Thirteen countries are either members of cOAlition S or signatories of Plan S³⁹⁰, whereas four countries have made an explicit reference to Plan S in the narrative part of their responses.

2.9.2. Policy regarding data/services

Policies regarding data/services are considerably less common amongst the responding countries. However, the reliability of the results may be disputed because some respondents implied that the question addressed open government data, as indicated by the narrative part of their responses.

Figure 3 shows that 31.91% (15) of the responding countries have a policy regarding data/services in place, whereas 46.81% (22) are planning to adopt one. As for the openness of data, it may be observed that the countries planning to adopt a policy have

386 (n.d.). Trends for open access to publications | European Commission. Retrieved July 13, 2020, from https://ec.europa.eu/info/research-and-innovation/strategy/goals-research-and-innovation-policy/open-science/open-science-monitor/trends-open-access-publications_en

387 (n.d.). Home - Danish Open Access Indicator. Retrieved July 13, 2020, from <https://www.oaindikator.dk/en>

388 (n.d.). The French Open Science Monitor - Ouvrir la Science. Retrieved July 13, 2020, from <https://www.ouvriirlascience.fr/the-french-open-science-monitor/>

389 (n.d.). Open and closed access scholarly publications in NARCIS per Retrieved July 13, 2020, from <https://www.narcis.nl/metrics/Language/en>

390 (n.d.). Plan S. Retrieved from <https://www.coalition-s.org/>

concerns as to whether data should be open or not. Out of 22 countries planning to adopt a policy, only 3 plans to mandate open data.

1.2. Is there a current policy regarding data / services in place?

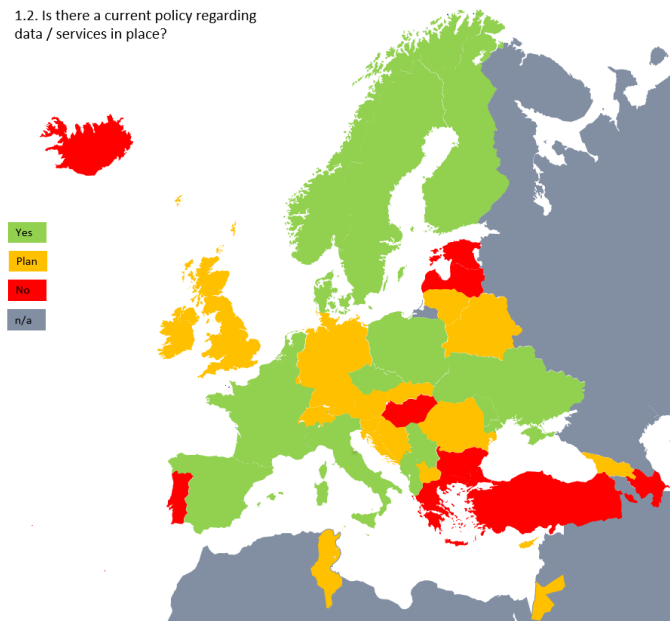


Figure 3: Policy regarding data and services

In conclusion, it is apparent that a greater number of countries have adopted policies regarding open access to publications than those regarding open science and FAIR data. This is expected, keeping in mind that the latter two concepts have taken shape fairly recently, compared to open access to publications.

2.9.3. Policy regarding research evaluation

Although it was clearly stated in the instructions: 'Please complete this part ONLY IF the current policy and responsibility are different from open science policy', we found that there were quite many responses to this question suggesting that many respondents did not understand the question. The question was intended to explore whether research evaluation was specifically addressed in policies. However, the fact that response was provided by countries that do not have a policy reveals that some respondents did not understand the question as intended. The majority of the respondents claimed that they had a policy on research evaluation, 46.81% (22), 21.28% (10) said that there was no policy in place, 10.64% (5) claimed that the policy was in the planning phase, whereas 21.28% (10) did not respond.

A significant number of institutions from the responding countries have already signed the Declaration on Research Assessment (DORA)³⁹¹. As many as 25 countries mentioned the DORA principles as the basis for the planned research evaluation policy in the narrative part of their responses. During the VW, the participants recognise the importance to be placed on the quality of the outputs, including on visibility and reproducibility of results. Research evaluation processes should give extra credits to individuals, groups and projects, that practice open science, based on appropriate indicators. There are already some good practices evident that need to be collected and further exploited.

391 (n.d.). San Francisco Declaration on Research Retrieved from <https://sfedora.org/>

1.3. Is there a current policy regarding research evaluation in place?

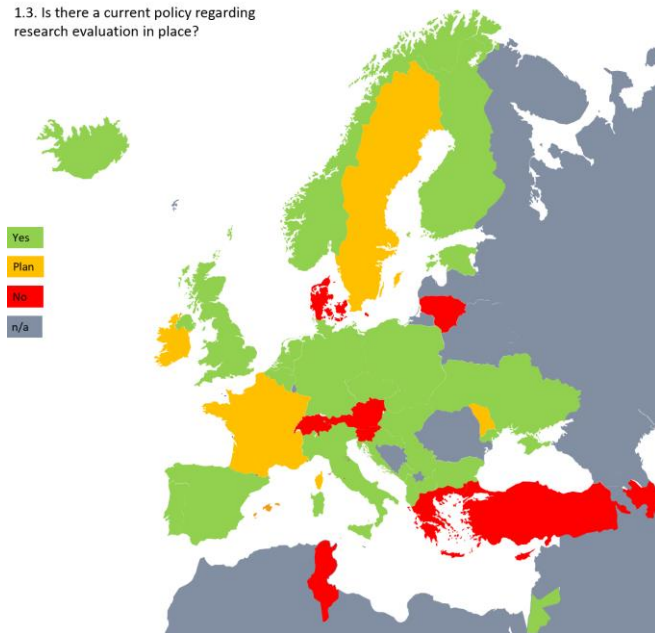


Figure 4: Policy regarding research evaluation

2.9.4. Policy regarding open learning

Only two responding countries (Netherlands and Slovakia) have already adopted a policy regarding open learning. The majority, 57.45% (27) of the respondents clearly stated that they had no such policy in place, whether 14.89% (7) said that they were working towards adopting an open learning policy.

1.4. Is there a current policy regarding open learning in place?

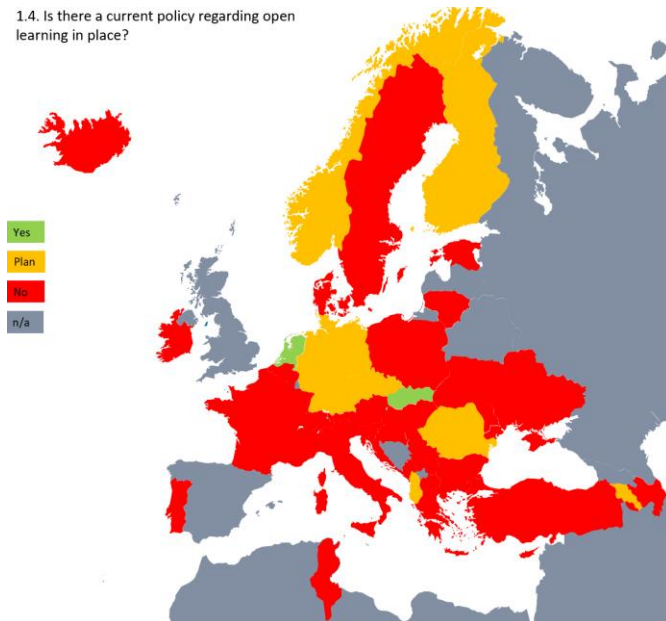


Figure 5: Policy regarding open learning

2.10. Reference to EOSC in the current policies

Figure 6 shows which responding countries make references to EOSC in their current policies. In 25.53% (12) of the responding countries, EOSC is not mentioned in national

2.11. National contact points

More than half of the countries responding to this question have already nominated contact points for open science 53.19% (25) and EOSC 42.55% (20). Other countries plan to do this in the future, which is a promising initiative towards establishing a network of institutions or individuals involved in the activities related to open science and EOSC (Figure 8). According to the results from the Validation Workshop, while the majority of the participants, 73%, are satisfied with the existing network of countries' experts involved in OS, 18% of the participants think a new network is needed and 9% did not know.

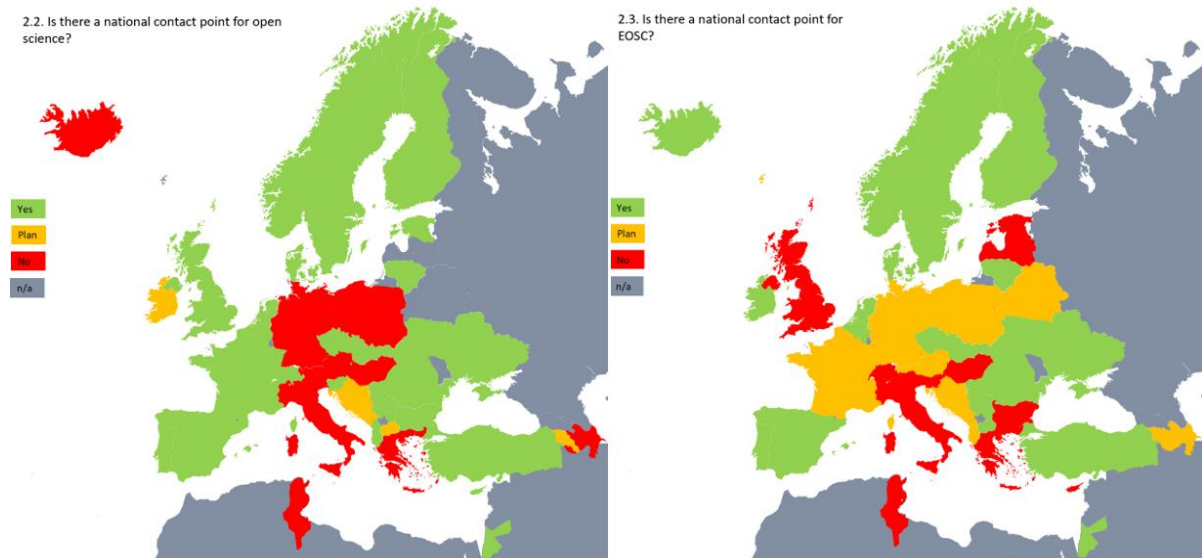


Figure 8: National contact points for open science and EOSC

Interestingly, most countries rely on their OpenAIRE NOAD-e (14) or NPRs (8). The OpenAIRE project is gathering and providing an updated overview of open science developments in individual EU MS and AC via the National Open Access Desks (NOADs) i.e. a dedicated reference or contact points (institutions or individuals).

2.12. National strategic documents

The recent SPARC Analysis of Open Science Policies in Europe presents an updated review of open data and open science Policies in Europe as of July 2019. It summarises policies in Europe by type, the processes of creation, and some of their specific features. The report concentrates on the EU MS, but it also covers relevant countries from the European Research Area, namely Iceland, Norway, Serbia and Switzerland.

Due to the varying phases at which national policies are developed, it is impossible to present a comprehensive overview. Accordingly, we will offer only a snapshot of activities in the responding countries. Even though some countries have national policies in place, these are being updated and developed to embrace FAIR data or open data mandates, or additional strategy documents are being prepared to ensure a stronger focus.

The activities mostly involve ministries, national funding bodies, or new teams and task forces established at the national level to coordinate the work on policy documents. These documents range from national plans, strategy documents or roadmaps, to codes of ethics, white papers, and even laws passed by national parliaments. The following table presents a snapshot of the ongoing work in each country.

Landscape of EOSC-Related Infrastructures and Initiatives

Country	Open Data and Open Science Policy Activity
Albania	All research organisations must have approved Open Access Policies. Academic or research institutions which are funded by public money must have an approved Document & Regulation before submitting applications for research grants from public funds.
Armenia	The open science activities are limited to a few projects supported by EIFL ³⁹² .
Austria	The working group of the Open Science Network Austria (OANA) has developed recommendations for a national open science strategy, which will be published in the spring of 2020 (https://oana.at/arbeitsgruppen/ag-open-science-strategie/#c310661). <i>Austrian Transition to Open Access (AT2OA)</i>
Azerbaijan	The first steps towards the adoption of open science principles are made by OSI and eIFL.
Belarus	The policies are being developed with the support from EIFL, UNESCO and BelCoLIB.
Belgium	The Brussels Declaration on Open Access, signed by the Science Policy Ministers of Flanders; Belgian Science Policy (BELSPO), which mandates Open Access to Publications, is validated by the Direction Committee of December 21, 2017
Bosnia & Hercegovina	Two institutions are joining OpenAIRE: the University of Banja Luka and CREDI. The Centre for Development Evaluation and Social Science Research. CREDI hosts and manages the DASS-BiH – a national data repository that preserves & disseminates social science research data.
Bulgaria	Consolidation of national policies is planned and a Fostering of Scientific Research and Innovation bill is drafted that includes commitments and regulations regarding open science. An OS portal and national repository are under development, recommendations to research institutions are being drafted, there is an active RDA BG Node.
Croatia	A new law on scientific activity, which will include regulation on open science is expected to be passed in 2020. The development of OA activities has been very intensive in line with the Open Access Declaration initiative (2012).
Cyprus	On 25 February 2016, the Council of Ministers of the Republic of Cyprus, approved the adoption of the National policy for Open Access in Cyprus Working Group for Open Access
Czech Republic	Action Plan for the implementation of the National Open Access to Scientific Information Strategy for 2017-2020, and was approved by the Czech government in April 2019.
Country	Open Data and Open Science Policy Activity
Denmark	National Strategy on Open Access (Ministry of Higher Education and Science).

392 (n.d.). eIFL.net. Retrieved from <https://www.eifl.net/>

Landscape of EOSC-Related Infrastructures and Initiatives

Estonia	In 2016, the Open Science Expert Group of the Estonian Research Council published a document with principles and recommendations for developing national policy: <i>Open Science in Estonia</i> .
Faroe Islands	The Open Arctic Research Index pilot project focused on the open-access research data and the open-access research documents published on Polar regions. Part of the wider UARCTIC network, that focuses on education and research in the North Region, the Arctic.
Finland	Jan 2020 published <i>Declaration for Open Science and Research 2020-2025</i> . It was jointly created by the Finnish research community, and approved by the National Open Science and Research Steering Group in December 2019.
France	The French policy is based on the <i>loi numérique</i> (2016), which lays the foundation for open science in France. In July 2018, the MESRI ministry presented the national strategy for open science (Plan national pour la science ouverte). An Open Science Committee is in place.
Georgia	National Open Access working group has been created. The Georgian Integrated Library & Information System Consortium (GILISC) and EIFL spread awareness about OA policy. Two national repositories and OA publishing platform established.
Germany	In 2016, the Federal Ministry of Education and Research (BMBF) published its Open Access Strategy. Several Länder (federal states) and Research Organisations have also implemented open access strategies. While there is no specific open science strategy, a number of ongoing activities on Federal and Länder level contribute to forwarding open science and FAIR data. Within "Projekt DEAL" German academic institutions (including universities, universities of applied sciences, research institutions, state and regional libraries) concluded nationwide publish and read-agreements with Wiley and Springer Nature in 2019 and 2020.
Greece	Open Access policies are slowly adopted by HEI of Greece. A National Open Science Task Force has been established, with the participation of OS stakeholders across the country. It is supported by the General Secretariat of Research and Technology and is about to release the OS Plan for Greece.
Hungary	A working group with the National Research, Development and Innovation Office (NKFIH/NRDIO) was established to formulate a policy on open science.
Iceland	The Science and Technology Policy council has included open science in its Policy and Action Plan since 2017. A national policy for open access to publications is currently under review in the Ministry.
Ireland	The National Open Research Forum (NORF) was convened to progress the wider Open Research agenda for Ireland. NORF has prepared a <i>National Framework on Transitioning to an Open Research Environment</i> to provide a coordinated framework for Irish research funders and institutions and the wider research ecosystem.
Country	Open Data and Open Science Policy Activity
Israel	Established the Israel Science Foundation, Israel-Europe Research & Innovation Directorate (ISERD).

Landscape of EOSC-Related Infrastructures and Initiatives

Italy	Appointing a Commission of national experts from different domains to support the definition of national OS priorities; Drafting a National Plan for open science.
Kosovo*	Kosovo social science data centre (KSSDC) works with CESSDA in order to develop knowledge and tools related to data service infrastructures.
Latvia	In 2016, the Ministry of Education and Science released the <i>Latvian European Research Area Roadmap 2016-2020</i> .
Lithuania	Recommendations for research performing institutions and research funding organisations with an action plan on open access to research information is being prepared by the Ministry of Education, Science and Sport.
Luxembourg	Luxembourg's research institutions and the National Library of Luxembourg support an open access policy. The FNR (Fonds National de la Recherche) supports the open access fund National Policy on Open Access (2015).
Malta	Work underway to compile a National Open Science Policy for Malta.
Moldova	OS is part of the Open government plan. Open Data portal (different ministries). Well-developed repository network.
Montenegro	Planning progress at the end of 2020.
Netherlands	In 2017, the Dutch government declared that open access and open science should be the norm for scientific research. The <i>National Plan for Open Science</i> was signed by the national science organisations in 2017. In 2019, a decision on EUR20 M annual investments in digital infrastructure was made which includes a network of so-called Digital Competence Centres at RPOs. A dedicated OS portal is currently in development.
Rep North Macedonia	Working toward joining the OpenAIRE. Library Information Systems and EIFL have started to spread open access awareness. Metamorphosis Foundation actively promotes OA.
Norway	The Research Council has prepared a policy for open science. The policy will be implemented from January 2020.
Poland	In 2015, the ministry responsible for science adopted the document Directions of development of open access to publications and research results in Poland.
Portugal	The National Council approved a resolution with the guidelines for the National Open Science Policy, and a working group was established to carry out an in-depth analysis of open science in Portugal and define recommendations. The recommendations have never been officially adopted.

Country	Open Data and Open Science Policy Activity
Romania	In November 2018, the Romanian government approved the National Action Plan 2018-2020 for Open Government Partnership (NAP 2018-2020). Proposal for an open science national strategy.

Landscape of EOSC-Related Infrastructures and Initiatives

Serbia	Adopted the National Open Science Platform in 2018. The Team for Open Science in Serbia (TONuS), 2020 established in order to identify and define all improvements, measures and regulations related to OS, and to ensure the implementation.
Slovakia	It is planned to develop and adopt the National Open Science Strategy by the end of 2020.
Slovenia	In 2015, the National strategy of open access to scientific publications and research data in Slovenia 2015-2020 was adopted.
Spain	Spanish Strategy on Science, Technology and Innovation 2013-2020 (promote OA), two additional documents produced.
Sweden	In April 2019, the <i>Swedish National Roadmap for European Research Area 2019-2020</i> was published, stating that, research products must comply with the FAIR principles as far as possible, and that scientific publications produced with public funds no later than 2020 should be directly and openly available.
Switzerland	Open access to publications is mandated by the National Open Access Strategy and the corresponding Action Plan, supported by the SNSF. The newly established Delegation for Open Science is responsible for the ongoing elaboration of a national Open Research Data Strategy.
Tunisia	There is no national open science policy and the relevant infrastructure is underdeveloped. Part of a few African and Arab initiatives for open access.
Turkey	The Scientific and Technological Research Council of Turkey (TUBITAK) has adopted the Open Science Policy.
Ukraine	In 2019, the government adopted an action plan in which Open science is a priority.
United Kingdom	Open Research Data Task Force, Open Research Data Concordat, and JISC is part of the UK National Open Access Desk (OpenAire).

Table 2 Summary of National strategy documents

3. DESCRIPTIVE EXAMPLES OF EUROPEAN, NATIONAL AND REGIONAL STRUCTURES AND INITIATIVES

The overall intention of this chapter is to present a range of initiatives, which might be used as case stories as contributions to the EOSC building processes. Moreover, the presentation of these illustrated cases is succinct, depicting the main objectives pursued

by the representatives of the respective initiatives/projects. The resulting picture should be considered as a starting point for further enquiries, to be discussed and decided with involvement of colleagues from the following working groups: Rules of participation, Sustainability, Internationalisation and Skill Development. Further, some aspects addressed by this section may then be deepened by other working groups, such as FAIR.

Input to this chapter has been derived from the country sheets, from reports of initiatives and European projects, and from individual input from EOSC WG Landscape members.

Section 5.1 describes how data is created with respect to FAIR data rules and how data management mechanisms (e.g. data management plans) are implied and made possible. Section 5.2 describes different approaches to data storage and how repositories are created and maintained. In Section 5.3, the possibilities of data processing using different types of infrastructures and ways of data preservation are presented. Solutions for persistent identifiers, such as DOIs and ORCID numbers, are presented in Section 5.4. Finally, Section 5.5 presents the surveys conducted by two of the INFRAEOSC-05B projects, EOSC-Synergy and EOSC-Pillar. These surveys, together with the ongoing and upcoming surveys from the other regional projects, will be an important input for the next part of this report, but results are not yet available at the present time.

3.1. IT services and data management mechanisms

3.1.1. FAIR data generation

For the first time, the European directive on open data and the re-use of public sector information 1024/2019³⁹³ includes research data, in recognition that the volume of research data generated is growing exponentially and has potential for re-use beyond the scientific community. Research data in this context includes statistics, results of experiments, measurements, observations resulting from fieldwork, survey results, interview recordings and images. It also includes metadata, specifications and other digital objects. In addition to open access, commendable efforts are being made to ensure that data management planning becomes standard scientific practice, and to support the dissemination of research data that are findable, accessible, interoperable and re-usable (the FAIR principles). For these reasons it is appropriate to motivate the Member States to adopt open access policies with respect to publicly funded research data, and ensure that such policies are implemented by all research performing organisations and research funding organisations.

Naturally, all sciences today are data producers, creating raw (binary) data, images, documents, and software. However, the FAIRness of data produced varies widely. The large, international scientific projects (e.g. ESFRIs) and research infrastructures lead in FAIR data production, as the combination of large data volumes and the distributed nature of the community involved, requires FAIR data in order to provide the high-quality scientific results expected. Universities also play a major role in data generation, as they often channel the scientific productivity of their researchers and help them to store their data in repositories (see next section). The FAIRness of data is also closely linked to good research data management, and as the first step in that, the construction of a data management plan.

In a more general context, a multi-step effort is necessary to achieve FAIR data generation for all communities, including the long tail of science. This is described in *Turning FAIR to*

393 (2019, June 26). DIRECTIVE (EU) 2019/ 1024 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 20 June 2019 on open data and the re-use of public sector information - EUR-Lex. Retrieved from https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=uriserv:OJ.L_.2019.172.01.0056.01.ENG

*Reality*³⁹⁴, the final report and action plan from the European Commission Expert Group on FAIR Data. Although some of the recommendations (in Section 8 of the report) have already been taken into account, it would be advisable to follow all the proposed priority recommendations and implementation plans in order to achieve FAIR data generation across countries and disciplines in Europe.

Of the 106 respondents to FAIRsFAIR's open consultation, two-thirds offer in-house support services. Most responses came from countries with a high level of commitment to open science and FAIR principles. In-house support was most frequently provided by respondents based in Belgium, Finland, the United Kingdom, the Netherlands, and Germany³⁹⁵. The related FAIRsFAIR policy landscape study found that 'while some HEIs are introducing domain-specific RDM support in faculties, most universities do not have the staff or financial resources to provide this level of support. As such, there is a need to develop and curate a shared set of discipline-specific guidance and training resources that can be easily found and reused. This should be done in close cooperation with the ESFRIs and related Cluster projects'³⁹⁶. While there is a relative abundance of studies and reports on research data management policies and support provision, the area of training provision within university curricula has received little attention. The *FAIR in European Higher Education* report³⁹⁷ establishes a foundation for the identification of existing Research Data Management and FAIR practices and the needs of higher education institutions. The report builds on information gathered through an online survey with 90 responses, and two live focus groups with a total of 50 participants implemented between September and November 2019. This report presents insights into three main dimensions, namely:

- a) the integration of FAIR and Research Data Management into higher education activities;
- b) the status of Research Data Management policies and support services and their relation to the FAIR principles; and
- c) university perspectives on the European Open Science Cloud.

Based on its findings, the report also synthesises possible recommendations on how to develop Research Data Management and FAIR competencies and capacities within the higher education sector.

Science Europe recently published a report, *Implementing Research Data Management Policies Across Europe*³⁹⁸, which is based on the experiences of seven member organisations that have already implemented research data management (RDM) and the RDM Guide³⁹⁹ into their policies. It features the organisations' approaches to developing research data management (RDM) policies and the forms of communication they use to inform researchers and their institutions on the concept of RDM and the requirements of these policies. It also explores the challenges faced by researchers, their home institutions and funding organisations, both during and after implementation of the new policies, and provides examples on how researchers can be supported in their RDM efforts.

394 https://ec.europa.eu/info/sites/info/files/turning_fair_into_reality_1.pdf doi: 10.2777/1524

395 FAIRsFAIR Policy and Practice Survey 2019 data for D3.1_D3.2_D6.1 <https://doi.org/10.5281/zenodo.3550529>

396 Davidson, Joy, Engelhardt, Claudia, Proudman, Vanessa, Stoy, Lennart, & Whyte, Angus. (2019). D3.1 FAIR Policy Landscape Analysis (Version v1.0_draft) <https://doi.org/10.5281/zenodo.3558172>

397 <https://doi.org/10.5281/zenodo.3629683>

398 (2020, January 3). Download - Science Europe. Retrieved from https://www.scienceeurope.org/media/jikjlb2g/se_rdm_best_practices.pdf

399 (n.d.). Practical Guide to the International Alignment of Research Data. Retrieved from <https://www.scienceeurope.org/our-resources/practical-guide-to-the-international-alignment-of-research-data-management/>

3.1.2. Data management plan

Data Management Plans (DMPs) are a basis of/support for good research data management. More practical support in setting up DMPs is provided on a local, regional, and/or national level, but greatly varies from country to country, and even in countries between regions and scientific domains. Transnational examples are RDA and OpenAIRE, which provide advice, discussions, and training to set up DMPs. Data access across data repositories is currently an area which many member states have not adequately addressed and is an area of current and future development.

The European Commission requests DMPs for projects funded under the current research and innovation framework Horizon 2020 and the future Framework Programme for Research and Innovation Horizon Europe (2021-2027).

In France, funding proposals to the National Research Agency (Agence nationale de la recherche (ANR)) have to include a data management plan. In order to help researchers in this, ANR collaborated with DORANum⁴⁰⁰ (Données de la Recherche: Apprentissage Numérique) to use DMP OPIDoR⁴⁰¹, an online tool that helps create DMPs.

The Finnish online tool DMPTuuli⁴⁰² also provides DMP services to researchers and contains the AKA DMP template along with other public DMP templates. In order to meet researchers' expressed needs, SRC (SE) is looking into possibilities to provide a DMPtool as well. NWO (NL) does not provide its own tool, but strongly encourages its researchers to use the DMPonline tool provided by the Digital Curation Centre (DCC). The NWO DMP template is also available on DMPonline. FWO (BE) similarly does not provide a tool, but uses a DMP template which was developed together with the Flemish universities. This DMP template is made available in DMPonline.be, which is an instance made available by the DMPBelgium Consortium, a result of cooperation between several Flemish and Walloon universities and scientific institutes.

Another interesting example is the Spanish National Research Council (CSIC) which also strives to support its researchers who encounter RDM-related problems. CSIC does this through different services available in the institutional repository DIGITAL.CSIC. These services include documentation, training and support on how to set up DMPs. It also provides support for different stages along the data lifecycle, including publication of datasets with a proper metadata document.

HRB (IE) is currently in discussion with the DCC to set a bespoke DMP platform that meets the needs of all actors involved. It is expected that such a platform will act as a one-stop-shop for the management of DMPs through the lifetime of the research project and will integrate the needs of the researcher, research institutions and funding organisations.

Other examples of countries where national agencies require DMPs are: Austria, where approved proposals have to include a DMP before the project starts; Belgium, where funding proposals to the FWO have to include a data management plan; and Switzerland, where the SNSF requires a DMP in funding proposals. Also, the Irish Health Research Board (HRB) and the Polish National Science Centre (NCN) have developed their DMP requirements.

The Swedish Research Council has within the assignment on national coordination of open access to research data appointed a working group to coordinate the work on data

400 (n.d.). Data Management Plan (DMP) - DoRANum. Retrieved from <https://doranum.fr/wp-content/uploads/FicheSynthDMP.pdf>

401 (n.d.). DMP OPIDoR. Retrieved from <https://dmp.opidor.fr/>

402 (n.d.). DMPTuuli. Retrieved from <https://www.dmptuuli.fi/>

management plans on the national level. The aim is to support increased open access to research data. The working group has representatives from higher education institutions and their units that support the processes of data management, representatives for infrastructures and services linked to storage and accessibility, representatives for research funders, and researchers.

In Sweden, there is also a collaborative infrastructure for Register-based Research, RUT, developed as a result of a government commission to the Swedish Research Council. The aim of RUT is to increase the value and use of Swedish registers, research databases, sample collections and research datasets. Through the RUT infrastructure, researchers are able to access and explore rich metadata and semantic descriptions in different registers, making the process of gathering and understanding knowledge about their content easier and more harmonised throughout the research process.

Also, the Swedish National Data Service (SND) is a national research infrastructure and consortium whose primary function is to support the accessibility, preservation, and re-use of research data and related materials. SND strives to create a national infrastructure for open access to research data, for example by ensuring that the organisations' metadata is made visible in a national domain-specific portal and/or other international portals. EOSC-Nordic⁴⁰³ is a project funded by the EU Commission and coordinated by the Nordic e-Infrastructure Collaboration under NordForsk. The Nordic e-Infrastructure Collaboration (NeIC)⁴⁰⁴, is a collaboration platform for different projects such as sensitive data, WLCG Tier-1 node, Nordic language processing. The EOSC-Nordic project started in 2019 and aims to foster and advance the take-up of the EOSC at the Nordic level by coordinating the EOSC-relevant initiatives in Finland, Sweden, Norway, Denmark, Iceland, Estonia, Latvia, Lithuania, Netherlands and Germany. One of the objectives is to improve interoperability practices across the national initiatives. Among other things, a series of demonstrators addressing different parts of the research and data lifecycle will be developed to test discovery and re-use, analysis and post-processing, data management (including sensitive data management), sharing and archiving.

Another relevant initiative on the Nordic level is focused on secure digital infrastructure for health data⁴⁰⁵. A report describing this initiative and vision of a Nordic secure digital infrastructure for health data, the Nordic Commons, was published in December 2019, and includes suggestions for policy implications with specific recommendations, supporting the vision of a common infrastructure supporting reproducible and open research for the benefit of Nordic public health and societies.

3.2. Data storage and data repositories

A prerequisite for any FAIR data activity is the storage of data. International scientific collaborations often distribute their storage over several sites in the participating countries, as, for example, the data of the LHC experiments at CERN. In other cases, data are stored centrally for international collaboration, as in the case of the European Spallation Source (ESS) at the Danish Data Management and Software Centre. In general terms, large scientific collaborations tackle the challenge of data storage of their large-scale experiments early on and include this aspect in their budget. Smaller-size experiments are more of a challenge throughout Europe as they often do not include a thorough plan for

403 <https://neic.no/news/2019/02/22/EOSC-Nordic-announcement/>

404 (2020, March 10). Home - NeIC web. Retrieved from <https://neic.no/>

405 https://www.nordforsk.org/no/publikasjoner/publications_container/a-vision-of-a-nordic-secure-digital-infrastructure-for-health-data-the-nordic-commons

data storage; instead, use e-infrastructures in an opportunistic or ad hoc manner such as using local disk storage or storing data in their geographical or scientific neighbourhood. Because data produced by all of these experiments is significant, several national initiatives have been launched in order to provide solutions for data storage. These solutions vary significantly in size, technology, and connected services.

In Sweden, for example, universities are generally responsible for data storage, however, some storage services are also provided by SUNET (the Swedish NREN), SNIC and SND.

In Finland, the Ministry of Education and Culture is carrying out the Data and Computing 2021 development programme (DL2021), which provides data storage disk capacity, and Norway also has a national data storage offer through NIRD and CLARINO.

National data storage initiatives in Eastern Europe include the National Open Access Research Data Archive (MIDAS) and LiDA⁴⁰⁶ in Lithuania; the Polish national system for secure data storage (KMD); and the Serbian AEGIS national data storage resources.

In France, data storage is for example provided by the NGI France Grilles, and (mainly for physics) in the CC-IN2P3 computing and data centre, as well as by a larger number of regional computing centres.

In Austria, the EODC⁴⁰⁷ provides multi-Petabyte-scale storage (discs and tape) connected to the EOSC cloud, while Germany recently launched its National Research Data Infrastructure (NFDI), which will provide national research data management services; data storage for various scientific disciplines is e.g. provided by the Helmholtz Data Federation (HDF) as well as by many university-based computing and data centres.

In Italy, there is a large number of local repositories at the level of the single university, a significant part of which adopt the Institutional Research Information System⁴⁰⁸ - IRIS, a local CRIS serving also as an Institutional OA repository. In addition, many thematic repositories from domain-specific RPOs are present. INFN, ENEA, INAF, INGV, ASI, OGS, CNR, CREA, have computing and data centres mainly for their researchers, but interdisciplinary usage is foreseen. It is worth mentioning that there are also a number of repositories for cultural heritage, most of which are part of Europeana⁴⁰⁹.

In the last two years, a network of 14 institutional repositories has been established in Serbia, which includes more than 30 000 records. They used open-source software (DSpace) and are working on permanent development and integration with relevant international infrastructures. This has significantly increased the visibility of local research (especially in humanities, where the sharing of OA content is above 90%). The network, which is still growing, may serve as a valuable source of high-quality metadata (available under the CC0 license) and OA content, as well as a solid basis for thematic services based on content aggregation, educational websites, etc.

The landscape of research data repositories in Europe is highly fragmented. Significant repositories, in terms of users and the quantity of data available, are mostly domain and community-specific. Large examples are e.g. open data⁴¹⁰ at CERN for particle physics,

406 (n.d.). Lidata.eu. Retrieved from <http://www.lidata.eu/en/>

407 (n.d.). EODC :: Collaboration for Earth Observation. Retrieved from <https://www.eodc.eu/>

408 (n.d.). IRIS - Institutional Research Information System | Cineca. Retrieved from <https://www.cineca.com/it/content/IRIS>

409 (n.d.). Europeana Collections. Retrieved from <https://www.europeana.eu/portal/>

410 (n.d.). CERN Open Data Portal. Retrieved from <http://opendata.cern.ch/>

CDS Strasbourg⁴¹¹, INAF IA2⁴¹² and ASI SSDC⁴¹³ for astrophysics, and the International Genome Sample Resource (IGSR)⁴¹⁴. Some of these examples are indeed intrinsically international, while others are national, which gives rise to different business and organisational models in various cases.

Multi-disciplinary repositories are mostly provided on an institutional or university level. They mainly serve their own researchers as a means to store and publish their research data. The Anglo-Saxon countries lead in this domain, but there are other significant, multi-disciplinary data repositories in e.g. Scandinavia, Switzerland, and the Netherlands. One step further is to combine forces between several universities and to provide services on a near-national level, as can be seen e.g. in the Dutch 4TU.ResearchData repository, which as of 2019, hosted 900 data collections from various disciplines, with a user base of 23 000 individuals in 2018.

Multi-disciplinary and international data repositories are hosted by international organisations. Examples here include the Zenodo⁴¹⁵ platform (CERN and OpenAIRE) and the Environmental Data Explorer (United Nations Environment Programme⁴¹⁶). These efforts also reflect the cross-disciplinary interests and/or mandates of the service providers.

A first step to provide access to the diverse range of data repositories are registries, which provide catalogues of repositories including basic information about them (e.g. access point, domain, origin, etc.). Examples include the re3data⁴¹⁷ registry of research data repositories, and the (commercial) Web of Science Master Data Repository List⁴¹⁸.

The challenge for the EOSC will be to act as an interface to a large variety of platforms, first on the subdomain level, then on the domain and interdisciplinary level. Solutions to this challenge are provided e.g. through the cluster projects.

The German Federal Government has issued a set of national strategies that outlines a roadmap for digital transformation⁴¹⁹. Likewise, in addition to universities, many science organisations in Germany (e.g. Helmholtz, Max Planck, Fraunhofer Society, Leibniz Association), have also defined digitalisation strategies that address big data, research data management, AI/ML, supercomputing, knowledge management and research software engineering (RSE).

There are nearly 40 repositories in Hungary registered in OpenDOAR. These repositories are run by 23 universities and research institutions. There is a specialised initiative in Hungary for the collection of references to all scientific publications of Hungarian researchers called MTMT⁴²⁰. Five data repositories are registered in the re3data database in Hungary. Two of them are run by research centres and mostly host data in the fields of SSH. The others include HunCLARIN, which is a member of the European project CLARIN

411 (n.d.). CDS, Strasbourg. Retrieved from <http://cdsweb.u-strasbg.fr/>

412 (n.d.). IA2 - Inaf. Retrieved from <https://www.ia2.inaf.it/>

413 (n.d.). SSDC - ASI Science Data Center Home Page. Retrieved from <https://www.asdc.asi.it/>

414 (n.d.). 1000 Genomes. Retrieved from <http://www.internationalgenome.org/>

415 (n.d.). Zenodo. Retrieved from <https://zenodo.org/>

416 (n.d.). UN Environment Programme. Retrieved from <https://www.unenvironment.org/>

417 (n.d.). Re3data. Retrieved from <http://re3data.org/>

418 (n.d.). Master Data Repository List - Web of Science Group. Retrieved from <https://clarivate.com/webofsciencigroup/master-data-repository-list/>

419 (n.d.). National Strategies | German Digital Technologies. Retrieved from <https://germandigitaltechnologies.de/national-strategies/>

420 <https://mtmt.hu>

and has a large collection of data in the fields of SSH; however, generally, it hosts cross-disciplinary data. Hungary is a member of GEOMIND, a centralised, cross-border gateway for geophysical data search and acquirement, and a partner in KADoNiS. A further specialised repository is developed and operated by KIFÜ for knowledge sharing and multimedia content⁴²¹. The Directory of Open Access Journals now lists 35 Hungarian scientific journals, and more are in progress.

3.3. Data processing and data preservation

Data preservation not only refers to the long-term storage of data, but also includes ensuring the preservation and maintenance of data, as well as its context, understandability, interpretability, authenticity and integrity. Preservation of scientific data requires data curation by IT experts as well as the active involvement of documentalists and scientists to guarantee long term usability of research data.

As a result, large-scale data preservation is often organised by long-term international projects and organisations. As an example, the CERN Advanced STORage system (CASTOR⁴²²) reached the milestone of 350 petabytes of data and more than 600 million individual files stored on tape at the end of 2019, with 12-13 petabytes written to tape every month.

Another example is the SIMBAD astronomical database at the Strasbourg astronomical Data Centre (CDS⁴²³). Alongside data curation and service maintenance responsibilities, the CDS undertakes R&D activities that are fundamental to ensure long-term sustainability in a domain in which technology evolves very quickly. R&D areas include informatics, big data, and development of the astronomical Virtual Observatory (VO).

On the European level, the ARCHIVER (Archiving and Preservation for Research Environments) project aims to improve archiving and digital preservation services, supporting the IT requirements of European scientists and providing end-to-end archival and preservation services which are cost-effective for data generated in the context of scientific research projects (see Annex I).

In addition, some countries provide national solutions to the data preservation challenge. In Estonia, for example, data preservation services are provided through NATARC/PlutoF and EKRK.

In Finland, data preservation is one of the main tasks in the UNIFIs 2018 Open Science and Data Action Programme for the Finnish Scholarly Community⁴²⁴.

One of the French national computing centres, CINES⁴²⁵, provides data preservation services for data and digital documents produced by the French community of Higher Education and Research.

Clearly, data preservation is not only a technical (and financial) challenge. FAIR data policies and carefully set-up data management plans are a prerequisite for data preservation. As such, data preservation relies on having good levels of knowledge of these

421 <https://videotorium.hu>

422 (n.d.). Home | castor.web.cern.ch. Retrieved from <http://castor.web.cern.ch/>

423 (n.d.). Centre de Données astronomiques de Strasbourg (CDS). Retrieved from <http://cdsweb.u-strasbg.fr/about>

424 (2018, May 28). Open Science and Data. Action Programme for the Finnish Scholarly Community - Doria. Retrieved from <https://www.doria.fi/handle/10024/164174>

425 (2019, May 6). Preservation | CINES. Retrieved from <https://www.cines.fr/en/long-term-preservation/>

areas within the communities that want to preserve their research data. Several centres and initiatives aimed at building capability and skills for research data management, such as the Digital Curation Centre (DCC⁴²⁶) in the UK, or the CINES training program⁴²⁷ in France.

Another approach was chosen in Austria, through a combined and systematic project, which gathered as part of one huge, national initiative, all Austrian Universities (except one), two huge extramural RIs, and the Austrian National Library. The project e-Infrastructures Austria (2014-2016/2017-2019) was co-financed by the Ministry of Science and the Universities. This project systematically covered the following areas: data storage, data repositories, data preservation, and permanent access. The project was initiated in 2014 by the Federal Ministry of Science, Research and the Economy (German: BMWFW) to promote the coordinated expansion and further development of repository infrastructures throughout Austria. The project involved all Austrian Universities except one (26 partners). The project aimed to ensure secure archival and provision of electronic publications, multimedia objects and other digital data produced from research and teaching. The second phase of the project ended in December 2019. The project was structured into twelve fields of action, including an extensive survey addressing all active researchers in Austria (36,000 individuals). The survey covered the identification of the status quo for handling research data in Austrian universities and extra-mural research activities. The project also explored existing initiatives, determined the requirements for future research data services in Austrian universities, libraries, and research service providers, and also identified needs of the scientists according to the different subject-specific work and publication processes. The analysis of the survey is described in the report *Researchers and their Data: Results of an Austrian Survey*⁴²⁸.

Following the Austrian example, in early 2017, the Bibliosan for Open Science (BISA) inter-institutional Working Group, including scientific information experts, mainly from Istituto Superiore di Sanità (ISS, Italian National Institute of Health), carried out a survey on the practical handling of research data produced by Bibliosan-affiliated institutions - the Italian Biomedical Research Libraries Network promoted by the Italian Ministry of Health. The Italian colleagues asked the Austrian colleagues for support, and the project e-Infrastructures Austria offered its questionnaire and findings resulting from their activities. The BISA online questionnaire collected over 2,400 responses obtained from 58 Bibliosan institutions. Among the various aspects of data management covered by the BISA questionnaire, one referred to the need for research data policy and guidelines to be adopted by Bibliosan research was carefully explored. The report is available online and it also contains a chapter offering a comparison of Italian and Austrian results⁴²⁹.

Data access across data repositories is currently an area which many member states have not adequately addressed and is an area of current and future development.

426 (n.d.). Digital Curation Centre. Retrieved from <http://www.dcc.ac.uk/>

427 (2017, November 6). Training | CINES. Retrieved from <https://www.cines.fr/en/services-2/training/>

428 "Researchers and Their Data. Results of an Austrian Survey", 2015, (PDF Full Report/en): https://phaidra.univie.ac.at/detail_object/o:409318

429 http://old.iss.it/binary/publ/cont/17_32_web.pdf

3.4. Persistent identifiers

3.4.1. Managed DOI-assignments in Italy

The assignment of digital object identifiers (DOIs) in Italy is managed at the national level by the Conference of Italian University Rectors (CRUI, in Italian), which is the Italian member of DataCite, through the CRUI DOI project⁴³⁰.

Italian organisations (universities, research organisations, libraries, etc.) can join the CRUI DOI project and get a DOI-prefix, just filling and signing some preparatory documents. The annual cost of a DOI prefix has recently increased from the initial 200 Euros to around 300-400.

Out of a prefix, one can create an unlimited number of sub-prefixes and, for each sub-prefix, an unlimited number of DOIs. When an organisation joins the CRUI DOI project, the responsible person gets the credentials to access the DataCite Fabrica portal (both through the web and the APIs) and manage the prefix autonomously.

In January 2017, in the context of the EU-funded Sci-GaIA project⁴³¹, an agreement was established between the University of Catania and the CRUI to extend the possibility to provide DOI-prefixes to all African organisations wishing to deploy an institutional Open Access Repository. So far, 5 DOI prefixes have been released to:

- The Sci-GaIA project (Intl.);
- The African Population and Health Research Centre (KE and Intl.);
- The Eko-Konnnect Research and Education Initiative (NG);
- The Ministry of Education of Ethiopia, managed by EthERNET, the Ethiopian NREN;
- The UbuntuNet Alliance (MW and Intl.).

Through these projects, the University of Catania took a leading role in the development of Open Access and Open Data management services in Ethiopia^{432 433 434}.

3.4.2. UK National Persistent Identifier Project

In the UK, Jisc is leading a project to establish equitable, consistent access to persistent identifier (PID) services for the UK research sector, and to build robust governance mechanisms to ensure that these systems remain open and sustainable for the long term. This project is evaluating current PID services, their adoption, and the interactions between them. It will assess the business case for building a UK national PID community structure, to provide access to and oversight of PID services. It will tackle the practical barriers to PID integrations in the tools and platforms that researchers rely on to conduct and share their work. The initial phase of the project will run through 2020, and will focus on stakeholder engagement and research.

In Belgium, the Department Economy, Science and Innovation of the Flemish Government is hosting the FRIS portal, which collects metadata on research information objects using

430 <https://www.crui.it/commissioni-crui/progetto-doi.html>

431 <https://cordis.europa.eu/project/id/654237>

432 <https://nadreweb.ethernet.edu.et>

433 <https://nadre.ethernet.edu.et>

434 <http://orcid.org/0000-0001-5971-6415>

common PIDs. In order to unambiguously collect, merge and exchange information, several rules are agreed upon by the information providers. These PIDs include: funder agreements, organisation IDs, ORCID, DOIs, etc.

3.4.3. The ORCID Austrian Consortium

Since January 2019, the TU Wien Bibliothek has coordinated, in cooperation with the university library of the University of Vienna, the Austrian ORCID consortium - ORCID Austria. The consortium is currently composed of eleven institutions (ten universities and one funder). Among the main goals are to establish ORCID iD as the main identifier of researchers in Austria and link the ORCID iDs to the last ten years of research contributions, preferably via automatic updates and integrations.

The TU Wien Bibliothek, as Lead of the consortium, administratively manages the consortium, acts as the contact point between the ORCID and the members, and is in charge of keeping the members informed of ORCID news, as well as the onboarding processes of new members. It maintains a website that serves as the first platform for information exchange ⁴³⁵.

Austrian non-for-profit organisations (universities, research organisations, funders, etc.) can join ORCID Austria and integrate ORCID in up to five institutional information systems using the ORCID Member API. The annual cost of the membership depends on the number of members according to ORCID official tiers.

Several outreach activities were organised, some internal to members and others open to the Austrian community, such as the launch workshop held in June 2019 at the TU Wien and an open webinar held in February 2020.

The next outreach activity, a workshop focused on ORCID Technical implementations, will take place in April 2020 and counts with the support of EOSC Secretariat via Co-Creation Budget.

In addition, the consortium reached further regions through the participation in the ORCID Spain Workshop in Málaga in 2019.

As part of the support activities, two documents have been published:

- Joint statement of principles (ORCID Austria) (in German) ⁴³⁶.
- *ORCID: Member API or Public API?* (in German) ⁴³⁷

A Zenodo community with workshop and training materials is also maintained⁴³⁸.

3.5. Regional surveys

The INFRAEOSC-05-2018-2019(B) projects (so-called 5B projects) are intended to coordinate EOSC-relevant national initiatives across Europe and to support prospective EOSC service providers (see Section 2.7 for a brief description of these projects). In this

435 <https://www.tuwien.at/kooperationen/orcid/>

436 <https://doi.org/10.25365/phaidra.104>

437 <https://doi.org/10.25651/1.2019.0011>

438 <https://zenodo.org/communities/orcidaustria-materials/>

context, the 5B projects are conducting surveys in their regions to evaluate EOSC awareness and readiness and EOSC participation possibilities.

The survey results are not yet available, but an update will be included in the next version of this report. This section presents two examples for these surveys, Synergy Survey and Pillar Survey to highlight the type of information they will provide.

3.5.1. EOSC-Synergy Survey

3.5.1.1. Overall approach and methodology

The EOSC-Synergy⁴³⁹ project extends the EOSC coordination to nine participating countries by harmonising policies and federating relevant national research e-infrastructures, scientific data and thematic services, bridging the gap between national initiatives and EOSC. In February 2020, the project issued a report presenting the results of the initial policy landscape analysis, which was then used as a foundation of the project's policy engagement strategy and its implementation.

In general, policy engagement serves several different roles, from being part of the overall sustainability of the service provision to being one of the enablers of disruptive innovation. Within a project, policy engagement is a service function: it needs to support requirement gathering and compliance activities of the technical work packages, as well as being part of the "organisational memory" when it comes to identifying solutions and workarounds that make federated service provision that complies with the relevant regulatory frameworks more efficient.

The initial landscaping work confirmed the a priori assumptions behind the policy engagement strategy of the EOSC-Synergy project. At the European level, the EOSC-related policy and funding structures are evolving rapidly, whereas the structures within individual countries tend to have longer evolutionary histories and more stable organisational and governance structures. However, national approaches to EOSC-related policy work are very diverse.

Thus, the engagement strategy needed to be adaptive and process-oriented. It was based on systematic, continuous surveying of the policy landscape, coupled with an efficient division of labour in the monitoring and engagement tasks. Rather than defining in advance which organisations and initiatives the project should engage (and how), the focus was on ensuring that new policy issues were logged and managed in a consistent manner.

From the point of view of external stakeholders, a big part of the consistency of the policy engagement is based on assigning "liaison persons" for each of the organisations the project engages with. In most cases, they will act as the primary contact points for initiating communications and will be responsible for maintaining an accurate picture of the project's relationship with the organisations they are responsible for.

Within the project, the policy engagement is closely aligned with all the project's activities, with a specific emphasis on the dissemination and exploitation activities. However, its scope as a service function is not limited to these specific tasks.

3.5.1.2. Initial policy landscape analysis

At the time of writing, the policy landscape on which the EOSC-Synergy project operates presents a number of challenges. The most obvious ones are related to the number of

⁴³⁹ <https://www.eosc-synergy.eu/>

ambitious, large-scale projects involved in realising the EOSC vision. On the other hand, this also represents an opportunity, since reaching the critical mass of activity, awareness and political commitment is much more likely with the high-level policy commitments in place. However, these commitments are still somewhat abstract in nature, and the EOSC activities are bringing together several pan-European and regional thematic and technological clusters that have developed slightly different ways of structuring, steering and documenting the collaborations.

For this reason, the high-level landscape is characterised by a number of open questions related to the details of the governance, funding and processes of the EOSC activities. Thus, especially when focusing on the issue of transnational access it is difficult to assess the relative impact of the current and emerging policy-related groups.

When designing the engagement strategy, it is assumed that the majority of the experts and policy-makers on a pan-European level are already involved in the EOSC-related governance work, typically simultaneously participating in several expert groups or task forces. As a consequence, when considering the information gathering and supporting the eventual uptake of the policy-related project results, EOSC-Synergy can focus on maintaining contacts between the project and the experts/representatives involved in the EOSC governance and sustainability work.

The landscape is slightly different on the national level: the key experts and policymakers tend to be focused on national issues, with EOSC-related topics representing only a small fraction of the topics covered by their formal responsibilities. There is also a wide range of organisational approaches to cover all the thematic, sectoral and infrastructure, as noted in the e-IRG survey of national nodes. For both of these reasons, the project cannot rely on existing contacts between policymakers and their counterparts in other countries.

3.5.2. EOSC-Pillar Survey

The H2020 project EOSC-Pillar⁴⁴⁰ is one of the INFRAEOSC regional projects which aims to coordinate national open science initiatives in Austria, Belgium, France, Germany and Italy with regard to open research data. The project aims to assess and harmonise these initiatives in order to help facilitate the federation of services to EOSC and the implementation of EOSC. EOSC-Pillar also aims at proposing new services and tools, establishing sustainable business models, promoting the FAIR principles and their implementation, as well as ensuring the engagement of stakeholders from the infrastructure and research communities.

In Work Package 3 of the project, information on existing national and thematic initiatives and research data infrastructures is collected and analysed as a first step. The aim is to build upon these findings with related project activities as well as inform all EOSC stakeholders on the status quo of national and thematic initiatives, the existence and operation of services, national funding structures, policies on open data aspects and other developments within the research infrastructure landscape.

The survey to assess these national and thematic initiatives was conducted among universities, funding bodies, research infrastructures and e-infrastructures. The aim of this endeavour is to create a comprehensive picture with state-of-the-art data on organisational, technical and legal aspects of open research data to foster discussions and support the implementation of EOSC.

440 <https://www.eosc-pillar.eu/>

The questionnaire that was developed was tailored to the different target groups and included questions on topics such as business models and Service Level Agreements (SLAs), legal aspects, such as access restrictions and policies, and further technical aspects, such as Authentication and Authorisation Infrastructure (AAI). Data management practices and compliance with the FAIR principles were assessed, as well as user communities and user support.

The survey was conducted in October and November 2019. A total of 2,204 organisations were contacted, and 688 responses gathered (response rate of 31%).

The full report on the results of the survey will be available in Q3 of 2020 and will include all relevant results of the survey. This report aims to provide a state of the art picture of the research infrastructure landscape in the EOSC-Pillar countries, give an insight into the existence of different services (including operational details), funding schemes and business models, the knowledge and implementation of the FAIR principles, etc. – ultimately to understand existing challenges and gaps, but also to assess the maturity level of service providers.

In addition to the full report, the data set will be curated and published for reuse via the repository AUSSDA under the following link and DOI⁴⁴¹. The questionnaire, as well as the list of targets, are already available under the same DOI.

441 <https://doi.org/10.11587/VOSVGK>

Landscape of EOSC-Related Infrastructures and Initiatives

Expert	Affiliation	Nomination
Kessy Abarenkov	University of Tartu Natural History Museum and Botanical Gardens	Estonia
Jean-François Abramatic	WG Architecture Coordinator	EOSC EB
Volker Beckmann	The French National Centre for Scientific Research (CNRS)	France
Juan Bicarregui	WG RoP Coordinator	EOSC EB
Artur Binczewski	Poznan Supercomputing and Networking Center	Poland
Isabel Bolliger	Swiss National Science Foundation	Switzerland
Paolo Budroni	TU Wien (also staff member of Vienna University)	Austria
Isabel Campos Plasencia	Spanish National Research Council	Spain
Christos Chatzimichail	European Commission	EC
Matthew Dovey	Jisc	UK
Odd Ivar Eriksen	Research Council of Norway	Norway
Alizée Francey	WG Rapporteur	EC
Christian Kirchsteiger	European Commission	EC
Biljana Kosanovic	University of Belgrade	Serbia
Vasiliki (Sylvia) V. Koukounidou	University of Cyprus	Cyprus
Sanja Halling	Swedish Research Council	Sweden
Jan Hrušák	J. Heyrovsky Institute of Physical Chemistry	EOSC EB
Sarah Jones	WG FAIR Coordinator	EOSC EB
Rupert Lueck	WG Sustainability Coordinator	EOSC EB

Landscape of EOSC-Related Infrastructures and Initiatives

Expert	Affiliation	Nomination
Thomas Midtgaard	Ministry of Science and Higher Education	Denmark
Thomas Neidenmark	European Commission	EC
Susanna Nykyri	Tampere University, Library, Open Science Services	Finland
Žibutė Petrauskienė	Vilnius University	Lithuania
Gianluca Polenta	Space Science Data Center, Italian Space Agency	Italy
Eloy Rodrigues	Minho University	Portugal
Petros Sampatakos	General Secretariat of Research and Technology	Greece
Ronald Stolk	Center for Information Technology / CIO University of Groningen	The Netherlands
Achim Streit	Karlsruhe Institute of Technology	Germany
Robert Sultana	University of Malta	Malta
Imre Szeberényi	Budapest University of Technology and Economics	Hungary
Sadia Vancauwenbergh	Hasselt University / ECOOM / euroCRIS	Belgium
John Womersley	European Spallation Source	EOSC EB

4. ABBREVIATION

AAI	Authentication and Authorisation Infrastructure
AC	Associated Countries to Horizon 2020
AE-RA	State Archives of Belgium
AEGIS	Academic and Educational Grid Initiative of Serbia
AENEAS	Advanced European Network of E-infrastructures for Astronomy with the Square Kilometre Array
AgID	Italian Agency for Digitisation of Public Administration
AI	Artificial Intelligence
AISBL	International Not-For-Profit Association
API	Application Programming Interface
ARCHIVER	Archiving and Preservation for Research Environments
ASI	Agenzia Spaziale Italiana
BDVA	Big Data Value Association
BE	Belgium
BELSPO	Belgian Federal Science Policy Office
BG	Bulgaria
BIRA-IASB	Royal Belgian Institute for Space Aeronomy
BMS	Biology and Medical Science
BSC	Barcelona Supercomputing Centre
C3S	Copernicus Climate Change Service
CAMS	Copernicus Atmosphere Monitoring Service
CASTOR	CERN Advanced STORage system
CCSD	Centre pour la Communication Scientifique Directe
CDI	Collaborative Data Infrastructure
CEA	Le Commissariat à l'énergie atomique et aux énergies alternatives
CÉCI	Consortium des Équipements de Calcul Intensif

Landscape of EOSC-Related Infrastructures and Initiatives

CEMS	Copernicus Emergency management service
CERIF	Common European Research Information Format
CERN	Conseil Européen pour la Recherche Nucléaire
CLARIN	Common Language Resources and Technology Infrastructure
CNAF	national centre of INFN (Italian Institute for Nuclear Physics)
CNRS	Centre National de la Recherche Scientifique
COAR	Confederation of Open Access Repositories
CoE	Centre of Excellence
CRIS	Current research information systems
CSC	CSC – IT CENTER FOR SCIENCE LTD
DANS	Data Archiving & Networked Services
DCI	Data Centre Interconnection
DEMO	Center for Demographic Research
DG CONNECT	Directorate General for Communications Networks, Content and Technology
DG RTD	Directorate-General for Research and Innovation
DIPG	Diffuse Intrinsic Pontine Glioma
DK	Denmark
DL2021	A national development programme for data management and scientific computing in Finland
DOI	Digital Object Identifier
DPHEP	Data Preservation in High Energy Physics
DRIS	Directory of Research Information Systems
e-IRG	e-Infrastructure Reflection Group
EARTO	European Association of RTOs
EB	Executive Board
EC	European Commission

Landscape of EOSC-Related Infrastructures and Initiatives

ECMWF	European Centre for Medium-Range Weather Forecasts
EDI	Electronic Data Interchange
EDP	European Data Portal
EFTA	European Free Trade Association
EGA	European Genome-phenome Archive (EGA)
EGI	European GRID Initiative
EIFL	Electronic Information for Libraries
EIROs	European Intergovernmental Research Organisations
eLABa	Lithuanian Academic Electronic Library
ELI	Extreme Light Infrastructure
eLTER	Long-Term Ecosystem Research in Europe
EMBL	European Molecular Biology Laboratory
ENEA	Italian National Agency for New Technologies, Energy and Sustainable Economic Development
ENVRI	Environmental Research Infrastructures
EO	Earth Observation
EOSC	European Open Science Cloud (the system resulting from the activities and initiatives promoted by the European Commission to support its policies on Open Science and Open Innovation 2.0)
EPOS	European Plate Observing System
ERA	European Research Area
ERAC	European Research Area and Innovation Committee
ESA	European Space Agency
ESCAPE	European Science Cluster of Astronomy & Particle Physics ESFRI
ESDC	European Science Data Centre
ESFRI	European Strategy Forum on Research Infrastructures
ESO	European Center Southern Observatory
ESRF	European Synchrotron Radiation Facility

Landscape of EOSC-Related Infrastructures and Initiatives

EU	European Union
EUA	European Universities Association
EURO-VO	European Virtual Observatory
ExPaNDS	European Open Science Cloud Photon and Neutron Data Service
FAIR	Findable, Accessible, Interoperable, Re-usable
FAIRsFAIR	Fostering Fair Data Practices in Europe
FCCN	Fundação para a Computação Científica Nacional
FCT	Fundação para a Ciência e a Tecnologia
FNS	Food Nutrition and Security
FREYA	Connected Open Identifiers for Discovery, Access and Use of Research Resources
FRIS	Flanders Research Information Space
F.R.S.-FNRS	Fonds de la Recherche Scientifique - Fund for Scientific Research
FWO	Research Foundation - Flanders
GA	General Assembly
GB	Governing Board
Gbps	Gigabits per second
GCS	Gauss Center for Supercomputing
GDPR	General Data Protection Regulation
GENCI	Grand équipement national de calcul intensif
GPU	Graphics Processing Unit
H2020	Horizon 2020 - eighth EU Framework Programme for Research and Innovation
HEP	Belgian High Energy Physics Community
HPC	High-Performance Computing
HTC	High Throughput Computing
ICDI	Italian Computing and Data Infrastructure

Landscape of EOSC-Related Infrastructures and Initiatives

ICHEC	Irish Centre for High-End Computing
ICOS	Integrated Carbon Observation System
ICT	Information Communication Technologies
IG	Interest Group
ILL	Institut Laue-Langevin
ILT	International LOFAR Telescope
IMI	Innovative Medicine Initiative
IN	Implementation Network
INAF	Istituto Nazionale di Astrofisica
INFN	Istituto Nazionale di Fisica Nucleare
INGV	Istituto Nazionale di Geofisica e Vulcanologica
IPB	Institute of Physics Belgrade
IPR	Intellectual Property Rights
IRIS	Institutional Research Information System
IRU	Indefeasible Rights of Use
IS-ENES	Infrastructure for the European Network of Earth System Modelling
KIT	Karlsruhe Institute of Technology
KMI-IRM	Royal Meteorological Institute of Belgium
KPI	Key Performance Indicator
LEAPS	League of European Accelerator-based Photon Sources
LENS	League of advanced European Neutron Sources
LHC	Large Hadron Collider
LiDA	Lithuanian Data Archive for Humanities and Social Sciences
LRF	Large-scale Research Facilities
MERIL	Mapping of the European Research Infrastructure Landscape
MESRI	Ministry of Higher Education, Research and Innovation

Landscape of EOSC-Related Infrastructures and Initiatives

MIAS	National Open Access Research Data Archive
MIDAS	National Open Access Research Data Archive
MIUR	Ministry of Education, University, and Research
ML	Machine Learning
MOOCs	Massive Open Online Courses
MPG	Max Planck Gesellschaft zur Foerderung Der Wissenschaften
MS	Member States
NCC	National Competence Centre
NDD	Neurodegenerative diseases
NeIC	Nordic eInfrastructure Collaboration
NFDI	National Research Data Infrastructure
NGR	Next Generation Repositories
NI4OS Europe	National Initiatives for Open Science in Europe
NIRD	National e-Infrastructure for Research Data
NL	Netherlands
NLI	National Library of Ireland
NOADs	National Open Access Desks
NORDi	Norwegian Open Research Data Infrastructure
NREN	National Research and Education Network
NSD	Norwegian Centre for Research Data
OA	Open Access
OAC	Open Access Centre
OCRE	Open Clouds for Research Environments project
OGS	Istituto Nazionale di Oceanografia e di Geofisica Sperimentale
ORCID	Open Researcher and Contributor ID
OSPP	Open Science Policy Platform

Landscape of EOSC-Related Infrastructures and Initiatives

PAs	Public Administrations
PaN	Photon and Neutron
PaNOSC	Photon and Neutron Open Science Cloud
PATC	PRACE Advanced Training Centre
PID	Persistent Identifier
PNR	National Research Programme
PNRI	National Program for Research Infrastructures
PRACE	Partnership for Advanced Computing in Europe
PTC	PRACE Training Centres
R&D	Research and Development
R&I	Research and Innovation
RCP	Wigner Research Centre for Physics
RDA	Research Data Alliance
RDM	Research Data Management
RI	Research Infrastructure
RIMS	Research Information Management Systems
RO	Romania
ROB	Royal Observatory of Belgium
RoP	Rules of Participation
RPO	Research Performing Organisation
RTO	Research and Technology Organisation
SE	Sweden
SIP	Strategic Implementation Plan
SISSA	Scuola Internazionale Superiore di Studi Avanzati
SKA	Square Kilometre Array
SME	Small and Medium-Sized Enterprises

Landscape of EOSC-Related Infrastructures and Initiatives

SND	Swedish National Data Service
SNIC	Swedish National Infrastructure for Computing
SODA	Social Sciences Data Archive
SSH	Social Sciences and Humanities
SSHOC	Social Sciences and Humanities Open Cloud
STRATOS	PRACE advisory group for Strategic Technologies
Sunet	Swedish University Computer Network
SWG OSI	Standing Working Group on Open Science and Innovation
Tbps	Terabits per second
TC	Technical Centre
THOR	Technical and Human Infrastructure for Open Research
TRL	Technology Readiness Level
TRUST-IT	Trust-IT Services Limited
UEDIN	University of Edinburgh
UGOE	Georg-August-Universität Göttingenstiftung öffentlichen Rechts
UiT	Arctic University of Norway
VEPS	Virtual Electronic Heritage System
VO	Virtual Observatory
VUB	Vrije Universiteit Brussel
VSC	Vlaams Supercomputer Centrum
VW	Validation Workshop
WG	Working Group
WIG	Working and Interest Groups
WLCG	Worldwide Large Hadron Collider Computing Grid
XDC	eXtreme DataCloud

5. ANNEXES

ANNEX I - EOSC-Relevant EU Projects

AENEAS – Grant agreement No 731016 – 01.01.2017 to 31.12.2019 **AGINFRA+** – Grant agreement No 731001 – 01.01.2017 to 31.12.2019

The AENEAS (*Advanced European Network of E-infrastructures for Astronomy with the SKA*) aims to develop a science-driven, functional design for a distributed, federated European Science Data Centre (ESDC). The ESDC will be part of a network of science data centres that will help the astronomical community make fundamental new discoveries with the largest radio telescope in the world - the Square Kilometre Array (SKA)⁴⁴² in Australia and South Africa. The European share of the global SKA regional centre network will be considerable in terms of volume of open scientific data, data processing and networking. Integration or alignment with EOSC is therefore foreseen.

AGINFRA+ supported agriculture and food scientists by enhancing more than 60 innovative data- and computing-intensive applications with open e-infrastructure resources and services from D4Science and EGI. It continued and evolved the data infrastructure of agINFRA⁴⁴³. It also continued the user engagement of CIP PSP VOA3R⁴⁴⁴, FP7 SemaGrow⁴⁴⁵, H2020 OpenMinTeD⁴⁴⁶, H2020 e-ROSA⁴⁴⁷ and projects that facilitated the wider open science engagement and alignment of stakeholders in the food and agriculture sector⁴⁴⁸. With almost 350 people participating in its user trials, the pilot demonstration work of AGINFRA+ has been pivotal in showcasing the potential of EOSC for this domain. Its SME-oriented activities for data science companies⁴⁴⁹ in the agtech and foodtech sectors have also been unique⁴⁵⁰.

ARCHIVER – Grant agreement No 824516 – 01.01.2019 to 31.12.2021 **BE OPEN** – Grant agreement No 824323 – 01.01.2019 to 30.06.2021

The ARCHIVER project - *Archiving and Preservation for Research Environments* - aims to introduce significant improvements in the area of archiving and digital preservation services for publicly funded research outputs in order to close critical gaps between what is currently available versus what is increasingly required by research funding agencies, requested by data creators and eventual users. ARCHIVER will combine multiple ICT technologies, including extreme data scaling, network connectivity, service interoperability and business models, in a hybrid cloud environment to deliver end-to-end archival and preservation services that cover the full research lifecycle. It will create an eco-system for specialist ICT

BE OPEN has brought onboard key transport and open-science-related communities in an attempt to promote, regulate and standardise open science in transport research⁴⁵². The main goals are to develop a framework of common understanding for realising open science services, create the TOPOS⁴⁵³ forum and observatory for stakeholders, provide a roadmap and concrete guidelines for operationalising open science services, and design the European code of conduct on open science in transport to support research organisations⁴⁵⁴.

442 (n.d.). Square Kilometre Array. Retrieved 6 November 2019 <https://www.skatelescope.org/>

443 <https://cordis.europa.eu/project/id/283770>

444 <https://cordis.europa.eu/project/id/250525>

445 <http://www.semagrow.eu>

446 <http://openminted.eu>

447 <http://erosa.aginfra.eu>

448 <http://aims.fao.org/activity/blog/open-harvest-2016-release-chania-declaration>

449 <https://medium.com/@AgroKnow/call-to-european-data-science-startups-who-is-going-to-win-the-10-000-prize-c90be1899f4b>

450 AGINFRA+ AgTech Innovators Meetup (<https://youtu.be/bN0MBnV3KNk>)

452 (2017, October 27). Funding & tenders - European Commission. Retrieved 6 November 2019 <https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/topic-details/mg-4-2-2018>

453 (n.d.). TOPOS – BE OPEN project Open Science in transport. Retrieved 6 November <https://beopen-project.eu/topos>

454 (n.d.). The project – BE OPEN project Open Science in transport. Retrieved 6 November 2019 <https://beopen-project.eu/the-project>

companies, active in archiving and digital preservation, that would like to introduce new services capable of supporting the expanding needs of research communities but are currently prevented from doing so because there is no common procurement activity for the advanced stewardship of publicly funded research data in Europe. ARCHIVER's final goal is to allow research groups to retain responsibility and stewardship of their data whilst leveraging best practices, standards and economies of scale⁴⁵¹.

Blue Cloud – Grant agreement No 862409 – 01.10.2019 – 31.09.2022

Blue-Cloud, piloting innovative services for marine research and the blue economy, aims to:

- build and demonstrate a pilot blue cloud by combining distributed marine data resources, computing platforms, and analytical services
- develop services for supporting research to better understand and manage the many aspects of ocean sustainability
- develop and validate a number of demonstrators of relevance for marine societal challenges
- formulate a roadmap for the expansion and sustainability of the blue cloud infrastructure and services. The project will federate leading European marine data management infrastructures (SeaDataNet, EuroBIS, Euro-Argo, Argo GDAC, EMODnet, ELIXIR-ENA, EuroBioImaging, CMEMS, C3S, and ICOS-Marine), and horizontal e-infrastructure (EUDAT, DIAS, D4Science) to capitalise on what exists already, and to develop and deploy the blue cloud. The federation will be at the levels of data resources, computing resources and analytical service resources.

CINECA – Grant agreement No 825775 – 01.01.2019 to 31.12.2022

To maximise the impact of data for large cohorts: researchers, healthcare, industry, patients and funders, the project has assembled a set of expert partners in resource delivery who are embedded in the communities which generate, analyse, standardise and share genomic data. The project also received funding from the Canadian Institute of Health Research under CIHR grant No 404896⁴⁵⁵.

CatRIS – Grant agreement No 824173 – 01.01.2019 – 31.06.2021

The CatRIS (*Catalogue of Research Infrastructure Services*) project is building an open, trusted and user-friendly portal to a harmonised and aggregated catalogue of services and resources provided by Research Infrastructures (RI), CoreFacilities (CF) and Shared Scientific Resources (SSR) across Europe, focusing on services provided by physical infrastructures and facilities. It is a bottom-up initiative that is populated and run by RI, CF and SSR service providers at European, national, regional and institutional levels. CatRIS will be complementary to and interoperable with the EOSC catalogue.

Cos4CLOUD – Grant agreement 863463 – 01.11.2019 – 28.02.2023

Cos4Cloud (*Co-designed Citizen Observatories Services for the EOS-Cloud*), aims to facilitate citizen science initiatives by designing and implementing services for citizen observatories in the EOSC framework. The innovative digital services will be based on deep machine learning, automatic video recognition, and other cutting-edge technologies. Cos4Cloud will use the experiences of platforms like Artportalen, Natusfera, and iSpot, as well as other environmental quality-monitoring platforms like FreshWater Watch, KdUINO, OdourCollect, iSpex, and CanAir.io. The final goal is to improve the implementation of existing and future citizen observatories, addressing the technological critical

451 (n.d.). About | Archiver-project. Retrieved 6 November 2019 <https://www.archiver-project.eu/about>

455 (n.d.). History – CINECA - Common Infrastructure for National Retrieved 6 November, 2019 <https://www.cineca-project.eu/history>

challenges facing them, and to contribute to ensuring their sustainability. Regarding EOSC landscape WG activities, Cos4Cloud's main value may serve as an example of how EOSC can interact with other types of knowledge infrastructures such as those being currently developed by citizen science observatories.

CS3MESH4EOSC – Grant agreement No 863353 – 01.01.2020 – 31.12.2022

The objective of CS3-MESH-4-EOSC is to create an interoperable federation of data and higher-level services to enable friction-free collaboration between European researchers. This will be achieved by capturing the momentum of recent cloud service provisioning and adoption by National Research & Education Networks (NRENs) and public research sector providers across Europe. CS3MESH4EOSC wants to integrate these local existing sites and services into a seamless infrastructure which is fully interconnected with EOSC-hub, as proposed in the European Commission's implementation roadmap for EOSC.

DEEP-Hybrid-DataCloud – Grant agreement No 777435 – 01.11.2017 to 30.04.2020

DEEP aims to support machine learning, artificial intelligence, and deep learning over distributed e-infrastructures in the European Open Science Cloud (EOSC), satisfying the needs of research, education communities and citizen science⁴⁵⁹. The project seeks to evolve existing services and technologies at technology readiness level (TRL) 6+ to TRL 8, including relevant contributions to the EOSC by the INDIGO-DataCloud⁴⁶⁰, which the project will enrich with new functionalities already available as prototypes⁴⁶¹.

DARE – Grant agreement No 777413 – 01.01.2018 to 31.12.2020

DARE aims to deliver a new working environment for researchers wrestling with the challenge of extreme data, computing and complexity. The project aims to present a platform and a set of tools that clearly visualise scientific workflows without excessive amounts of technical detail. DARE works with two RIs: EPOS (European Plate Observing System)⁴⁵⁶ and IS-ENES (Infrastructure for the European Network of Earth System Modelling)⁴⁵⁷, engaging in the co-design and production use of extreme methods that address these challenges⁴⁵⁸. DARE accelerates innovation in e-science while providing the technical framework to virtualise existing research infrastructures.

DigitalHealthEurope – Grant agreement No. 826353 – 01.01.2019 -31.12.2020

DigitalHealthEurope (DHE) supports the Digital Transformation of Health and Care (DTHC) in the Digital Single Market⁴⁶². In addition to providing direct funding and support for digital solutions for health and care, DHE facilitates the creation of multi-stakeholder communities, one for each of the three priorities of the DTHC. Key outputs generated are recommendations for EU coordination and support for DTHC beyond 2020. The activities on the Priority 2 rating: 'Better data to advance research, disease prevention and personalised health and care' crucially align with the EOSC, particularly when dealing with health data. Therefore, the exchange of information between DHE and EOSC is fundamental and mutually profitable.

456 (n.d.). European Plate Observing System. Retrieved 6 November, 2019 <https://www.epos-ip.org/>

457 (2019, April 1). Welcome to the ENES Portal – vERC. Retrieved 6 November 2019 <https://portal.enes.org/>

458 (n.d.). Da.Re. project. Retrieved 6 November 2019 <http://dare-project.eu/>

459 (n.d.). DEEP – Hybrid DataCloud. Retrieved 6 November 2019 <https://deep-hybrid-datacloud.eu/>

460 (n.d.). INDIGO DataCloud: Home. Retrieved 6 November 2019 <https://www.indigo-datacloud.eu/>

461 (n.d.). The project – DEEP – Hybrid DataCloud. Retrieved 6 November 2019 <https://deep-hybrid-datacloud.eu/the-project/>

462 COM/2018/233 on enabling the digital transformation of health and care in the Digital Single Market; empowering citizens and building a healthier society <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2018:233:FIN>

e-InfraCentral – Grant agreement No 731049 – 01.01.2017 to 30.06.2019

eInfraCentral aimed to address the challenge faced by researchers navigating a fragmented e-infrastructure landscape. The goal was to develop a portal as the main entry point to European e-infrastructure services to enhance accessibility, discoverability, and comparability of services/resources. Key results of the project include:

- The Scientific Resources Description Template (SDT) for EOSC⁴⁶³.
- An all-inclusive catalogue of e-services/resources - the first catalogue for EOSC⁴⁶⁴.
- APIs for enabling EOSC interoperability.
- Online services and assets representations.
- A set of portal cataloguing functionality.
- Registration services for onboarding to EOSC, and analytics and visualisations.
- A platform for providers to build their own EOSC-compliant catalogue.

ENVRI-FAIR – Grant agreement No 824068 – 01.01.2019 to 31.12.2022

ENVRI-FAIR is the connection of the cluster of Environmental Research Infrastructures (ENVRI) to the EOSC. It develops tools and resources for easy and seamless access to environmental data and research services provided by ENVRI research infrastructures, according to the FAIR principles. The highest priority is the provision of high-quality data using open licences, standard mechanisms and protocols. Its high-impact ambition is to prepare the foundations for a federated machine-to-machine interface – the ENVRI-hub. The hub forms the interface to the EOSC and will be realised as the services across ENVRI and even between environmental subdomains become progressively more integrated.⁴⁶⁸

e-IRGSP6 – Grant agreement No 823761 – 01.01.2019 to 30.06.2021

e-IRGSP6 aims to support e-IRG in its activities by producing high-level policy recommendations for the implementation of EOSC, Electronic Data Interchange (EDI), and the e-Infrastructure Commons overall. Through these supporting activities by e-IRGSP6, e-IRG will contribute to the implementation of EOSC and promote the cultural change towards open science principles⁴⁶⁵. The most recently published policy document *National Nodes - Getting organised; how far are we?* provides a representative picture of the European e-infrastructure landscape in its current state⁴⁶⁶. e-IRGSP6 also constructed a knowledge base for e-infrastructure in Europe⁴⁶⁷.

EOSC Enhance – Grant agreement No 871160 – 01.12.2019 – 30.11.2021

EOSC Enhance will consolidate the EOSC Portal as the universal access point for researchers by facilitating and improving the findability and discoverability of EOSC services and resources. It will enrich the EOSC offering for services and data by connecting the thematic clusters and clouds currently in development. EOSC Enhance pursues four objectives:

- Enhance the service provider interface and incorporate new services and resources into the EOSC catalogue.
- Accelerate the deployment and uptake of EOSC services and resources.
- Increase user demand for EOSC services and resources via portal improvements and development
- Enable easier access to thematic cloud services and data⁴⁶⁹.

463 Search for “eInfraCentral+github” or <https://github.com/eInfraCentral>

464 (n.d.). eInfraCentral Platform. Retrieved 6 November 2019 <https://www.einfracentral.eu/>

465 (n.d.). Introduction - e-Infrastructures Reflection Group - e-IRGSP6. Retrieved 7 November 2019 <http://e-irgsp6.e-irg.eu/introduction>

466 <http://e-irg.eu/catalogue/eirg-1006>

467 <http://knowledgebase.e-irg.eu/>

468 (n.d.). ENVRI-FAIR homepage. Retrieved 7 November 2019 <https://envri.eu/home-envri-fair/>

469 <https://www.eosc-portal.eu/>

EOSC-hub – Grant agreement No 777536 – 01.01.2018 to 31.12.2020

The EOSC-hub⁴⁷⁰ brings together 100 partners including major e-infrastructures and ESFRI research infrastructures, to create the hub: a single contact point for European researchers and innovators to discover, access, use and reuse a broad spectrum of EOSC resources. This will favour broader access to services supporting discovery and collaboration across disciplinary and geographical boundaries. The list of project key-exploitable results includes components contributing to the implementation of the EOSC roadmap: the EOSC Marketplace and the EOSC Portal AAI, services for the realisation of EOSC as a federated system (the “Hub Portfolio”), the first prototype of the EOSC Service Management System for the delivery of services of the EOSC federating core, the EOSC Digital Innovation Hub for industrial collaborations, business and sustainability models, input to the EOSC Rules of Participation and Integration and Interoperability guidelines, and training resources and events complemented by the EOSC Early Adopter Programme.

EOSC-Life – Grant agreement No 824087 – 01.03.2019 to 28.02.2023

In EOSC-Life the 13 European life science RIs (ELIXIR⁴⁷¹; BBMRI-ERIC⁴⁷²; EATRIS-ERIC⁴⁷³; ECRIN-ERIC⁴⁷⁴; EMBRC⁴⁷⁵; EMPHASIS⁴⁷⁶; ERINHA⁴⁷⁷; EU-OPENSOURCE⁴⁷⁸; EuroBioImaging⁴⁷⁹; INFRAFRONTIER⁴⁸⁰; Instruct-ERIC⁴⁸¹; ISBE⁴⁸²; MIRRI⁴⁸³) publish their FAIR data in EOSC and establish the policies (e.g. for GDPR) needed for researchers to access and combine resources from multiple RIs in new projects. The project works with the developer community to create an ecosystem of life-science tools in EOSC compatible clouds, and connect these to users via a shared life science login (compatible with EOSC AAI). Through open calls for projects, researchers will be able to get support for novel data-driven research in EOSC⁴⁸⁴.

470 <https://www.eosc-hub.eu/>

471 (n.d.). ELIXIR Europe. Retrieved 7 November 2019 <https://elixir-europe.org/>

472 (n.d.). BBMRI-ERIC. Retrieved 7 November, 2019 <http://www.bbmri-eric.eu/>

473 (n.d.). EATRIS. Retrieved 7 November 2019 <https://eatris.eu/>

474 (n.d.). ECRIN: Facilitating European Clinical Research. Retrieved 7 November 2019 <https://www.ecrin.org/>

475 (n.d.). EMBRC. Retrieved 7 November 2019 <http://www.embrc.eu/>

476 (n.d.). Emphasis. Retrieved 7 November 2019 <https://emphasis.plant-phenotyping.eu/>

477 (n.d.). ERINHA. Retrieved 7 November 2019 <https://www.erinha.eu/>

478 (n.d.). EU OPENSOURCE - European high-capacity screening Retrieved 7 November 2019 <https://www.eu-openscreen.eu/>

479 (n.d.). Euro Bioimaging. Retrieved 7 November, 2019 <https://www.eurobioimaging.eu/>

480 (n.d.). INFRAFRONTIER - The European infrastructure for Retrieved 7 November 2019 <https://www.infrafrontier.eu/>

481 (n.d.). Instruct-ERIC. Retrieved 7 November 2019 <https://instruct-eric.eu/>

482 (n.d.). ISBE Project Website. Retrieved 7 November, 2019 <http://project.isbe.eu/>

483 (n.d.). Home | MIRRI - Microbial Resource Research Infrastructure Retrieved 7 November 2019 <https://www.mirri.org/>

484 (n.d.). EOSC Life: Home. Retrieved 7 November 2019 <http://www.eosc-life.eu/>

EOSC-Nordic – Grant agreement No 857652 – 01.09.2019 to 31.08.2022

EOSC-Nordic aims to foster and advance the take-up of the EOSC at the Nordic level by coordinating the EOSC-relevant initiatives taking place in Denmark, Estonia, Finland, Germany, Iceland, Latvia, Lithuania Netherlands, Norway, and Sweden. , It also exploits synergies to achieve greater harmonisation of policy and service provisioning across these countries, in compliance with EOSC-agreed standards and practices⁴⁸⁵.

EOSC-Pillar – Grant agreement No 857650 – 01.07.2019 to 30.06.2022

EOSC-Pillar is one of the projects funded in the INFRAEOSC-05 call, dedicated to thematic and regional initiatives. The project aims to support the coordination and harmonisation of national initiatives relevant to EOSC in Austria, Belgium, France, Germany and Italy. The project intends to integrate a bottom-up approach (by voicing the requirements and needs expressed by the different scientific communities operating at the national level) and a top-down one (by harmonising the national strategies and translating them into a viable work plan)⁴⁸⁶.

EOSCpilot – Grant agreement No 739563 – 01.01.2017 to 31.05.2019

EOSCpilot supported the first phase of the EOSC's development. The project delivered contributions to the EOSC in the areas of governance, policies, interoperability, architecture, and services, and provided the first "EOSC in practice" science demonstrators. Having delivered these, EOSCpilot has established its legacy and its outputs are used by several other projects funded to establish the EOSC⁴⁸⁷. A mapping of which EOSCpilot deliverables are most relevant to each EOSC Working Group has been provided⁴⁸⁸.

EOSC-Secretariat.eu – Grant agreement No 831644 – 01.01.2019 to 30.06.2021

EOSCsecretariat.eu addresses the need for the set-up of an operational framework supporting the overall governance of the EOSC. It supports EOSC governance by channelling messages to the stakeholders and following up on implementation, and maintains a practical approach to addressing the specific needs of the coordinated structure expected by the EOSC⁴⁸⁹.

EOSC-synergy – Grant agreement No 857647 – 01.09.2019 to 28.02.2022

EOSC-synergy delivers services and supports selected scientific use cases that span several countries by pushing the state-of-the-art in software and services life-cycle through a quality-driven approach to services integration. It focuses on the identification of obstacles and barriers preventing close international collaboration and minimises them by harmonising policies and federating-relevant national research e-infrastructures, scientific data and thematic services. All this bridges the gap between national initiatives and the EOSC, and expands service adoption by developing new capabilities and by

ESCAPE – Grant agreement No 824064 – 01.02.2019 to 31.07.2022

ESCAPE is a single collaborative cluster of seven ESFRI and Landmark projects (CTA, SKA, KM3NeT, ELT, EST, FAIR, HL-LHC), and two pan-European organisations (ESO, CERN) in the area of astronomy- and accelerator-based particle physics in order to implement a functional link between the concerned ESFRI projects and EOSC. These ESFRI projects have aligned challenges of data-driven research, with demonstrated capabilities in addressing various stages of data workflow and concerned with fundamental research through complementary approaches. The networks of ASTRONET, APPEC and HEP (CERN),

485(n.d.). EOSC-Nordic. Retrieved 7 November 2019 www.eosc-nordic.eu and <https://neic.no/eosc-nordic/>

486 (n.d.). EOSC-Pillar. Retrieved 7 November 2019 <https://www.eosc-pillar.eu/>

487 (n.d.). eoscspilot.eu. Retrieved 7 January 2020 <https://eoscspilot.eu/news/eoscspilot-rounds-key-contributions-eosc>

488 <https://eoscspilot.eu/news/eoscspilot-maps-key-deliverables-use-eosc-executive-board-working-groups> (Retrieved 7 January 2020)

489 (n.d.). About Us | EOSC Secretariat. Retrieved 7 November 2019 <https://www.eoscsecretariat.eu/about-us>

Landscape of EOSC-Related Infrastructures and Initiatives

opening national thematic services to European access, based on a robust human network and advanced training tools.

NuPECC are involved in ESCAPE. ESCAPE participants are involved in EOSC WGs - Architecture and FAIR⁴⁹⁰.

ExPaNDS – Grant agreement No 857641 – 01.09.2019 to 31.08.2022

ExPaNDS (*EOSC Photon and Neutron Data Services*) aims to deliver standardised, interoperable and integrated data sources and data analysis services for national photon and neutron facilities to the EOSC. It complements the PaNOSC project which has similar objectives for the ESFRI PaN RIs. For the EOSC Landscape WG, ExPaNDS established a baseline of the current state of FAIR data policies and data management practices among the project's RIs and the e-infrastructure EGI.

FAIRsFAIR – Grant agreement No 831558 – 01.03.2019 to 28.02.2022

FAIRsFAIR (*Fostering Fair Data Practices in Europe*) aims to supply practical solutions for the use of the FAIR data principles throughout the research data life cycle with an emphasis on fostering FAIR data culture and the uptake of good practices in making data FAIR, in particular in the context of the European Open Science Cloud (EOSC). FAIRsFAIR will deliver and support recommendations on data policy and practice, provide solutions and support for semantic interoperability, support certification of trustworthy data repositories and data assessment, as well as develop a FAIR competence centre and framework for higher education⁴⁹¹.

FAIRsFAIR's three landscaping activities on Semantics and Interoperability, FAIR Data Policies and Practices, and Research Data and FAIR Data Principles (in higher education) are relevant inputs for the information gathering exercise of the EOSC Landscaping WG regarding national data policies, available infrastructure, and training and skills⁴⁹².

Fair4Fusion – Grant agreement No 847612 – 01.09.2019 to 31.08.2021

The overall objective of Fair4Fusion is to make European funded data more widely available to the fusion community, other science communities, funding bodies, and the public at large in order to maximise the impact of the data and demonstrate the importance of the work done at relevant sites. Fair4Fusion aims to provide a reference architecture for an open data platform. Where possible, Fair4Fusion will use existing services and tools, adapting them where necessary to meet the needs of the fusion community⁴⁹³.

FAIR4Health – Grant agreement No 824666 – 01.12.2018 to 30.11.2021

The overall objective of FAIR4Health is to facilitate and encourage the EU health research community to FAIRify, share and reuse their datasets derived from publicly-funded research initiatives, and real-world data (Electronic Health Records)⁴⁹⁴. FAIR4Health will apply privacy-preserving distributed data mining techniques to the shared and FAIRify datasets to develop two pathfinder case studies: supporting the discovery of disease onset triggers and disease association patterns in comorbid patients, and prediction service for 30-days re-admission risk in complex chronic patients. FAIR4Health develops activities of interest to the EOSC strategy, especially in the field of FAIR data and specific infrastructures.

490 <https://projectescape.eu/about-us>

491 (n.d.). The Project | FAIRsFAIR. Retrieved 7 November 2019 <https://www.fairsfair.eu/the-project>

492 FAIRsFAIR deliverables: <https://www.fairsfair.eu/reports-deliverables>

493 (n.d.). CORDIS. Retrieved 7 November 2019 <https://cordis.europa.eu/>

494 (n.d.). Project - FAIR4Health. Retrieved 7 November 2019 <https://www.fair4health.eu/en/project>

FAIRplus – Grant agreement No 802750 – 01.01.2019 to 30.06.2022

The FAIRplus project aims to develop tools and guidelines for making life science data FAIR. The project has 22 partners from academia and industry. FAIRplus aims to increase the discovery, accessibility and reusability of data from selected projects funded by the EU Innovative Medicine Initiative (IMI), and internal data from pharmaceutical industry partners. The increased FAIRness of data will lead to a wider sharing of knowledge, greater opportunities for innovation, and more insights that benefit society⁴⁹⁵.

FNS-Cloud – Grant agreement No 863059 – 01.10.2019 – 30.09.2021

Health-related RIs focus on clinical, molecular and biological sciences whilst existing food, nutrition and security (FNS) resources (data, knowledge rules) are fragmented, lack critical mass, and access by user communities is unevenly distributed. FNS-Cloud aims to develop an on-demand, federated network (cloud infrastructure), supporting access to and exploitation of FNS resources, integrated with the European Open Science Cloud (EOSC). Also, because FNS domains lack tools for data management and predictive modelling, FNS-Cloud will develop advanced methods and services for user communities, making FNS data FAIRer (findable, accessible, interoperable and reusable) and adding-value to publicly funded research for citizens.

FREYA – Grant agreement No 777523 – 01.12.2019 to 30.11.2020

FREYA is extending a robust environment for persistent identifiers (PIDs) into a core component of European and global research e-infrastructures, motivated by the vision of a rich "PID graph" of interconnected entities. The resulting FREYA services will cover a wide range of resources in the research and innovation landscape and enhance the links between them, so that they can be exploited in many disciplines and research processes. This will provide an essential building block of the European Open Science Cloud (EOSC). Moreover, the FREYA project will establish an open, sustainable, and trusted framework for collaborative self-governance of PIDs and services built on them—the "PID Commons".

GN4-3 and GN4-3N (GEANT) – Grant agreement No 856726 and 856728 – 01.01.2019 to 31.12.2022

The projects are proposed to last 48 months to implement, diminishing the digital divide through the GÉANT partnership. GÉANT is Europe's leading collaboration on network and related infrastructure and services for the benefit of research and education, contributing to Europe's economic growth and competitiveness. The organisation develops, delivers and promotes advanced network and associated e-infrastructure services, and supports innovation and knowledge-sharing amongst its members, partners and the wider research and education networking community. It currently reaches over 50 million users at 10 000 institutions across Europe, and more than 100 countries worldwide. The EU-funded GN4-3 is the third specific grant agreement under a framework partnership agreement (FPA) between the GÉANT Consortium and the European Commission. It aims to help take European research to the next level, promoting scientific excellence, access and re-use of research data.

GN4-3N entails a very ambitious restructuring of the backbone network operated by GÉANT in order to provide equal access to clouds and other e-infrastructure services in the European research area and beyond. It will improve the overall resilience and reliability of the GÉANT network significantly, and offer a base for future improvements in access, transmission speeds and capacity wherever needed⁴⁹⁶.

495 (n.d.). About the FAIRplus project| FAIRplus. Retrieved 7 November, 2019 <https://fairplus-project.eu/about/>

496 (2019, October 31). GN4-3N Project | H2020 - Cordis. Retrieved 14 February 2020 <https://cordis.europa.eu/project/id/856728>

ICEDIG – Grant agreement No 777483 – 01.01.2018 – 31.03.2020

ICEDIG (*Innovation and consolidation for large scale digitisation of natural heritage*) is an EU-funded project that aims to support the implementation phase of the new Research Infrastructure Distributed System of Scientific Collections (DiSSCo) by designing and addressing the technical, financial, policy and governance aspects necessary to operate such a large distributed initiative for natural sciences collections across Europe⁴⁹⁷.

INODE – Grant agreement No 863410 – 01.11.2019 – 31.10.2022

INODE – Intelligent Open Data Exploration – aims to advance open data exploration and democratisation in the EOSC ecosystem by providing a suite of fit-for-purpose and sustainable services for the intuitive linking and exploration of open data. These services will allow users to search for data using natural language and examples, and optimise answers and queries through a combination of service functions that provide recommendations, explanations, analytics, and interactive visualisations. INODE's service offering is shaped by the needs of three communities in the areas of biomedical research, astrophysics, and research and innovation policy making⁴⁹⁸.

NEANIAS – Grant agreement No 863448 – 01.11.2019 -31.10.2022

NEANIAS –(*Novel EOSC Services for Emerging Atmosphere, Underwater & Space Challenges*) aim to promote Open Science practices and actively contribute to the materialisation of the EOSC ecosystem by engaging large scientific and professional communities, extending its offerings and supporting its technological, regulatory, procedural, strategic and business development. NEANIAS will drive the co-design and delivery of innovative thematic services, derived from state-of-the-art research assets and practices in three major sectors – underwater, atmospheric and space research – and will seek business innovation cases by exemplifying reuse in energy, smart cities and other domains, engaging multitudinous academic, research and business actors⁴⁹⁹.

InRoad – Grant agreement No 730928 – 01.01.2017 to 31.12.2018

InRoad looked at ways to foster a higher degree of coordination of priority setting, evaluation and funding mechanisms, and to ensure sustainable planning for RIs in Europe. The analysis of the extensive data collected during the project activities allowed the project partners to identify common trends and good practices that are summed up in the InRoad final report.⁵⁰⁰

MERIL – Grant agreement No 262159 – 01.10.2010 to 31.12.2012 and **MERIL-2** – Grant agreement No 262159 – 01.03.2016 to 31.08.2019

The MERIL (*Mapping of the European Research Infrastructure Landscape*) portal provides access to a database that stores information about openly accessible RIs in Europe, across all scientific domains, including Social Sciences and Humanities (SSH). The MERIL database is a dynamic resource that was continuously updated. MERIL database consists of identified, eligible

NI4OS-Europe – Grant agreement No 857645 – 01.09.2019 to 31.08.2022

NI4OS aims to be a core contributor to the European open science cloud initiatives in 15 EU MS and AC in the overall scheme of EOSC governance. The overall approach is that the national open science landscape in all countries will be systematically mapped and analysed to facilitate both the creation of national open science cloud initiatives to support the overall EOSC governance, and to engage all stakeholders⁵⁰². NI4OS will federate the existing

497 (n.d.). icedig: Front. Retrieved 14 February 2020 <https://www.icedig.eu/>

498 (n.d.). The INODE project – INODE. Retrieved 7 January 2020 <http://www.inode-project.eu/>

499 The NEANIAS project - <https://www.neanias.eu/>

500 (n.d.). InRoad Project. Retrieved 7 November 2019 <https://www.inroad.eu/>

502 (n.d.). NI4OS-Europe Project - CORDIS. Retrieved 7 November 2019 https://cordis.europa.eu/project/rcn/224431/en?WT.mc_id=RSS-Feed&WT.rss_f=project&WT.rss_a=224431&WT.rss_ev=a <https://ni4os.eu/> ,

RIs, and a set of data for each individual RI, collected and displayed in a standardised format. The MERIL-2 project built on the previous phases of MERIL, and provided the means for making informed assessments and decisions about the RI landscape in Europe, and encouraged accessibility, new partnerships and collaborations within the scientific community. The MERIL-2 project further expanded the coverage of RIs included in the database, and improved the depth and accuracy of the information held on them⁵⁰¹.

OCRE – Grant agreement No 824079 – 01.01.2019 to 31.12.2021

The OCRE (*Open Clouds for Research Environments*) project aims to accelerate cloud adoption in the European research community, by bringing together cloud providers, Earth Observation organisations and the research and education community, through ready-to-use service agreements with cloud service providers that meet the specific requirements of the research community, saving institutions the time-consuming and complex process of doing this themselves⁵⁰³.

EOSC-relevant services in the target countries by making them visible and compatible with the core building blocks of EOSC. NI4OS will collaborate with the other EOSC-related initiatives to contribute to the common EOSC platform, including a set of policies, rules and principles for managing services and research data across EOSC ecosystem.

OpenAIRE-Advance – Grant agreement No 777541 – 01.01.2018 to 31.12.2020

OpenAIRE-Advance continues the mission of OpenAIRE⁵⁰⁴ to establish a European/global scholarly communication commons by:

- i) providing services to:
 - researchers for making their research open (Zenodo, Amnesia, Argos);
 - content providers for linking their content to the European infrastructure (Metadata Guidelines for literature, data, software repositories, ScholExplorer);
 - policy makers for monitoring research outcomes and impact, and research communities for managing open research.
- ii) establishing national nodes, National Open Access Desks (NOADs), as a pivotal part within national infrastructure environments.
- iii) consolidating Europe's global role, extending collaborations with Latin America, the US, Japan, Canada, and Africa⁵⁰⁵.

501 (n.d.). MERIL portal. Retrieved 7 November, 2019 <https://portal.meril.eu/meril/>

503 (n.d.). About | OCRE. Retrieved 7 November 2019 <https://www.ocre-project.eu/about>

504 (n.d.). OpenAIRE. Retrieved 7 November 2019 <https://www.openaire.eu/>

505 (2019, May 2). OpenAIRE Advance project | Projects. Retrieved 7 November 2019 <https://www.openaire.eu/openaire-advance-project>

OpenRiskNet – Grant agreement No 731075 – 01.12.2016 to 30.11.2019

OpenRiskNet aims to develop an open e-infrastructure providing resources and services to a variety of communities that require risk assessments of chemicals, cosmetic ingredients, therapeutic agents or nanomaterials. Virtual environments are provided, which can run on different types of computer hardware ranging from single computers to cloud infrastructure, on which a multitude of data, modelling and simulation services can be deployed and combined to answer complex risk assessment questions. Case studies demonstrate the applicability of the infrastructure in productive settings supporting research and innovation⁵⁰⁶.

PaNOSC – Grant agreement No 823852 – 01.12.2018 to 30.11.2022

PaNOSC (*Photon and Neutron Open Science Cloud*) aims to make FAIR data a reality in six European RIs, developing and providing services for scientific data and connecting these to the EOSC⁵⁰⁷.

PRIMAGE – Grant agreement No 826494 – 01.12.2018 to 30.11.2022

PRIMAGE proposes an open-cloud-based platform to support decision-making in the clinical management of two paediatric cancers. PRIMAGE is based on the use of computational imaging, which allows the extraction of multiparametric data, multiscale models, visual analytics and artificial intelligence, leading to a new era in radiomics, characterised by high-throughput extraction, storage, and analysis of a large number of quantitative imaging features and parameters (imaging biomarkers). Imaging biomarkers linked to clinical, molecular and genetic data, will be part of a high-quality repository with anonymised data, which will be used as an observational in silico study to finally have a Clinical Decision Support (CDS) tool. As a result, the PRIMAGE platform will be able to provide quantitative relevant information (virtual biopsies) for the early disease diagnosis, disease phenotyping, disease grading, targeting therapies and evaluation of disease response to treatment in children with neuroblastoma and Diffuse Intrinsic Pontine Glioma (DIPG).

PROCESS – Grant agreement No 777533 – 01.11.2017 to 31.10.2020

PROCESS aims to deliver a comprehensive set of mature service prototypes and tools specially developed to enable extreme scale data processing in both scientific research and advanced industry settings. PROCESS demonstrators seek to pave the way towards data services that aim to accelerate innovation and maximise the benefits of the emerging “very large data” solutions. PROCESS provides an ecosystem of distributed services based on virtualisation principles, which necessitates containerisation of applications, refactoring software stacks using a micro-service approach, and supporting orchestration on the infrastructures⁵⁰⁸.

506 (n.d.). About • OpenRiskNet. Retrieved 7 November 2019 <https://openrisknet.org/about/>

507 (n.d.). The Photon and Neutron Open Science Cloud (PaNOSC) Retrieved 7 November 2019 <https://www.panosc.eu/>

508 (n.d.). Project Objectives – PROCESS. Retrieved 7 November 2019 <https://www.process-project.eu/project-objectives/>

RDA Europe 4.0 – Grant agreement No 777388 – 01.03.2018 to 31.05.2020

The Research Data Alliance (rd-alliance.org) is an international community-driven initiative building social and technical bridges to enable the open sharing and re-use of research data. The RDA Europe 4.0 project is mandated to ensure that European political, research, industrial and digital infrastructure stakeholders are aware of, engaged with, and actively involved in the global RDA activities. RDA provides an international neutral forum for discussing and agreeing on relevant technical standards for the implementation of the EOSC. In addition, RDA supports the communication and dissemination of EOSC developments across the globe⁵⁰⁹.

RISCAPE – Grant agreement No 730974 – 01.01.2017 to 31.12.2019

The goal for the RISCAPE project is to provide a systematic, focused, high-quality, comprehensive, consistent and peer-reviewed international landscape analysis report on the position and complementarities of the major European research infrastructures in the international research infrastructure landscape⁵¹⁰.

SSHOC – Grant agreement No 823782 – 01.01.2019 to 30.04.2022

SSHOC (*Social Sciences and Humanities Open Cloud*) aims to realise the social sciences and humanities' part of the European Open Science Cloud (EOSC) where data, tools, and training are available and accessible for users of SSH data. All aspects of the full research data cycle and human-centric approach are engaged in creating links between people, data, services and training. SSHOC will advance secure environments for sharing and using sensitive and confidential data, and will contribute to innovations stemming from the coupling of heterogeneous data types, as well as work on the Interoperability principle of FAIR. The consortium aims to align with necessary technical and other EOSC requirements for making the SSHOC services sustainable beyond the duration of the project⁵¹¹.

TRIPLE – Grant agreement No 863420 – 01.10.2019 – 31.03.2023

TRIPLE (*Transforming Research through Innovative Practices for Linked interdisciplinary Exploration*) aims to develop an innovative multilingual and multicultural discovery solution for Social Science and Humanities. Based on the Isidore search engine, the TRIPLE platform will provide a single access point for users to discover and reuse open scholarly SSH resources, i.e. research data and publications, which are currently scattered across local repositories to:

- i) find and connect with other researchers and projects across disciplinary and language boundaries.
- ii) use innovative tools to support research.
- iii) discover new ways of funding research.

The project's final goal is to integrate the discovery solution into the EOSC marketplace⁵¹².

509 (n.d.). About RDA EU 4.0 - RDA Europe - Research Data Alliance. Retrieved 7 November 2019 <https://www.rd-alliance.org/rda-europe>

510 (n.d.). RISCAPE in a nutshell - RISCAPE. Retrieved 12 November 2019 <https://riscape.eu/riscape-project/>

511 The SSHOC project - <https://www.sshopencloud.eu/about-sshoc>

512 (n.d.). About TRIPLE |GOTRIPLE. Retrieved 8 January 2020 <https://www.gotriple.eu/about/>

VirtualBrainCloud – Grant agreement No 826421 – 01.12.2018 to 30.11.2022

The central goal of this project is the development of a cloud-based platform for biomedical research and clinical decision-making that helps to improve early patient-specific diagnosis and treatment of neurodegenerative diseases (NDD), such as Alzheimer’s disease and Parkinson’s and has substantial potential for significant positive socio-economic impact. The objective is to develop and validate VirtualBrainCloud, a dedicated cloud-based environment that leverages the potential of big data and high-performance computing (HPC) for personalised prevention and treatment of NDD⁵¹³.

XDC – Grant agreement No 777367 – 01.01.2017 to 31.01.2020

XDC (*eXtreme DataCloud*) aims to develop scalable technologies for federating storage resources and managing data in highly distributed computing environments. The services provided aim to operate at the unprecedented scale required by the most demanding, data-intensive, research experiments in Europe and worldwide. XDC is based on existing tools, whose technical maturity is proved, and the project seeks to be enriched with new functionalities and plugins already available as prototypes (TRL6+) that will be brought at the production level (TRL8+) at end of XDC. The XDC software will be released as open-source platforms available for general exploitation⁵¹⁴.

513 (n.d.). VBC Project - VirtualBrainCloud. Retrieved 7 November 2019 <https://virtualbraincloud-2020.eu/vbc-project.html>

514 (n.d.). The project | XDC - eXtreme DataCloud. Retrieved 7 November 2019 <http://www.extreme-datacloud.eu/the-project/>

ANNEX II – Country Sheets Template

Country Sheet

[Please insert country's name, e.g. Austria]

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Current policy[1] on open science and FAIR data

1. Is there a current policy on open science and FAIR data in place? <i>[Please answer by adding an (x) in the appropriate cell.]</i>		
Yes	No	In planning
Responsibility regarding policy making (strategic level): <i>[Please detail the current policy in the country concerned. Please add the responsibility at national level. Please also add the ongoing preparation (plan) if no current policy is in place or if updates are expected. Max. ≈ 150 words]</i>		
Responsibility regarding funding (supporting open science and FAIR data in practice): <i>[Please detail the current funding mechanisms in the country concerned. Please add the responsibility at national level. Please also add the ongoing preparation (plan) if no current funding policy is in place or if updates are expected. Max. ≈ 150 words]</i>		
Further observations / information: <i>[Please include here any further observations or precisions, which are part of open science and FAIR data but do not fit the previous boxes. E.g. there is no national policy, but X and Y university have their own policies Max. ≈ 150 words]</i>		

1.1. Is there a current policy regarding publications[2] in place? <i>[Please answer by adding an (x) in the appropriate cell.]</i>		
Yes	No	In planning
1.1.1. If yes, does it include open access to publications ? <i>[Please answer by adding an (x) in the appropriate cell.]</i>		
Yes	No	In planning

Landscape of EOSC-Related Infrastructures and Initiatives

Responsibility regarding policy making (strategic level): <i>[Please complete this part ONLY IF the current policy and responsibility regarding publications are different from open science policy. If this is the case, please detail the current policy regarding publications and add the responsibility. Max. ≈ 150 words.]</i>		
Responsibility regarding funding: <i>[Please complete this part ONLY IF the current funding mechanisms regarding publications are different from open science funding mechanisms. If this is the case, please detail the current funding mechanisms regarding publications and add the responsibility. Max. ≈ 150 words.]</i>		

1.2. Is there a current policy regarding data / services in place? <i>[Please answer by adding an (x) in the appropriate cell.]</i>		
Yes	No	In planning
1.2.1. If yes, does it include open data ? <i>[Please answer by adding an (x) in the appropriate cell.]</i>		
Yes	No	In planning
Responsibility regarding policy making (strategic level): <i>[Please complete this part ONLY IF the current policy and responsibility are different from open science policy. If this is the case, please detail the current policy regarding data / services and add the responsibility. Max. ≈ 150 words.]</i>		
Responsibility regarding funding: <i>[Please complete this part ONLY IF the current funding mechanisms regarding data / services are different from open science funding mechanisms. If this is the case, please detail the current funding mechanisms regarding data / services and add the responsibility. Max. ≈ 150 words.]</i>		

1.3. Is there a current policy regarding research evaluation in place? <i>[Please answer by adding an (x) in the appropriate cell.]</i>		
Yes	No	In planning

Landscape of EOSC-Related Infrastructures and Initiatives

Responsibility regarding policy making (strategic level): <i>[Please complete this part ONLY IF the current policy and responsibility are different from open science policy. If this is the case, please detail the current policy regarding research evaluation and add the responsibility. Max. ≈ 150 words.]</i>		
Responsibility regarding funding: <i>[Please complete this part ONLY IF the current funding mechanisms regarding research evaluation are different from open science funding mechanisms. If this is the case, please detail the current funding mechanisms regarding research evaluation and add the responsibility. Max. ≈ 150 words.]</i>		

1.4. Is there a current policy regarding open learning in place? <i>[Please answer by adding an (x) in the appropriate cell.]</i>		
Yes	No	In planning
Responsibility regarding policy making (strategic level): <i>[Please complete this part ONLY IF the current policy and responsibility are different from open science policy. If this is the case, please detail the current policy regarding open learning and add the responsibility. Max. ≈ 150 words.]</i>		
Responsibility regarding funding: <i>[Please complete this part ONLY IF the current funding mechanisms regarding open learning are different from open science funding mechanisms. If this is the case, please detail the current funding mechanisms regarding open learning and add the responsibility. Max. ≈ 150 words.]</i>		

2. Are there references to EOSC in the current policies? <i>[Please answer by adding an (x) in the appropriate cell.]</i>		
Yes	No	In planning
References to EOSC: <i>[Please detail the current references to EOSC in the country concerned. Max. ≈ 150 words]</i>		
2.1. Is funding or criteria for funding mentioned (with regards to EOSC)? <i>[Please answer by adding an (x) in the appropriate cell.]</i>		

Landscape of EOSC-Related Infrastructures and Initiatives

Yes	No	In planning
Funding: <i>[Please detail the current funding or criteria for funding mentioned (with regards to EOSC) in the country concerned. Max. ≈ 150 words]</i>		
2.2. Is there a national contact point for open science? <i>[Please answer by adding an (x) in the appropriate cell.]</i>		
National contact point for open science: <i>[Please detail information regarding national contact point for open science in the country concerned. Max. ≈ 150 words]</i>		
2.3. Is there a national contact point for EOSC? <i>[Please answer by adding an (x) in the appropriate cell.]</i>		
National contact point for EOSC: <i>[Please detail information regarding national contact point for EOSC in the country concerned. Max. ≈ 150 words]</i>		

Current e-infrastructure landscape

3. Current e-infrastructure that is to be federated / accessible to the EOSC[3]	
<i>[Please detail the current e-Infrastructure landscape that is to be federated / accessible to the EOSC. Max. ≈ 300 words in total (including 3.1-3.3.)]</i>	
3.1. Data infrastructures	<i>[Please add the responsibilities considering financing (€).]</i>
	<i>[Please add the responsibilities considering operating.]</i>
	<i>[Please add information / responsibilities regarding plans/future.]</i>
	<i>[Please add information regarding the number of researchers.]</i>

Landscape of EOSC-Related Infrastructures and Initiatives

	<i>[Please add information / responsibilities regarding the funding of researchers (estimated salary + amount of research project as well as the responsible institution.)]</i>
3.2. HPC infrastructures	<i>[Please add the responsibilities considering financing (€).]</i>
	<i>[Please add the responsibilities considering operating.]</i>
	<i>[Please add information / responsibilities regarding plans/future.]</i>
	<i>[Please add information regarding the number of researchers.]</i>
	<i>[Please add information / responsibilities regarding the funding of researchers (estimated salary + amount of research project as well as the responsible institution.)]</i>
3.3. Repositories	<i>[Please add the responsibilities considering financing (€).]</i>
	<i>[Please add the responsibilities considering operating.]</i>
	<i>[Please add information / responsibilities regarding plans/future.]</i>
	<i>[Please add information regarding the number of researchers.]</i>
	<i>[Please add information / responsibilities regarding the funding of researchers (estimated salary + amount of research project as well as the responsible institution.)]</i>

[1] Please understand policy as anything from guideline to mandate to code of conduct or actual law. Please aim for very high-level descriptive statements.

Please add a footnote if you think the way you understood a certain term should be specified as the Glossary Task Force will work on the terminology at a later date.

[2] Please consider national funders and policy encouraging open access to publications.

[3] Please count only the resources that could, in principle, be federated into or accessible from the EOSC. If it is not possible to estimate the costs, please state an estimation, e.g. "over 100MEUR" or "over 1 billion over the past ten years."

Please add an asterisk to the infrastructures that have already committed.

Getting in touch with the EU

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The Landscape Working Group (WG) of the EOSC Executive Board has surveyed and documented the landscape of infrastructures, initiatives and policies across Europe relating to the development of the European Open Science Cloud (EOSC).

This report describes activities in the Member States (MS) and Associated Countries (AC) related to EOSC, summarising existing policies and investments based on input from the MS and AC, the expert knowledge of the WG members and delegates to the EOSC Governing Board, as well as information from Horizon 2020 research projects and from open sources.

The work builds on existing surveys and information provided by national authorities, stakeholder communities and the relevant H2020 projects in close collaboration with MS and AC. A Validation Workshop was held online in April 2020, to validate the provided contributions.

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