



Progress on Open Science: Towards a Shared Research Knowledge System

Final Report of the Open Science Policy Platform

Progress on Open Science: Towards a Shared Research Knowledge System – Final Report of the Open Science Policy Platform

European Commission
Directorate-General for Research and Innovation
Directorate G — Research & Innovation Outreach
Unit G.4 — Open Science
Contact René Von Schomberg
Email rene.VonSchomberg@ec.europa.eu
RTD-PUBLICATIONS@ec.europa.eu
European Commission
B-1049 Brussels

Manuscript completed in April 2020.

The European Commission is not liable for any consequence stemming from the reuse of this publication.
The views expressed in this publication are the sole responsibility of the author and do not necessarily reflect the views of the European Commission.

More information on the European Union is available on the internet (<http://europa.eu>).

PDF ISBN 978-92-76-18882-7 Doi:10.2777/00139 KI-02-20-348-EN-N

Luxembourg: Publications Office of the European Union, 2020

© European Union, 2020



The reuse policy of European Commission documents is implemented based on Commission Decision 2011/833/EU of 12 December 2011 on the reuse of Commission documents (OJ L 330, 14.12.2011, p. 39). Except otherwise noted, the reuse of this document is authorised under a Creative Commons Attribution 4.0 International (CC-BY 4.0) licence (<https://creativecommons.org/licenses/by/4.0/>). This means that reuse is allowed provided appropriate credit is given and any changes are indicated.

For any use or reproduction of elements that are not owned by the European Union, permission may need to be sought directly from the respective rightholders.

Progress on Open Science: Towards a Shared Research Knowledge System

Final Report of the Open Science Policy Platform

Eva Mendez (Chair, OSPP Mandate 2), Rebecca Lawrence (Editor and Coordinator),
Catriona J. MacCallum (Writing Chair), Eva Moar (Rapporteur), together with all the
members of the Open Science Policy Platform

Table of contents

Executive Summary	3
1. The Open Science Policy Platform: the voice of the stakeholders	5
1.1. First Mandate (2016-2018): Recommendations for Open Science to the main stakeholders and actors	6
1.2. Second Mandate (2018-2020): Practical Commitments for Implementation	8
2. Practical Commitments for Implementation (PCIs) by Stakeholder	11
2.1. Summary of PCIs for each of the eight ambitions of Open Science	11
2.2. Barriers to PCI progress and next steps	14
3. Beyond Open Science: a call to action for a Shared Research Knowledge System by 2030	21
3.1. Rationale	21
3.2. The Call to Action	23
3.3. Five attributes of a Research System based on shared knowledge by 2030	23
Annex A: Practical Commitments for Implementation (PCIs) by Stakeholder	29
Annex B: Open Science Policy Platform (OSPP) members and alternate representatives by stakeholder organisation in the platform	57
Glossary and Acronyms	60

Executive Summary

This final report of the EU Open Science Policy Platform (OSPP) provides a brief overview of its four-year mandate from 2016 to 2020, followed by an update on progress by each stakeholder group over the past two years since the publication of the OSPP's recommendations across the European Commission's eight ambitions on Open Science, (OSPP-REC¹). This summary of Practical Commitments for Implementation with specific examples of progress by each stakeholder community across Europe (see **Annex A**) is followed by a perspective from each group on the major outstanding blockers to progress and possible next steps. The group of 25 key stakeholder representatives have then come together to propose a vision for moving beyond Open Science to create a shared research knowledge system by 2030.

Practical Commitments for Implementation

Across the stakeholder communities, our assessment suggests that there is reasonable progress on **rewards and incentives**, with some new initiatives starting to move into the implementation phase. A similar level of progress is being made in **next-generation metrics** although some stakeholders feel that progress here has now started to move towards adoption.

The **European Open Science Cloud (EOSC)** will be moving into the implementation phase in 2021 and this was recognised by many of the stakeholders. Key to the success of the EOSC is that the research community is making their **data FAIR**, and so it is reassuring that most of the stakeholders felt that FAIR data is moving beyond implementation to adoption and even to becoming common practice. There are substantial differences in both progress and awareness however, among disciplines.

There seems to be a general consensus that the **future of scholarly communication** has started to move from planning to implementation and even adoption of more open practices. This shift in focus, especially in the publishing community, has been significantly assisted by cOAlition S² and the associated Plan S.

There is an interesting disparity in views on progress on **research integrity**. Universities and research performing organisations, researchers, and scientific societies and academies view progress at the level of adoption or even being common practice. By contrast, research funding organisations, research libraries, policy making organisations, and publishers feel there is still much to do, suggesting that our progress is still at the earlier stages of discussion, planning and implementation. Similarly, in **skills and education**

on Open Science, research performing organisations and libraries feel they have now progressed this to the level of adoption, whereas many of the other stakeholders feel we are still in the discussion, planning or implementation phase.

Finally, while the citizen science community believes that **Citizen Science** across Europe is at the level of adoption, the rest of the stakeholders have evaluated progress as being still in the early stages of discussion, planning and some initial implementation. This may again reflect disciplinary differences.

Disparity in the assessment of progress between stakeholders suggests that there is a need for greater discussion between communities to better understand the different opinions. Without a common view on the challenges and progress, the danger is a divergence in implementation and a polarization between actors. Some stakeholders view the progress of other actors as insufficient, even where those actors feel they have made significant advances. For real progress to happen, stakeholders need to come together to have constructive dialogue to understand each others' perspective.

Another area where significant progress needs to be made is in addressing the dilemma faced by business and industry in adopting Open Science practices and principles whilst fulfilling requirements for Intellectual Property Rights (IPR) and commercial practices. Since much of the funding and innovation in research involves industry, there is an urgent need for a debate and discussion between academia and industry concerning the Open Science challenges in public-private partnerships. It is especially important to develop a general framework ensuring that the open diffusion of knowledge does not disadvantage players that are already underprivileged.

1 https://ec.europa.eu/research/openscience/pdf/integrated_advice_opssp_recommendations.pdf

2 <https://www.coalition-s.org>

Moving beyond Open Science to a shared research knowledge system by 2030

Even though the tools and technology to enable Open Science has been available for almost two decades, progress has been slower than anticipated and there remain real obstacles to overcome. Notably, there is a disparity in progress and motivation among different disciplines and institutions, among different actors and organisations, and among researchers at different stages of their career. This is compounded by a lack of policy alignment across local, regional, national and international jurisdictions, such as across Member States, and no clear legal or regulatory framework, often associated with insufficient cost/benefit analysis of Open Science requirements.

Open Science for its own sake has never been the goal. While a focus on Open Science as a mechanism must be emphasised in any transition, Open Science must ultimately be embedded as part of a larger more systemic effort to foster all practices and processes that enable the creation, contribution, discovery and reuse of research knowledge more reliably, effectively and equitably. Research cannot be ‘excellent’ without such attributes at its core.

As representatives of key stakeholders in the research system, we call on all European Member States and other relevant actors from the public and private sectors to help co-create, develop and maintain a ‘Research System based on shared knowledge’ by 2030. As a start, we commit to working together to implement a system with the five attributes outlined below.

- 1. An academic career structure that fosters outputs, practices and behaviours to maximise contributions to a shared research knowledge system.** To this end, in discussion with the OSPP, the Research Data Alliance has committed to spearhead a new collaborative platform³ to share both the intention and outcomes of pilots and other initiatives taken by different actors that specifically address the academic reward system. All Member States will have the opportunity to contribute to this so that everyone can benefit from the innovation of others by sharing what works and what doesn’t in different contexts.
- 2. A research system that is reliable, transparent and trustworthy.** To achieve this, Member States should agree to coordinate a series of workshops to research, develop, implement, test and share a minimum set of community-based standards of research integrity, specific to different disciplines where relevant. In particular, they should ensure there is training, support, monitoring and appropriate enforcement of research integrity standards for researchers at publicly funded institutions and in the practice, communication and/or publication of Open Science outputs of publicly funded research.
- 3. A research system that enables innovation.** Five key elements were identified as necessary to facilitate such a research system:
 - a. Clear relevant policies that aim to increase the availability and reuse of research knowledge and technology in a global competitive context;
 - b. A global interoperable infrastructure of tools, services, hardware and software;
 - c. Clear regulatory frameworks to manage each stakeholder’s interests for the collective good;
 - d. A transparent competitive market;
 - e. A shared research system based on reciprocity.
- 4. A research culture that facilitates diversity and equity of opportunity.** To enable such a culture to develop, all actors need to work together to articulate the shared values for a shared global research knowledge system and to create a legal and social framework within which these values can be implemented.
- 5. A research system that is built on evidence-based policy and practice.** To enable this, we recommend that a coordinated strategy for funding and delivering a programme of ‘research on research’ is developed, including identifying priority areas for investigation, involving representatives from the key stakeholders in research: researchers, funding agencies, institutions, publishers, learned societies and others. This could be a pilot, time-limited activity in the first instance to consider how it works.

³ www.openscienceregistry.org

1. The Open Science Policy Platform: the voice of the stakeholders

The **European Open Science Policy Platform (OSPP, also known as EUOSPP)** is a High-Level Advisory Group established by the Directorate- General for Research and Innovation (RTD) of the European Commission (EC) in May 2016. This group is made up of 25 expert representatives of the broad constituency of European science stakeholders, divided in eight groups namely: Universities, Research Organizations, Academies and Learned Societies, Funding organizations, Citizen Science Organizations, Publishers, Open Science Platforms and Intermediaries, and Libraries⁴. Some individuals representing each organization might have changed or alternate in several cases, but still keeping a strong commitment and representation (see **Annex B**).

Although these eight groups covered most of the main stakeholders involved in Open Science, we are aware that not all stakeholder communities are as strongly represented such as small to mid-size enterprises (SMEs), industry and non-governmental organisations (NGOs). We have worked to try and address this as much as possible during the process of formulating this final document, but we recognise that there are still significant areas and topics raised in this document where the challenges faced by business and industry are not yet properly addressed. Whilst it has therefore been more difficult to fully represent the views and challenges faced by the business and industry community, we hope that these initial conversations between academic and industry stakeholders will continue beyond the OSPP mandate to try and address the significant challenges in coming to an agreed mutual position on how to address Open Science, especially in public-private partnerships where such understanding is crucial. This is similarly true for Researchers and Policy Making Organisations, which are considered as stakeholder groups but these two communities are not specifically named in the list of OSPP members.

The members of the OSPP were announced in May 2016 during the Competitiveness Council on 26-27 May 2016⁵, (after an open call for expressions of interests⁶), in order to provide advice about the development and implementation of Open Science policy in Europe. Since its constitution and first meeting (September 2016) the main roles of the OSPP have been to:

- Advise the Commission on how to further develop and **practically implement** Open Science policy.
- Support **policy formulation** by identifying the issues to be addressed and providing recommendations on the required policy actions.
- Support policy implementation by reviewing best practices, drawing policy guidelines and encouraging their **active uptake** by stakeholders.
- Provide advice and **recommendations** on any cross-cutting issue affecting Open Science.
- Function as a dynamic **stakeholder-driven mechanism** for bringing up issues of concern for the European science and research community and its representative organisations.

One can probably find as many definitions of **Open Science** as actors talking about it. Some of the more significant ones are cited here ^{7,8,9,10}. However, it is important to reflect on what we mean by ‘Open Science’, and to reiterate that it is so much more than Open Access. This is especially important, not only because of the ongoing COVID-19 pandemic that has seen many individuals and actors from the public and the private sector collaborate over a shared objective, but also in potentially helping to address many other major challenges, such as the Sustainable Development Goals (SDG) and the EC Green Deal.

4 See the updated list of nominated members in accordance with their stakeholder group:
https://ec.europa.eu/research/openscience/pdf/ospp_nominated_members.pdf#view=fit&pagemode=none

5 <https://www.consilium.europa.eu/media/22779/st09357en16.pdf>

6 https://ec.europa.eu/research/openscience/pdf/call_for_expression_of_interest_high_level_advisory_group_ospp.pdf#view=fit&pagemode=none

7 http://www.rin.ac.uk/system/files/attachments/RINews_Issue_11_0.pdf

8 https://en.wikipedia.org/wiki/Open_science

9 <https://www.consilium.europa.eu/media/22779/st09357en16.pdf>

10 <https://op.europa.eu/en/publication-detail/-/publication/3213b335-1cbc-11e6-ba9a-01aa75ed71a1>

Open Science leads to significant challenges in how to make Science immediately available to ALL, while balancing the necessary safeguards to protect the interests of different stakeholders in the research arena, thereby requiring a complex change in the entire scientific system. The OSPP has therefore been working to drive forward the systemic change needed to make Open Science (which is intended here to include Open Research and Open Knowledge) a reality in Europe and to develop Research and Innovation policies and practices in a useful way. This document summarizes the OSPP endeavors to help Open Science to flourish.

The European Open Science Policy Platform, has been working during the past four years on two mandates:

First mandate, from May 2016 to April 2018, chaired by Prof. Johannes Vogel, Ph.D., representative of the European Citizen Science Association, and Director of the Museum für Naturkunde Berlin.

Second mandate, from May 2018 to April 2020, chaired by Dr Eva Méndez, Chair of the Open Science Working Group of the Young European Research University Network (YERUN) and Deputy Vice-President for Research Policy at Universidad Carlos III de Madrid.

This report gathers the work achieved by the OSPP during its two mandates, helping the European Commission to discuss and practically implement Open Science in the European Research landscape. In this section, we summarize the main actions and outcomes from the platform in each mandate. We also underline the crucial role that all the stakeholders have in building a Global Open Science approach from transversal and diverse perspectives, beyond that of the Member States or the European Commission.

1.1. First Mandate (2016-2018): Recommendations for Open Science to the main stakeholders and actors

During the first Mandate, the OSPP members embraced the eight challenges of Open Science, as defined by the European Commission: 1) rewards, 2) altmetrics (renamed next generation metrics), 3) European Open Science Cloud, 4) changing business models for publishing (renamed future of scholarly publishing), 5) research integrity, 6) citizen science, 7) open education and skills, and 8) FAIR open data. This was alongside the five lines for action of the (always draft) European Open Science Agenda (2016)¹¹ that relied on the stakeholder's actions:

- Fostering and creating incentives for Open Science;
- Removing barriers for Open Science;
- Mainstreaming and further promoting Open Access policies to research data and publications;
- Developing research infrastructures for Open Science;
- Embedding Open Science in society to make science more responsive to societal and economic expectations.

During this mandate (2016-2018), along with the OSPP, the European Commission nominated High Level Expert Groups (HLEG) to analyse and address the issues related to most of the eight challenges, leading to a series of reports and recommendations including on Rewards and Incentives¹², Next Generation Metrics¹³, Skills and Career Development¹⁴, FAIR data¹⁵ and EOSC¹⁶. **Figure 1** shows the role of the OSPP in the Open Science scenario, in discussing and adopting the specific reports. The OSPP held five in-person plenary meetings during this period, as well as different focused meetings with the HLEG, in order to discuss and align the thematic challenge discussions with the stakeholders' perspective.

11 https://ec.europa.eu/research/openscience/pdf/draft_european_open_science_agenda.pdf#view=fit&pagemode=none

12 https://ec.europa.eu/research/openscience/index.cfm?pg=rewards_wg

13 https://ec.europa.eu/research/openscience/index.cfm?pg=altmetrics_eg (this webpage includes information about the HLEG on Altmetrics and its report on Next Generation Metrics (<https://ec.europa.eu/research/openscience/pdf/report.pdf#view=fit&pagemode=none>), and the information about Indicators, created later during the 2nd mandate of the OSPP)

14 https://ec.europa.eu/research/openscience/index.cfm?pg=skills_wg

15 The report of the FAIR data HLEG was released, along with the II report on EOSC, during the event of the EOSC launch on 29th November 2019: https://ec.europa.eu/info/sites/info/files/turning_fair_into_reality_1.pdf

16 The EC named two Expert Groups on EOSC during the OSPP mandates. See information about both of them and their reports: <https://ec.europa.eu/research/openscience/index.cfm?pg=open-science-cloud-hleg>

Different position papers, statements, assessments and specific reports were adopted by the OSPP during this period:

- [Recommendations of the OSPP on Next-Generation Metrics](#) (October 2017)
- [Position statement on the Future of Scholarly Publishing](#) (April 2017)
- [Report on the governance and financial schemes for the European Open Science Cloud](#) (May 2017)
- [OSPP Working Group Initial assessment on the Report of Rewards and Incentives](#) (November 2017, adopted March 2018)
- [OSPP Working Group Initial assessment on the Report of Education and Skills](#) (November 2017, adopted March 2018)
- [Recommendations of the OSPP on Citizen Science](#) (April 2018)
- [Combined Recommendations for the embedding of Open Science](#) (April 2018)

At the end of the OSPP’s first mandate (May 2018), the stakeholder members came together to agree a set of recommendations to take forward each of the eight challenges of Open Science, leading to the publication of the OSPP-REC¹⁷, also known as the ‘Integrated advice of the Open Science Policy Platform on the eight prioritised Open Science ambitions’.

The OSPP-REC was presented at the Competitiveness Council in May 2018. The document introduces a set of five general recommendations, which are extended by a series of key recommendations at stakeholder level covering the eight Open Science challenges in Europe during Horizon 2020.

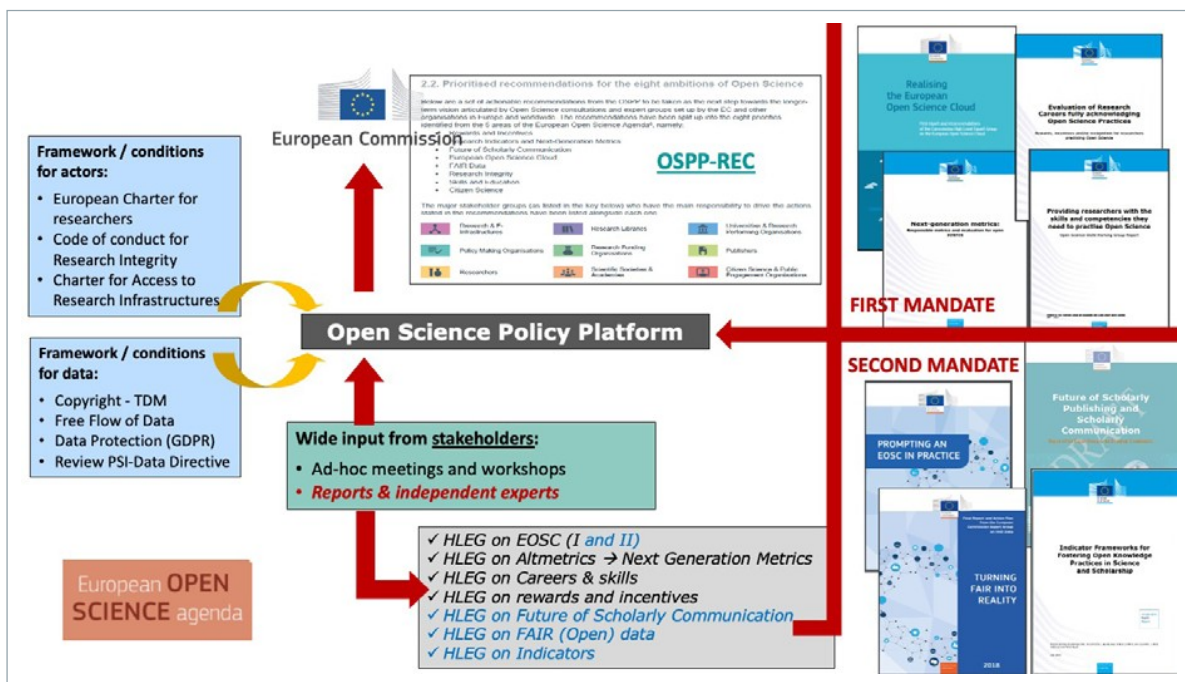


Figure 1 Open Science Policy Platform (OSPP) in the European Open Science state of play (2016-2018)

17 https://ec.europa.eu/research/openscience/pdf/integrated_advice_opssp_recommendations.pdf

1.2 Second Mandate (2018-2020): Practical Commitments for Implementation

After the Competitiveness Council in May 2018, Commissioner Moedas gave the OSPP a second mandate to focus on implementation and to address the cultural change needed for Open Science. Given the systemic nature of the transition towards Open Science, success will depend on the buy-in and active support of all stakeholders represented in the OSPP and beyond, and their commitment to help implement Open Science policies and advocate these policies vis-à-vis their respective constituencies. The particular elements of this mandate were¹⁸:

- The OSPP will encourage stakeholder groups and their representative constituencies to adopt and act on previous OSPP recommendations through practical implementation, best practices and pilot cases.
- The OSPP will adopt an evidence-based policy approach by actively encouraging relevant groups and stakeholder communities to carry out and report back on pilot studies and experiments of OSPP recommendations and their implementation.
- The OSPP will actively monitor the adoption of the policy recommendations and their implementation, including exemplars from the pilot cases, by inviting updates from the relevant stakeholder groups about progress towards best practice and implementation. These will be made publicly available where appropriate.
- The OSPP will further support policy implementation by reviewing and reporting on best practices and implementation of recommendations where pilot cases are not deemed necessary.
- The OSPP will support the development of the European Open Science Policy Agenda by providing a roadmap, informed by relevant expert groups or other types of expert advice. The roadmap will set out both the medium and longer-term recommendations to operationalise the Open Science Agenda with practical and pragmatic interim steps for the transition towards Open Science.

This specific mandate implied a shift from ‘Recommendation Mode’ to ‘Implementation Mode’, through PCIs: Practical Commitments for Implementation at stakeholder level. A PCI is a realistic and affordable action that a stakeholder (or a representative) has the will and jurisdiction to implement in relation to a particular aspect or recommendation in Open Science. For example, Plan S could be considered as a PCI from the involved funders: it has driven a shift in scientific publication that they were able to articulate at a practical level of implementation where they have jurisdiction.

¹⁸ https://ec.europa.eu/research/openscience/pdf/terms_of_reference_ospp.pdf#view=fit&pagemode=none

¹⁹ <https://op.europa.eu/en/publication-detail/-/publication/464477b3-2559-11e9-8d04-01aa75ed71a1>

During this mandate, the European Commission nominated two further High-Level Expert Groups (HLEG) to analyse and address the issues related to the Future of Scholarly Communication¹⁹, and Indicators for Researchers' Engagement with Open Science²⁰. The OSPP have worked closely with these two Expert Groups, for example, giving a formal response from the stakeholders' perspective on the report of Future Scholarly Publishing and Scholarly Communication (November 2019), or by looking for scenarios and pilots to practically implement the new indicators and indicator frameworks for Open Science (January-July 2019), as well as coordinating actions with Member States' responsible for Open Science.

In this mandate we also worked to reach more members of the European Open Science operational ecosystem with clear and continuous communication amongst OSPP stakeholders, as well as their communities and representatives that are also key to fostering the uptake of Open Science policies and practices (Figure 2). There have been several overarching activities over the past couple of years that are expected to make a significant contribution to progress towards Open Science in Europe across the broad scholarly community. Two major such activities are: a) OSPP registry of pilots and implementations of responsible metrics, and b) the Council for National Open Science Coordination (CoNOSC).



Figure 2 Twitter Account of the EU-OSPP (@euospp). Photo of members of the Second Mandate with Jean Eric Paquet, Director General RTD (Picture taken: 5 February 2020; snapshot of the Twitter account 25 April 2020).

20 https://ec.europa.eu/research/openscience/index.cfm?pg=altmetrics_eg

a. OSPP registry of pilots and implementations of responsible metrics

There are now a number of frameworks that provide support and guidance to the various stakeholders in research around the responsible use of metrics in research and researcher assessment^{21,22}. Additionally, a broadening array of different indicators and metrics that can be selected and used in relevant contexts continue to emerge²³. There are now several examples of the contextualised (and responsible) use of research metrics in research evaluation^{24,25,26,27}. We now believe the most effective and practical way to drive towards more responsible use of metrics and the broad uptake of open knowledge practices across our scholarly research ecosystem is to call for parties at all levels (organisation, consortium, national, regional/ local, disciplinary) to set up pilots or new policy implementations and infrastructures and to openly share the learnings from these activities.

Given the complexity of the issues involved, there will be many potential impacts of such changes to the research system, hopefully most being anticipated but likely also some unintended consequences. We therefore believe that it is crucial to share information, both early on about planned or early-stage activities, followed later by the outcomes of subsequent review and analysis of the impacts of those activities – practicing what we preach through our own open knowledge practices!

This will provide a base of evidence for the future development of Open Science indicators across stakeholder groups, and exemplars of what works (and what doesn't) that others can use to support their own activities. The OSPP is uniquely positioned to propose such initiatives as a research stakeholder body that is transnational, spans stakeholder groups and disciplines, and has been charged by the European Commission with a brief to promote and progress Open Science.

To this end, we are working towards the development of a structured registry (similar in nature to clinicaltrials.gov to ensure full searchability), initiated and shaped by the OSPP and coordinated by the Research Data Alliance (RDA)²⁸, followed by a call to all communities and organisations to ensure that any relevant pilots, roadmaps and implementations that aim to shift towards a more responsible use of metrics are added to this registry, ideally when the initiative is first set-up. We will then ask for a commitment to return to these registry entries after an adequate period (possibly a few months or 1-2 years, as appropriate) to complete them with information and underpinning FAIR data (where feasible) around the effects of any implementations (both positive and negative), together with analysis of what can be learned from this for the benefit of others. The scoping and planning phase is due to start in June 2020, subject to funding.

b. Launch of CoNOSC: Council for National Open Science Coordination

General Recommendation 1 in the OSPP-REC²⁹ called for the appointment of national coordinators and task forces for the implementation of Open Science. Over the past couple of years, a number of National Coordinators have been appointed, including in The Netherlands, and many Member States have developed National Open Science Plans, such as in Finland, Ireland and France, and with support from Open Science experts such as the OpenAIRE National Open Access Desks (NOAD). In October 2019, 21 Member State representatives came together as part of the Finnish EU Presidency to create the Council for National Open Science Coordination (CoNOSC)³⁰ with the stated aim of helping to fill in the gaps in national Open Science coordination across the European Research Area, and providing insight into activities through dialogue with other international partners.

21 <http://www.leidenmanifesto.org>

22 <https://responsiblemetrics.org/the-metric-tide>

23 <https://op.europa.eu/en/publication-detail/-/publication/b69944d4-01f3-11ea-8c1f-01aa75ed71a1/language-en/format-PDF/source-108756824>

24 <https://www.timeshighereducation.com/news/glasgow-rate-collegiality-professorial-promotions>

25 https://www.fwf.ac.at/fileadmin/files/Dokumente/Antragstellung/Einzelprojekte/p_application-guidelines.pdf

26 <https://www.leru.org/files/LERU-AP24-Open-Science-full-paper.pdf>

27 <https://avointiede.fi/fi/luonnos-tutkijan-vastuullinen-arviointi>

28 www.openscienceregistry.org

29 https://ec.europa.eu/research/openscience/pdf/integrated_advice_opsp_recommendations.pdf

30 <https://conosc.org>

2. Practical Commitments for Implementation (PCIs) by Stakeholder

2.1. Summary of PCIs for each of the eight ambitions of Open Science

We have reviewed the relevant OSPP-REC recommendations³¹ from the first OSPP mandate per stakeholder group, and assessed where that group has made progress, focussing on those where that stakeholder community had been identified in the OSPP-REC as having the main responsibility for driving the actions stated in the recommendations.

It is important to note that while the OSPP contains members from across many of the major stakeholder communities in the scholarly ecosystem in Europe, the members do not provide full representation of these communities. In addition, as discussed in Section 1, we are aware that not all stakeholder communities are as strongly represented such as SMEs, industry and NGOs, although we have tried to address this as much as possible in this process of formulating this document.

For each of the eight ambitions, we have categorised the level of progress according to the categories below:

Discussion: stakeholders are discussing the implications of the recommendations, but there is no clear commitment yet

Planning: the stakeholders understood the implications and are developing an approach to implementation

Implementation: the stakeholders are implementing the recommendations

Adoption: the recommendation is implemented and adoption by beneficiaries is in progress

Common practice: the recommendation is implemented and benefits being in place

Below is the top-line summary of the level of progress by each stakeholder against each ambition. Where no progress level is given against a stakeholder, this is because they had not been identified as a key contributor to making progress on this specific Open Science ambition. In some cases, a range of progress has been provided as naturally many stakeholder members are at different stages in the process of uptake. A much more detailed summary of progress by stakeholder for each of the eight ambitions is included in **Annex A**, which also provides specific examples of Practical Commitments for Implementation by each stakeholder.

Stakeholders key

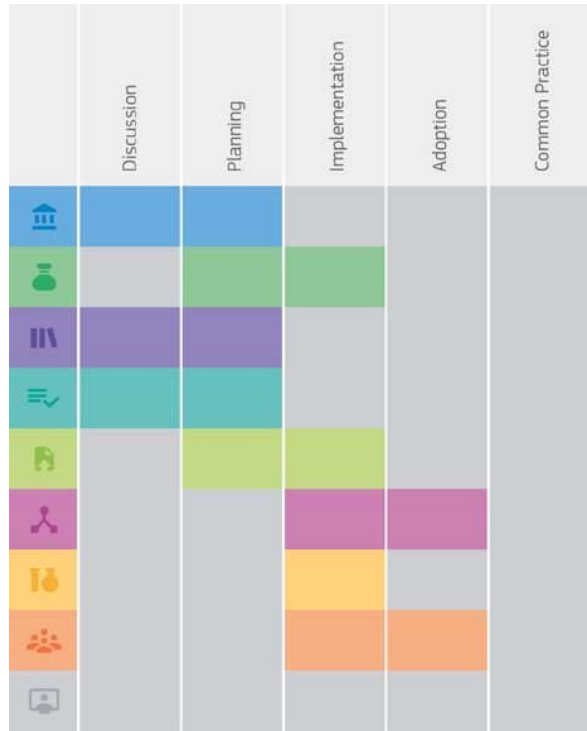
 Universities & Research Performing Organisations	 Policy Making Organisations	 Researchers
 Research Funding Organisations	 Publishers	 Scientific Societies & Academies
 Research Libraries	 Research & E-Infrastructures	 Citizen Scientists & Public Engagement Organisations

31 https://ec.europa.eu/research/openscience/pdf/integrated_advice_opssp_recommendations.pdf

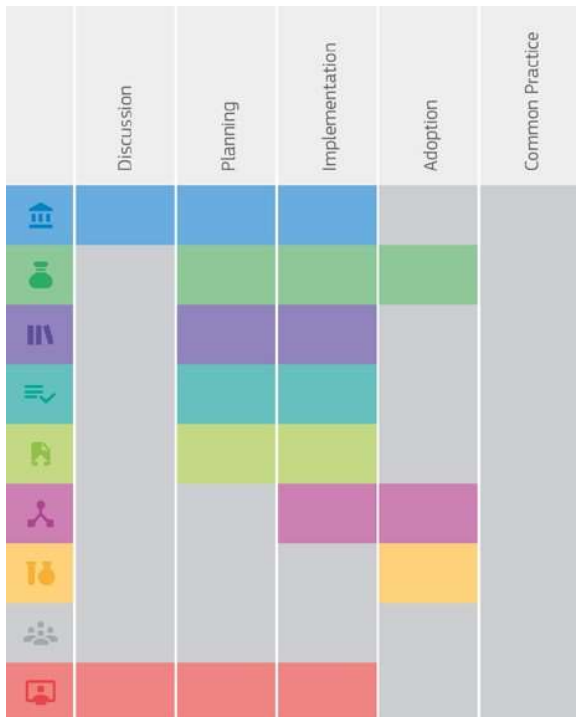
Rewards and Incentives



Indicators & Next-Generation Metrics



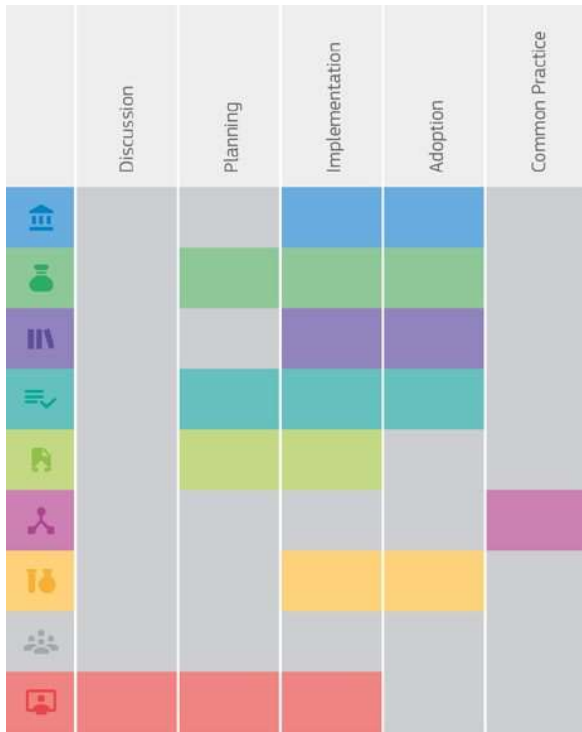
Future of Scholarly Communications



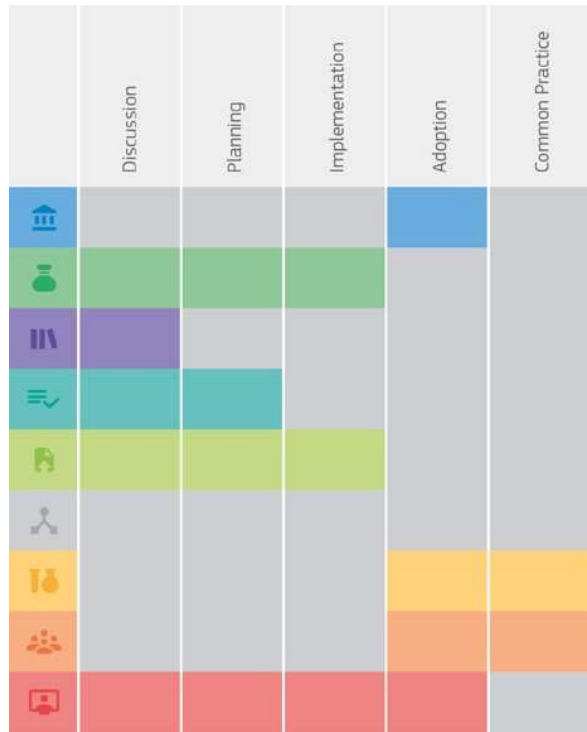
EOSC



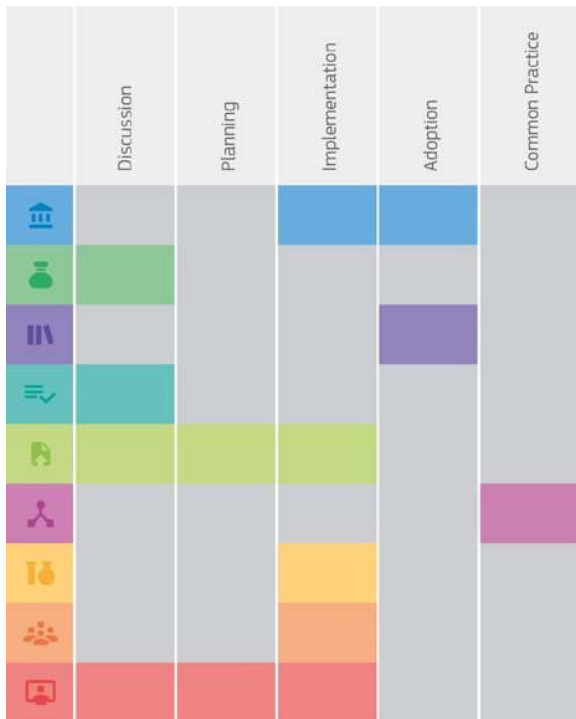
FAIR Data



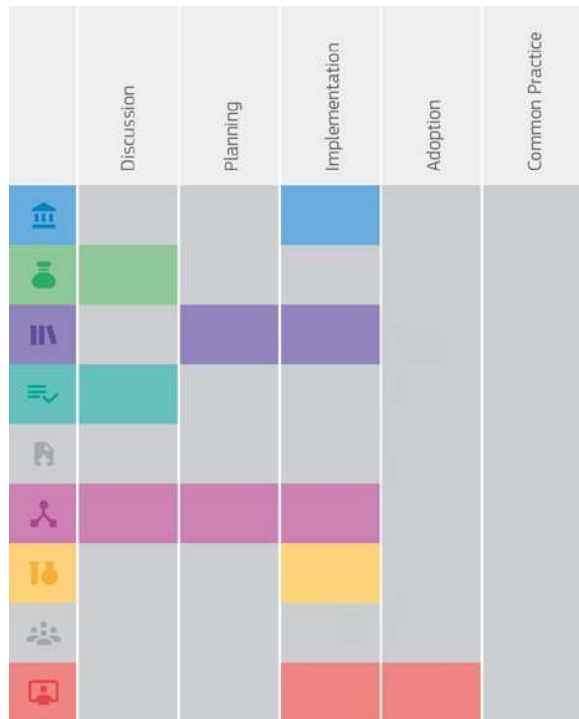
Research Integrity



Skills & Education



Citizen Science



2.2. Barriers to PCI progress and next steps

At the level of each stakeholder community, we have looked at areas where little progress has yet been made against specific recommendations. We have identified possible blockers and how these might be addressed going forward. It should be noted that the blockers identified are those that the specific stakeholder group felt were blockers for them. In some cases, other stakeholders may hold a different view of why progress has been slow. Rather than trying to come to a consensus view, it was felt important to recognise the true view of the blockers for that stakeholder so that a real understanding can be reached and an open conversation can be started between stakeholders to come to a more common understanding of progress in that area and how best to move forward together

2.2.1. Universities and Research Performing Organisations

Incentive and reward structures for academic careers remains an obstacle for the transition to Open Science. The lack of cost-neutral commercial Open Access publishing venues and continued slow progress of Open Access transformation across scholarly publishers, including Gold and Green Open Access is another major problem. The final blocking factor lies in the lack of funding for additional support activities during the transition period (e.g. establishment of Open Science support services, infrastructures) and often a lack of funding for Open Access publishing. A concerted approach uniting the main actors is needed to meet those challenges, as well as a structured overview of the existing institutional and national efforts and their main elements.

Other key challenges for universities and research performing organisations include:

- a. Using responsible research indicators and Next-Generation Metrics to validate a broader range of academic activities;
- b. Providing conditions conducive for the mainstreaming of FAIR research data management (i.e. supportive infrastructure, scientific protocols and workflows, improved acceptance, adequate funding etc);

- c. Training researchers and upskilling staff with new profiles (e.g. data stewards, experts in data management & data protection);
- d. Improving transparency and competition in scholarly publishing to improve knowledge dissemination and the progress towards a European research and innovation system based on excellent and Open Science;
- e. Mainstreaming Citizen Science and public engagement in the structure and working process of institutions (including training and education at undergraduate level).

2.2.2. Research Funding Organisations

There are a number of areas where further improvements are needed:

- a. **Funder policy alignment.** Whilst it will take time to bring all communities (across sectors) to embrace open ways of working, without stronger guidance from Member States, organisations are free to embark on the Open Science journey at their own speed leading to a broad range of adoption speeds and levels spanning from discussion to implementation. Sustained efforts are dedicated to foster greater alignment on policies between Europe-level and national-level funders and indeed with funder policies more globally. In addition, best practice examples from those who have already made significant progress are being shared to support others to make their own progress – this is the intention of the planned OSPP registry of pilots and implementations of responsible metrics.
- b. **Funding to support implementation.** Where progress is being made on policies towards Open Science, there is often a lack of adequate funding to support their implementation, thereby stymying progress. There needs to be stable and transparent funding for EOSC and this needs to be guaranteed as a core infrastructure underpinning the research system in Europe. Consideration also needs to be given to supporting a transition towards FAIR data by ensuring adequate budgets and time/incentives are made available, whilst balancing cost versus benefit, to enable researchers to achieve especially the Interoperable and Reusable elements of FAIR.

- c. **Involving industry.** More consideration is required on how to address the complexities of European research involving public-private partnerships and how to balance the issues in relation to IPR and competitiveness with the benefits of Open Science. This includes ensuring there is adequate representation of industry in key discussions around Open Science in Horizon Europe and in the EOSC governance structure.
- d. **Need for standards.** Funders have made significant progress in requiring Output Management Plans (OMPs) for grant applications and are striving to align their respective requirements. However, researchers are still facing practical difficulties in completing OMPs including a skills and training gap, lack of adequate time, and lack of knowledge of potential legal implications (where relevant) of sharing data. To maximise use and reuse of OMPs by making these machine-readable, we also need standards for OMPs and tools (e.g. AI), as well as investment (including for training).
- e. **Training, accreditation and standards in research integrity.** There lacks a common understanding of research integrity, of common practices and of sanctioning procedures. Above all, despite research integrity being vital for the credibility and endorsement of Open Science, and to ensure progression towards Open Science practices, training on good research practice is often seen as voluntary with responsibility laying with the individual researcher. However, it needs to be seen as the responsibility of the research community as a whole, with institutions and research funders raising awareness of good research practices, to promote and support adherence. Moving from principles to implementation and actions is a priority, as well as promoting good research practices as an integral part of the research process. Sanctions for misconduct should be explicit and public in a European repository, to provide transparency. Furthermore, training and subsequent accreditation on research integrity should be mandatory and used as a selection criteria for researchers, and for funding for research institutions. The Data Stewardship training programme that Dutch National funders are supporting across universities in the Netherlands could provide a possible model³².
- f. **Best practices and infrastructures for Citizen Science.** A common and universal Open Science booklet on Best Practices is needed that can be endorsed and adopted by research funders and others. While Citizen Science must develop its own code of conduct to safeguard reliability, integrity and ethics, research funders and institutions need to put in place adequate infrastructure and a dedicated space for interaction between Citizen Science and traditional science to showcase the added value that Citizen Science can bring.
- g. **Unintended consequences.** New initiatives and programmes designed to support Open Science and incentivise Open Science behaviour will impact the science ecosystem and may have unintended consequences. cOAlition S is creating a monitor to track the impact of Plan S on the research community so as to avoid or mitigate any potential negative impact.

2.2.3. Research Libraries

Research libraries are motivated to support Open Science and are well placed to fulfil their role as Open Science champions. They support and enable Open Science through their roles as trainers and multipliers, being essential for research and academia. Increasingly they have the tools, knowledge and skilled staff to support the ongoing transition by universities and other research performing organisations (i.e. collections of best practices, training capacity etc), and new training opportunities continue to appear. For example, in 2020, research libraries will benefit from a series of LIBER-run workshops highlighting the important role of, and possibilities for, research libraries in relation to the EOSC. Collaboration between LIBER and the Community of Practice for training coordinators is ongoing, and input has recently been provided to the EOSC Working Groups on Rules of Participation and on Skills and Training. Furthermore, the library community is continuously engaged through collaborative activities between LIBER working groups and Open Science-related EU-funded projects that LIBER participates in.

At the same time, libraries face challenges and barriers in their quest to advocate for Open Science and the role of research libraries supporting digital (Open) Science is not well articulated in general. In the exceptional situation where its role is highlighted, the focus is merely on curation, archiving and preservation of the past (cf. Richard Ovenden, 2019 keynote speech to the LIBER Annual

32 https://www.go-fair.org/wp-content/uploads/2019/12/06_goTRAIN_DataStewardshipNL_V3_191125.pdf

Conference). The potential role of research libraries to support digital science is still undervalued and, in contrast, too little effort and directed guidance is invested in thought leadership and scenarios for a build-up of digital science libraries and 21st century academic information support structures. Awareness of Open Science activities and opportunities (as well as challenges), and of available expertise/support by libraries is still rather low, i.e. more effort is needed to build up and sustain networks (such as data stewards, early career, cross-discipline, etc.). Additional mechanisms for funding, rewarding and sustaining such activities would be desirable. Research libraries need to make their more ‘technical’ work part of the broader discussion, both within their institution and on an international level. Specific challenges faced by research libraries include:

- a. **Copyright.** The great advantage of Open Science is that it makes huge amounts of information openly available. In order to effectively analyse this wealth of knowledge and make new discoveries, however, researchers need to be able to use computers to look for trends and patterns. It is positive that Europe’s incoming Directive on Copyright in the Digital Single Market contains two new exceptions³³ allowing text and data mining (TDM) but it remains to be seen how easily researchers can make use of these exceptions. Researchers will need support from librarians, but many librarians will first need training in order to be able to support researchers in this exciting new area of work. Furthermore, libraries may need to be robust with publishers in asserting this new right in European law and ensuring that any technical issues or access-blocking experienced by the institution are resolved quickly.
- b. **Metrics & Rewards.** Research-related metrics fluctuate. Bigger is not always better and numbers don’t reveal the whole picture. A policy change which values research culture over metrics can, for example, lead to a (temporary) decrease in research indicators. This concept is clear to research libraries and others who work closely with research outputs. For those working at a higher strategic level, however, the patterns and trends driving research metrics may not be fully understood. Libraries need guidelines for engaging with and increasing understanding among management when discussing responsible research indicators (a report on this

from LIBER’s Innovative Metrics Group³⁴ (due to be published in spring 2020).

- c. **Research Data Management & FAIR Data.** Libraries, RDM and the FAIR movement in general are too narrowly focused on after-the-fact research artefacts. To some extent this contrasts with the necessity to invest in support structures that are integrated and closely connected to the primary research process. More direct investments should therefore be made in, for example, library support structures to foster FAIR’s machine-actionable aims. Hence, it is no surprise that the focal point in the Open Science discussion is now on gathering data-reuse showcases to illustrate the return on investment of Open Science data.
- d. **Funding & Language Barriers.** Lack of funding and understaffing can be a barrier for libraries in specific regions (e.g. countries in South East Europe). Inclusivity is key here, and mixed measures are needed: increased budgets, knowledge transfer, policies implementation, etc. Language barriers can also form a stumbling block for libraries, in keeping up with developments in the Open Science ecosystem, as well as in advocating for it.
- e. **Citizen Science.** The role of Citizen Science in generating societal impact is not yet well positioned. Research libraries are working towards this goal, exploring and furthering their role in supporting Open Science through Citizen Science: LIBER has established a Citizen Science Working Group in 2019 and is participating in the INOS project³⁵, aiming at integrating Open Science and Citizen Science into active learning approaches in higher education.
- f. **Skills & Education.** The array of knowledge, skills and competencies needed to practice Open Science effectively can be daunting for many librarians and researchers, particularly those who are new to Open Science concepts and practices. The wide range of required skills can be seen in this Open Science Skills visualisation³⁶, produced by LIBER’s Digital Skills for Library Staff and Researchers Working Group³⁷. Furthermore, there is a need for more online training which is accessible to all, regardless of an individual’s location, and which is affordable for institutions that do not have generous training budgets.

33 <https://libereurope.eu/blog/2019/03/29/new-european-copyright-directive-a-detailed-look/>

34 <https://libereurope.eu/strategy/innovative-scholarly-communication/metrics/>

35 <https://inos-project.eu/>

36 <https://libereurope.eu/blog/2020/03/10/open-science-skills-diagram/>

37 <https://libereurope.eu/strategy/digital-skills-services/digitalskills/>

2.2.4. Policy Making Organisations

The key barrier is a lack of Open Science policy development, coordination and implementation. Policymakers, governments and Member States have made progress in some areas (e.g. around Plan S) but there remains little evidence-based policy development of Open Science within different contexts and a lack of policy alignment among policy making organisations, especially at the level of Member States and institutions. The following urgent actions are required:

- a. **Changes to rewards and incentives policy and practice for researchers should be emphasised more within Horizon Europe and in model grant agreements**, alongside fundamental and synergistic changes to how publicly funded institutions are assessed, ranked and funded within Member States.
- b. **Experimentation of different funding/ business models for Open Access in different contexts.** This must not disadvantage early career researchers or disciplines for which there is currently insufficient project-based funding for Open Access. It must also facilitate equity of opportunity for researchers and other research actors from Low-to-Middle Income Countries (LMICs).
- c. **Explicit support and investment for the transition costs towards Open Science and its ongoing maintenance and development.** There are two main areas that require attention:
 - i. First, the transition to Open Access for publications requires separate and additional investment to ensure the market is competitive and promotes innovation within scholarly communications itself. In particular, the market needs to be managed to the extent that it enables new public or private entrants and reduces risk for small- and medium-sized scholarly societies or enterprises.
 - ii. Second, there needs to be the creation and ongoing maintenance of an interoperable research infrastructure to enable different actors and entities to contribute and exchange knowledge safely and with confidence. This includes a means with which business and industry can interact with EOSC (and contribute FAIR data) as well as the development of mechanisms that promote equity of opportunity for other actors engaging with the European research system.

For example, guidance principles should be elaborated and inserted in Horizon Europe to provide a clear framework for international cooperation on Open Science/EOSC.

- d. **Policy alignment among European Member States and between Europe and other international governments.** This is necessary to maximise opportunities for multidisciplinary and multinational collaboration and co-creation, and to avoid penalising research actors from specific disciplines, jurisdictions or geographical areas.
- e. **Creation and adherence to common standards and best practice for Research Integrity.** All research actors require education, training, support and enforcement of research integrity practice. While there needs to be codes of research integrity specific to certain disciplines, core principles must be embedded within any reward or evaluation practice of researchers and institutions, and in the procurement of Open Science service providers, including publishing services. Policy making organisations, including scholarly societies and academies, need to take a lead in developing standards and best practice and providing mechanisms to enforce these. Lack of awareness is particularly acute in some disciplines, such as the humanities, arts and social sciences. As detailed in the OSPP-REC General Recommendation 3³⁸, institutions that apply for the 'Human Resources in Research Award' should also be required to demonstrate explicitly how research integrity is integrated into their human resources processes and strategies.
- f. **Education, training and support for an Open Science curriculum.** There remains a deep lack of awareness of Open Science and the skills and roles required to deliver it. Member States still need to secure support for the development of an accredited curriculum for Open Science skills training that fosters Open Science behaviours such as IT and data literacy, from primary school through the whole educational system (OSPP-REC General Recommendation 4). They also still need to do much more to raise awareness and communicate the benefits of Open Science among decision makers, research and education bodies, private sector, industrial and citizen organisations (OSPP-REC General Recommendation 5).

38 https://ec.europa.eu/research/openscience/pdf/integrated_advice_opspp_recommendations.pdf#view=fit&pagemode=none

- g. **Evidence-based policy development and implementation.** Policy intention and outcomes by policymaking organisations must be tracked, monitored and the data made available for independent analysis to assess effectiveness in different contexts.

2.2.5. Publishers

Although significant progress has been made in many areas, there are still many key areas where there is still much more to do:

- a. Pure Open Access publishers are currently compliant with the policy. Progress towards Open Access for existing subscription and hybrid journals remains slower than the 2020 timeframe because the regulatory framework for publishers, whose customers are international, is not aligned. There also remain questions for some publishers about the sustainability of a transition to Open Access within a specified timeframe.
- b. Most focus has been on the Article Processing Charge (APC) business model of Open Access, which may not be appropriate in Low-to-Middle Income Countries (LMICs) and for certain disciplines. This, along with a reward system that disadvantages the research community from LMICs, risks creating further inequity in any system involving Open Science. There needs to be more exploration of the consequences on different countries and contexts of both a business model for Open Access and an academic reward system based on largely European and US methods of scholarly communication. Much more experimentation with a range of different funding models for Open Access is required from publishers and funders to ensure that there are no barriers to researchers and other relevant actors to read or to publish.
- c. Many of the large national transformative deals have focused on a few major publishers. There is a risk to small-to-medium sized publishers, in particular with respect to scholarly societies, and a concern from some full Open Access publishers that they may be put at a competitive disadvantage.

- d. Publishers are often at the front line of issues about the reliability and integrity of published research. Some publishers apply a series of scholarly credential checks on all research – defined by strict and openly available policies³⁹. However, if problems are found, publishers may or may not be given the authority to investigate beyond the work itself, and particularly in cases of author disputes or disputed conflict of interest statements, there may be issues at play beyond the work that the authors’ institutes may decide not to share. Furthermore, any such investigations can be very time consuming and expensive and need to therefore be covered by publication income. The interactions between publishers and institutes needs to be more clearly delineated and responsibilities at that intersection defined, see⁴⁰.

2.2.6. Research and E-Infrastructures

The e-Infrastructures commitment to equipping the researcher community with the skills required for the transition to Open Science has been strong, and much good work has already been established. Ensuring this work has a high profile will be important going forward to avoid duplication of effort. The shift of focus in **research assessment** to Open Science will gain increasing attention, and research and e-infrastructures will support this evolution over the next few years, preferably in a global, participatory infrastructure that will collect and distribute all types of data to be used in metrics. Such examples include open citations, OpenAIRE’s usage data, and DataCite’s ‘Make Data Count’ system.

Supporting the transition to **FAIR data** at a higher level is less advanced however, as this work will require facilitating the slow and complex efforts of culture change at the grass roots. e-Infrastructures have planned and, in many cases launched, excellent initiatives to approach this thorny problem, but support for this kind of work will need to be tailored and sustained going forward to bring fundamental change. **Future scholarly communications systems** will need a broader focus than publications so that all types of artefacts in the research cycle can be published and connected, and infrastructures are already starting to evolve in that direction. For example, the Open Research Europe⁴¹ platform due

39 <https://f1000research.com/about/policies>

40 <https://www.biorxiv.org/content/10.1101/139170v1>

41 <https://ec.europa.eu/research/openscience/index.cfm>

to launch in early 2021 will provide a platform for Horizon 2020 and Horizon Europe beneficiaries to be able to publish a much broader range of their research outputs compared with many traditional publications, and will include the requirement for the associated underlying data, software and other associated materials to be made FAIR. All outputs will be published immediate Open Access and utilise an open and transparent peer review approach. This platform will be accompanied by significant educational and outreach initiatives and activities with researchers and associated communities across Europe.

Citizen science will need to ensure its proper place in this environment, and infrastructures need to work to connect with them, as individuals, as groups, as well as to connect with machines.

In the area of **research indicators**, the progressive adoption of Open Science indicators needs to continue among research and e-infrastructures. The selected indicators should be regularly measured and made publicly available for both human and machine consumption, and growing adoption of ORCID should continue in services and research assets to support better interoperability of information and reporting.

With regards to the **EOSC**, the stakeholders should continue with their commitment to create an operational EOSC supported by a robust, transparent and participative governance and should mobilise their communities and network to ensure engagement in decision making, to achieve greater uptake and impact of the decisions. The development of EOSC training needs to continue and the materials should be more easily discoverable and accessible across initiatives.

2.2.7. Researchers

Several barriers remain to increasing adoption of Open Science amongst the researcher community. These can be addressed by:

- a. Clearly identifying the legal and funding issues encountered during the adoption phase of Open Science by researchers and ensuring these are reported to the policymakers and their research organisations so they can be addressed.
- b. A clearer reward and career structure for Open Science practice and outputs.
- c. A consistent aligned message from funders, institutions and other policy making organisations for Open Science practices and implementation. This also requires simplifying workflows across different stakeholders to reduce the administrative burden on researchers.
- d. Training and support for all Open Science practices, in particular in research integrity, FAIR data management and sharing. This needs to be applied across all career levels and adapted appropriately for all disciplines.
- e. Adoption of Open Science practices, in particular FAIR data, requires an agreed framework for security, data management, reuse and valorisation.
- f. Extending Data Management Plans (DMPs) to include other types of research outputs (Output Management Plans). There is also still a need to raise awareness and provide more training on OMPs among researchers.
- g. More guidance on how to involve Citizen Science in research projects, where it is appropriate, and to be rewarded for doing so.

2.2.8. Scientific Societies and Academies

Scientific societies, networks and academies organize and group together researchers. They have limited resources, do not prescribe the behaviour of their members and they usually do not create research infrastructures. This is a real barrier for the implementation of concrete Practical Commitments for Implementation in Open Science. After all, investment and progress in implementation are mostly in the hands of national education, research and funding institutions.

Nevertheless, scientific societies, networks and academies play an important role in creating awareness around Open Science among their members. They have employed large campaigns of information and recommendations (e.g. by websites, workshops, surveys, magazines). This can still be amplified and improved, e.g. by putting Open Science high on the agenda in their meetings, creating Open Science contact points and Open Science Working Groups, and initiating more education and training around Open Science.

As organizations of scientists, academies, societies and networks also represent the voice of scientists in the policy arena, as such they have helped shape European policy on Open Science. They have also contributed to the debate by issuing statements, writing reports and supporting research around Open Science. Next steps should build on the work already accomplished. There is a need for further surveys among the scientific community, for instance, to collect opinions on the development and acceptance of FAIR open data. They can also use their authority to convince education, research and funding institutions to implement more Open Science measures, e.g. by suggesting the nomination of an Open Science Coordinator in each university and research institute. Academies and societies should also work together to propose new evaluation indicators for awards, hiring and promotion, in order to reduce the reliance on quantitative assessment systems.

A second obstacle is the heterogeneity of scientific societies, networks and academies. Societies range greatly in size, infrastructure, means and culture. Networks of scientists are equally heterogeneous. Scientific academies are not as diverse but still differ widely in traditions, practices and means, especially if one takes into account the recently founded Young Academies. This means that the

scientific community does not always speak with one voice. This should be recognized instead of lamented, because depending on discipline, age group or scientific function (e.g. teaching/research/technical staff), Open Science presents very different opportunities and challenges. Heterogeneity also makes overarching guidelines and coordinated action difficult, and this should make all stakeholders more aware of the need for a localized and contextual implementation of Open Science.

Finally, in so far as scientific societies, networks or academies are publishers of journals or books, they need to create a roadmap and work towards making these publications Open Access.

2.2.9. Citizen Science & Public Engagement Organisations

In the Member States, the development of Citizen Science initiatives, networks, communities and platforms is very heterogeneous. The European Network of Living Labs, founded during the Finnish Presidency of European Council, has been promoting citizen engagement in Open Innovation and Open Science since 2006. Since the first Citizen Science network emerged in the US in 2011, several Citizen Science networks have been founded in Europe (e.g. Germany, Austria, Belgium, France, Netherlands, Spain, Italy, Denmark, Sweden, Malta). Most of them have Open Science policies or adhere to ECSA's ten principles and other guidelines with Open Science recommendations.

Yet, there are areas where little progress has been made, mainly skills & education on Citizen Science. Based on the long experience of participatory research and innovation, it is evident that success in Open Science and Citizen Science calls for infrastructures and coordination of different actors and activities. There is also no or only little formal education or training for Citizen Science methods. The EU-Citizen.science report on training needs highlights four elements that are crucial to take Citizen Science to the next level: a review of the socio-demographic context of Citizen Science, a literature review of learning in relation to Citizen Science, a community survey of training needs, and a detailed analysis of a set of training resources. Several clusters of training needs have been identified, like scientific training, volunteer management training or schools training (see EU-Citizen.science report on training needs⁴²).

42 <https://zenodo.org/record/3690768>

3. Beyond Open Science: a call to action for a Shared Research Knowledge System by 2030

3.1. Rationale

“Research and innovation is critical to tackling the current global public health crisis” (Mariya Gabriel⁴³). The response from the research community^{44,45}, scientific publishers^{46,47}, funders^{48,49,50} and other relevant experts has been the almost real-time sharing and assessment of data, code and articles about the coronavirus pandemic alongside the creation of shared public platforms (e.g.^{51,52}). This global collaboration of research and expertise by individuals and organisations from public and private institutions (e.g. COVID-19⁵³) has provided new insights into the spread and mitigation of the virus much more rapidly than would have happened otherwise and is testament to the innovative power of opening up science, sharing knowledge and collaborating. The benefit of such a joint response to humanity is indisputable. We must now leverage these collective benefits, and the lessons learned, to make more structural changes to the research system to ensure that all of science can advance more rapidly and effectively, for the good of science and society.

Open Science has been defined by the European Commission as a process based on cooperation and the diffusion of knowledge⁵⁴. It encompasses Open Access to research publications and to research data and is enabled by digital technologies and new collaborative tools⁵⁵.

Open Science involves a fundamental shift in mindset from one that prioritises individual interest to one that prioritises collective interest and a common objective of advancing science, innovation and knowledge through a practice of openness, sharing, collaboration and co-creation. In 2016, The Amsterdam Call to Action⁵⁶ clearly outlined the changes Member States and different actors in the research system would need to make if the benefits of Open Science were to be realised, benefits we are witnessing now. This call centred on four overarching goals:

- a. full Open Access for all scientific publications;
- b. a fundamentally new approach towards optimal reuse of research data;
- c. new assessment, reward and evaluation systems;
- d. alignment of policies and exchange of best practices.

43 Science|Business Newsletter ‘Mariya Gabriel: “Research and Innovation Is Critical to Tackle This Global Crisis”’. Accessed 24 March 2020. <https://sciencebusiness.net/news/gabriel-research-and-innovation-critical-tackle-global-crisis>

44 Carolyn Y. Johnson. ‘Scientists Are Unraveling the Chinese Coronavirus with Unprecedented Speed and Openness’. Washington Post. Accessed 21 April 2020. <https://www.washingtonpost.com/science/2020/01/24/scientists-are-unraveling-chinese-coronavirus-with-unprecedented-speed-openness/>

45 Ian Le Guillou. ‘Covid-19: How Unprecedented Data Sharing Has Led to Faster-than-Ever Outbreak Research’. Horizon: The EU Research & Innovation Magazine. Accessed 21 April 2020. <https://horizon-magazine.eu/article/covid-19-how-unprecedented-data-sharing-has-led-faster-ever-outbreak-research.html>

46 ‘Publishers Make Coronavirus (COVID-19) Content Freely Available and Reusable | Wellcome’. Accessed 21 April 2020. <https://wellcome.ac.uk/press-release/publishers-make-coronavirus-covid-19-content-freely-available-and-reusable> and ‘COVID-19 Academic Research Communication Platform – Chinese Medical Journals Network’. Accessed 21 April 2020. <http://medjournals.cn/COVID-19/index.do;jsessionid=8E8462F12BCD0FE409CF07D80BFD1174>

47 ‘Coronavirus (COVID-19): Sharing Research Data | Wellcome’. Accessed 21 April 2020. <https://wellcome.ac.uk/coronavirus-covid-19/open-data>

48 Europe, Science. ‘Our Priorities COVID-19’. Science Europe. Accessed 21 April 2020. <https://www.scienceeurope.org/our-priorities/covid-19/>

49 European Commission. ‘Horizon 2020 Projects Working on the 2019 Coronavirus Disease (COVID-19), the Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2), and Related Topics: Guidelines for Open Access to Publications, Data and Other Research Outputs’. European Union, 2020. Accessed 21 April 2020. https://ec.europa.eu/research/participants/data/ref/h2020/other/hi/oa-pilot/h2020-guidelines-oa-covid-19_en.pdf

50 江工魏. ‘China Strengthens Int’l Cooperation in COVID-19 Vaccine Development: Official - Chinadaily.Com.Cn’. Accessed 21 April 2020. <https://www.chinadaily.com.cn/a/202003/26/WS5e7c5e24a310128217282414.html>

51 <https://connect.medrxiv.org/relate/content/181>

52 COVID-19 Data Portal’. Accessed 21 April 2020. <https://www.covid19dataportal.org/>

53 ‘NCBI Insights: COVID-19: A New Machine Readable COVID-19 Literature Dataset’. NCBI Insights, 26 March 2020. <https://ncbiinsights.ncbi.nlm.nih.gov/2020/03/26/covid-19-a-new-machine-readable-covid-19-literature-dataset/>

54 Directorate-General for Research and Innovation, European Commission, ed. Open Science. Luxembourg: Publications Office of the European Union, 2016. http://publications.europa.eu/resource/ellar/3213b335-1cbc-11e6-ba9a-01aa75ed71a1.0001.02/DOC_2

55 ‘Commission Recommendation (EU) 2018/790 of 25 April 2018 on Access to and Preservation of Scientific Information’. OJ L. Vol. 134, 31 May 2018. <http://data.europa.eu/eli/reco/2018/790/oi/eng>

56 <https://www.government.nl/documents/reports/2016/04/04/amsterdam-call-for-action-on-open-science>

Since this call, and even though the tools and technology to enable Open Science have been available for almost two decades, progress has been slower than anticipated and there remain real obstacles to overcome (see Section 2). Notably, there is a disparity in progress and motivation among different disciplines and institutions, among different actors and organisations, and among researchers at different stages of their career. This is compounded by a lack of policy alignment across local, regional, national and international jurisdictions and no clear legal or regulatory framework.

Open Science for its own sake has never been the goal. Openness is a vital instrument which, when used responsibly, can fuel a faster, more effective, more reliable, more trustworthy, more equitable and more innovative shared research knowledge system. Research cannot be 'excellent' without such attributes at its core. This is a system that has the potential to not only respond to the world's greatest practical challenges but to also benefit industry, technology, society and scholarly research itself. The more knowledge is used, the more it is created. If we can remove delays and barriers to creating, sharing, verifying and discovering research expertise and knowledge, we can not only respond more quickly and effectively to public health emergencies, but we can also harness this collective knowledge to ensure that the UN Sustainable Development Goals are achieved more quickly, and that science itself is enhanced, across every discipline.

A shared research knowledge system entails active partnerships and collaboration among all sectors and disciplines, including the involvement of researchers, business and local communities as well as institutions, research funders, governments as well as citizens. Importantly, if such a system is to be trusted and effective, it must also manage the needs and responsibilities of different stakeholders, communities and jurisdictions⁵⁷. If it is to take full advantage of human ingenuity, it also has to reflect the full range of human diversity and skills that contribute to this creativity by facilitating a diversity of people, research disciplines, skills and roles, and by harnessing the creative power of teams as well as the insight of individuals.

Such a multi-stakeholder environment can only function if there is a common understanding of the importance and value of a shared research knowledge system and a responsibility from all in how that research and research knowledge is conducted, produced and shared reliably. All actors and organisations, regardless of the sector or jurisdiction they come from, have a role in creating and contributing to this new system. **While a focus on Open Science as a mechanism must be emphasised in any transition, Open Science must ultimately be embedded as part of a larger more systemic effort to foster all practices and processes that enable the creation, contribution, discovery and reuse of research knowledge more reliably, effectively and equitably.**

This larger endeavour also requires the creation of a secure common interoperable infrastructure, with community-based standards, to underpin the entire system. Such measures will fuel the development of new technology, tools and services that can help address the societal and economic challenges we face and which, in turn, will make a more open, shared and innovative knowledge system trustworthy, reliable, viable and sustainable.

At the heart of such a system are the researchers themselves. To harness their skills and expertise, this shared knowledge system needs to be embedded within a research culture that motivates experimentation, sharing, trust and collaboration while ensuring there is space for individual creativity and exchange with society, as well as economic return. It must also facilitate equity of opportunity across the globe in how knowledge and expertise is contributed to this system, as well as how it is accessed, disseminated, discovered and reused.

57 Hess, C., & Ostrom, E. (Eds.). (2007). *Understanding Knowledge as a Commons: From Theory to Practice*. Cambridge, Massachusetts; London, England: The MIT Press. <https://mitpress.mit.edu/books/understanding-knowledge-commons>

3.2. The Call to Action

As representatives of key stakeholders in the research system we call on all European Member States and other relevant actors from the public and private sectors to help co-create, develop and maintain a 'Research System based on shared knowledge' by 2030. As a start, we commit to working together to implement a system with the five attributes outlined below.

Our aim is not to provide detailed recommendations for every possible actor or individual in the research system but to provide a common framework with which to align interests and motivation across multiple stakeholder groups. We appreciate that many of these attributes have been identified by others and will refer to key documents as appropriate.

3.3. Five attributes of a Research System based on shared knowledge by 2030

Attribute 1: An academic career structure that rewards a broad range of outputs, practices and behaviours to maximise contributions to a shared research knowledge system

Researchers and institutions must have the freedom, support and motivation to contribute to this new collective knowledge system. A key barrier to the diffusion and exchange of scholarly knowledge is the current reward system. There is no researcher, no institution and no discipline that is not negatively affected by a system based on rewarding a very limited set of research behaviours, outputs and venues. The consequences have been articulated numerous times elsewhere^{58,59,60,61}. Researchers need to be empowered by a reward system that encourages them to collaborate and share their work openly, to be creative, honest and transparent and to take responsible risks. They should not be stigmatised for failure nor penalised for the publication and sharing of null, negative or inconclusive results.

This entails a wholesale change to the reward and tenure system to align the reputation and career progression of researchers, and the mission of publicly funded institutions with the processes, practices and outputs that best serve science and society, and which include both applied and fundamental research.

For both, publicly and privately funded research, intellectual property rights (IPRs) must be embedded within an Open Science framework that protects the interests of different stakeholders, including private and commercial research organisations but without limiting the scientific and societal benefits of sharing and reuse of scholarly knowledge for all humanity (see Attribute 3.iii). This also includes enabling researchers from different jurisdictions and organisations to contribute to, as well as access, research knowledge, tools and practices (see Attribute 4).

All actors with the capacity to do so must explore and openly report on new ways to motivate and evaluate researchers, institutions, and their contributions to this knowledge system. Importantly, any change to the system must be sensitive to, and reflective of, different contexts and jurisdictions, and decision makers at different levels must undertake the necessary steps to be aligned.

To this end, in discussion with the OSPP, the Research Data Alliance has committed to spearhead a new collaborative platform⁶² to share both the intention and outcomes of pilots and other initiatives taken by different actors that specifically address the academic reward system. All Member States will have the opportunity to contribute to this so that everyone can benefit from the innovation of others by sharing what works and what doesn't in different contexts.

58 Smaldino, Paul E., and Richard McElreath. 'The Natural Selection of Bad Science'. *Royal Society Open Science* 3, no. 9 (21 September 2016). <https://doi.org/10.1098/rsos.160384>

59 Alberts, Bruce, Marc W. Kirschner, Shirley Tilghman, and Harold Varmus. 'Rescuing US Biomedical Research from Its Systemic Flaws'. *Proceedings of the National Academy of Sciences* 111, no. 16 (22 April 2014): 5773–77. <https://doi.org/10.1073/pnas.1404402111>

60 Brems, Björn, Katherine Button, and Marcus Munafò. 'Deep Impact: Unintended Consequences of Journal Rank'. *Frontiers in Human Neuroscience* 7 (2013). <https://doi.org/10.3389/fnhum.2013.00291>

61 Ioannidis, John P. A. "Concentration of the Most-Cited Papers in the Scientific Literature: Analysis of Journal Ecosystems." *PLoS ONE* 1, no. 1 (December 20, 2006). <https://doi.org/10.1371/journal.pone.0000005>

62 www.openscienceregistry.org

Attribute 2: A research system that is reliable, transparent and trustworthy

The utility of a shared research knowledge system depends on ensuring that there is trust in the research process and the reliability of the outputs, and in the ways data and results are made reusable and re-used (e.g. where there are ethical considerations). The extent to which research is reliable has been explored in some disciplines^{63,64,65,66,67} but less so in others⁶⁸. Reliability and trustworthiness of research outputs is an essential component of research integrity but is not commonly used as part of research or researcher evaluation.

Rather, quality or excellence is often a synonym for impact, which is context-dependent and which may not reflect the actual reliability of research practice or outputs⁶⁹.

Ensuring the reliability and integrity of research outputs is crucial to speed up scientific advances and to enable innovation. Several expert reports and surveys have demonstrated a lack of awareness, support, training and leadership around research and publication ethics and integrity, in particular among researchers⁷⁰. It is also clear from the OSPP-REC Practical Commitments for Implementation (**Annex A**) that many actors in the research system in Europe have not yet taken sufficient action to implement and improve standards of research integrity within their stakeholder group (with the exception of some funders and publishers). This is reflected in the contrasting progress self-reported by different stakeholder groups within the OSPP (see Section 2). Where codes of conduct do exist (e.g. The European Code of Conduct for Research Integrity⁷¹), there are limited data or analyses about the extent to which these actually improve research practice or are adhered to by researchers or enforced by funders or institutions.

Open Science shines a spotlight on research ethics, practice and integrity because the same digital tools and services that enable Open Science also expose publication bias, bad or sloppy practice, and outright fraud. Open Science is therefore part of a toolkit

with which to increase the reliability and integrity of research, including processes such as peer review itself (for example making the reports from peer reviewers available for independent scrutiny).

It is important to note that the aim of research integrity is not to penalise honest mistakes or 'failure'. Rather, research integrity is about ensuring the process and practice of research is as reliable as possible. For example, there is substantial evidence that publication bias is created when researchers do not publish null, negative and inconclusive results. Good research practice should therefore require the sharing of such findings to ameliorate this bias. Publication bias is likely to exist in some form in all disciplines, including the arts, humanities and social sciences, and yet research into the prevalence of such bias and its consequences have largely been limited to clinical and preclinical disciplines (see Attribute 4). Nevertheless, to avoid stigmatizing error and failure, and to promote risk-taking and cutting-edge science, we need a more supportive research culture. A renewed focus on sharing results and valuing sharing practices in research assessment will be crucial in this regard.

All research practice across all disciplines and from all research sectors should include agreed standards of ethics and integrity for how that research is conducted and communicated. The focus of science communication should be less on fashion, novelty and dramatic results and more on reliability in order to restore trust in science. Different stakeholder groups need to collaborate to develop and implement community standards for different disciplines, actors and sectors in the system (public and private) that are responsible for how research is taught, practiced, reported, published and shared. In order to ensure high quality standards, monitoring tools and non-compliance mechanisms need to be thought of in parallel.

Member States should agree to coordinate a series of workshops to research, develop, implement, test and share a minimum set of

63 Head ML, Holman L, Lanfear R, Kahn AT, Jennions MD (2015) The Extent and Consequences of P-Hacking in Science. *PLoS Biol* 13(3): e1002106. <http://doi.org/10.1371/journal.pbio.1002106>

64 Landis SC, et al. (2012) A call for transparent reporting to optimize the predictive value of preclinical research. *Nature* 490(7419):187–191. <http://doi.org/10.1038/nature11556>

65 Fang, Ferric C., and Arturo Casadevall. "Retracted Science and the Retraction Index." *Infection and Immunity* 79, no. 10 (October 1, 2011):3855–59. <http://doi.org/10.1128/IAI.05661-11>

66 Tressoldi PE, Giofre D, Sella F, Cumming G. High impact = high statistical standards? Not necessarily so. *PLOS ONE* 2013; 8(2):e56180. <http://doi.org/10.1371/journal.pone.0056180> PMID: 23418533

67 Macleod MR, et al. (2015) Risk of Bias in Reports of In Vivo Research: A Focus for Improvement. *PLOS Biol* 13(10): e1002273. <http://doi.org/10.1371/journal.pbio.1002273>

68 Peels, Rik. 'Replicability and Replication in the Humanities'. *Research Integrity and Peer Review* 4, no. 1 (9 January 2019): 2. <https://doi.org/10.1186/s41073-018-0060-4>

69 Moore, Samuel, Cameron Neylon, Martin Paul Eve, Daniel Paul O'Donnell, and Damian Pattinson. "'Excellence R Us': University Research and the Fetishisation of Excellence". *Palgrave Communications* 3 (19 January 2017): 16105. <https://doi.org/10.1057/palcomms.2016.105>

70 'What Researchers Think about the Culture They Work in | Wellcome'. Accessed 9 February 2020. <https://wellcome.ac.uk/reports/what-researchers-think-about-research-culture>

71 https://ec.europa.eu/research/participants/data/ref/h2020/other/hi/h2020-ethics_code-of-conduct_en.pdf

community-based standards of research integrity, specific to different disciplines where relevant. In particular, they should ensure there is training, support, monitoring and appropriate enforcement of research integrity standards for researchers at publicly funded institutions and in the practice, communication and/or publication of Open Science outputs of publicly funded research.

Attribute 3: A research system that enables innovation

Innovation enhances scientific, societal and technological progress and increases the well-being of society, and it may be supported via the following processes:

- Promoting the rapid sharing of research knowledge
- Maximising use and reuse
- Maximising discoverability
- Maximising opportunities for collaboration

Open Access, FAIR data, a global interoperable infrastructure and mechanisms for co-creation underpin these four interdependent processes and rely on, and benefit from, actors from both the private and public sector. Each process requires dedicated tools, technology, appropriate funding and services set within an interoperable infrastructure and a clear legal regulatory framework to permit different actors and entities, commercial and not-for-profit, to contribute and gain from the system. At a minimum, a shared research system for innovation must include:

- i. Clear relevant policies that aim to increase the availability and reuse of research knowledge and technology in a global competitive context**
Openness has limits and is not an end in itself. Rather, policy development should focus on the creation of a shared reliable and secure research knowledge and communication system. The emphasis needs to be placed on the availability and wide dissemination of knowledge and technology for reuse in a more global competitive context, based on a principle of reciprocity (see point v. below, and also Attributes 4 and 5).
- ii. A global interoperable infrastructure of tools, services, hardware and software**
Key to sharing and re-use of research knowledge is the existence of dedicated and relevant ‘easy to use’ and secure infrastructures to host research data, methods, results and interpretation, upon

which services and tools can be built to access, mine, discover, collaborate and co-create. This requires huge upfront investment, community agreed standards for disciplines and sectors and an appropriate ‘business model’ to sustain the maintenance and ongoing development of cybersafe infrastructures and services. The European Open Science Cloud (EOSC) is taking on these issues but as yet lacks the necessary hardware infrastructure, which deeply limits its innovative potential. More technical support is also required for researchers to train them on how to use the infrastructures and the artificial intelligence tools necessary to crawl the immense quantity of data and results.

- iii. Clear regulatory frameworks to manage each stakeholder’s interests for the collective good**
Regulatory frameworks must favour a community driven and accepted approach to data and metadata standards (e.g. format and sharing). In particular, there needs to be more focused and active support of licensing models and other intellectual property (IP) tools to boost the awareness of the value of IP in the research system, and the individual contribution of research actors in providing solutions to societal challenges. The balance between openness of data and the protection of intellectual property rights (IPR) should be in line with the principle ‘as open as possible, as closed as necessary’.

Any interoperable and secure infrastructure should encompass FAIR research data management, licensing concepts, repositories of non-exploited research outputs and management of IP assets as well as the basic infrastructures to manage the research process and practice.

In particular, future regulatory systems should distinguish between the concepts of ‘FAIR’ versus ‘open’. FAIR is broadly understood as a standard for data management, which benefits research actors because it creates a common language for how to create, host and steward data. It can in principle also be applied to text. FAIR, however, does not automatically mean open nor free of charge; it only provides standards for how data should be packaged so that it can be found, accessed, shared and reused. FAIR data are not openly and freely available per se because the data can be stored, for example, in repositories or servers that are not meant nor conceived to be openly accessible by any internet user.

Preparing data in a way that can then be made available for reuse requires an investment by the data creator which should be recognized as such when establishing conditions for re-use. Mechanisms have to be established which also provide for adequate funding and tools for the data creator to make the data reusable. Making data FAIR requires the creation of practices and regulatory frameworks that would guarantee to the data producer that the data will be used according to pre-agreed principles and ethics, and be recognized as scientific work and valorised as such in new research assessment criteria. Equally important, however, are the role and rights of data re-users and consumers; there need to be mechanisms in place to ensure that data consumers are not excluded because of affordability.

iv. A transparent competitive market

It is in the interest of European citizens and the European economy to ensure a transparent competitive market that enables private companies, including small and mid-size enterprises (SMEs), as well as publicly funded organisations such as universities and research organisations, to contribute and benefit from a shared research knowledge system. This is not fully exploited yet, due to a wrongly perceived incompatibility with IPR and competitiveness policies or conflicting internal financial and legal rules.

The market is further complicated by an academic reward and incentive system that currently focuses on external brands rather than specific research contributions and outputs. This affects all actors in the system and makes it difficult for any individual stakeholder to disrupt. The consequences on the market of any system of rewards and incentives must be carefully assessed.

The right balance between Open Science, the potential to maximize the use and re-use of research data and outputs, IPR, and private companies' competitiveness must be promoted and become a central feature of the next round of discussions on the future of a shared research knowledge system. There are limits to openness and these must be acknowledged and taken into account as the system changes^{72,73}.

New digital tools and services have already substantially changed the traditional mechanisms of research communication and collaboration. How text and data are validated, shared and reused is likely to also change the suppliers, workflows and systems even further. If the appropriate tools and frameworks for both public and private research are developed, the traditional scholarly publishing market, for example, can be enriched by new public and private entrants providing new publishing tools and services that adhere to community standards of research ethics and integrity, and which can guarantee that services are aligned with a more open research knowledge system. This is an opportunity for all actors and organisations to contribute to Open Science.

Any new legal framework should also ensure specifically that there are appropriate rules of engagement for existing and new entities who provide tools and services around publicly funded research in a shared research knowledge system.

v. A shared research system based on reciprocity

Dissemination of research knowledge should also take place on a reciprocal basis, especially at an international level. Open Science policies must be jointly developed together with IPR policies to ensure a working framework for all actors of the European research knowledge system and those outside the system who contribute and benefit from it. Open Science policies can boost the performance of both the European economy and global economy, while IPR ensures the added value falls within European boundaries when appropriate (i.e. without jeopardising the health of the global system). While reciprocity is an important enabler of global collaboration, it must also not present an obstacle for low-to-middle income countries (LMICs) to contribute, reuse and collaborate, within community agreed standards (see also Attribute 4).

72 Ananny, Mike, and Kate Crawford. 'Seeing without Knowing: Limitations of the Transparency Ideal and Its Application to Algorithmic Accountability'. *New Media & Society*, 13 December 2016, 1461444816676645. <https://doi.org/10.1177/1461444816676645>

73 Bezuidenhout, L. et al (2017) Beyond the Digital Divide: Towards a Situated Approach to Open Data. *Science and Public Policy* 44(4): 464-475. <http://doi.org/10.1093/scipol/scw036>

Attribute 4: A research culture that facilitates diversity and equity of opportunity

A shared research knowledge system is one that is truly open and equitable for all. It must enable all researchers and other relevant actors from all sectors, all strands of society and all cultures to not only access and reuse the knowledge within it but to contribute to that knowledge as well.

The COVID crisis is a reminder that all humans are inextricably connected to each other and to the environment. We now have an opportunity to rearticulate our shared values in ways that transcend individual disciplines, organisations, culture and politics. We already have the technology, skills and ingenuity to change the way scholarly research is communicated, published, shared and reused, and to co-create and maintain a shared global research knowledge system that can benefit all.

All actors need to work together to articulate the shared values for a shared global research knowledge system and to create a legal and social framework within which these values can be implemented.

Attribute 5: A research system that is built on evidence-based policy and practice

How we work – the funding processes, how we recruit and support researchers, how we share, review and publish research findings, and how we incentivise all aspects of the research system – is perhaps the most influential factor in the production of research insights and output. It is therefore critical that we understand how, where and when new ways of working and changes to existing, and perhaps entrenched practices, work and should be changed.

One of the most important trends that is crucial among attempts to redress research culture is the growth in interest and activity around meta-research (or ‘science of science’). Although not a new concept, and there have been years (if not decades) of work in primary fields (e.g. as mediated by the INGSA organisation⁷⁴), the importance of meta-research as a direct bridge to evidence-based policy is now getting more attention. A lack of translation of this research into policy is in part responsible for the ease with which we can criticize all that might be wrong with our ‘closed’ research system and made it hard to deliver consensus upon our alternative ‘open’ future. Several welcome initiatives have sprung up intended to help build an evidence base for what works and what doesn’t for aspects of our collective research system (see for example: the US Center for Science of Science and Innovation (CSSI)⁷⁵ and the Research on Research Institute (RORI)⁷⁶). It is important, as we do for funded research projects, to review and evaluate how the ways that we work can bring benefits and/or have unintended or negative consequences, for research and the communities and society that it serves.

As the OSPP, we want to endorse such initiatives and work to embed a culture of reflection and robust ‘research on research’ as part of our collective Open Science future.

We recommend that a coordinated strategy for funding and delivering a programme of ‘research on research’ is developed, including identifying priority areas for investigation, involving representatives from the key stakeholders in research – researchers, funding agencies, institutions, publishers, learned societies and others. This could be a pilot, time-limited activity in the first instance to consider how it works.

74 <https://www.ingsa.org>

75 <https://www.air.org/project/center-science-science-and-innovation-policy>

76 <http://researchonresearch.org/>

Annexes

Annex A: Practical Commitments for Implementation (PCIs) by Stakeholder

Below each stakeholder group has reviewed the OSPP-REC⁷⁷ recommendations and provided a summary with some examples of where progress has made since their publication in May 2018. Stakeholders have primarily provided updates on those recommendations where they were specifically listed and identified as having key responsibility for driving progress. For each of the EC's eight ambitions of Open Science, we have categorised the level of progress according to the categories below:

Discussion: stakeholders are discussing the implications of the recommendations, but there is no clear commitment yet

Planning: the stakeholders understood the implications and are developing an approach to implementation

Implementation: the stakeholders are implementing the recommendations

Adoption: the recommendation is implemented and adoption by beneficiaries is in progress

Common practice: the recommendation is implemented and benefits being in place

It is important to note that while the OSPP contains members from across many of the major stakeholder communities in the scholarly ecosystem in Europe, the members do not provide full representation of these communities. In addition, as with the OSPP-REC, we are also aware that not all stakeholder communities are as strongly represented such as small to mid-size enterprises (SMEs), industry and non-governmental organisations (NGOs), although we have tried to address this as much as possible in this document.

The summaries below are also by no means comprehensive. Where possible, one or two illustrative examples have been included to highlight progress made, but we are aware that in many cases, there are many other examples across Europe that have not been listed.

**Ambition 1:
Rewards and Incentives**

REC 1	REC2	REC 3	REC 4
<p>Funders, research institutions and other evaluators of researchers should actively develop/adjust evaluation practices and routines to give extra credit to individuals, groups and projects who integrate Open Science within their research practice.</p>	<p>Studies must be commissioned and funded to propose guidelines for best practice and tools for research assessment by 2019, together with an active delivery plan and associated timeline for their implementation. These guidelines must take into account career stage and discipline, and be appropriately tailored to their target such as individual, institution and so forth. Exemplars of innovation and good Open Science practice must be collated, taking into account the DORA Declaration, the Leiden Manifesto, the OS-CAM and other relevant initiatives.</p>	<p>Public research performing and funding organisations (RPOs/ RFOs) should provide public and easily accessible information about the approaches and measures being used to evaluate researchers, research and research proposals.</p>	<p>The traditional academic career structure disincentivises Open Science because of the current focus on tenured positions based solely or largely on publication output. Institutions need to have a career and reward structure for all researchers, and particularly for Early Career Researchers (ECRs), that values and promotes a diverse range of outputs, activities and career directions. This should include facilitating a means by which researchers can, for example, move between academia and industry or between national jurisdictions.</p>

Stakeholders	Discussion	Planning	Implementation	Adoption	Common Practice
Universities & Research Performing Organisations	Active	Active	Active	Passive	Passive
Research Funding Organisations	Passive	Active	Active	Passive	Passive
Research Libraries	Passive	Active	Passive	Passive	Passive
Policy Making Organisations	Active	Active	Passive	Passive	Passive
Publishers	Passive	Passive	Passive	Passive	Passive
Research & E-Infrastructures	Passive	Passive	Passive	Passive	Passive
Researchers	Passive	Passive	Active	Passive	Passive
Scientific Societies & Academies	Passive	Passive	Passive	Active	Passive
Citizen Scientists & Public Engagement Organisations	Active	Active	Passive	Passive	Passive

Universities and Research Performing Organisations

Research evaluation approaches with greater attention to Open Science are being piloted by an increasing number of institutions across Europe. In addition, national consortia of universities and other research performing organisations, research funding organisations, learned societies and policymakers are developing (and in the case of the Netherlands, implementing) coordinated approaches to review academic career assessment to include more attention on Open Science. While progress varies widely between institutions and countries, notable examples include Ghent University in Belgium and the national consortia in the Netherlands and Finland⁷⁸. OSPP stakeholders such as EUA and Science Europe have supported this transition by gathering comprehensive and up-to-date information on the current state-of-play across Europe and facilitating discussion and exchange of good practices between their members.

Research Funding Organisations

In 2019, Science Europe conducted a study to investigate how their member organisations are selecting the best proposals for funding and the best researchers in career progression schemes, and if they are doing so in a fair and efficient manner. The findings of this extensive study are now being used as a knowledge base from which a set of policy recommendations are being developed and expected to be published in 2020.

12 of the 39 research organisations that responded to the Science Europe study stated that they currently use ‘the open science practices of the applicant(s)’ in assessments, for example the Dutch Research Council (NWO, Netherlands)⁷⁹ and Wellcome (UK)⁸⁰. The Irish research funders are also leading the development of a National Open Science Framework (NORF)⁸¹ to support the transition to Open Science practices across Ireland. Some funders, such as the NWO, are also piloting a framework to provide researchers with increased flexibility to present the information that they

think is most relevant / important in their grant applications⁸². Other funders, such as the Academy of Finland (AKA), specifically invite applicants to consider “merits related to open science: production and distribution of research results and research data” when preparing their CV⁸³.

Many Science Europe member organisations, such as FWF (Austria), conduct self-evaluation studies of their assessment procedures to ensure and establish good practices and tools. Many Science Europe member organisations also already provide publicly detailed information on their assessment and decision-making procedures, such as FORTE (Sweden), FWF (Austria), UKRI (UK) and ANR (France).

Research Libraries

Despite institutions and national consortia (cf. supra) being transparent about revising their research evaluation approaches⁸⁴, no structured overview of these efforts and their main elements exists apart from a few community organised blogs. However, research libraries can draw on a wealth of tools and skilled staff to help change this.

Policy Making Organisations

The European Commission (EC) commissioned a series of expert reports, e.g. on rewards and incentives, and are acting to implement changes to the reward and evaluation system within Horizon Europe. Finland, Ireland, France and the Netherlands are also spearheading the development of CoNOSC, the Council of National Open Science Coordinators, to align and develop practices and incentives for Open Science.

In discussion with the OSPP, the RDA is building a platform to register the initiatives and pilots, including outcomes, of any work taken by any stakeholder to revise what qualitative and quantitative metrics might be used to evaluate and incentivise Open Science practices by any stakeholder within the EC Member States.

78 More information on the initiatives by Ghent University: <https://www.ugent.be/en/research/research-strategy/research-evaluation.htm> the Dutch consortium: https://www.vsnu.nl/en_GB/news-items/nieuwsbericht/543-knowledge-sector-takes-major-step-forward-in-new-approach-to-recognising-and-rewarding-academics.html and the Finnish consortium: <https://avointiede.fi/sites/default/files/2020-03/responsible-evaluation.pdf>

79 <https://www.nwo.nl/en/policies/open-science>

80 <https://wellcome.ac.uk/what-we-do/our-work/open-research>

81 <http://norf-ireland.net/>

82 <https://sfdora.org/2019/11/14/quality-over-quantity-how-the-dutch-research-council-is-giving-researchers-the-opportunity-to-showcase-diverse-types-of-talent/>

83 <https://www.aka.fi/en/funding/apply-for-funding/az-index-of-application-guidelines/cv-guidelines/>

84 <https://eua.eu/resources/publications/888-research-assessment-in-the-transition-to-open-science.html> p. 19

Researchers

Work and funding to develop guidelines for best practice and tools for research assessment indicators according to the San Francisco Declaration on Research Assessment (DORA)⁸⁵ and the Leiden Manifesto⁸⁶ declarations are ongoing. These guidelines will then need to be integrated into research work. However, a remaining constraint is the slow changing research assessment framework, which only seldom accounts for Open Science activities. To be successful, the adoption of a transparent and fair set of indicators at national and institutional level is required.

Institutions must develop career and reward structures for all researchers. Researcher associations will continue to promote a diverse range of programs on career development including policy expertise, policy reports, opinion or editorial articles, patents, innovative media or social platforms, and more.

Scientific Societies and Academies

Scientific societies and academies encourage via their networks and sections (EPS Young Minds⁸⁷, European Younger Chemists Network⁸⁸) or via Young Academies (Global Young Academy⁸⁹ and many National Young Academies⁹⁰) early career researchers to actively develop their leadership, networking and outreach skills to enhance their career opportunities, including guidelines on how to integrate Open Science activities and skills in their curriculum.

Young Academies are signing and adopting DORA and helping to shape the international discussion on research assessment⁹¹.

Institutions must put in place practical indicators for career assessment and practical support to help integrate Open Science activity into the daily work of researchers.

Citizen Science & Public Engagement Organisations

There is no clear career and reward structure for researchers who engage in Citizen Science. This has to be addressed mainly by the Research Performing Organisations.

85 <https://sfdora.org/>

86 <http://www.leidenmanifesto.org/>

87 <https://www.epsyoungminds.org/>

88 <https://www.euchems.eu/divisions/european-young-chemists-network/>

89 <https://globalyoungacademy.net/>

90 <https://globalyoungacademy.net/national-young-academies/>

91 <https://globalyoungacademy.net/wp-content/uploads/2018/10/APOS-Report-29.10.2018.pdf>

Ambition 2: Indicators & Next-Generation Metrics

REC 1	REC2	REC 3	REC 4
<p>Evaluations of individual researchers or of research groups should not use journal brand or Impact Factor as a proxy for research quality. Those responsible for hiring, promotion, funding and/or the evaluation of researchers must use a broader, tailored range of quantitative and qualitative indicators of research activity, progression and impact that incentivises and rewards open research practice. All publication venues must prominently display a broad range of indicators for all research outputs.</p>	<p>Quantitative and qualitative indicators need to be identified and developed for research assessment that captures the full range of contributions to the knowledge system. These should reflect the complexity and varied context of the research environment, the specific characteristics of the research being undertaken, as well as the new kinds of questions and results that might emerge in an open system.</p> <p>Experiments, pilots and case studies assessing the validity of such indicators need to be undertaken urgently, and included as part of FP9 with appropriate funding allocated to support them. The results and data of these pilots must be made publicly available as exemplars for further implementation.</p>	<p>All researchers need to be identified through an ORCID ID. Best practice for CV/biosketch evaluation should be developed and publicly showcased to encourage a broader recognition of the range of verifiable (and especially open) contributions individuals make to the knowledge system, including teaching and peer review, and the production of a broad range of output types. The career narrative should be central to the evaluation of individual researchers as it provides the crucial context in which indicators can be interpreted.</p>	<p>The data, metadata and methods that are relevant to research evaluation, including but not limited to citations, downloads and other potential indicators of academic re-use, should be publicly available for independent scrutiny and analysis by researchers, institutions, funders and other stakeholders.</p>

Stakeholders	Discussion	Planning	Implementation	Adoption	Common Practice
 Universities & Research Performing Organisations					
 Research Funding Organisations					
 Research Libraries					
 Policy Making Organisations					
 Publishers					
 Research & E-Infrastructures					
 Researchers					
 Scientific Societies & Academies					
 Citizen Scientists & Public Engagement Organisations					

Universities and Research Performing Organisations

Research indicators and next-generation metrics that capture a broad range of academic activities remain a key challenge in the transition to a better research system and Open Science. Comprehensive surveys on the current state-of-play have shown that European universities predominantly rely on a limited set of evaluation practices, mostly geared towards assessing research publications. Quantitative publication metrics, notably the Journal Impact Factor and H-index, are still the most important metrics being used for evaluating researchers and their output.

Other methods are increasing in practice, such as using peer review by international independent experts (especially in some research institutes), and including a much broader range of indicators but in many cases this is often still less well developed as part of individual-level incentive and reward structures.

Research Funding Organisations

Several funders (e.g. Wellcome, EMBO) are now requiring grant funding committees to adhere to the DORA principles, and some like Wellcome are going further and requiring their funded institutes to also adhere to DORA, issuing clear guidance to support implementation of this policy⁹².

Qualitative assessment is used by most of the respondents in the Science Europe 2019 study on research members (33 of the 39), whereas less than 40% use citation tools such as the H-Index. For instance, DFG (Germany) exclusively uses qualitative assessment for researchers and projects⁹³.

Several new initiatives are being designed to support more 'research on research', of which developing new sound research-related indicators (including those with a focus on Open Science) is a key aspect. Such initiatives include the new Research on Research Institute (RoRI)⁹⁴, and a new project associated with the Netherlands' National Open Science Plan⁹⁵.

An increasing number of funding agencies are either now recommending, or in some cases mandating, the use of an ORCID ID in their grant workflows, including FWF, FCT (Portugal), Wellcome, and the NIHR (UK), and some like the UK National Institute for Health Research (NIHR)⁹⁶ are starting to also integrate the ID into their workflows to support information exchange. Other projects such as ELIXIR⁹⁷ and Fenix are utilising eduTEAMS⁹⁸, an open federated ID service provided by GÉANT, which is interoperable and compatible with ORCID.

Some funding agencies internationally are using standard Curriculum Vitae (CV)/biosketch formats to encourage researchers to present a more holistic view of their expertise and strengths. e.g. NWO (the Netherlands) have introduced Narrative CVs⁹⁹ and SNSF (Switzerland) are piloting Biosketch-style CV assessments¹⁰⁰.

Research Libraries

Research indicators and next-generation metrics that capture a broad range of academic activities remain a key challenge in the transition to a better research system and Open Science. LIBER has provided recommendations for scholarly metrics, including activities and suggestions for libraries that want to promote the transparent, standardised and responsible use of scholarly metrics. They particularly recommend these metrics and related services and tools to be open.

Policy Making Organisations

In addition to actions taken in response to Rewards and Incentives, some policy making organisations, such as the funders who are part of Coalition S have committed to signing and implementing DORA as part of Plan S.

92 <https://wellcome.ac.uk/how-we-work/open-research/guidance-research-organisations-how-implement-dora-principles>

93 https://www.dfg.de/formulare/1_304/1_304_en.pdf

94 <http://researchonresearch.org/>

95 <https://www.openscience.nl/en/projects>

96 <https://orcid.org/organizations/funders/policies>

97 <https://elixir-lang.org/>

98 <https://eduteams.org/>

99 <https://www.nwo.nl/en/news-and-events/news/2019/12/nwo-introduces-narrative-cv-format-in-the-2020-vici-round.html>

100 <http://www.snf.ch/en/researchinFocus/newsroom/Pages/news-200131-scivc-snsf-tests-new-cv-format-in-biology-and-medicine.aspx>

Publishers

- a. Many publishers have signed DORA (San Francisco Declaration of Research Assessment)¹⁰¹, a set of recommendations developed in 2012 by publishers, with a commitment to provide a comprehensive picture of the impact of scientific research published within their journals.
- b. EMBO and EMBO Press, PLOS, Hindawi, eLife, Company of Biologists and F1000 Research, alongside Wellcome, took the initiative in 2017 to relaunch DORA in 2018 by agreeing to provide initial two-year funding. Stephen Curry was nominated Chair and there has been an increasing influence of DORA on policy.
- c. Many publishers have adopted a range of alternative metrics for published outputs. There are a range of platforms available and used by many publishers, including Altmetric, which provides authors with a summary of the online activity surrounding their scholarly content.
- d. Publishers are increasingly supporting the publication of a wide range of research outputs and article types. There are also several collaborative projects to highlight research roles beyond simply the 'author', such as the Contributor Role Taxonomy (CRediT) to capture structured information around the diversity of contributions to scholarly published output. In addition, NISO (the National Standards Organisation) is running the projects 'Toward a Compatible Taxonomy, Definitions' and 'Recognition Badging Scheme for Reproducibility in the Computational and Computing Sciences'¹⁰².
- e. Publishers are raising awareness of ORCID among authors and many have mandated the ORCID ID for corresponding authors, and in some cases, also for peer reviewers where available.
- f. Full Open Access publishers are making article metadata available on fully Open Access licenses, following industry standard metadata specifications to enable the connections between research projects, researchers and their outputs, including: ORCID ID; Crossref Funding information and Research Organization Registry (in progress).

For all publisher members of Crossref, the extent to which the metadata are available is made public via Crossref reports.

- g. More generally, many publishers have made their citation data openly available via Crossref, with more than 60% of citation metadata submitted to Crossref now available, up from 1% in 2016. OASPA Publisher Membership criteria were updated in 2019 to include mandatory criteria to make the citation data associated with research articles that are submitted to Crossref publicly available.

Research and E-infrastructures

The OSPP group evaluated the EC Expert Group report on Open Science indicators¹⁰³ that provides a collection of indicators that can be used by different stakeholder categories. Some infrastructures have started to analyse them and implement those that are more applicable. For example, the EGI Foundation will identify those applicable to the EGI Federation and publish them on an annual basis, as of the end of 2020.

With regards to ORCID, research and e-Infrastructure services such as GÉANT eduTEAMS¹⁰⁴ and the EGI Check-in service¹⁰⁵ (services that connect different identity providers to access and use services) now support ORCID IDs. GÉANT, NISO, STM, ORCID and Internet2 announced an initiative in 2019 to improve access to publications and other online resources under the name SeamlessAccess.org. By adopting SeamlessAccess.org access control, usability of authentication for access to online resources increases significantly. Another example is Elsevier, who were early adopters in integrating ORCID into their data and systems.

The availability of rich metadata associated with research assets is making it possible to automatically discover associations between assets for public consumption. For instance, the OpenAIRE Open Science Monitor¹⁰⁶ is using text mining (topic modelling) to discover hidden structures and identify useful patterns, similarities, correlations, trends and communities. This capability is available as a service to funders, research organisations, research communities and research administrators.

101 <https://sfedora.org/>

102 <https://www.niso.org/niso-io/2019/01/new-niso-project-badging-scheme-reproducibility-computational-and-computing>

103 'Indicator frameworks for fostering open knowledge practices in science and scholarship'
<https://op.europa.eu/en/publication-detail/-/publication/b69944d4-01f3-11ea-8c1f-01aa75ed71a1>

104 <https://eduteams.org/>

105 <https://www.egi.eu/services/check-in/>

106 <https://monitor.openaire.eu/>

Researchers

There is growing awareness of the need to integrate more indicators of open practices and outputs. However, there is substantial concern about how qualitative and quantitative indicators will be enforced at both the funder and institutional level, and the impact that this may have on the activities of researchers and on their careers and funding.

Scientific Societies and Academies

Societies and Academies will continue to promulgate the DORA principles and Leiden Manifesto to their researchers and member organisations. Quality of research and researchers must be evaluated on the basis of true scientific merit and not on bibliometric indices and journal prestige. High-quality peer review remains the core value of scientific publications. Through constant dialog, the creation of tailored quantitative and qualitative indicators of research activity, progression and impact will be favoured, e.g. via e-learning courses and other initiatives. It is also important to pay attention to delicate situations where openness is not always possible (e.g. industry related and restricted projects, etc.) and to recognise this in any new set of indicators.

Young academies are also raising awareness about the importance of ORCID and the importance of career narratives.

Ambition 3: Future of Scholarly Communications

REC 1	REC2	REC 3	REC 4
All published research outputs from public funding in Europe must be made public in a way that ensures both immediate Open Access and full text and data mining rights of that content, while being sensitive to disciplinary differences*. Venues used for the publication of research outputs must ensure long-term archiving and provide clear, consistent and easily accessible and machine-readable information on their Open Science policies.	Each Member State, together with its respective stakeholders, must develop policies to guarantee compliance with the EU Open Access mandate, including both incentives and enforcement, by 2020. This needs to happen in ways that are sensitive to disciplinary differences, the financial investment required and fast-changing publishing systems.	All authors must make their data and software (i.e.excluding, if relevant, data owned by third-parties, etc) appearing in their Open Access publications FAIR (Findable, Accessible, Interoperable and Reusable). To this end, a key requirement is deposition in a trusted repository that adheres to FAIR principles. In addition, all publications must include a statement of FAIR compliance for the source data underpinning their claims and the licence for its reuse.	All publication venues must prominently display their Open Access and FAIR data policies.

Stakeholders	Discussion	Planning	Implementation	Adoption	Common Practice
 Universities & Research Performing Organisations					
 Research Funding Organisations					
 Research Libraries					
 Policy Making Organisations					
 Publishers					
 Research & E-Infrastructures					
 Researchers					
 Scientific Societies & Academies					
 Citizen Scientists & Public Engagement Organisations					

Universities and Research Performing Organisations

At the level of networks of institutions, there is a widespread use of the creative commons license for their own publications. Networks have also taken the lead in engaging their membership in an active dialogue about policies and actions to implement Open Access, especially after Plan S was launched. Through their participation in networks, institutions have committed to delivering on the aspirations of 100% Open Access; actual progress however depends on the countries and existing national policies¹⁰⁷. Many institutions are using the repository route to enable Green compliance with Open Access.

There is a structured dialogue in place in which institutions discuss key topics around Open Science with their national authorities, often through their conference of rectors in the case of universities. There are also advancements in transparency and dialogue on publishing agreements and associated costs among institutions and at the network level^{108,109}, and institutions are starting to share between them mechanisms for controlling Article Processing Charge (APC) costs (OpenAPC)¹¹⁰.

Research Funding Organisations

On 4 September 2018, a group of national research funding organisations, with the support of the EC and the European Research Council (ERC), announced the launch of cOAlition S, an initiative to make full and immediate Open Access to research publications a reality¹¹¹. To date, 22 funders, including 15 national European funders, have formally joined the cOAlition and fully advocate a roadmap to achieve Open Access ('Plan S'). While this is not the majority of research funders, the cOAlition has helped to galvanise further action and initiatives designed to deliver full Open Access to research outputs from across a wide range of research funders across the world.

The cOAlition S funders have been explicit in their assertion that a variety of business models can be used to ensure Open Access to research findings from across countries and disciplinary areas – but importantly, to meet the requirements of the cOAlition funders, the approach to achieving Open Access needs to maximise the discoverability and options for use and reuse of research through the use of open and machine-readable content licences.

Most funders that are not members of cOAlition S also continuously develop their Open Access policies. For example, at the Swiss National Science Foundation (SNSF, Switzerland), all funded publications should be freely accessible. An embargo of a maximum of six months (12 months for academic books) is accepted. Some funders, such as Deutsche Forschungsgemeinschaft (DFG, Germany) have also set up tools to support the implementation of these policies (e.g. funds to cover Open Access costs).

New Open Access strategies are also being considered in countries which so far did not have strong policies at national or funder level. Reflections and consultations are for example currently taking place in Romania. The Executive Agency for Higher Education, Research, Development and Innovation Funding (UEFISCDI), but also representatives of the research community, are part of an advisory working group and currently organising a series of workshops to inform the future Open Access/Open Science policy.

Some funders are also developing and testing their own approaches to achieve Open Access in ways that suit them and the communities that they support. For example, several funders (including Wellcome and Health Research Board Ireland) have commissioned the development of a publishing platform as an option for their researchers to publish rapidly and fully Open Access^{112,113} – with all fees paid directly by the funder to the platform provider under a 'Diamond Open Access' agreement; the EC followed suit in March 2020, announcing that it has commissioned the delivery of a publishing platform as an option for beneficiaries of Horizon 2020 and Horizon Europe funding¹¹⁴.

107 <https://rio.jrc.ec.europa.eu/en/policy-support-facility/mle-open-science-altmetrics-and-rewards>

108 <https://eua.eu/resources/publications/889:decrypting-the-big-deal-landscape.html>

109 <https://eua.eu/resources/publications/829:2019-big-deals-survey-report.html>

110 <https://www.intact-project.org/openapc/>

111 <https://www.coalition-s.org/>

112 <https://wellcomeopenresearch.org/>

113 <https://hrbopenresearch.org/>

114 <https://ec.europa.eu/research/openscience/index.cfm>

Research Libraries

LIBER's five-year Strategy – covering the period 2018-2022 – includes as a key pillar the vision of a research landscape in which Open Access is the predominant form of publishing. LIBER has collaborated with stakeholders to:

- Identify opportunities for research libraries to take a leading role in promoting Open Access;
- Encourage all routes to Open Access;
- Prioritise transparency;
- Inform and provide guidelines for our network;
- Act as an Open Access publisher for the research library community;
- Support critical Open Access infrastructure.

LIBER fully supports the ambitions of Plan S. It aligns with LIBER's 2018-2022 Strategy – specifically the goal to make Open Access the main form of publishing – and the LIBER Open Science Roadmap. LIBER was pleased to see that the green route to Open Access has been acknowledged as it believes there is no single route to Open Access. LIBER appreciates the guidance of cOAlition S, which matches the strategic goal of making Open Access the main form of scholarly communication by 2020.

At the same time, LIBER recognises the complexities and challenges faced by research libraries to implement publishing or update services to follow Plan S. Libraries still face uncertainties, however, in terms of the exact steps needed to become Plan S compliant. That is why LIBER, through its Open Access Working Group, tries to identify and feature the experiences of libraries that are already working on becoming Plan S compliant and/or moving towards 100% Open Access.

Policy Making Organisations

There is better recognition of the issues regarding compliance with the EU Open Access mandate and Plan S has explicitly tried to address some of these issues, but in general there has been insufficient action by Member States due to lack of awareness, resources and training.

The most significant development is Plan S, launched on 4 September 2018, by cOAlition S, a group of research funding organisations (including research councils and charitable foundations), with the support of the European Commission and the European Research Council (ERC).

Plan S has ten principles and one key objective to ensure that, by 2021, all scholarly publications arising from research funded by public or private grants provided by national, regional and international research councils and funding bodies, must be published in Open Access Journals, on Open Access Platforms, or made immediately available through Open Access Repositories without embargo. They have also agreed to implement the ten principles of Plan S in a coordinated way.

UKRI (UK Research and Innovation) has also conducted an Open Access review and committed to mandating Open Access to all research articles by 2022 and to all monographs and book chapters by 2024. This new policy is currently under consultation. Internationally, the EC and/or EU Member States have acted to strengthen Open Access policies under the remit of UNESCO. The UN is also exploring the role of Open Access and Open Science as part of the Technology Facilitation Mechanism (TFM) to support the achievement of the Sustainable Development Goals (SDGs)¹¹⁵.

115 'The future is now science for achieving sustainable development', United Nations publication issued by the Department of Economic and Social Affairs '24797GSDR_report_2019.Pdf'. Accessed 22 April 2020. https://sustainabledevelopment.un.org/content/documents/24797GSDR_report_2019.pdf

Publishers

- a. Full immediate Open Access journals are increasingly common, alongside journals transitioning from the subscription model. The first major transformative deals are in place, and more are being worked on by publishers in EU Member States and worldwide. The Microbiology Society is openly sharing both financial and other data associated with implementing a transformative deal for Open Access, so that other Scholarly Societies can learn from this. One scholarly society Member (Royal Society) helped to cofound the Society Publishers' Coalition (SocPC)¹¹⁶, committed to transitioning to Open Scholarship, and now has 64 members.
- b. Text and data mining (TDM) is being enabled for research purposes across most major publishers, via Crossref and the Copyright Clearance Centre (CCC) for small to mid-sized enterprises (SMEs). Full Open Access publishers enable TDM for any purpose, and some subscription publishers enable TDM of their subscription content by commercial researchers.
- c. Creative Commons licence options¹¹⁷ are increasingly used as the default for most Open Access articles. CC BY as the only option for Open Access remains contentious among some publishers, authors and disciplines.
- d. Publishers are committed to long-term hosting and preservation – the archival strategy includes participation in LOCKSS¹¹⁸ and Portico¹¹⁹, and discipline-specific archiving e.g. to PubMed Central¹²⁰. Some publishers are also providing direct deposits of articles to institutions.
- e. Machine-readable policies are being put in place e.g. through the development of common standards such as JATS4R 5. Many publishers have launched preprint servers to increase the speed of publication, for example BMJ with Yale and Cold Spring Harbor Laboratory launched medRxiv¹²¹, a preprint server dedicated to the medical sciences.

Research and E-infrastructures

Infrastructures are increasingly implementing open policies and making them machine readable on their portals. DARIAH began to promote its Open Access guidelines for the arts and humanities in February 2019. An important factor in their policies is expressing the connection between objects, like ScholExplorer¹²², a joint effort of among others, the Research Data Alliance, the World Data System and OpenAIRE, which aims to generate a comprehensive global view of the links between scholarly literature and data.

Researchers

There is growing awareness and uptake of Open Access, but this varies substantially between different disciplines and is highly dependent on individual institutional, funder or government policies. Despite individual champions, there remains a lack of awareness and real concerns about Open Access and Open Science among the researcher community.

Citizen Science & Public Engagement Organisations

National Citizen Science Platforms are currently developing quality standards, including Fair and Open Data and Open Access principles. The Austrian platform Österreich forscht¹²³ is a pioneering example in Europe. They ask all Citizen Science projects to publish their results openly: *“the results will be published in an open-access format, unless there are legal or research-ethical arguments against this.”* The German platform ürger schaffen Wissen¹²⁴ has published guidelines that include Open Access publishing and using Open Science methods in general: *“It is also important to strengthen the exchange and access to knowledge for the scientific and social community. This also includes open source or open science methods and the presentation of the results in and with the public.”*

116 <https://www.socpc.org/>

117 <https://creativecommons.org/licenses/>

118 <https://www.lockss.org/>

119 <https://www.portico.org/>

120 <https://www.ncbi.nlm.nih.gov/pmc/>

121 <https://www.medrxiv.org/>










122 <https://scholexplorer.openaire.eu/#/>

123 <https://www.citizen-science.at/>

124 <https://www.buergerschaffwissen.de/>

Ambition 4: European Open Science Cloud (EOSC)

REC 1	REC2	REC 3
<p>The European Open Science Cloud (EOSC) needs to implement a robust, transparent and participative governance structure to ensure that it has the trust and confidence of all stakeholders, including Member States. It must also support the diversity of requirements across all disciplines. The structure should provide clear channels for feedback, and be compatible with other related initiatives including national, European and Global Research infrastructures to ensure interoperability and the free movement of information across all national and international boundaries and between disciplines, while being sensitive to ethical, societal and legal issues. The EC has to take the lead in bringing the relevant parties together to agree on how this should be done, including the rules of engagement and a range of business models by end-2019.</p>	<p>EOSC must have a long-term baseline funding commitment to become trustworthy. An agreement on how this is to be done needs to be decided within 12 months (by April 2019). The EC must take the lead in bringing the appropriate funders together. EOSC must be free and easy to use for research and education purposes.</p>	<p>For FP9, all researchers must receive appropriate EOSC training and be required to deposit their research outcomes in EOSC-compliant infrastructures. This should be funded by a non-transferable allowable contribution from funders. To this end, access from all parties must be easy and inexpensive if it is to obtain universal support.</p>

Stakeholders	Discussion	Planning	Implementation	Adoption	Common Practice
 Universities & Research Performing Organisations					
 Research Funding Organisations					
 Research Libraries					
 Policy Making Organisations					
 Publishers					
 Research & E-Infrastructures					
 Researchers					
 Scientific Societies & Academies					
 Citizen Scientists & Public Engagement Organisations					

Universities and Research Performing Organisations

Networks of universities and of research performing organisations are engaged in European Open Science Cloud (EOSC) projects and/or in EOSC governance, undertaking an instrumental role in the further development of EOSC post-2020, and in the approach taken to ensure EOSC sustainability post-2020.

Networks of institutions are in the process of identifying the needs related to providing e-infrastructures and e-services in order to exploit data adequately. Ensuring that all researchers are well aware of the development of EOSC training remains a challenge.

Research Funding Organisations

The current EOSC Governance is in place until the end of 2020. It includes representatives from umbrella organisations, research institutes and data service providers in an advisory function (EOSC Executive Board). Currently, a legal entity to represent EOSC as of 2021 is being developed. Interested organisations (research funding organisations, research performing organisations, research institutes, data service providers, industry) are invited to express interest in becoming members of this new legal entity and thus contribute to designing the post-2020 EOSC governance.

EOSC will build on existing initiatives with critical mass at the Member State level, such as the German National Research Data Infrastructure (NFDI) managed by the DFG¹²⁵. NFDI aims to systematically manage research data, provide long-term data storage, backup and accessibility, and network the data both nationally and internationally. It will bring multiple stakeholders together in a coordinated network of consortia tasked with providing science-driven data services to research communities.

Some funders, such as EMBO, are allowing researchers to use their funds for a broad range of activities including to access EOSC training when and should that become available. Funding training to easily access and use EOSC should be part of the training program of each organization (public or private). However, the compulsory aspects of publishing research results from Horizon Europe on EOSC needs some further analysis to ensure this takes into account issues around intellectual property rights (IPR) and competitiveness for those projects that involve public-private partnerships.

Research Libraries

Research libraries and librarians play an essential role in supporting the EOSC and in mediating between researchers and EOSC service providers: they promote the EOSC, provide related training to students, researchers and other staff members, and advocate for higher education institutions to embed infrastructure training into the curricula of students.

Their expert role has already been demonstrated through the EOSCpilot project¹²⁶, the FOSTER Open Science trainer bootcamps¹²⁷ and the SSHOC project¹²⁸ (which is building the social science and humanities part of the EOSC). LIBER has also been invited to join the EOSC executive board in March 2020 as an observer.

As research libraries pay for services that support the research process, they should be consulted on issues related to the type of not-for-profit services that will be publicly funded for EOSC. Several EOSC projects still seem to have the perception that in order to advance Open Science, everything revolves around consolidating infrastructures. These are the bricks, but piling up bricks doesn't make a wall. You need mortar and that would be services that research libraries can build. The most important services have to be performed by units within research performing organisations, which is why top-to-bottom policies that involve more institutional units, such as research administration units, science administration units, quality assurance units and of course libraries will have to operationalize these policies.

125 https://www.dfg.de/en/research_funding/programmes/nfdi/

126 <https://eoscpilot.eu>

127 <https://www.fosteropenscience.eu>

128 <https://sshopencloud.eu>

Policy Making Organisations

The Executive Board of EOSC is establishing a Strategic Research and Innovation Agenda and Roadmap for the implementation phase starting in 2021. For the governance of this next phase, an Association is being set up that will take into account the interest of its members (stakeholders of EOSC). This Association aims to enter into a partnership with the EC. The involvement of the private sector is planned from 2024 onwards. For this, policy making organisations need to ensure that the private sector will be able to contribute and build services based on EOSC. In addition, the cooperation with, and contribution from, international bodies to EOSC needs to be looked at such that there are reciprocal international arrangements with e.g. US, China etc.

Research and E-infrastructures

The EC has established an EOSC governance structure to engage the stakeholders in taking implementation decisions for the EOSC¹²⁹. Several working groups are active and representatives from the various stakeholder groups are actively contributing to them. Implementation documents are periodically published, and wider community feedback is collected to improve them and converge on shared decisions and models. Organisations represented in the OSPP are very active in this process at different levels (e.g. membership in the EOSC Executive Board and EOSC Working Groups as well as in actively participating in the dissemination of Open Science principles and providing visibility for EOSC in international projects.

A growing number of EOSC training materials are being made available by all infrastructures. For instance, the EOSC cluster project SSHOC¹³⁰, coordinated by CESSDA, built the SSH Open Marketplace¹³¹ to make EOSC relevant and simple for SSH researchers, in particular those who create the 'long tail' of cultural/humanities research data. The EOSC-hub project coordinated by the EGI Foundation has developed various training materials on how to access and use a large variety of services available in the EOSC portal¹³².

Researchers

EOSC is being designed with the aim that the necessary training for researchers should require no more knowledge than FAIR (Findable, Accessible, Interoperable, Reusable) training, such as on FAIR implementation, and / or to have enough help on hand from data stewards to conduct the research data management (RDM) planning and to ensure that the data is being put in EOSC-linked FAIR-compliant repositories. Such FAIR training needs to be promoted or even be part of the regular training organized by Societies and Academies and in particular, addressing early career researchers.

129 <https://www.eoscsecretariat.eu/>

130 <https://sshopencloud.eu/>

131 <https://www.sshopencloud.eu/ssh-open-marketplace>

132 <https://www.eosc-hub.eu/training-material>

**Ambition 5:
FAIR (Findable, Accessible, Interoperable, Reusable) Data**

REC 1	REC2	REC 3
Funders and Research Performing Organisations should give credit for Findable, Accessible, Interoperable and Reusable (FAIR) data resulting from research work, similar to publications, methods, code etc.	Output Management Plans (OMPs, including Data Management Plans, DMPs) and their implementation should be mandatory for all research projects. OMPs should be machine readable and regularly modified to reflect ongoing research developments.	Data resulting from publicly funded research must be made FAIR and citable, and be as open as possible, as closed as necessary.

Stakeholders	Discussion	Planning	Implementation	Adoption	Common Practice
 Universities & Research Performing Organisations					
 Research Funding Organisations					
 Research Libraries					
 Policy Making Organisations					
 Publishers					
 Research & E-Infrastructures					
 Researchers					
 Scientific Societies & Academies					
 Citizen Scientists & Public Engagement Organisations					

Universities and Research Performing Organisations

Some institutions already have a data management policy (DMP) and/or roadmap in place (including training kits). Sometimes they are included in their larger Open Science strategy. Others implement single actions (such as proposing institutional DMPs).

Research data management (RDM) based on FAIR (Findable, Accessible, Interoperable, Reusable) principles is largely being considered as a precondition for making data usable and reusable, including for making them open where appropriate.

DMPs enable optimisation of the re-use of research data according to the principle “*as open as possible, as closed as necessary*”, ensuring the balancing of interests between stakeholders. They further enable institutions to decide the conditions under which data are being shared, since ‘open’ does not automatically mean ‘free of charge’. The extent to which FAIR data management is applied by researchers is still however very discipline specific. Many institutions already have developed and use their own DMPs for all types of projects.

Research Funding Organisations

Little progress has been made in giving specific credit for making data FAIR, probably due to a lack of standards around FAIR data, and lack of enforcement. Whilst the concept of FAIR data is now fairly well established, the implementation is challenging particularly in relation to making the data truly Interoperable and Reusable. Transitioning towards FAIR data implies a budget and time/incentive that is not always available, and there is more work needed to ensure an appropriate balance of cost vs benefit.

Tangible examples of Output Management Plans (OMPs) are being shared and best practices are emerging (e.g. Science Europe’s ‘Practical Guide to the International Alignment of Research Data Management (RDM)’ (RDM Guide)¹³³, released in January 2019). These templates¹³⁴ are now being used by some European funders, such as

FWF (Austria)¹³⁵, AKA (Finland), ANR (France), HRB (Ireland), NWO (the Netherlands)¹³⁶, NCN (Poland) and VR (Sweden).

In 2018, Science Europe presented a framework for the creation of domain-specific protocols to take into account the particularities of different scientific disciplines in DMPs. These protocols can be used as standardised templates, reducing the administrative burden for researchers, research organisations, and funders alike. Going forward, NWO (the Netherlands) allows researchers to use organisational DMP templates from their home institutions as long as those templates are approved by the NWO. Approval of institutional templates depends on them matching the requirements of the Science Europe RDM Guide (mentioned above). A similar approach could be envisaged for discipline-specific DMP templates once the different disciplines have developed their domain-specific protocols.

Further work is needed to address outstanding concerns around intellectual property rights (IPRs) where private companies are involved in Public-Private Partnerships in H2020 and Horizon Europe projects. In general, DMPs are being developed at project level but only relating to the foreground data, leaving background data to be retained at the company level.

Research Libraries

In its Open Science Roadmap¹³⁷, LIBER advises libraries to work with their institutions, research infrastructures and funders to make the use of FAIR-compliant OMPs and DMPs mandatory: “*DMPs should be machine actionable and support automated evaluation of project plans*”. In order to provide examples of good practice, inspiration and support, LIBER’s RDM Working Group has launched a DMP Catalogue¹³⁸. This central hub for DMPs from different disciplines includes quality reviews of each DMP (providing guidance on what is done well and what could be improved for others). Research libraries support FAIR data through their services, usually by maintaining archives and adopting policies fostering the FAIR principles, as well as through their data stewards.

133 <https://www.scienceeurope.org/our-resources/practical-guide-to-the-international-alignment-of-research-data-management/>

134 https://www.scienceeurope.org/media/jikilb2g/se_rdm_best_practices.pdf

135 <https://www.fwf.ac.at/en/research-funding/open-access-policy/open-access-to-research-data/>

136 <https://www.nwo.nl/en/news-and-events/news/2019/12/nwo-to-update-its-data-management-protocol-in-january-2020.html>

137 <https://zenodo.org/record/1303002>

138 <https://libereurope.eu/dmpcatalogue>

Policy Making Organisations

There has been some work towards developing DMP/FAIR data standards, for example the development together with many funders in Europe of ScienceEurope's DMP template, and work ongoing through the Research Data Alliance's Common Standards Working Group. However, more coordination is required among Member State policies on DMPs to bring better harmonization and standardization. Private research and business also need IPR safeguards and secured access infrastructure if they are to more fully contribute to FAIR data and Open Science.

Publishers

Many publishers support the FAIR data principles and are introducing data sharing policies on their journals and platforms:

- a. STM launched in January 2020 the 'STM 2020 Research Data Year' (STM2020RDY)¹³⁹ with a dedicated project plan to increase the number of journals with data policies, expand the number of journals depositing links and grow the volume of citations to datasets. Currently 12 STM members, representing over 50% of published content, are participating in the STM2020RDY. Currently 30% of journals have implemented a formal data sharing policy although requirement and enforcement varies.
- b. Publishers are collaborating as part of numerous cross-sector community initiatives committed to advancing Open Science through the sharing, linking and citing of research data from published papers e.g. Force11¹⁴⁰, ORCID¹⁴¹, SCHOLIX¹⁴², Research Data Alliance¹⁴³, FAIRsFAIR (Fostering Fair Data Practices in Europe)¹⁴⁴.
- c. Some publishers, such as F1000 Research, have proposed the open and FAIR publication of DMPs across all its Platforms¹⁴⁵, making them citable and machine readable with support for enhanced metadata and versioning.

- d. Many publishers are working on associated tools to make articles discoverable based on data content, e.g. EMBO's SourceData¹⁴⁶.
- e. Publishers have adopted a range of strategies to raise awareness of the need for FAIR data among researchers and the publisher community, including at conferences and via webinars etc.

Research and E-infrastructures

All of the e-Infrastructures manifest a commitment to the progressive development of FAIR data in ways that align with their own specific capacities and audiences. Recognising that the adoption of the FAIR Data principles is more of a cultural than a technical challenge, many of the initiatives currently operate at the level of promotion of FAIR data to research communities and fostering communication between key players. Supporting the production of DMPs and OMPs has formed a key part of this commitment. The output of this work is varied, and covers a wide range of approaches, disciplines and aspects of the research workflow, ranging from inward facing policies, to outward facing support, and from individualised consultancy to reusable, online tools and standards.

The RDA FAIR Data Maturity Assessment Model Working Group¹⁴⁷ is creating a common set of core assessment criteria for FAIRness and a generic and expandable self-assessment model for measuring the maturity level of a dataset.

ARGOS¹⁴⁸, developed in OpenAIRE, is an online tool to support automated processes to create, manage, share and link DMPs with research artefacts that they correspond to.

139 <https://www.stm-researchdata.org/>

140 <https://www.force11.org/>

141 <https://orcid.org/>

142 <http://www.scholix.org/>

143 <https://www.rd-alliance.org/>

144 <https://www.fairsfair.eu/>

145 <https://f1000research.com/for-authors/data-guidelines>

146 <https://sourcedata.embo.org/>

147 <https://www.rd-alliance.org/groups/fair-data-maturity-model-wg>

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

Researchers

With the introduction of DMPs in Horizon 2020, the practice is becoming more common. Adoption maturity is different among research communities.

Research networks have promoted FAIR principles across all phases of research careers. However, the massive challenge to FAIR data adoption is the current lack of specific recommendations on data management, including on security access, quality issues, curation and reuse of data, and on evaluation.

Citizen Science & Public Engagement Organisations

In many Citizen Science projects, especially those funded by national governments and the European Commission, DMPs or the management of datasets exist to ensure best practice in terms of metadata and archiving and to make sure that the data is FAIR for other potential users. Such users include researchers and practitioners in the field of Citizen Science, as well as any other interested parties. Here, the Austrian platform Österreich forscht is a pioneering example: *“all data and metadata, provided that there are no legal or research-ethical arguments against it, are made publicly accessible; the results are findable, reusable, accessible and transparent.”*

Ambition 6: Research Integrity

REC 1	REC2	REC 3	REC 4
<p>All research organisations must have a research integrity policy, including promotion of good research practices, clear procedures for dealing with allegations of research misconduct and a description of possible sanctions for proven cases of misconduct. This policy must be enforced and adequately staffed and financed to investigate any allegation pertinent to their staff. The processes for dealing with such issues should be public, transparent and prominently displayed. Outcomes should be published where the allegations are upheld, taking into account the sensitivity of the issues involved.</p>	<p>All published research outputs should be reported according to recognised community standards where they exist. For any research project, researchers should define conditions by which their work can be replicated or otherwise verified by others.</p>	<p>All researchers must receive regular training and accreditation on research integrity pertaining to Open Science, including the ethical, legal and social implications of their research practices. Funders (including the EC through FP9) must ensure that there is adequate training given to the researchers they fund, either through the researcher’s institution, or provided via other means.</p>	<p>Publishers, data platform and infrastructure providers must agree a standardised set of minimum quality control checks on outputs and openly display the results. The task of undertaking these independent checks needs to be adequately funded. Outputs that pass these checks should be recognised and rewarded in research and researcher evaluation systems, such as FP9.</p>

Stakeholders	Discussion	Planning	Implementation	Adoption	Common Practice
Universities & Research Performing Organisations					
Research Funding Organisations					
Research Libraries					
Policy Making Organisations					
Publishers					
Research & E-Infrastructures					
Researchers					
Scientific Societies & Academies					
Citizen Scientists & Public Engagement Organisations					

Universities and Research Performing Organisations

Most institutions have research ethics and integrity principles and policies in place. The focus is on defining the concepts, raising awareness, promoting good research practices, as well as regulating scientific misconduct. However, enforcement of these principles is not always institutionalised. Some networks of universities, research organisations and research funders are supporting their members by mapping existing policies, procedures and practices. Finally, tools, support and training on research integrity are available for researchers in many institutions, with a focus on early career researchers.

Research Funding Organisations

Science Europe published a Survey Report 'Research Integrity Practices in Science Europe Member Organisations' in July 2016¹⁴⁹ which maps existing policies, procedures and practices for promoting research integrity and makes 18 key recommendations for improving it including processes and policies, awareness raising, training, and collaboration.

These policies have been picked up by some funders (e.g. EMBO); however, from a funder perspective there is often little that can be done on handling allegations of misconduct and sanctioning as it is dealt with at the level of the home institutions. Many funders have research integrity related policies or guidelines e.g. EMBO, ANR (France, Ethics and Scientific Integrity Charter), DFG (Guidelines for Safeguarding Good Research Practice), UKRI (Policy and Guidelines on the Governance of Good Research Conduct). It is important for these policies to recognize the need to have a clear description of what is meant by research integrity, to contribute to raising awareness about it, and to foster or support its training and implementation. Funders, and most importantly home institutions should have the means to identify misconduct, to handle allegations and have effective sanctioning tools in cases of misconduct, and adequate safeguarding measures for whistle-blowers against disciplinary actions.

Some funders such as EMBO require their post-doctoral fellowships and young investigators to undertake certified training in good research practices, which can be through their institutions or through EMBO.

Research Libraries

In its Open Science Roadmap, LIBER has described that research libraries have a key role in supporting research integrity. They can fight against fake and predatory publishers. They can ensure that their institution has appropriate policies in place, and they can provide services related to copyright and intellectual property rights (IPR). They can investigate plagiarism and they can offer training: facilitating, guiding and educating young researchers about the rules and tools needed to conduct research according to the highest standards.

Libraries are ethically, legally and competently well positioned to do all of these things, in tight collaboration with relevant research communities. Additionally, libraries can provide the technical infrastructures to support research integrity in terms of systems for keeping, accessing and publishing research outputs.

Some aspects of research integrity have been addressed in different working groups of LIBER.

Policy Making Organisations

There has been a general increase in the awareness of issues around research integrity at policymaker level with some EC-driven stakeholder discussions, and some progress has been taken at the local or institutional level. However, there has been insufficient action on training, implementation and compliance. Research integrity is part of The European Charter for Researchers¹⁵⁰ and has been incorporated into Horizon Europe grant agreements but it is not clear to what extent this is being monitored.

149 <http://scieur.org/integrityreport>

150 <https://euraxess.ec.europa.eu/jobs/charter/european-charter>

Publishers

Publishers have acted collectively and individually to improve the integrity of articles in different ways including the following:

- a. Many major publishers have a comprehensive set of policies to support the publishing process and policies to ensure the ‘Research Integrity’ of the work published.
- b. For some disciplines and across all articles for some journals or publishers (e.g. PLOS ONE, Hindawi Ltd, F1000 Research), publishers screen submitted or accepted papers for compliance with human and/or animal reporting guidelines, additional ethical and dual use issues, any competing interests, and ensure there are statements in relation to who has funded the research.
- c. Publishers have also collaborated to collectively detect and take action against misconduct and fraud, including plagiarism, and image and data manipulation by authors, fraud by reviewers and editors, and also by inauthentic publishing operations (e.g. tools such as Think Check Submit¹⁵¹).
- d. In addition, there are services or guidance provided for publishers by membership organisations such as Crossref, the Committee on Publishing Ethics (COPE) and OASPA and by commercial entities such as Research Square and other new emerging service providers.

Researchers

It is not clear to what extent research integrity is understood by researchers and how the community norms and standards vary between disciplines. There are also few comprehensive reports about the extent and consistency of training and support for researchers in this area. It is crucial that training does not focus solely on early career researchers but spans the whole range of career levels and researcher roles.

Scientific Societies and Academies

ALLEA (the European Federation of Academies of Sciences and Humanities) created and recently revised *The European Code of Conduct for Research Integrity*¹⁵², based on input by YEAR, GYA and other academies and scientific societies, which also encourage their members to adhere to its principles.

As one of several workshops on research integrity policy, EPS will organize in 2020 a workshop on ‘Code of conduct and good practice in a conference setting’. Other topics of importance requiring recommendations are diversity balance in science, gender equality, education, teaching values, science journalism and communication. In its e-learning course ‘Good Chemistry – Methodological, Ethical, and Social Implications’ EuChemS is addressing many aspects of research integrity¹⁵³. The GYA contributed a Young Scientist Perspectives on Replicability and Reproducibility in Science and Engineering to a National Academies of Science (NAS) report on Reproducibility and Replicability.

Citizen Science & Public Engagement Organisations

The European Citizen Science Community¹⁵⁴ has formulated its own standards and ethical research principles early on, which apply specifically to the conduct of Citizen Science. The ‘10 principles of Citizen Science developed by ECSA are widely accepted as a standard in the European Citizen Science community.

However, reproducibility and verification by other researchers is not always given in Citizen Science projects. The implementation of open methods, data and metadata will contribute to a considerable improvement in this area.

151 <https://thinkchecksubmit.org/>

152 <https://allea.org/code-of-conduct>

153 <http://www.elearning-euchems.eu>

154 <https://eu-citizen.science/>

Ambition 7: Skills & Education

REC 1	REC2
<p>Research Performing Organizations (RPOs) need to work towards the design of appropriate Open Science training that is consistent across Member States, including data literacy, ethics and research integrity, for:</p> <ul style="list-style-type: none"> • All researchers, at all levels from early career researchers to senior researchers (R1-R4). Open Science skills need to be explicitly tailored to diverse career paths. • Research managers and administrators, and other staff involved in the research ecosystem (librarians, repository managers, IT services, data stewards, etc.). • Students (both undergraduate and graduate levels). 	<p>Policy makers, funders and institutions must provide incentives and support towards developing Open Science mentoring and training within a supportive culture and environment.</p> <p>A fundamental part of a researcher’s education is to have a common set of baseline skills on Open Science which must be integrated in the European Framework of Research Careers (EFRC) and the Innovative Doctoral Training Principles (IDTP).</p>

Stakeholders		Discussion	Planning	Implementation	Adoption	Common Practice
	Universities & Research Performing Organisations					
	Research Funding Organisations					
	Research Libraries					
	Policy Making Organisations					
	Publishers					
	Research & E-Infrastructures					
	Researchers					
	Scientific Societies & Academies					
	Citizen Scientists & Public Engagement Organisations					

Universities and Research Performing Organisations

Increasing skills is being considered as essential for implementing the idea of Open Science. Most institutions offer training and awareness-raising sessions for their staff at different levels. Topics covered range from FAIR (Findable, Accessible, Interoperable, Reusable) data management practices, the standardisation of metadata, responsible research and innovation (RRI), balancing intellectual property rights (IPR) protection and Open Science, research integrity/responsible research, data protection, and Citizen Science or science communication. Institutions also act as partners in projects aiming at developing innovative teaching and training material.

Research Funding Organisations

Some funders such as EMBO acknowledge any mentoring and training in Open Science that their grantees undertake.

Research Libraries

Research libraries have a long track record of offering training, both to individual scholars and researchers and in collaboration with departments and labs across their institutions. LIBER has supported this role in many ways. Its Digital Skills Working Group¹⁵⁵ has published a series of case studies on Open Science skilling and training programmes in Europe¹⁵⁶.

They have also mapped Open Science Skills for librarians and are writing a ‘starters guide’ for Open Science-oriented library services (both to be released in the first half of 2020). In addition, LIBER has participated in many European projects focused on training (e.g. EOSCpilot¹⁵⁷, SSHOC¹⁵⁸, LEARN¹⁵⁹, FOSTER¹⁶⁰), which boost the training capacity of libraries through workshops, webinars and other resources.

Since 2016, 26 ‘Focus on Open Science’ workshops have been organised by Scientific Knowledge Services, University College London (UCL), LIBER and local organisers across Europe.

155 <https://libereurope.eu/strategy/digital-skills-services/digitalskills>

156 <https://zenodo.org/record/3484595>

157 <https://eoscipilot.eu/>

158 <https://sshopencloud.eu/>

159 <https://learneurope.eu>

160 <https://www.fosteropenscience.eu/>

Policy Making Organisations

There is as yet no coherent, aligned implementation of mentoring or training for Open Science by policy making organisations at a Member State level, although there are some specific individual examples of leadership being shown by organisations such as the Wellcome Trust.

Publishers

Publishers recognize that if researchers are to adhere to guidance regarding research integrity and about how to include principles of Open Science in their work, they need to be trained. While some institutes are able to deliver comprehensive training, some cannot, and the offerings from publishers may complement or, in some cases, serve as institutional training.

Some of these efforts are related to long-standing responsibilities of publishers to authors and readers (e.g. archive and make available information), some have been taken up in collaboration with other stakeholders (e.g. providing research integrity training courses for academic institutions), and some are relatively new and unclear where responsibility lies (e.g. training in providing FAIR data).

- a. Many publishers (for example, EMBO Press, Springer Nature) are involved now in efforts to provide advice and training to researchers on aspects of Open Science. Advice, guidelines, and certifications are being offered by F1000 Research and many of the publishers within STM.
- b. Editors frequently design and lead courses not only on ‘how to publish’ but also in research integrity, technical issues around data, etc. Such training of course incurs costs, and therefore fees to users (or their institutions).

Research and E-infrastructures

Skills and Education is an area where the e-infrastructures are generally active, developing creative responses to the need for skills development opportunities in the emerging area of Open Science. In particular, the European Open Science Cloud (EOSC) is an area of focus, but the skills development tools developed by the e-infrastructures go far beyond this. The range of modalities used is broad: from online curricula and training videos, to webinars and conference sessions, to blogs.

DARIAH has developed a number of resources through which to support the Open Science skills development of arts and humanities researchers at all career stages, such as the online modules: 'Manage, Improve and Open up your Data'¹⁶¹ and 'Citizen Science in the (Digital) Arts and Humanities'¹⁶² as well as the DARIAH Open blog¹⁶³.

Engagement by the GEANT Learning and Development Team in Open Science Training through OpenAIRE¹⁶⁴ and Eurodoc Open Science Online webinars are in progress.

Researchers

There has been significant growth in training available for researchers on Open Science practices from research performing institutions, libraries, scientific societies and networks, publishers and others. However, there remains a huge amount of work still to be done to incorporate the training and education needed to embed the skills for Open Science practice among researchers across all disciplines.

Scientific Societies and Academies

Open Science mentoring and training is provided by societies and academies via their members and sections in many European countries for early career researchers, from undergraduate to postdoctoral level and higher. This is also being reflected by awards, e.g. EMBO Gold Medal¹⁶⁵, and induction citations. Acknowledgements of such activities are also being provided to the institutions of those individuals. Young Academies have created working groups to raise awareness and educate young researchers about Open Science. In recognition that Open Science has a global impact, they have started an integrated global working group to exchange knowledge and best practices between the global north and global south¹⁶⁶.

Strategies for team building and for task and responsibility sharing also need to be included in a researcher's education.

Citizen Science & Public Engagement Organisations

The platform eu-citizen.science will host a series of Open Access training modules on Citizen Science, tailored to specific stakeholder groups and focusing on capacity building for Citizen Science projects. Although individual Living Labs and many research performing organisations hosting Living Labs have provided physical and/or virtual environments for Open Science and Citizen Science training, or have provided students with the fundamentals of Citizen Science by combining Open Science principles with the UNESCO Recommendations on Open Educational Resources, training opportunities in many scientific institutions are still widely missing.

161 <http://training.parthenos-project.eu/sample-page/manage-improve-and-open-up-your-research-and-data/>

162 <https://training.parthenos-project.eu/sample-page/citizen-science-in-the-digital-arts-and-humanities/>

163 <https://dariahopen.hypotheses.org/>







164 <https://www.openaire.eu/support>

165 <http://www.embo.org/funding-awards/gold-medal>

166 <https://globalyoungacademy.net/launch-of-new-open-science-global-working-group/>

Ambition 8: Citizen Science

REC 1	REC2	REC 3	REC 4
Publicly funded Citizen Science projects (as part of FP9 projects) should actively apply the principles of Open Science (including openness and reuse of all research outputs, data and publications).	Research-performing organisations (RPOs) are encouraged to promote infrastructures and human capacity to create a supportive and open environment for Citizen Science, which can further strengthen the outreach of RPOs to society. Research libraries are well placed, amongst others, to contribute actively to the necessary coordination and communication infrastructures as well as relevant training, fostering skills such as community management, co-production of knowledge, Open Science standards and social diversity. Appropriate funding and incentives need to be put in place to support this endeavour.	The EC must support an online toolkit for Citizen Science in Europe. This tool must promote Citizen Science as a European asset, offering an entry point and mutual learning space, interconnecting with existing activities and infrastructures at the European, national and local level. It should highlight particular achievements and best practices, and promote a clear set of principles, guidelines & quality criteria for Citizen Science.	Funding for Citizen Science projects should be flexible, long-term and allow for small or experimental projects in collaboration with key stakeholders to be funded. A small section of FP9 should be set aside for citizens to propose research topics or projects. These should be chosen on the basis that they are high risk, beyond traditional research fields and conform to the rigorous standards expected of other projects. Successful proposers will need to work with compliant institutions.

Stakeholders	Discussion	Planning	Implementation	Adoption	Common Practice
 Universities & Research Performing Organisations					
 Research Funding Organisations					
 Research Libraries					
 Policy Making Organisations					
 Publishers					
 Research & E-Infrastructures					
 Researchers					
 Scientific Societies & Academies					
 Citizen Scientists & Public Engagement Organisations					

Universities and Research Performing Organisations

At EU level, there are examples of projects developing and implementing methodologies on Citizen Science (e.g. ORION¹⁶⁷).

At institutional level, progress is scattered: individual staff at institutions are involved in projects with citizens, mainly for the collection of data, but also in participating in Living Labs or other community-based settings where users/citizens are immersed in a space for designing and experiencing new technologies and innovations in a real-life scenario, in a co-creation process (LivingLabs, Enoll¹⁶⁸; MakerSpace, UC3M¹⁶⁹).

Other institutions have gone a step further at a centralised level to provide guidance to their researchers on how to implement Citizen Science in an effective way. Some institutions are incorporating centralised structures where they plan to promote Citizen Science initiatives including engaging with citizens to discuss future research priorities their institutions should work on e.g. University of Southern Denmark (SDU)¹⁷⁰. These initiatives at institutional level are part of social involvement strategies addressing Sustainable Development.

Increasingly, training and awareness-raising on the societal impact and dimension of research is being provided by institutions to their researchers.

Research Funding Organisations

Open Science as applied to Citizen Science is still very much being applied at an individual level and on a voluntary basis. Funding schemes for Citizen Science are starting to emerge at institutional and national levels, such as in Germany, and Horizon Europe has provided some funds for Citizen Science; however more could be done to actively encourage and incentivise this, maybe through the continuation of programmes such as SwafS¹⁷¹.

Research Libraries

LIBER has, since 2019, a Citizen Science Working Group¹⁷² which is working on strengthening the role of research libraries in Citizen Science by offering training and delivering a librarian's guide to Citizen Science. In addition, LIBER participates in the INOS project¹⁷³ which is working on ensuring that Open and Citizen Science are more integrated in higher education institution (HEI) teaching practices. In this regard, recommendations have already been published for HEIs¹⁷⁴ and an analysis of the pedagogical underpinnings of Open Science, Citizen Science and Open Innovation activities has been performed¹⁷⁵.

Policy Making Organisations

The European Commission (EC) and ECSA are pulling together sets of recommendations for best practice in Citizen Science such as togetherscience.eu¹⁷⁶. In addition, EU-citizen.science, a consortium of partners and third parties across 14 Member States representing a variety of stakeholders, are developing a platform that includes a series of standards and criteria for Citizen Science. The platform will provide a definition and criteria of 'good' Citizen Science that will be verified by experts in the field and agreed upon by the project partners with the aim of guaranteeing that all the resources available on the platform are of high quality. However, there is still a lack of any clear policy or implementation by individual policy making organisations in relation to Citizen Science and no alignment among them or among Member States in general.

167 <https://www.orion-openscience.eu/>

168 <https://enoll.org>

169 <https://www.uc3m.es/makerspace/inicio>

170 <https://www.sdu.dk/en/forskning/forskningsformidling/citizenscience>

171 <https://ec.europa.eu/research/swafs/index.cfm>

172 <https://libereurope.eu/strategy/innovative-scholarly-communication/citizenscience>

173 <https://inos-project.eu>

174 https://inos-project.eu/wp-content/uploads/2020/02/INOS_O1A3Recommendations_v1.pdf

175 https://inos-project.eu/wp-content/uploads/2020/03/INOS_O2A1_SOTA_V1.pdf

176 https://ecsa.citizen-science.net/sites/default/files/ditos-policybrief3-20180208-citizen_science_and_open_science_synergies_and_future_areas_of_work.pdf

Research and E-infrastructures

Open Access infrastructures are supporting Citizen Science projects, by showing the potential of their service for discovery on the one hand, and as a platform where citizens can share scientific data on the other. OpenAIRE runs a two-phase pilot for schools to demonstrate just that¹⁷⁷.

Researchers

Citizen Science is a crucial part of research in some disciplines and not in others. Researchers need more guidance on how to involve Citizen Science in their research, where it is appropriate, and to be rewarded for doing so.

Citizen Science & Public Engagement Organisations

The '10 Principles of Citizen Science (ECSA 2015)¹⁷⁸ already mention the principles of Open Access and Open Data as standards for Citizen Science projects. Nevertheless, the development of tools and standards is an ongoing task. While Open Science practices have long been standard for large (e.g. EU-funded) projects, the possibilities for smaller projects are often limited. With the development of the EU-Citizen-science platform, which will provide resources, training and tools, an important step has been taken. The Citizen Science Characteristic¹⁷⁹, developed in 2019/2020 by ECSA with OSPP support, also highlights Open Science practices like transparent data ownership, data sharing and Open Access as core principles of Citizen Science. Yet, privacy concerns have to be addressed, especially in fields like medical and health research.

177 <https://www.openaire.eu/citizen-science-activities-in-openaire>

178 <https://ecsa.citizen-science.net/engage-us/10-principles-citizen-science>

179 Haklay, Muki. (2020, April 1). ECSA's Characteristics of Citizen Science. Zenodo. <http://doi.org/10.5281/zenodo.3758668> Haklay, Muki. (2020, April 1). ECSA's Characteristics of Citizen Science: Explanation Notes. Zenodo. <http://doi.org/10.5281/zenodo.3758555>

Annex B: Open Science Policy Platform (OSPP) members and alternate representatives by stakeholder organisation in the platform

The [list of current nominated members, as of October 2019](#), can be found on the [OSPP page on the European Commission Website](#). However, this Annex gathers all the representatives, alternates, and others that have served at some point in the OSPP on behalf of their constituencies, over the two mandates of the platform. Institutions are listed in alphabetic order.

ACEU: Alliance of Central and Easter Universities

Manuela Epure, ACEU Vice-President

Business Europe

Gioia Venturini, Director at SAFRAN and Vice-President for R&T International cooperation and Public Affairs

Other representatives:

Alexander Affre, Director, Industrial Affairs & ASGroup Manager

Carolina Vigo, Business Europe Adviser, Industrial Affairs

Jan van den Biesen (former representative)

CESAER: Conference of European Schools for Advanced Engineering Education and Research

Karel Luyben, CESAER Vice-President Research, and Chairman of the Task Force on Open Science

DARIAH: Digital Research Infrastructure for Arts and Humanities

Jennifer Edmond, President, DARIAH

Other representatives:

Erzsébet Tóth-Czifra, Open Science Officer at DARIAH

EARTO: European Association of Research and Technology Organisations

Eva Maria Moar, EARTO Core Team Member of Working Group on Legal Issues

Other representatives:

Ernst Kristiansen, Member of Executive Board at EARTO (former representative)

ECSA: European Citizen Science Association

Johannes Vogel, ECSA Chair, Chair OSPP Mandate 1 (former representative)

Maïke Weisspflug, ECSA Researcher and Strategy Officer

EGI Federation: Advanced Computing for Research

Sergio Andreozzi, EGI Foundation Head of Strategy, Innovation and Communications

EMBO: European Molecular Biology Organization

Michele Garfinkel, Head of the EMBO Science Policy Programme

ENoLL: European Network of Living Labs

Tuija Hirvikoski, Council Member and former elected President of ENoLL

EPS: European Physical Society

Christophe Rossel, former EPS President

Other representatives:

Luc van Dyck, Consultant on EU affairs at EPS

EUA: European University Association

Norbert Lossau, Vice-President of the University of Göttingen

Other representatives:

Lidia Borrel-Damián, former EUA Director Research and Innovation (former representative)

Vinciane Gaillard, EUA Acting Director Research and Innovation

EuChemS: European Association for Chemical and Molecular Sciences

Wolfram Koch, member of the EuChemS Executive Board

Other representatives:

Kenneth Ruud, member of the EuChemS Executive Board and Chair of Open Science Task Group

Robert Parker, member of the EuChemS Executive Board

Nineta Hrastelj, EuChemS Secretary General

EU-LIFE: Alliance of independent European research institutes in the life sciences

Michela Bertero, member of the Strategy Group EU-LIFE; Head of International and Scientific Affairs at the Centre for Genomic Regulation

Other representatives:

Lieve Ongena, Sr Science Policy Manager and Head of Grant Officer at Vlaams Instituut voor Biotechnologie (VIB, Belgium)

Marta Dias Agostinho, EU-LIFE Coordinator

F1000 Research

Rebecca Lawrence, F1000 Research, Managing Director

Other representatives:

Liz Allen, F1000 Research, Director of Strategic Initiatives (alternate)

GÉANT (A pan-European collaboration on e-infrastructure and services for research and education)

Matthew Scott, GÉANT Chief Programmes Officer

Other representatives:

Edit Herczog, GÉANT Senior EU Liaison Adviser

Steve Cotter, former CEO at GÉANT (former representative)

GYA: Global Young Academy

Sabina Leonelli, GYA elected member (former representative)

Koen Vermeir, GYA Co-Chair

LERU: League of European Research Universities

Kurt Deketelaere, LERU Secretary General (former representative)

Paul Ayriss, Co-Chair of the INFO Community at LERU; Pro-Vice- Provost (UCL Library Services)

Other representatives:

Alain Smolders, LERU Senior Policy Officer

LIBER: Association of European Research Libraries

Kristiina Hormia Poutanen, former President of LIBER

OASPA: Open Access Scholarly Publishers Association

Catriona J. MacCallum, Member of the OASPA Board; Director of Open Science at Hindawi

Other representatives:

Paul Peters, former OASPA President (former representative)

OpenAIRE

Natalia Manola, OpenAIRE Managing Director

Other representatives:

Inge Van Nieuwerburgh, member of the OpenAIRE Project Steering Committee (alternate)

RDA: Research Data Alliance

John Wood, Emeritus RDA Council Co-Chair

Other representatives:

Hilary Hanahoe, RDA Secretary General

Science Europe

Stephan Kuster, former Science Europe Secretary General (former representative)

Lidia Borrell-Damián, Science Europe Secretary General (since September 2019)

Matthias Kleiner, Member of Governing Board, Science Europe (former representative)

Other representatives:

Maud Evrard, Head of Policy Affairs, Science Europe (alternate)

STM: International Association of Scientific, Technical and Medical Publishers

Michael Mabe, former Chief Executive Officer

Other representatives:

Stephane Berghmans, STM Policy & Advocacy Committee

Philip Carpenter, STM Board Member

Eefke Smit, STM Director, Standards and Technology

Ian Moss, STM Chief Executive Officer (since 2020)

YEAR: Young European Associated Researchers Network

Michela Vignoli, YEAR Board Member

Other representatives:

Alexis Sevault, YEAR, International Relations

Jan Rörden, YEAR Board Member

YERUN: Young European Research University Network

Eva Méndez, YERUN Open Science WG co-chair; Deputy Vice-President for Scientific Policy, Open Science, Universidad Carlos III de Madrid, Chair OSPP Mandate 2

Other representatives:

Silvia Gómez Recio, YERUN Secretary General

Glossary and Acronyms

APC	Article Processing Charge
DARIAH	Digital Infrastructure for Arts and Humanities [See]
DORA	Declaration on Research Assessment [a.k.a.: SFDORA] [See]
DMP	Data Management Plan
ECSA	European Citizen Science Association [See]
EMBO	European Molecular Biology Organisation [See]
eNoLL	European Network of Living Labs [See]
EOSC	European Open Science Cloud, a large infrastructure (cloud) for research data in Europe. EOSC is the vision of the EC to support and develop Open Science and Open Innovation in Europe and beyond, to give Europe a global lead in scientific data infrastructures and to ensure that European scientists reap the full benefits of data-driven science. [See]
EPS	European Physical Society [See]
EUA	European University Association [See]
EuChemS	European Chemical Society [See]
FAIR	Findable, Accessible, Interoperable and Reusable. Set of agreed principles applicable to Research Data. [See]
GYA	Global Young Academy [See]
HEI	Higher Education Institution
HLEG	High Level Expert Group. Related expert groups established by the Commission
IP	Intellectual Property
IPR	Intellectual Property Rights
LIBER	Ligue des Bibliothèques Européennes de Recherche – Association of European Research Libraries [See]
LMICs	Low-to-Middle Income Countries
NGO	Non-Governmental Organisation
NISO	National Information Standards Organisation [See]
OA	Open Access [See]
OASPA	Open Access Scholarly Publishers Association [See]
OMPs	Output Management Plans (includes Research Data Management Plans)

ORCID	Persistent digital identifier for researchers [See]
OSPP	Open Science Policy Platform. High Level Advisory Group established by the Commission in May 2016 to provide advice on the development and implementation of Open Science in Europe. (See Annex B) and [See]
OSPP-REC	The prioritised set of actionable recommendations issued by the Open Science Policy Platform members in April 2018 [See]
PCI	Practical Commitments for Implementation
RDA	Research Data Alliance [See]
RDM	Research Data Management
RFO	Research Funding Organisation
RTD	Directorate-General for Research and Innovation of the European Commission
RPO	Research Performing Organisation
SME	Small and Mid-Sized Enterprise
STM	International Association of STM Publishers [See]
YEAR	Young European Association Researchers network [See]
YERUN	Young European Research Universities Network [See]

Getting in touch with the EU

IN PERSON

All over the European Union there are hundreds of Europe Direct information centres.

You can find the address of the centre nearest you at: https://europa.eu/european-union/contact_en

ON THE PHONE OR BY EMAIL

Europe Direct is a service that answers your questions about the European Union.

You can contact this service:

- by freephone: 00 800 6 7 8 9 10 11 (certain operators may charge for these calls),
- at the following standard number: +32 22999696, or
- by email via: https://europa.eu/european-union/contact_en

Finding information about the EU

ONLINE

Information about the European Union in all the official languages of the EU is available on the Europa website at: https://europa.eu/european-union/index_en

EU PUBLICATIONS

You can download or order free and priced EU publications from:

<https://op.europa.eu/en/publications>. Multiple copies of free publications may be obtained by contacting Europe Direct or your local information centre (see https://europa.eu/european-union/contact_en)

EU LAW AND RELATED DOCUMENTS

For access to legal information from the EU, including all EU law since 1952 in all the official language versions, go to EUR-Lex at: <http://eur-lex.europa.eu>

OPEN DATA FROM THE EU

The EU Open Data Portal (<http://data.europa.eu/euodp/en>) provides access to datasets from the EU. Data can be downloaded and reused for free, for both commercial and non-commercial purposes.

This final report of the EU Open Science Policy Platform (OSPP) provides a brief overview of its four-year mandate from 2016 to 2020, followed by an update on progress by each stakeholder group over the past two years since the publication of the OSPP's recommendations across the European Commission's eight ambitions on Open Science, (OSPP-REC). This summary of Practical Commitments for Implementation with specific examples of progress by each stakeholder community across Europe is followed by a perspective from each group on the major outstanding blockers to progress and possible next steps. The group of 25 key stakeholder representatives have then come together to propose a vision for moving beyond Open Science to create a shared research knowledge system by 2030.

Research and Innovation policy