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Highlights of the “Software Pillar of Open Science” workshop

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“Software and Source Codes” College

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About the workshop

Software has become essential in all areas of scientific research, both as a tool for research, a product of research, and a research object in itself. In the quest to make research results reproducible, and pass knowledge to future generations, we must preserve three main pillars: the research articles that describe the results, the data sets used or produced, and the software source code that embodies the logic of the data transformation. Indeed, the preservation of software source code is as essential as preserving research articles and data sets.

The main aim of this in-person half-day event, organized by the French Committee for Open Science on November 29th 2023, was to bring together high-level stakeholders from a variety of backgrounds, including researchers, research software engineers, research evaluation bodies, infrastructures, academic open source program offices (OSPOs), and financial backers, to share their experience and views on research software.

The workshop featured three panel sessions, in which speakers focused on major dimensions of relevance to software in open science:

- Acknowledgment of software as a key pillar for reproducible research;
- Recognition and support for the dissemination of software;
- Highlighting of the social impact of software.

Getting in touch with the “Software and Source Codes” College:

To submit a proposal, ask a question, please write to coso-logiciels-contact@groupes.renater.fr

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1.1 | Welcome address from Roberto Di Cosmo

Welcome address from Roberto Di Cosmo, co-chair "Software and Source Codes" College; director, Software Heritage; senior researcher, Inria; and professor, Paris Cité University

Welcome from the "Software and Source Codes" College!

The Committee for Open Science mobilizes education and research stakeholders to support the implementation of National Open Science Policy in a dynamic and coordinated manner. It is made up of several bodies that put forward guidelines, examine cases, make decisions and promote and support the actions linked to all of this. It is a fluid structure which facilitates the expression and feedback of ideas, commitments and contributions.

The French Committee for Open Science relies on colleges and expert groups, that are permanent bodies made up of experts on the various aspects of the National Open Science Policy. They examine subjects, provide opinions, propose guidelines and initiate and steer projects.

Five colleges provide guidance for, and implement, the French national Open Science policy:

- Publications;
- Research Data;
- European and International relations;
- Skills and Training;
- Software and Sources Codes.

Timeline of the "Software and source codes" college

Landscaping	2018	Within the Committee for Open Science, creation of a working group dedicated to software
	2019	Release of an opportunity note on research software
First concrete actions	2020	Contribution to the UNESCO Open Science consultation
	2021	Software chapter in the second National Open Science Policy Launch of the first Open Science Free Software Award Open call for interest
Federating the community	2022	Workshops on software April 2022: Kickoff meeting ; the working group on software becomes the "Software and source codes" college, a permanent body of the Committee for Open Science. The college leads are Roberto Di Cosmo, professor in informatics at Université Paris Cité, senior researcher at Inria and director of Software Heritage, and François Pellegrini, professor in informatics at Université de Bordeaux, and VP at the French data protection authority (CNIL) June 2022: plenary session at the Ministry of Higher Education and Research

Missions and structure of the “Software and source codes” college

The college deals with the processes allowing the provision to the scientific community, ideally under free/libre licenses, of the source codes and/or software produced in the context of research activities. It is interested in the processes of creation of such software, but also in their distribution, their sustainability, their valorization and the recognition of the work carried out by those who contribute to these activities.

The college drives, carries out or manages operational projects that contribute to the measures identified in the software axis of the Second French Plan for Open Science (PNSO 2). The actions of the college are deeply rooted at a national level, but, as software is international per se, the topics of interest to the college go well beyond the French perimeter.

The work of the college is organized around five topics:

- Topic 1: Identification and promotion of software production;
- Topic 2: Tools and best technical and social practices;
- Topic 3: Valorization and sustainability;
- Topic 4: Skills networks / International cooperation;
- Topic 5: Recognition and careers.

The “Software and source codes” college gathers representatives from the categories of actors involved in research software: scientists from various disciplines, research and development engineers, valorization actors, legal experts, etc. Outside experts as well as representatives of other CoSO colleges may be invited to participate in the work of the college.

A selection of resources produced by the college is available in the section: “Resources of interest”.

1.2 | Welcome address from Nicolas Fressengeas

Open Science Officer in charge of international affairs for the French Ministry of Higher Education and Research: “Open source software policy”

The national context: the Second French National Plan for Open Science, the continuation of an ambitious trajectory

In 2016, the Law for a Digital Republic draws an ambitious action plan to support open science. In France, the legislator very early perceived the interest of the opening of data and source codes produced by public organizations. For this reason, they promulgated in 2016, the Law for a Digital Republic to promote the opening of source codes and the creation of digital commons.

On July 6th, 2021, the Second French National Plan for Open Science is launched by the Ministry for Higher Education, Research and Innovation. This plan is built around four pillars:

- generalizing open access to publications;
- structuring, sharing and opening up research data;
- opening up and promoting source code produced by research. To this aim, the scope of the national plan for open science is extended to software and source code;
- transform practices to make open science the default principle.

Open science means opening all research products and methods for a more cumulative, robust and reproducible science, and for a science fully transparent and accessible to all. This opening up thus concerns all scientific productions:

- publications;
- research data;
- software and source code.

Focus on the software and source code chapter of the Second French National Plan for Open Science, the continuation of an ambitious trajectory

Because the opening of software source code is a major challenge for the reproducibility of scientific results, opening up and promoting source code produced by research is acknowledged as a key action for open science. In this domain, the three major milestones have been defined as follows:

- recognize and support the dissemination under an open source license of software produced by publicly funded research programs;
- highlight the production of source code from higher education, research and innovation;
- define and promote an open source software policy. Therefore, distribution of software products under open source license will be preferred.

To support this challenge, a college of experts in source code and software has been created within the Committee for Open Science. They have been tasked to help define and promote an open source software policy by:

- developing the link between data and software, through a network of chief data and software officers in the various universities and organizations performing research;
- developing the economic models of open source software and making them known within valorization services;
- supporting the universal library of source code Software Heritage and recommending it for the archiving and referencing of source code.

Building an ecosystem that connects code, data and publications requires developing proper coordination between software forge operators, open publication archives, data repositories and the scientific publishing sector.

The French Open Science Monitor was developed by the Ministry of Higher Education and Research and Innovation, in partnership with Inria (the French National institute for research in digital science and technology) and Université de Lorraine. This monitor applies a generic text analysis process to publication contents to detect the use, production and openness of datasets and software. It uncovered several key facts:

- in 2021, 20% of French publications share their software and code;
- the academic fields with the biggest proportion of publications mentioning the use of code or software are: computer and information science; earth, ecology, energy and applied biology; fundamental biology. Moreover, mentions to code and software also appear in the fields of social sciences and humanities.

The French Plan for Open Science has provided France with a coherent and dynamic policy in the field of open science, and is firmly attached to a European-wide vision.

2 | Highlights from the sessions

2.1 | Recognition of research software contributions and visibility of research software

This session was designed to focus on the importance of recognizing research software contributions and making them visible. Methodologies and expectations concerning research software catalogs and tools to monitor software's evolution have been addressed. Mechanisms such as national awards and other approaches to career recognition for software contributions by researchers and engineers have also been discussed.

Chairs:

Mathieu Giraud: CNRS, University of Lille (France)

Violaine Louvet: CNRS, Jean Kuntzmann Laboratory, Grenoble Alpes University (France)

Speakers :

Michelle Barker: director of the Research Software Alliance (ReSA), former director of the Australian Research Data Common (ARDC) (Australia)

Jean-Paul Chaput: research engineer, Analog and Mixed Signal Team, LIP6 (France)

Sandrine Blazy: professor, University of Rennes; deputy director, IRISA laboratory (France)

Jean-Marie Saurel: research engineer, Institut de Physique du Globe (France)

Éric Jeangirard: data scientist, Ministry of Higher Education and Research (France)

Challenges to be addressed

- Measuring the impact of software in research requires to keep track of it. However, at the moment, software citation practices are inconsistent: some authors provide links to a forge, while others only mention the software name. This lack of consistency hampers discoverability, attribution, and reuse.
- Increasing the visibility of software calls for a strategy for culture change. Brian Nosek's strategy for culture change defines five levels of action:
    - "Make it possible": infrastructure (e.g.: Software Heritage and scholarly infrastructures);
    - "Make it easy": skills and training (e.g.: The Carpentries);
    - "Make it normative": communities supporting citation, software development, or even funding;
    - "Make it rewarding": incentives (e.g.: prizes, awards, career recognition);
    - "Make it required": policy (e.g.: https://www.researchsoft.org/software-policies/).
- Software visibility calls for a broad set of skills. Research software engineers and researchers need support, as they may not have the knowledge and time to make software visible, including through external communication.
- While software is widely used in all academic fields, lobbying in favor of its recognition is a necessity.
- Software's specificities call for a reform of the research assessment system. Tools and methods used for publications are not always relevant for software.

- Attributing credit to software creators and contributors is complex. The level of contribution to a software is not reducible to figures such as the number of code lines or commits pushed to a forge. Involvement in software is extremely diverse, involving many roles apart from code authorship.

Solutions to address the challenges

- The French Open Science Barometer uses a full-text approach from French publications to detect code and software. This approach is based only on publications for which the full text has been downloaded as part of the barometer. For now, the scope is national, but it should be extended to international publications in a second stage. An HTTP API is not yet provided, but the data sets are open and available: https://doi.org/10.57745/456JF7 .
- ReSA advances the research software ecosystem by collaborating with decision makers and key influencers. In collaboration with the Research Data Alliance, a working group about policies has been created.
- Acknowledging software impact in research is of paramount importance. Software has to be recognized as a research output in itself. In France, the Open Science Software Award is designed to take into account its diversity among disciplines and research communities: the existence of several categories is a way to promote different paths to software excellence. Australia also developed a prize, based on the French award. These awards go beyond formal recognition because, in research institutions, prizes have an impact on career promotions.
- The Amsterdam Declaration on Funding Research Software Sustainability (ADORE.software) is an example of a lobbying initiative to support research software staff. The ADORE.software Toolkit aims to support implementation of the Declaration. It provides examples of funded programs, policies, and resources for each of the Declaration's recommendations in the four areas of research software practice, research software ecosystem, research software personnel, and research software ethics.
- The SoFAIR project (from Making Software FAIR) aims to address the critical issue of the lack of traceability of software mentions, by enhancing the management of the research software lifecycle and ensuring research software and data adheres to the FAIR (Findable, Accessible, Interoperable, and Reusable) principles.

Promotion criteria should evolve, in order to go beyond quantitative indicators. The question is less the extent of the contribution than its impact on the project. For instance, contributing to the creation of useful documentation should be taken into account by evaluation committees.

Related documents and resources

The French Open Science Barometer

The Amsterdam Declaration on Funding Research Software Sustainability

The RDA/ReSA working group about software policies

2.2 | Software contribution to research reproducibility

This session focused on the contribution of software to research reproducibility. The discussions aimed at identifying challenges, opportunities, and best practices to enhance reproducibility and transparency in research, emphasizing the role of software and development practices.

Chair:

- **Nicolas Rougier**: Inria, University of Bordeaux, CNRS (France)

Speakers:

- **Sorina Camarasu-Pop**: research engineer in distributed computing at CREATIS laboratory, Lyon; managing director of the Virtual Imaging Platform; laureate of the CNRS crystal medal in 2021 (France)
- **Anne Laurent**: professor in informatics; vice-president for open science and research data at University of Montpellier; head of the informatics and management department; director of ISDM (France)
- **Étienne Roesch**: professor at the School of Psychology and Clinical Language Sciences at the University of Reading; programme director of the MSc Cognitive Neuroscience; deputy director of CINN (United Kingdom)

Challenges to be addressed

- There is no unique definition of reproducibility.
- Researchers may be reluctant to invest time and energy to increase the reproducibility of their work because some of them don't perceive the added-value.
- When people are not trained very early in their career to reproducibility's best practices, it's harder for them to integrate these methods and tools.
- It is difficult to define upstream the proper level of reproducibility to be reached.
- More resources are needed to support researchers in their effort towards a more reproducible research.
- The industry too faces the reproducibility challenge.

Solutions to address the challenges

- Journals should provide accurate workflows to enable reviewers to reproduce results with a platform. The source code should be available on the platform.
- Delivering training and offering support to different stakeholders: researchers, engineers but also reviewers and publishers. From this respect, the Mooc "Reproducible research": methodological principles for transparent science" provides guidance for researchers from different academic fields.
- The Virtual Imaging Platform (VIP) has been mentioned as an example of open service (web portal) for medical simulation and image data analysis, providing an easy to use environment to more than 1200 scientists worldwide.

Related documents and resources

The website of the French reproducible research network

The Turing Way handbook to reproducible, ethical and collaborative data science

2.3 | Social impact and sustainability of publicly funded research software

Impact is a broad concept that goes beyond mere technological transfer, and software sustainability needs to be addressed globally from financial, organizational, and technical perspectives. This session explored this complex issue, reviewing guidelines from financing bodies and institutions, as well as various approaches to support and maintain over time software of proven use.

Chair:

- **Daniel Le Berre**: University of Artois, CNRS

Speakers:

- **Pierre Boulet**: professor in informatics and vice-president for digital matters at University of Lille, France; president of VP-Num, the association of VPs for digital matters in French universities
- **Almudena Claudio García**: director of technological and digital innovation at the Spanish Foundation for Science and Technology (FECYT)
- **Maria Cruz**: program leader for open research software and senior policy advisor for open science at Open Science NL, part of the Duch Research Council (NWO); chair of the Science Europe Working Group on Open Science.
- **Josh Greenberg**: director of the technology program at the Alfred P. Sloan Foundation; member of the U.S. National Academies' Board on Research Data and Information; member of the American Council of Learned Societies' Commission on Fostering and Sustaining Diverse Digital Scholarship; board advisor for Code for Science and Society
- **Dario Taraborelli**: science program officer at the Chan Zuckerberg Initiative (CZI); co-founder of the Initiative for Open Citations

Challenges to be addressed

- Policies are needed to make a culture change.
- Due to the lack of monitoring, it is very difficult to estimate the percentage of research software production that reaches the society outside academia.
- There is not enough research studying open source and scientific software.
- Even if tools such as software management plans are available, training support is required.
- To make the distribution of research software as open source software sustainable, requires extra workforce and funding.
- The allocation of budget should be re-designed because at the moment, it is easier to pay a license fee than to get some funding for software maintenance.

Solutions to address the challenges

- Distributing a research software under an open source license may extend its impact. Creating and nurturing communities of practice is an important stake. Other questions should be answered as early as possible in the project lifespan: is there going to be a formalized governance? Will there be a maintainer? Who takes the responsibility?
- The eScience center devised software management plans. A software management plan (SMP) helps to implement best practices during software development and ensures that software is accessible and reusable in the short and longer terms. It also contributes to the reproducibility of

results and stimulates collaborative work on open-source software for research. SMPs offer different levels of management, and the high level contains support and risk analysis.

- The labor of maintaining and scaling open source software should be acknowledged, by appearing on mission statements of research oriented jobs.
- Software should not be compared with publications: publications are much more static then software, that evolves over time, that can be modified.
- In the United States, open source program offices (OSPOs) may be found in multiple universities: it "is the center of competency for an organization's open source operations and structure. Its role can include setting code use, distribution, selection, auditing, and other policies, as well as training developers, ensuring legal compliance, and promoting and building community engagement that benefits the organization strategically."

Related documents and resources

- Universités : l'« open education », clé de la résilience post-Covid ?
- L'écosystème du Libre à l'université, in La collection numérique n° 13, p. 10
- Ten simple rules for funding scientific open source software
- Practical Guide to Software Management Plans
- The CZI Open Science program
- Essential Open Source Software for Science program
- The Altmetrics Manifesto
- New data reveals the hidden impact of open source in science
- Dario Taraborelli blog : https://nitens.org
- What is an Open Source Program Office and why you should have one

3 | Closing remarks

3.1 | Closing remarks from Bhanu Neupane

Closing remarks from Bhanu Neupane, Programme Manager for ICT and Sciences and Open Access to Scientific Research, Unesco [Transcription from the floor discussion]

In this speech, I will mostly read out the notes that I took during the very engaging discussions you had during the course of the afternoon.

My first message is to invite you to join a process started some years ago, on opening research for every one. Some of you mentioned the Recommendation on Open Science. In this Recommendation, which our 184 Members agreed on precisely two years ago today, you will find software cited 19 times, acknowledging its role as a pillar of open science. The promotion of open-source software, a strong tool that encompasses concepts critical to the evolution of our common knowledge, is at the heart of this Recommendation.

Software is not just a product, but also a tool, a process that advances open science and a content in and around open science. For instance, the Recommendation emphasizes software as a foundation for providing accessible data-bases, allowing researchers to scrutinize methodologies, and ensure accountability and reliability in scientific research.

Reproducibility is another pillar in open science, which needs to be explored and discussed also within the context of software. The panel discussion on reproducibility rhymed with the Recommendation on Open Science. Indeed, reproducibility encourages the development of processes that allow for the sharing of code and tools used in experiments, enabling verification and cooperation.

Collaboration is yet another pillar mentioned in the Recommendation. Collaboration is mandatory for open science, particularly also between the North and the South. It requires scientists from many disciplines and institutions to work together in order to contribute to improving and increasing the capabilities of scientific tools. This iterative development, which is a hallmark of open source, drives innovation by allowing for constant adaptability to changing scientific needs.

Another hallmark of the Recommendation is a call to strive for interoperability. Interoperability was not as forcefully discussed as it should have been today. If software is to be at the heart of openness, advancing interoperability is a must, in helping democratizing access to computational tools around the world, particularly in developing countries we are answerable to.

The Recommendation also stated that open source should be used as an educational resource. To provide insights into best practices, coding standards, and new advanced techniques, more accessible teaching tools and processes are required. While evocating the features for sustainability, the panel did note the need for continuous capacity building as a support feature for free and open-source software to remain useful.

In my opinion, today, there was a missing discussion on openness of AI as a tool for scientific research. As AI becomes a more vital tool for advancing science, the community's involvement in developing open AI initiatives is essential.

Also, software fuels better utilization of data. One crucial takeaway from the advice is that software aids in doubling the pace of data processing; hence, it is critical that software initiatives entice more and more projects to profit from open data. It simplifies data sharing, analysis, and collaboration, resulting in a more open and linked approach to data-driven research.

If we look at French open science monitoring, we can see that software has been the foundation for generating crucial indicators that let us gauge the openness of science across its various pillars, such as open access to research, open data, and so on.

I would like to underline here that progress monitoring is critical in the quest of open science. Thus, from the standpoint of software, the development and inclusion of a few key indicators in the open science monitoring system is critical.

The incorporation and influence of open software and source codes in the scientific process has to be assessed. In two years, all 184 UNESCO member States will be invited to report on their progress in

mainstreaming open science in their developmental routes. When they do so, providing simple country-level metrics can not only serve as benchmarks, but also aid Member States in furthering the adoption of open source software.

It is essential to suggest, develop and recommend to Member States a few important metrics to be integrated in open-science monitoring frameworks. These indicators could comprise the number of open source projects across fields, community engagement levels, consumption statistics, or reproducibility. funding, or sustainability indicators, to emphasize the need of long-term support for the preservation and growth of open source scientific tools and communities. The amount and utilization of code repositories, software citations in papers, and integration with open data platforms are some more indicators that might illuminate the concrete impact of open source tools on scientific research. Calculating reproducibility rates, interoperability and accessibility metrics, innovation effect assessments, and educational adoption indicators, for example, could assist in highlighting the global availability, influence, and integration of open source software in scientific organizations.

By including these indicators into the open science monitoring process, member states can be encouraged to actively contribute to and benefit from the growing software ecosystem. Not least, this has the potential to build a worldwide ecosystem that values transparency, collaboration, and creativity across scientific fields.

As a result, I'd like to take advantage of this occasion to ask for your participation in developing a framework for key indicators analyzing the influence of software on scientific openness. On December 19th, 2023, UNESCO and the French Ministry will host a one-day workshop in Paris on building an Open Science Monitoring Framework, using open technologies. We will examine how robust open technologies are available to assist capture the progress made on open research as a result of this summit, and try to replicate it around the world.

As a last point, I would like to stress that software is ubiquitous in the digital age. However, a critical component of open science, software heritage and preservation, was overlooked. Recognizing this, UNESCO and Inria have joined forces to launch the 'Paris Call on Software Source Code as Heritage for Sustainable Development.' This program promotes open science ideals while acknowledging software's role as human knowledge and creative problem-solving.

The Software Heritage project, which is now six years old, is the world's first repository for preserving and curating software source code. This shared commitment to safeguarding digital legacy exemplifies the spirit of Open Science – a pillar of our present and a driver of a sustainable future.

3.2 | Closing remarks from Marin Dacos

Closing remarks from Marin Dacos, national coordinator for open science for the French ministry of higher education and research [Transcription from the floor discussion]

Software may be compared as a “hidden continent”: it is a pillar of science and society, yet it is hardly mentioned in research policies, even in open science policies. This is now changing, as many countries are defining and implementing open source software policies, but we are only at the beginning of this process. Hence, we are here to learn from you, to hear your recommendations, and to challenge you, as well as you may challenge us here, about the way forward.

For instance, we do not have yet a clear view on how to address the sustainability challenge. In this respect, the nightmare for a Ministry would be to have to sustain thousands of software, each of them being used by a few users only. A proposal is to be able to provide easily some money for projects coming from the users, and not in a top-down approach. Indeed, top-down approaches have often lead to “white elephants”: objects that cost a lot, with no result, no success, and no interest from the community. We need to look for ways to create lively ecosystems.

The whole life cycle has also to be considered. Like journals, software may die. Therefore, archiving software is a priority. However, even before this happens, can we implement relevant actions during all the software life-cycle, and after, to help preserve it?

Another considerable challenge is reproducibility. Many researchers are upset when trying to implement open science principles, but it is even more so with reproducibility: most of them consider it an unreachable goal. Consequently, this issue has to be addressed by levels: trust is a first step, and reproducibility is the ultimate stage.

France is actively promoting abroad its vision of open science. For instance, in 2021, when France chaired the Council of the European Union, all 27 countries of the EU unanimously voted the EU Council conclusions on open science, advocating for a reform of the research assessment system. This text emphasized the great diversity of academic products and activities, which includes research software. This led to the creation of the Coalition for advancing research assessment (CoARA), a body created by members in the EU, but which is open to organizations abroad.

We need to learn more from science on science, and there is clearly a need for a global coordination of research on research. In this context, we consider it is paramount to create an open science monitoring framework, in the context of a global coalition to coordinate research on open science. It is also important to coordinate the coordinators. In 2018, only the Netherlands and Finland created such positions in Europe. Now, the CoNOSC (Council for National Open Science Coordination) network brings together representatives from 26 countries. The CoNOSC is a light-weight structure, which helps the coordinators to synchronize and to push their national agendas, and learn from others.

Monitoring is the cornerstone of public policy. The first step is to understand what needs to be changed. There is no public policy without knowing what we are trying to regulate. Therefore in France, the Barometer of Open Science had been implemented even before implementing policies. Now, we know if our policies have influence. One of these indicators, which may be perfectible, concerns software sharing.

The workshop that will take place on the 19th of December aims at setting-up principles for an open science monitoring framework. At this stage, it is not about providing tools, technologies, or software. Before that, we need principles and specifications for implementing and monitoring open science, in order for countries to compare with others. Here as well, your contributions are most welcome.

To conclude, I want to thank the organizers of today's event, and to thank you all for your participation. We will be happy to have feedback from tomorrow's conference.

4 | Resources of interest

- Second French Plan for Open Science: https://www.ouvrirlascience.fr/second-national-plan-for-open-science/
- The “Software and source code” college: https://www.ouvrirlascience.fr/software-and-source-codes-college/
- Blog post about the college mission and subgroups: https://www.ouvrirlascience.fr/research-software-as-a-pillar-of-open-science/
- Software forges in higher education: https://www.ouvrirlascience.fr/higher-education-and-research-forges-in-france-definition-uses-limitations-encountered-and-needs-analysis/
- Opportunity notes on software in Higher Education and Research: https://www.ouvrirlascience.fr/opportunity-note-encouraging-a-wider-usage-of-software-derived-from-research/
- Introduction to source code and software for Higher Education: https://www.ouvrirlascience.fr/source-code-and-software/
- How to archive and reference source code: https://www.softwareheritage.org/howto-archive-and-reference-your-code/
- Data, source code and algorithms roadmap for the French Ministry of Higher Education and Research (in French): https://www.ouvrirlascience.fr/politique-des-donnees-des-algorithmes-et-des-codes-sources-feuille-de-route-2021-2024/
- News from the Open Science Committee: https://www.ouvrirlascience.fr/category/news/blog-en/
- Educational resources in English from the Committee for Open Science: https://www.ouvrirlascience.fr/the-passport-for-open-science-collection-has-been-enriched/