

Towards a Software Pillar for Open Science

from policy to implementation

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Software Heritage
THE GREAT LIBRARY OF SOURCE CODE

- 1 Introduction
- 2 Open Science
- 3 A policy framework is emerging
- 4 Towards implementation: assessing the needs for a software pillar
- 5 Focus on ARDC and infrastructures
- 6 Demo time!
- 7 Actions



Short Bio: Roberto Di Cosmo

Computer Science professor in Paris, now working at INRIA

- 30+ years of research (Theor. CS, Programming, Software Engineering, Erdos #: 3)
- 20+ years of Free and Open Source Software
- 10+ years building and directing structures for the common good



1999 *DemoLinux* – first live GNU/Linux distro

2007 *Free Software Thematic Group*

150 members 40 projects 200Me

2008 *Mancoosi project* www.mancoosi.org

2010 *IRILL* www.irill.org

2015 *Software Heritage* at INRIA

2018 *National Committee for Open Science*, France

2021 *EOSC Task Force on Infrastructures for Software*,
European Union

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Why Open Science?

Open Science ([Second National Plan for Open Science](#), France, 2021)

Unhindered dissemination of results, methods and products from scientific research. It draws on *the opportunity provided by recent digital progress* to develop *open access to publications* and – as much as possible – *data, source code and research methods*.

Jean-Eric Paquet (EU DGRI, [on the objective of Open Science](#))

“Increase scientific quality, the pace of discovery and technological development, as well as societal trust in science.”

Mariya Gabriel ([EU Commissioner](#) for Research)

The COVID-19 crisis has also shown that cooperation at international level in research and innovation is more important than ever, including through *open access to data and results*. *No nation, no country can tackle any of these global challenges alone.*

Yuval Noah Harari (on COVID 19)

“The real antidote [to epidemic] is scientific knowledge and global cooperation.”

Two well known pillars of Open Science

Open Access (a long, painful, unfinished story)

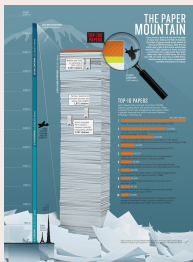
- 19XX's compulsory exclusive copyright transfer to publishers (unlawful?)
(notable exceptions: [US federal agencies](#) and [UK Crown Copyright](#))
 - 1990's Internet, Web and ArXiv break the [marriage of convenience of researchers with publishers](#)
 - 2000's declarations (Budapest, 2001; Berlin 7, 2009) and actions (LIPIcs, 2009)
 - 2010's reactions (SciHub, 2011; [Plan S](#), 2018) and transformations ([not so easy](#))
- TL;DR: see [my viewpoint in 2005](#) and [the SIGPLAN blog in 2020](#)

Open Data (less painful, but still unfinished story)

- 1957-1958: International Geophysical Year shows the way
- 2006 (and 2021): OECD recommendation on [publicly funded research data](#)
- 2016 and later: FAIR terminology (*focus on metadata, sort of forgets open...*)

Software is a pillar of Open Science

Software powers modern research



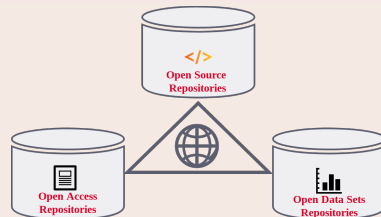
[...] software [...] essential in their fields.

Top 100 papers (Nature, 2014)

Sometimes, if you don't have the software, you don't have the data

Christine Borgman, Paris, 2018

A key pillar: software (source code)



The links in the picture are **important**

Nota Bene

software may be a *tool*, a *research outcome* and a *research object*

access to the *source code* is essential!

Preserving (the history of) source code is necessary for *reproducibility*

Software Source Code is Precious Knowledge

Harold Abelson, Structure and Interpretation of Computer Programs (1st ed.)

1985

“Programs must be written for people to read, and only incidentally for machines to execute.”

Apollo 11 source code (excerpt)

```
P63SP0T3      CA      BIT6      # IS THE LR ANTENNA IN POSITION 1 YET
              EXTEND
              RAND   CHAN33
              EXTEND
              BZF    P63SP0T4      # BRANCH IF ANTENNA ALREADY IN POSITION 1

              CAF    CODE500      # ASTRONAUT: PLEASE CRANK THE
              TC     BANKCALL      # SILLY THING AROUND
              CADR   GOPERF1
              TCF    GOTOP00H      # TERMINATE
              TCF    P63SP0T3      # PROCEED SEE IF HE'S LYING

P63SP0T4      TC     BANKCALL      # ENTER INITIALIZE LANDING RADAR
              CADR   SETPOS1

              TC     POSTJUMP      # OFF TO SEE THE WIZARD ...
              CADR   BURNBABY
```

Quake III source code (excerpt)

```
float Q_rsqrt( float number )
{
    long i;
    float x2, y;
    const float threehalfs = 1.5F;

    x2 = number * 0.5F;
    y = number;
    i = * ( long * ) &y; // evil floating point bit level hacking
    i = 0x5f3759df - ( i >> 1 ); // what the fuck?
    y = * ( float * ) &i;
    y = y * ( threehalfs - ( x2 * y * y ) ); // 1st iteration
    // y = y * ( threehalfs - ( x2 * y * y ) ); // 2nd iteration, this
    // can be removed

    return y;
}
```

Len Shustek, Computer History Museum

2006

“Source code provides a view into the mind of the designer.”

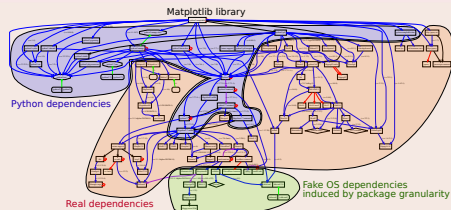
Source code is *special* (software is *not* data)

Software *evolves* over time

- projects may last decades
- the *development history* is key to its *understanding*

Complexity

- *millions* of lines of code
- large *web of dependencies*
 - easy to break, difficult to maintain
 - *research software* a thin top layer
- sophisticated *developer communities*



The human side

design, algorithm, code, test, documentation, community, funding

and so many more facets ...

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RECOMMENDATIONS

COMMISSION RECOMMENDATION (EU) 2018/750

of 25 April 2018

on access to and preservation of scientific information

THE EUROPEAN COMMISSION,

Having regard to the Treaty on the Functioning of the European Union, and in particular Article 292 thereof,

Whereas

- (1) The European Commission adopted in July 2012 a scientific information package, consisting of the communication 'Towards better access to scientific information: Boosting the benefits of public investments in research' (1) and of Commission Recommendation 2012/417/EU (2). Recommendation 2012/417/EU states that the Commission will review the progress made across the Union to assess whether further action is needed to achieve the objectives laid down.
- (2) The communication 'A Digital Single Market Strategy for Europe' (3) highlights the importance of data driven from an enabling for economic growth, innovation and digitalisation across all economic sectors, particularly for small and medium-sized enterprises (and start-ups) and for society as a whole. It recognises that big data and high-performance computing are changing the way research is performed and knowledge is shared as part of a transition towards a more efficient and responsive open science (4). It announces that the Commission would encourage access to public data to help drive innovation and work towards a research open science cloud as part of the European Cloud Initiative. In its mid-term review of the Digital Single Market Strategy (5), the Commission announces its intention to further improve the accessibility and re-use of public and publicly funded data.
- (3) The communication on the European Cloud Initiative: Building a competitive data knowledge and economy in Europe (6) presents the revised and broad plan for developing the European Open Science Cloud (EOSC) as a trusted, open environment for scientific communities for storing, sharing and re-using scientific data and results. It also announces the Commission would see Recommendation 2012/417/EU on access to and preservation of scientific information as encouraging scientific data sharing and the creation of scientific systems, research systems and education and training programmes for researchers and business to share data. The Staff Working Document 'Implementation Roadmap for the EOSC' (7) presents the results of the consultation with Member States and stakeholders of possible governance and financing mechanisms for the EOSC, and further details the action lines for developing the EOSC as a Federation of research data infrastructures.
- (4) Directive 2003/98/EC of the European Parliament and of the Council (8) establishes the principle that all accessible data held by a public sector body need to also be made available for commercial and non-commercial purposes by all interested parties under non-discriminatory conditions for a comparable category of re-use and at the marginal cost linked to the distribution of the data at minimum.

(1) COM(2012) 401 final of 17 July 2012.

(2) Commission Recommendation 2012/417/EU of 17 July 2012 on access to and preservation of scientific information (OJ L 194, 21.7.2012, p. 16).

(3) COM(2015) 192 final of 5 May 2015.

(4) Open science refers to an approach to scientific progress based on cooperative work and new ways of disseminating knowledge, ensuring accessibility to a wide variety of research outputs by using digital technologies and/or collaborative tools.

(5) COM(2017) 229 final of 10 May 2017.

(6) COM(2018) 17 final of 17 April 2018.

(7) SWD(2018) 6 final of 14 March 2018.

(8) Directive 2003/98/EC of the European Parliament and of the Council of 17 November 2003 on the re-use of public sector information (OJ L 345, 31.12.2003, p. 96).

Selection from EU 2018 recommendation

"Member States should set and implement clear policies (as detailed in national action plans) for"

- Preservation and re-use of research outputs
"reinforcing the preservation and re-use of scientific information (publications, data sets and other research outputs)"
- Infrastructures
"further developing infrastructures underpinning the system for access to, preservation, sharing and re-use of scientific information and"

The Paris Call on Software Source code (2019, UNESCO)

Experts call for greater recognition of software source code as heritage for sustainable development

6 November 2018



UNESCO, Inria, Software Heritage invite
40 international experts to meet in Paris



The call is published on Feb 2019

"[We call to] promote software development as a valuable research activity, and research software as a key enabler for Open Science/Open Research, sharing good practices and recognising in the careers of academics their contributions to high quality software development, in all their forms"

<https://en.unesco.org/foss/paris-call-software-source-code>

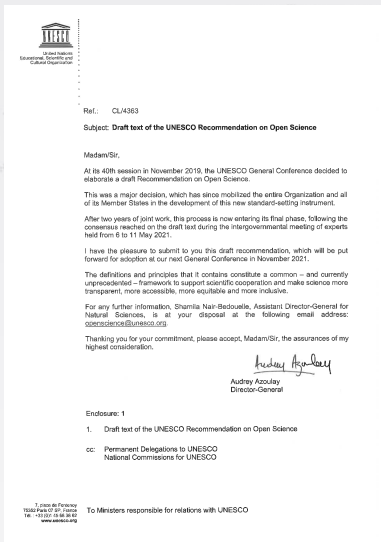
Selection from [the recommendations](#)

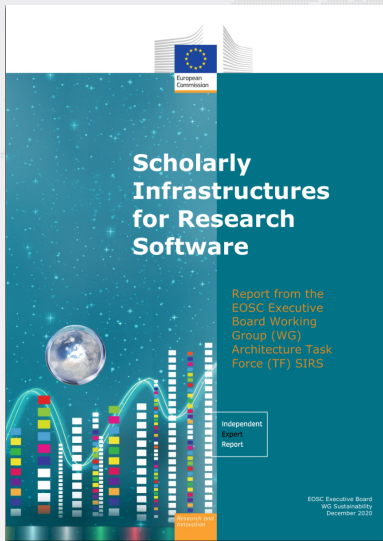
- Open Source for Open Science

"The source code must be included in the software release and made available on openly accessible repositories and the chosen license must allow modifications, derivative works and sharing under equal or compatible open terms and conditions"

- Infrastructures

"Open science infrastructures should be organized and financed upon an essentially not-for-profit and long-term vision, which enhance open science practices and guarantee permanent and unrestricted access to all, to the largest extent possible."



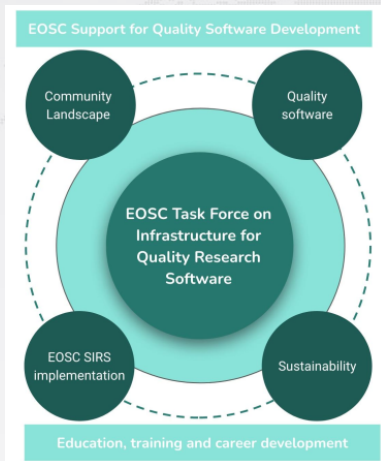


Important *policy tool* in Open Science (Dec 2020)

- 9 infrastructures
 - 3 archives
 - 3 open access publishers
 - 3 aggregators
- recommendations
 - **archive in Software Heritage, use SWHID**
 - **open non profit**
 - **default to open source** for research software

"all research software should be made available under an Open Source license by default, and all deviations from this default practice should be properly motivated"

See <https://doi.org/10.2777/28598>



Ongoing action in the EOSC

Task force on infrastructures for quality research software

- Foster the development and deployment of tools and services that allow researchers to properly archive, reference, describe with proper metadata, share and reuse research software.
- Improve the quality of research software, both from the technical and organizational point of view ...
- Increase recognition to software developers and maintainers of research software ...

See [the charter of the task force](#).



2nd National Plan for Open Science (6/7/2021)

Open and promote research software source code

- actions (selection)
 - charter for research software policy
 - recognize software development (see [announcement of the 2021 prize](#))
 - coordinate communities of practice
 - connected ecosystem of research outputs
- recommendations (selection)
 - archive in Software Heritage
 - standardise and use SWHID
 - build a national catalog of research software
 - leverage ADAC network

See [official announcement](#)

Breaking news: the [Software Chapter of the CoSO is live!](#)



MINISTÈRE
DE L'ENSEIGNEMENT
SUPÉRIEUR
ET DE LA RECHERCHE

*Liberté
Égalité
Fraternité*

[Accueil](#) > [Recherche](#) > [Science ouverte](#)

Publié le 05.02.2022

Sommaire

- [The Coq proof assistant](#) : lauréat de la catégorie Scientifique et technique
- [Scikit-learn](#) : lauréat de la catégorie Communauté
- [Faust](#) : lauréat de la catégorie Documentation
- [Gammapy](#) : prix du jury
- [Jury](#)

Remise des prix science ouverte du logiciel libre de la recherche

Le ministère de l'Enseignement supérieur, de la Recherche et de l'Innovation remet pour la première année les Prix science ouverte du logiciel libre de la recherche. Dix logiciels mis au point par des équipes françaises sont récompensés pour leur contribution à l'avancée de la connaissance scientifique.

Five action lines

- Identifying and highlighting research software production
- Technical and social tools and best practices
- Valorization and sustainability
- Liaison and animation at national, European, and international levels
- Recognition and careers

Leveraging experience and connections

- Open Source thematic group in Systematic (since 2007, more on demand)
- Collaboration with DINUM, Eclipse Foundation, OW2, ...

The Open Science award for Open Source research software

See [the official page at MESRI](#)

Twenty-four active members

Chairs: Roberto Di Cosmo and François Pellegrini

- Florent CHUFFART (Univ Grenoble Alpe)
- Mélanie CLÉMENT-FONTAINE (Univ Paris-Saclay - Versailles Saint-Quentin)
- Laurent COSTA (UMR 7041 ArScAn)
- Ludovic COURTÈS (Inria)
- Sébastien GÉRARD (Univ Paris-Saclay, CEA, List)
- Mathieu GIRAUD (CNRS, Univ Lille)
- Timothée GIRAUD (CNRS)
- Jean-Yves JEANNAS (Univ Lille, AFUL)
- Nicolas JULLIEN (IMT Atlantique)
- Daniel LE BERRE (Univ Artois, CNRS)
- Violaine LOUVET (CNRS / GRICAD - Univ Grenoble Alpes)
- Camille MAUMET (Inria, Univ Rennes, CNRS, Inserm)
- Clémentine MAURICE (CNRS)
- Grégory MIURA (Univ Bordeaux Montaigne)
- Raphaël MONAT (LIP6, Sorbonne Université)
- Patrick MOREAU (CNRS)
- Sophie RENAUDIN (AP-HP)
- Nicolas ROUGIER (Inria, Univ Bordeaux, CNRS)
- Filippo RUSCONI (CNRS-Univ Paris-Saclay)
- François SABOT (IRD)
- Sylvie TONDA-GOLDSTEIN (Inria)
- Samuel THIBAUT (Univ Bordeaux) (Univ Paris-Saclay)

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A plurality of needs

Researchers

- **archive** and **reference** software used in articles
- **find** useful software
- get **credit** for developed software
- verify, **reproduce**, improve results

Laboratories/teams

- **track** software contributions
- produce reports
- maintain web page

Research Organization

know its **software assets**

- technology **transfer**
- **impact metrics**
- funding **strategy**
- career **evaluation**

Archive

Research software artifacts must be properly **archived**
make sure we can *retrieve* them (*reproducibility*)

Reference

Research software artifacts must be properly **referenced**
make sure we can *identify* them (*reproducibility*)

Describe

Research software artifacts must be properly **described**
make it easy to *discover* and *reuse* them (*visibility*)

Cite/Credit

Research software artifacts must be properly **cited** (*not the same as referenced!*)
to give *credit* to authors (*evaluation!*)

What is at stake: beyond ARDC

Sustainability, technology transfer

Organisational schemas, legal tools, economic models, processes and policies to ensure research software can be maintained and sustained over time, maybe in connection with industry

Evaluation (funding, careers, etc.)

beware of *naive software citation counting!*

- human-in-the-loop evaluation (see the [French National Prize](#))
- identify *roles* in software projects, see:



P. Alliez, R. Di Cosmo, B. Guedj, A. Girault, M.-S. Hacid, A. Legrand and N. Rougier
Attributing and referencing (research) software: Best practices and outlook from Inria,
CiSE 2020 ([10.1109/MCSE.2019.2949413](https://doi.org/10.1109/MCSE.2019.2949413))

Regulations are coming

software management plans, licensing, metadata and identification standards

What is at stake: before ARDC

Development practices and tools

- version control system
- key metadata information (README, AUTHORS, LICENCE, etc.)
- build system
- test suites
- continuous integration
- ...

Opening up

- documentation
- community building
- ...

needs proper training, and identification of best practices

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Where is the source code?

Collaborative development platforms (aka "forges")

- BitBucket, GitLab(.com), GitHub, etc.
- support for version control, issues, etc.
- example:
 - <https://github.com/rdicosmo/parmap>
 - <https://gitlab.inria.fr/gt-sw-citation/bibtex-sw-entry/>

Distribution platforms

- CTAN, CRAN, PyPi, Debian, etc.
- example: <https://ctan.org/pkg/biblatex-software>

Archives

- Software Heritage
- example: [archived version of biblatex-software](#)

Forges are *not* archives!

2015: the first big bad news

Google Code and Gitorious.org shutdown: ~1M endangered repositories

- broken links in the web of knowledge (my papers too)

2019: big bad news keep coming in

- summer 2019: BitBucket announces Mercurial VCS sunset
- july 2020: BitBucket erases 250.000 repositories (including research software)

2021: ... in Academia too

- october 2021: Inria's old gforge is unplugged
 - **breaks the build chain** of the OCaml package manager (Opam)

Bottomline

we need a universal archive of software source code: now we have one!



Software Heritage

THE GREAT LIBRARY OF SOURCE CODE

Collect, preserve and share *all* software source code

Preserving our heritage, enabling better software and better science for all

Reference catalog



find and **reference** all software source code

Universal archive



preserve all software source code

Research infrastructure



enable analysis of all software source code

The largest software archive, a shared infrastructure

Cultural Heritage



Industry



Research



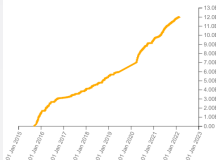
Public Administration



Software Heritage

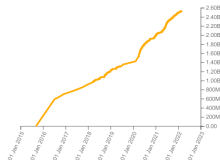
Source files

12,032,627,304



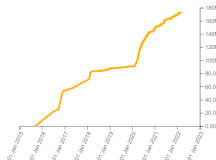
Commits

2,536,918,821



Projects

173,242,749



Directories

9,946,192,395

Authors

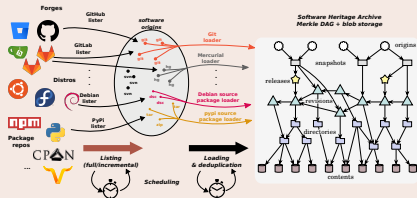
47,334,620

Releases

31,763,605

Addressing the four needs (see ICMS 2020 for details)

Archive (12B+ files, 170M+ projects)



- save.softwareheritage.org
- deposit.softwareheritage.org

Describe

- *Intrinsic metadata* from source code
- Contributed the [Codemeta generator](#)

Reference (20 billion SWHIDs)

Intrinsic, decentralised, cryptographically strong identifiers, SWHIDs



Now supported in [SPDX 2.2](#), [Wikidata](#) etc.

Cite/Credit

- Contributed *software citation* style
[biblatex-software](#), v 1.2-2 now on [CTAN](#)

Archiving and referencing

For **all source code** used in research (*yes, even small scripts!*)

- ensure it is archived in Software Heritage (see [save code now](#))
- get the proper **SWHID** for your software (see [detailed HOWTO](#))
- add it to research articles for reproducibility (see [detailed HOWTO](#))

Describing and Citing/Crediting

For **software you want to put forward** (*mention in your CV, reports, etc., get citations and credit for it*), do the following **extra steps**:

- add **codemeta.json** with description (see the [codemeta generator](#))
- reference in the HAL portal (french partners, see [online HAL documentation](#))
- cite software using the [biblatex-software](#) package (in CTAN and TeXLive)

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Overview of the Software Heritage / HAL synergy

<https://hal.archives-ouvertes.fr/hal-02130801>

Free and accessible knowledge

Home | Submit | Browse | Search | Documentation

HAL
ARCHIVES-OUVERTES

Abstract: LinBox is a C++ template library of routines for solution of linear algebra problems including linear system solution, rank, determinant, normal polynomial, characteristic polynomial, and Smith normal form. Algorithms are provided for matrices with integer entries or entries in a finite field. A number of matrix storage types is provided, especially for blockwise representation of sparse or structured matrix classes. A few algorithms for rational matrices are available. LinBox also uses underlying data structures and algorithms for integer, rational, polynomial, finite fields and rings, as well as dense and sparse matrix formats coming from the "Givens" (<https://www.givens.org/papers/engrav-givens-rijndael/>) and "FFLAD-FRANCK" (<http://hal.archives-ouvertes.fr/hal-00000043>) libraries.

Document type: **Software Heritage**

Domains: **Computer Science [cs]**, **Computer Science [cs] | Symbolic Computation [cs.SC]**

Complete list of metadata: **None**

BROWSE

Software Heritage

sw:1:dir:393b611a1424f032e83569bf6762502371cfc6f6

Browse the archive Enter a SWHID to resolve or keyword(s) to search for it

<https://hal.archives-ouvertes.fr/hal-02130801>

14 June 2019, 13:43 UTC

Code Branches (1) Releases (0) Visits

Revision: e8e18328952266b775c692963b11963b1496107 393b611 / linbox-1.6.3 / linbox / config-bias.h

Tip revision: e8e18328952266b775c692963b11963b1496107 authored by Software Heritage on 11 June 2019, 08:12 UTC

hal: Deposit 297 in collection hal

config-bias.h

```
1 /* config-bias.h
2 * Copyright (c) 2005 Pascal Giorgi
3 * 2007 Clement Perret
4 * Written by Pascal Giorgi <pgiorgi@waterloo.ca>
5 *
6 * =====LICENSE=====
7 * This file is part of the Library LinBox.
8 *
9 * LinBox is free software: you can redistribute it and/or modify
10 * it under the terms of the GNU Lesser General Public
11 * License as published by the Free Software Foundation; either
12 * version 2.1 of the License, or (at your option) any later version.
13 *
14 * This library is distributed in the hope that it will be useful,
15 * but WITHOUT ANY WARRANTY; without even the implied warranty of
16 * MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE. See the GNU
17 * Lesser General Public License for more details.
18 *
19 * You should have received a copy of the GNU Lesser General Public
20 * License along with this library; if not, write to the Free Software
21 * Foundation, Inc., 51 Franklin Street, Fifth Floor, Boston, MA 02110-1301 USA
22 * =====LICENSE=====
23
24 #ifndef LINBOX_CONFIG_BIAS_H
```

sw:1:dir:393b611a1424f032e83569bf6762502371cfc6f6

For italian colleagues: compare the HAL example above with an example from IRIS

- Browse [the archive](#)
- [Trigger archival](#) of your preferred software in a breeze
- Get and use SWHIDs ([full specification available online](#))
- Example with Parmap: [development on Github](#), [archive in SWH](#), [curated deposit in HAL](#)
- [Curated deposit in SWH via HAL](#), see for example: [LinBox](#), [SLALOM](#), [Givaro](#), [NS2DDV](#), [SumGra](#), [Coq proof](#), ...
- Extracting all the software products [for Inria](#), [for CNRS](#), [for LIRMM](#) or [for Rémi Gribonval](#) using HalTools
- Example in a journal: [an article from IPOL](#)

Growing adoption of SWH in Academia (selection)

HAL software curated deposit workflow

Curated Archiving of Research Software Artifacts
International Journal of Digital Curation, 2020

Reference archive for swmath.org



See *code* links, e.g.
SemiPar package

IPOL (image processing)



- archive (deposit)
- reference
- **BibLaTeX**

eLife (life sciences)



- archive (save code now)
- reference

JTCAM (mechanics)

- **instructions for authors**
- biblatex-software in journal \LaTeX class

Policy: France



National Plan for Open Science

Policy: Europe



EOSC SIRS report

- SWHIDs
- archive

Guidelines



Software Heritage

- 1 Prepare your public repository README, AUTHORS & LICENSE files
- 2 Save your code <http://dx.doi.org/10.26434/chemrxiv-2019-07>
- 3 Reference your work (full repository, specific version or code fragments)

- **summary**
- **ICMS 2020**

Sharing the vision



United Nations
Educational, Scientific and
Cultural Organization



And many more ...

www.softwareheritage.org/support/testimonials

Donors, members, sponsors



Diamond sponsor



Platinum sponsors



Gold sponsors

openinventionnetwork



Silver sponsors

AdaCore



Google

GitHub



vmware

Bronze sponsors

DANS

FQSSID

Red Hat



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Call to action on ARDC: let's foster adoption!

Train students and colleagues to [archive and reference relevant source code](#)

- full details in the [ICMS 2020](#) article
- short operational [HOWTO online](#)

Engage conferences, journals, learned societies to use Software Heritage and SWHIDs

APIs for [save code now](#) and [deposit](#) are available to integrate with

- Research Articles
- Artifact Evaluation Committees
- Badging initiatives

Help grow and structure the community

- Promote the [ambassador program](#)
- Encourage our institutions to
 - include Software Heritage in their Open Science policy
 - become [member/sponsor](#)
 - build a Software Heritage mirror (see ENEA)

Call to action: let's engage with policy makers (it may be us!)

Institutional representation

we need an (open source) software VP in

- universities
- ministries
- governments

Funding for infrastructures

push for funding instruments adapted to digital infrastructures (e.g. ESFRI):

- cost of human resources is *predominant*
- *much shorter* time frame

Set the default to open: pass the message

publicly funded research software should be open source

exceptions must be justified






Career evaluation and incentives

- recognize *quality* software development
 - see e.g. [the 2021 Inria guidelines](#) (in french) and [this CiSE 2020 article](#) (in english)
 - see [the French National Open Science Award](#) for Research Software
- keep the human in the loop, avoid number games

it's a long road, but together we can make it

Questions?

References

-  UNESCO, *Draft recommendations on Open Science* 2021, ([online](#))
-  French Ministry of Research, *Second National Plan for Open Science* 2021, ([online](#))
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-  J.F. Abramatic, R. Di Cosmo, S. Zacchiroli, *Building the Universal Archive of Source Code* CACM, October 2018 ([10.1145/3183558](#))