

FAIR Principles for Research Hardware - FAIR4RH

Introduction:

Research hardware represents a physical artifact and may incorporate mechanical, electrical, and even software components. For example, laboratory equipment which is the result of scientific research represents research hardware. It is an inherent part of research, together with research data and research software. However, while the latter have been recognized as research outputs by funders and institutions (leading to for example the creation of novel career paths in academia), research hardware has not been receiving much attention so far as a research output. This is particularly visible in the absence of hardware making role in the [contributor role ontology, CRediT](#) or DataCite Schema v4 (section [7.a](#)), used widely by publishers, and the number of hardware publication platforms (two found in February 2022: hardwareX from Elsevier and the journal of open hardware from Ubiquity Press).

On the other hand, the need for appropriate guidelines for disseminating research hardware has already been recognized in the scientific community ([Ezoi, Boujut, & Pingué, 2021](#)). Research hardware is peculiar because: (1) only its documentation can be shared digitally, while physical components are required for its operation and (2) the documentation often contains both (different types of) data and software. In order to conform to open-science practices, research hardware should ideally be shared as Open Hardware (OH) under free and open-source licenses, especially in cases of publicly funded research ([Bath Open Source Hardware group](#)). The open source hardware community has also been trying to define best practices in sharing hardware documentation, in order to allow re-use and further development of the hardware, such that they have been advocating for Hardware FAIRness without using this terminology. The work of this IG wants to address both open source hardware as well as research hardware disseminated under intellectual property rights (IPR), as both routes would benefit from FAIRification of hardware.

Available good practices for research outputs disseminated as digital assets and in particular for research data are based on the adoption of FAIR principles ([Wilinson et al., 2016](#)). The objectives of FAIR principles in research data are to secure findability, accessibility, interoperability, and reusability of research data by both humans and machines. Similar initiatives emphasized the importance of FAIR principles for research software. The most notable recent work of the FAIR for Research Software group ([FAIR4RS WG](#)) in collaboration with other initiatives and organizations led to the definition of guidelines for dissemination of research software that conforms to the FAIR principles. In FAIR4RH **“we believe that adapting and expanding the FAIR principles for the domain of research hardware can facilitate and improve hardware dissemination practices”**.

While FAIR initiatives for software, data and publishing are integral for research hardware, it is important to recognize that they do not sufficiently address the complexity of FAIR hardware. In particular, the important link between the virtual and physical artifacts, the downstream need for calibration and accreditation, and the variability of expertise in building physical hardware all offer new challenges that require the critical examination of FAIR principles for research hardware. This also includes work on the definition of research hardware, and its relation to open source hardware. Ultimately, this group wants to go beyond that and address obstacles preventing a sustainable and inclusive adoption of hardware documentation in the scholarly commons. We also believe that technical transfer processes of research hardware towards market players, civil society, and other actors may also lead to indirect wider benefits for commons beyond the scholarly community.

We believe the group's objectives align well with the RDA interest in fostering the production and publication of non-text research outputs (artifacts that are not manuscript). On the one hand, we hope to leverage the community and experience the RDA has been able to bring to the [FAIR4RS WG](#). On the other hand, this IG will bridge open hardware communities, civic tech, as well as production engineering communities within the RDA.

User scenario(s) or use case(s) the IG wishes to address:

- *Researchers aiming to build hardware used in a laboratory and field environment, either for performing an experiment or for reproducing experimental results at another lab (e.g., reuse of components, design improvements, etc.),*
- *Researchers who want to publish their hardware documentation and share it publicly under free and open licenses following open science practices (e.g., for free technical knowledge sharing, defense publishing, increased transparency, open collaborative development with external or joint project partners, maximized technology transfer, etc.),*
- *Funders and institutions that would want to promote quality and openness in hardware creation in academia,*
- *Repositories for hardware documentation seeking for methodological guidance.*

Objectives and outcomes :

This group aims at the recognition of hardware as an integral part of the research process and foster an inclusive recognition of the people contributing to the hardware design and dissemination. In order to avoid the discussion about patent strategies versus open source hardware and to address both open and “closed” hardware, we want to talk primarily about FAIR research hardware. To this end, we identified several challenges, which will correspond to expected outcomes of this group:

- **Definition of research hardware**
- Analysis of **current practices** and gaps in research hardware lifecycle:
 - Documentation
 - Dissemination channels
 - Maintainability
- Interoperability of **hardware metadata** schemas and academic metadata
- **Definition of FAIR principles for research hardware** (see below)
- Identification of **practical means** of achieving FAIR research hardware
- Contributor **recognition** systems

Specifically, we aim to expand previous work ([Miljković, Trisovic, & Peer, 2021](#)) towards the adaptation and expansion of FAIR principles for research hardware. The role model for our group will be [FAIR4RS WG](#) as we will elaborate on unique characteristics of research hardware in relation to the existing FAIR principles for data and software. Possible relationships between principles will also be explored. Moreover, we will provide a detailed analysis of current obstacles in application of FAIR principles for research hardware (e.g., transferability of existing FAIR principles, added value, exhaustiveness, interdependencies of FAIR principles, and how to detail/reorient the principles accordingly). In particular, we will emphasize all important factors that influence research hardware (e.g., research hardware documentation, available technology, knowledge, materials, standardized processes, and components (or lack thereof), specific demands for hardware licensing and to the hardware repairability). Additionally, we will focus on the complex dependencies to other hardware and/or software.

Importantly, we will put lots of energy into making our work as inclusive as possible and available to everyone. Our outcomes will also take needs, achievements, and practices from Low and Middle Income Countries (LMIC) into account as research hardware is a growing field of activity in these regions. Therefore, and following initiatives from the RDA Secretariat, **involving communities from the Global South will be one of the objectives** of this group.

Participation :

This interest group aims to collaborate with and encourage RDA membership from:

- The RDA community and relevant WGs to facilitate open discussions on FAIR principles for research hardware,
- OH communities: Gathering for Open Science Hardware (GOSH), Open Source Hardware Association (OSHA), Africa Open Science and Hardware ([Africa OSH](#)), Regional GOSH for Latin America ([reGOSH](#))
- Scientific research projects involving OH: [Open.Make](#), [OPENNEXT](#), [Open Hardware Delft](#),
- Maker communities and other instrumentation initiatives: [Open Hardware Observatory \(OHO\)](#), Materials Equipment 4TU (<http://labs.tudelft.nl/>),
- Hardware specific organization: [Internet of Production Alliance](#) (IoP)
- Metadata producer and users: datacite, [OHO](#), [IoP](#),
- Open Science Aggregators: [OpenAIRE](#), and
- Other interested parties: European Organization for Nuclear Research ([CERN](#))

In particular, we will expand our current collaboration with RDA groups on specific subtopics:

- Persistent-identification-instruments-wg: Metadata schema for research hardware (Julien Colomb is member)
- FAIR4RS-wg: overall strategy, outreach maximization. (Nadica Miljković and Alexander Struck are members)
- RDM4engineering: definition of research hardware, analysis of hardware documentation and maintainability. (Robert Mies is a member)

Mechanism:

On top of asynchronous work, the group will meet online at least every four months to report on thematically distinct subgroups progress.

As long as no subgroups are formed, the entire IG has been meeting monthly. Currently, group activities are oriented towards research hardware definition.

Subgroups:

In order to tackle the issue of FAIR for research hardware application, we are planning to create subgroups to tackle specific sub-topics, once these subtopics will be set (by the whole IG). Indeed, similarly to what the FAIR4RS group did, three to seven specific topics and point of views toward FAIR4RH will be defined, each one will be worked separately by a subgroup, before these points of views will be merge into one document. We have so far envisaged to analyze the following topics and their relation to FAIR for research hardware principles (this list is neither exhaustive, nor definitive):

- FAIR4research data principles (in relation to hardware)
- Particularities of FAIR4research software principles (in relation to hardware)
- Hardware certification processes
- Open research hardware examples and dissemination practices

- ~~Wishful~~ best practices for open hardware.

Each topic will be taken up by a subgroup. Each subgroup will have a manager (to organize the subgroup activities) and a reporter (giving updates to the RDA IG). Depending on the number of members in the RDA, the sub-groups may work concurrently or one after the other.

In the worst case scenario, we will discuss these different approaches consecutively with the whole group.

Engagement (especially with LMIC):

The creation of this IG is the first step into gathering a community around the recognition of FAIR hardware as a research output. We hope to get more engagement with our IG after the 2022 RDA plenary, where we planned two sessions to reach a maximum of RDA members. We will reuse this presentation to introduce our group to other communities (for instance, during the GOSH unconference that will be held in *Panamá*) or sharing it with specific organizations like Africa OSH or CERN, and directly with researchers developing research hardware.

In order to get more engagement from LMIC participants, we have been reaching out to specific local OSH communities like Africa OSH and we will carry on after the plenary and potential RDA endorsement. We will make use of the current momentum toward open source hardware in LMIC (OSHWA lists about 40/143 science projects coming from LMIC) and hopefully we will be able to gather expertise from LMIC researchers and increase RDA membership. In case we fail, we will try to get inputs from LMIC during the open review processes of our outputs, hoping to at least disseminate the outputs of the IG through recognized communities and organizations, with the aim to inform them on our progress.

Timeline (Describe draft milestones and goals for the first 12 months):

- Create a larger and more inclusive group, our aim is to reach 60 active members with at least 10 from the LMIC countries in the following 12 months.
- Definition of research hardware.
- Create subtopics and subgroups to approach the question of FAIR principles for research hardware from different angles.
- Start edition of a "FAIR principles for research hardware" document

Potential Group Members (Include proposed chairs/initial leadership and all members who have expressed interest):

| FIRST NAME | LAST NAME | EMAIL | TITLE |
|------------|--------------|--|----------------------------------|
| Alexander | Struck | alexander.struck@hu-berlin.de | Research Software Engineer & CIO |
| Santosh | Ilamparuthi | s.ilamparuthi@tudelft.nl | Data Steward |
| Julien | Colomb | julien.colomb@fu-berlin.de | Data curator |
| Jerry | de Vos | j.devos-2@tudelft.nl | Research Hardware Engineer |
| Nadica | Miljković | nadica.miljkovic@etf.bg.ac.rs | Associate Professor |
| Robert | Mies | robert.mies@tu-berlin.de | Research associate |
| Louise | Bezuidenhout | louise.bezuidenhout@dans.knaw.nl | Senior data expert |
| Andreas | Czerniak | andreas.czerniak@uni-bielefeld.de | Project Officer/Researcher |
| Moritz | Maxeiner | moritz.maxeiner@fu-berlin.de | Research assistant |

Add more lines as needed by hitting the 'tab' key at the very end of the 'Title' line.