Open.Make II - Implementing FAIR and open hardware

30 months project starting in 01/2024

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Introduction, objectives, and transfer potential

Summary

The open science hardware community has identified a lack of recognition of research hardware developers and their work as a main bottleneck towards broader adoption of open hardware in academia. Open.Make II aims to address this issue by promoting the recognition of (open) research hardware as a valuable research output. In this project, we will focus on bridging this gap across various disciplines that involve the use of hardware, ranging from biology to arts to machine tools. Our vision is to gradually build an open hardware centre of competence (CoC) that integrates and connects expertise within and beyond the BUA. Building on the insights from the Open.Make project, Open.Make II takes a socio-technical approach to cultivate a recognised community of professional open hardware developers and makers in the BUA. While Open.Make I primarily focused on understanding the requirements for improving the open hardware space, we will now build on that by combining, consolidating, and extending the community's tools for documenting, reviewing, and archiving hardware projects. The emanating technical foundation for an open hardware publication ecosystem will be embedded into novel infrastructure of the envisaged CoC: We will provide support to the community through dedicated spaces, expert advice, structured educational programs, and extensive networking opportunities. In conclusion, Open.Make II is poised to make a significant impact by addressing the recognition gap faced by research hardware developers. By building an open hardware community within the BUA, we will bring together diverse expertise, create opportunities for collaboration, and drive the recognition of research hardware as a valuable research output. Through our inclusive approach bringing together all four BUA members and our focus on building robust recognition mechanisms, we aim to empower open hardware engineers, foster interdisciplinary collaboration, and advance scientific research on the national and international level.

General context

Open access publishing, open data, and free/libre and open source software (FLOSS) have become important pillars of responsible research and innovation, an approach for maximising the integrity and impact of research. The use of the FAIR principles (findable, accessible, interoperable, and reusable) to promote publication of quality data and recognition of data sharing as a valuable research task has informed new research policies. Recent advances of these policies and changes in mandates from research funders have been successful in promoting greater adoption of open access to publications and data in science. Specifically, we see a larger recognition of the work of research software engineers who publish their work open source. In this context, the advocacy work of communities of practice (including academics, citizen scientists, entrepreneurs, artists and teachers) is also pushing towards the adoption of open hardware in research. Mostly represented by the Gathering for Open Science Hardware (GOSH)[1] and the Research Data Alliance interest group "FAIR principles for research hardware" [2], these efforts aim to extend open science to include FAIR and open hardware. Last but not least, open hardware can be seen as a faster and more sustainable technology transfer route. Protecting intellectual property is costly and impedes collaborative hardware research and development. Open hardware can proactively circumvent "patent thickets" in technology areas, fostering a free baseline of knowledge that enables the emergence of new industries.

Open hardware was first recognised as a pillar of open science strategies in the UNESCO Open Science

[1] https://forum.openhardware.science

[2] https://www.rd-alliance.org/groups/fair-principles-research-hardware

recommendation in 2021[3]. This global consultation effort harmonised definitions of open science and provides guidance towards institutionalisation of open science practices. Researchers worldwide are increasingly producing and sharing open science hardware designs. Fast-paced research requires highly customisable instruments and as a result, the interest in better documenting and sharing hardware designs is growing. Furthermore, FAIR and open hardware presents an opportunity for new career pathways and an alternative to traditional intellectual property rights practices, amplifying the impact of academic research in society.

Central project goals

This project proposes two central complementary objectives:

Objective 1: Foster a BUA open hardware community

Inspired by the TU Delft Open Hardware Community[4], this implementation project aims to build an open hardware community within the BUA context - with the help of numerous actors in Berlin that are aligned with the project's mission, either relevant in community building or in hardware production or dissemination. In order to cultivate an active community, we will provide expertise and collaboration space, direct mentoring, and networking with both maker communities inside and outside the universities) and technology transfer officers at the BUA partners.

In addition, we will consolidate the community by providing tailored training opportunities by transforming and extending existing materials into teaching modules and short training formats. These foundational materials will enable the development of a future curriculum for the research hardware engineer role.

Ultimately, the team will document the decision criteria, failures and successes of this work as it takes place. These reflections are aimed to inform a sustainability strategy to continue the idea of a BUA CoC for open hardware beyond the duration of the project.

Objective 2: Foster research hardware publication and recognition

Lack of recognition of open hardware work in academia is a socio-technical problem. In order to facilitate hardware documentation, publication, and quality control, we will design a software platform based on the requirements collected via interviews of open hardware developers and workshops with institutional representatives and specialists. The team will build and adapt software tooling to facilitate the edition of the documentation (including generation of hardware-specific metadata to facilitate discovery), test automatically for compliance with best practices, create citable and archived versions, and doing so, add an extra layer of quality control.

An upcoming workshop in the Open Science Conference in June 2023 [5] will be an instrumental step in the direction of defining the ecosystem more broadly and towards deriving a multi-perspective strategy. The team is seeking collaboration and advice of technical infrastructure specialists in Berlin and beyond, especially in university libraries.

At the same time, the project team will actively foster the adoption of FAIR and open hardware. At the local level, we will be liasing with science funders, university tech transfer offices, and career evaluation counsellors. Internationally, we will continue the ongoing work inside the RDA and the GOSH

[3] https://en.unesco.org/science-sustainable-future/open-science/recommendation
[4] https://www.tudelft.nl/en/open-science/about/about/open-hardware
[5] https://www.openmake.de/blog/2023/05/11/2023-05-11-workshop-at-the-open-science-conference/

community. This work will allow the recognition of hardware publication and certification processes internationally, which is necessary for the adoption of the hardware publication platform.

In addition, we will build new local connections to the Center for the Science of Materials[6] via Prof. Matthew Larkum, that are active in the dissemination of FAIR and open material. Second, we will investigate relations between open hardware and medical devices in interaction with the European Testing and Experimentation Facility Health AI and Robotics (TEF-Health[7]) via Prof. Dr. Petra Ritter, and the OpenLab MedTec project[8] led by the PTB in Berlin.

Subject of implementation / transfer potential

Open.Make II aims to achieve the following outputs: 1) An active and dynamic BUA open hardware community; 2) open educational resources (OERs) on open research hardware for practitioners and institutional stakeholders; 3) a publication platform demonstrator which delivers first insights from a diverse set of use cases; and 4) community-led position papers and policy briefs for adoption, for instance on FAIR principles for research hardware. Community building activities and teaching formats, combined with an internationally recognised infrastructure to document and communicate research hardware, will lay the foundation for a pioneering CoC for open hardware in the BUA. We see transfer potential as different industries and engineering disciplines could be inspired to engage in research and technology development activities based on open hardware principles. We will specifically analyse the transfer potential for the use cases directly accessible in our network, such as medical devices, open materials and projects already in our network (e.g. the OpenFlexure microscope). Moreover, developed and refined OERs for training programs for research hardware developers and makers will be shared to allow replicability of the approach.

As we will release our self-hostable publication platform and all associated documentation under open source licenses, open hardware maker communities outside the traditional academic environment will be able to reuse and build upon it. We will foster this as part of our continued outreach activities. A proposal for a national or international implementation project with higher technology readiness level is envisaged towards the end of the Open.Make II project to further develop and exploit the demonstrator.

Moreover, joint policy initiatives will create transfer potentials in different directions for research hardware. One potential direction is the very active field of space science (e.g. NASA Transform to Open Science (TOPS) programme). Another is the engagement of research funding agencies such as EC / DFG / BMBF acknowledge research hardware evaluation practices. Focus groups will be organised on evaluation needs and how to specify call topic requirements for sharing and collaborative development of research hardware. The results will be documented and published as open access policy briefs.

Relation to Open.Make (I)

Open.Make (I) delivered insights on the following three areas which can be built upon for further implementation:

[6] https://www.adlershof.de/en/news/where-the-future-is-materialising
[7] https://www.tefhealth.eu
[8] https://openhsu.ub.hsu-hh.de/bitstream/10.24405/14534/1/openHSU_14534.pdf

Hardware publication system requirements

Based on accounts from 15 interviews with representatives of a diverse set of leading open hardware projects from academia all over the world, the Open.Make team gathered user stories and has been deriving critical needs for open hardware development and sharing. The project will validate these needs in interactive workshops and focus groups with experts in scholarly communication and infrastructure providers in 2023. The community will design a roadmap for the creation of a hardware publication ecosystem. The implementation project will transfer this knowledge into the creation of a scalable product.

Open hardware guidelines

Taking advantage of our liaison with the Open Hardware Makers training program[9] via the incoming fellowship of Dr. Julieta Arancio, and with the Turing Way collaborative community[10], we will develop comprehensive guidelines for the development and sharing of open research hardware in the coming months. This knowledge will be used to design different training programs inside the BUA, and guides the development of tools facilitating hardware documentation.

International connections

The project Open.Make has been highly community-oriented with the foundation of the Research Data Alliance (RDA) „FAIR Principles for Research Hardware Interest Group“ (endorsed by the RDA in 2022) and the co-organisation of the global “unconference” Gathering for Open Science Hardware (GOSH) in 2022 in Panama. The Open.Make team has been tightening its relation with the TU Delft Open Hardware Community and its managers. Also, the two incoming fellowships (funded by the Fellowship Programme of Objective 3) of Dr. Sacha Hodencq from G-SCOP labs at Université Grenoble Alpes (6 months) and Dr. Julieta Arancio from University of Bath (3 months) have been instrumental in solidifying strong relationships with these institutions, which will be utilised in Open.Make II. We count on connections to open science hardware practitioners in the Global South through civil society partnerships like the Berlin-based association Global Innovation Gathering e.V. (GIG) and the Latin American chapter of the GOSH community, co-founded by Dr. Julietta Arancio. The international network is a prerequisite for the legitimacy and inclusive nature of of the proposed implementation solutions in an international context. This network will be strengthened and new connections will be created.

Positioning of the project in relation to the international state-of-the-art

Due to the emerging state of open hardware in academia, we will focus our efforts on cooperation with existing initiatives, both national and international, as outlined below:

Open hardware institutionalization

We have a strong connection to the TU Delft which has led the implementation of open science practices, specifically in terms of open hardware. The outgoing fellowship gave us a possibility to observe their work and strategy; we will build on this experiences to adapt the strategy to the BUA context. TU

[9] https://openhardware.space/

[10] https://the-turing-way.netlify.app

Delft was the first university to recently install a position for an open hardware engineer, and build an open hardware community at the university level. They also developed a specific curriculum (the Open Hardware Academy), which ran for the first time in 2022.

Research hardware recognition

By founding the FAIR for research hardware RDA interest group, we have been leading initiatives aiming at the recognition of research hardware as a research output. There is still much work to do to raise awareness, but the connection to the RDA community is allowing us to raise the issues of hardware recognition in international initiatives.

Hardware publication

Hardware journals exist, but they do not respond to the need of the community. In particular, the need for a streamlined (publication done directly from the documentation tool) and free of charge (diamond open access) system is not well represented in HardwareX, the leading journal for hardware publication.

Systems for the quality control and dissemination of open hardware have been emerging during the last years in Germany (OHO - Open Hardware Observatory e.V., Open Source Ecology Germany e.V.), where the DIN SPEC 3105 was also developed under participation of TUB to define and attest open hardware. We are closely linked with these different players and plan to adopt their workflow into our hardware publication ecosystem.

On the other hand, tooling developed for the publication or archival of software are under development[11], and we are for instance in contact with the HERMES team[12] which is developing tools for the archival of software into data publication platforms that are often used in university libraries (Dataverse and InvenioRDM, the latter being the software running Zenodo). Especially the automatic transfer of specific metadata types is an interesting and pioneering approach for software publication.

Work schedule

The project's ambitious goals will be tackled as part of four different types of activities described here as work packages. Actions will be taken to build a network of open hardware makers in the BUA, create and provide educational resources, develop a technical platform for hardware publication and support international initiatives devoted to the recognition of open hardware as a research output. The work packages will act synergistically. In **M24**, we will organise a mini-conference to present our results and discuss recommendations for the creation of a sustainable CoC for open hardware in Berlin.

WP1 - Maker Community building [M1 - M24]

Community initiation and gathering [M1 - M7]: We will first map and connect with existing communities in Berlin and Brandenburg related to open science (Open Science Working Group of the FU Berlin), to maker communities inside (workshops / makerspaces, engineers, student groups) and outside (Top Lab e.V., Motion Lab, Happy Lab, Verbund offener Werkstätten) the universities, to scholarly communication (Project HERMES, Open-Access-Büro Berlin), technology transfer, in addition to the existing BUA

[11] https://doi.org/10.48550/arXiv.2201.09015
[12] https://project.software-metadata.pub/

community. We will organise community gathering events as milestone of this task and keep an updated list of communities on our website.

Community building [M8 - M24]: Following the Delft open hardware initiative example, we will provide spaces and mentoring to BUA hardware developers and makers. A research hardware engineer will help them create and document their hardware, He will also introduce them to the guidelines and training offers that will be further developed in WP2. To mitigate the risk of seeing the rise of a closed community, we will take particular care in implementing strategies (code of conducts, easy onboarding) to facilitate the interaction with underrepresented communities. Concerning the space, we will implement different strategies. We will have a central workshop [from **M8**], a pop-up or a mobile workshop [from **M12**], and provide advice on site [from **M12**]. This diversity of activities should mitigate the risk of reaching a small part of the target group, while starting with the simpler approach will prevent us to be overwhelmed with the complexity of the task.

In the last phase of the project, we will target university officers facilitating the socio-economic impact of academic production and technology transfer. To this end, we will run an awareness building campaign that connects open hardware practitioners and university administration officers in interactive formats. For this, we will join forces with existing institutions like the Open Hardware Alliance Germany where TUB is a member. Dedicated sessions [in **M15**] will provide concrete information on how to support and foster the recognition of open hardware by individual researchers or joint research projects and how to measure the impact produced by publishing high quality FAIR and open hardware.

WP2 – Education and training [M1 – M30]

The first component of WP2 involves aligning and testing already existing training formats, materials and OERs with the needs of the emerging community. We will target different status groups, developers and makers of research hardware from the four BUA partner institutions considering their respective training needs and expectations. In order to offer training to early career researchers, students and PIs interested in open hardware (as part of their research activities), the team will continuously develop both the project-based university 6 ECTS seminar with practice partners[13] over three semesters (from summer semester 2024 to summer semester 2025) and short hybrid training formats (e.g. 1 day) combining theory input with practice examples and interactive parts. All teaching and training activities will be held by two team members who will record each others feedback and create logs for lessons learnt. Participants' expectations will be surveyed on a voluntary basis before and after interventions using qualitative as well as quantitative questions for evaluation. The lessons learnt will be utilised for continuous improvement of the course module and the training formats on the one hand and to record reflections of the teaching methodology and learning outcomes in a scientific paper on the other hand. In addition, developed resources will be published as OERs that can be taken up by anyone interested and modified for other target groups.

WP3 - ICT infrastructure development [M1 – M18]

We will build the technical infrastructure needed to publish hardware in collaboration with the university libraries and IT infrastructure specialists that will be invited during another Open.Make workshop in September/October 2023. The user needs discovered during the first phase of Open.Make will guide the work and be expanded by external software development resources as needed. The principal goal

[13] see TUB course: https://www.tu.berlin/qw/studium-lehre/lehrveranstaltungen/oshs-open-source-hardware-seminar

for the design of the ecosystem will be providing support for hardware makers, interfacing with established practices, and combine existing tools. We have identified requirements based on interviews and observational studies, and therefore plan to work on the different aspects of the creation and publication of research hardware. In the Landgraf lab, the hardware-related projects, e.g. a DFG-funded project on robotic fish, will serve as content to be tested on the publication platform.

Documentation creation and automatic checks [M1 - M6]: We will expand the GitBuilding tool, which enables automatic generation of HTML documentation, adding better onboarding functionalities and allowing for PDF generation for example. Furthermore we will reuse the EU-funded software osh-tool, which can be employed in continuous integration for compliance checks. We will add additional checks for documentation practices, such as testing for existence and validity of metadata files or the reusability of source documentation files.

Manual checks and peer review [M5 - M13]: For the quality control process, we will reuse and integrate the workflow of the MediaWiki-based tool developed by OHO and the CADCloud prototype, which allows for online viewing of CAD files. The scalability of this approach will be monitored and other types of peer review systems may be built, tested and implemented.

Archival and Recognition [M10 - M15]: We will reuse and adapt workflows developed for software archival by the HERMES project to export to existing repositories, such as Zenodo. We will also extend osh-tool to generate Open Badges[14] for attestation of automatic tests. Open Badges will also be test deployed for attestation of peer review quality.

Bundling [M12 - 18]: The different components will work together in a modularised fashion and can be self-hosted. There will be a web-based control interface facilitating the interoperation of the individual components. Users will be able to register their git repositories with it to make use of its services. By only using FLOSS, we will enable research engineers and libraries to set up their own instances. The use of metadata standards will allow for the discoverability of hardware independently of their place of publication.

WP4 - Networking [M1 - M30]

While WP1 - 3 focus on the local/national (BUA, Berlin, Germany) community, we would like to grow and connect our network internationally. This will stimulate exchanges of ideas and people, and will eventually ensure the lasting success of Open.Make II. These activities are planned to span the entire project period, and will be led by Mr. Robert Mies (TUB). We plan to perform several workshops and present our work in different conferences during the project, especially RDA plenaries and open science conferences or festivals. We will continue our efforts inside the RDA group that Dr. Colomb is presently co-chairing. A publication of a consolidated declaration document about the application of FAIR principles for research hardware is planned for 2025.

With the help of the SHK students, we will also consolidate relations with related projects in Berlin in the materials and medical technology domains, by means of standardisation efforts for documentation and dissemination strategies. In particular, we have direct contact to the newly created Center for the Science of Materials at the HU, as Prof. Matthew Larkum is a member of the centre; to the TEF-Health project, as Prof. Dr. Petra Ritter is the coordinator of this consortium of 51 European partners; and to the OpenLab MedTec project, as the coordinator PTB in Berlin are our external cooperation partners (see letter of intent).

[14] Certificates with embedded metadata: https://www.imsglobal.org/sites/default/files/Badges/OBv2p0/index.html

Milestone plan

Milestone 1, M6, WP1 – Establishing of local network / **Means of verification (MoV)**: Relevant connections made in Berlin area including as part of a community gathering event with the main target groups and internal planning for continuous engagement formalised. **Milestone 2, M9, WP2** - Short format training/ **MoV**: Report with lessons learnt, about the first short format training workshop for researchers. **Milestone 3, M13, WP1** - Mobile workshop / **MoV**: A mobile or pop up workshop is set to a first location in Berlin. **Milestone 4, M13, WP3** – Technology validation / **MoV**: First working prototype of technology infrastructure ready for testing in the lab. **Milestone 5, M24, WP4** - Closing out of RDA initiative / **MoV** - Submission of RDA declaration for final review.

Risk assessment

Adoption of new technology may be harder than it is initially thought (WP3). This is often due to user interfaces (UI) not matching the user needs, so surveys will be used to investigate this issue. The planned hire of external designers to improve the UI will be beneficial as well. By building on existing tools already in use, we can moreover make sure that the tools will be able to archive hardware documentation of a certain quality standard. On the other hand, no manual peer review system has been tested at scale yet (WP1 & 3). Indeed, attestation of quality is a difficult question and we may need to follow different socio-technological paths, and use different tools. We will therefore continue discussions with the scholarly communication ecosystem, research hardware and software engineers, and other interested communities, in order to find working solutions that address their needs. Experience gathered inside the Open Hardware Observatory [15] and Open Source Ecology Germany [16] hardware review attempts will be additional resources to build the platform in a user-friendly way. Additionally, community, teaching and networking activities (WP1, 2 & 4) may not reach the target groups, so dissemination and communication through existing channels used in Open.Make (1) and through the BUA and partnering institutions will be used to mitigate this. Finally, should too much interest be created it can be managed by using the network to buffer spikes. We are confident that the expertise of the Open.Make team and BUA partners, combined with external help from the Open.Make network developed in WP4 will overcome these challenges.

Information on potential practical use of results

Our results will have a practical and replicable nature by design. OERs are meant to be reused in different training formats and university courses offered by Open.Make PIs. The environment for hardware documentation and publication will be based on FLOSS and streamline the documentation, reviewing, and archival of hardware design. The tool is therefore aimed at users both inside and outside academia. The envisaged Berlin hardware developer and maker community will help each of its members to thrive for producing quality open hardware, following the FAIR principles. This will widen the reach of every project, and we will therefore enable future practical use of these hardware pieces.

Concept of implementation and dissemination of potential applications

We believe this project will build the foundation for the development and recognition of open hardware in research (training concepts, guidelines aimed at the different target groups, publication and recognition

[15] https://en.oho.wiki/wiki/Home

[16] https://wiki.opensourceecology.de/Open_Source_Ecology_Germany

system), and serve as an enabler for open hardware advocates. We will foster this advocacy locally, and internationally, both by raising awareness and by documenting our processes.

By continuing to interconnect through the BUA, e.g. through workshops and events, the project will increase the local visibility of the project itself, as well as the visibility of other open hardware research projects in Berlin. To ensure inclusivity and diversity, we will actively involve the non-academic makers community from the early stages. Through interactive sessions and networking opportunities, we will establish a common ground between research hardware developers, university officers, makers outside academia, citizen scientists and interested teachers. This approach, proven successful in Delft and exemplified by the Libre Solar project[17], which we interviewed during Open.Make, enables cross-pollination of ideas and experiences. It also allows for the dissemination of our outputs within civil society, particularly at the local level.

Open.Make (I) has been investigating best practices in research hardware development and dissemination. While doing so, we have built a strong network with other actors in this sector, especially through GOSH and the RDA. We will continue to actively recruit additional collaborators and grow our network, especially within the new framework of the RDA group FAIR4RH that we co-founded as part of Open.Make (I). It is currently co-chaired by Dr. Nadica Miljković (University of Belgrade) and Dr. Julien Colomb and has grown to 45 members. This growing network will be used to disseminate the applications of the publication platform and our educational resources. We will support these communities that are working on introducing policies for funders and institutions on open research hardware, as having more OERs and software tools to recommend to practitioners will strengthen their positions. In particular, we will continue to collaborate with civil society partners like the Open Hardware Alliance (which is led by the Open Knowledge Foundation) and the Internet of Production Alliance[18]. The former is doing policy work for the recognition of open hardware as a viable research output to maximise societal impact and the latter is developing community standards for open hardware.

By documenting success and failures in our community building tasks, we will make it possible for other players to follow the same path and build hardware communities as part of future open source programme offices.

Exploitation plan for academic and non-academic users

We will ensure sustainability by securing long term funding for the exploitation of our outputs (the hardware platform and the community). By making it possible for academic and non-academic users to continue the work, our outputs will rely less on the core team. We will take special attention to include low and middle income countries as putative partners in the exploitation of our outputs. In addition, we will use this program to present the BUA with a long term sustainability plan involving the creation of a Center of Competence for research hardware in Berlin. Concerning the hardware publication platform, we will on one hand engage with institutions and communities that can deploy the tool at scale. University libraries (also outside of the BUA) will be a strong partners, especially for the long term archival of hardware documentation. The GOSH community is another strong partner who may exploit our tool in the long term. We are also in direct contact with the Invest in Open Infrastructure [19]community (via our interaction with the Turing Way community) that might assist us to expand our platform demonstrator into a sustainable, diamond open access solution for hardware publication. On the other hand, our work

[17]https://libre.solar/
[18]https://www.internetofproduction.org/
[19]https://investinopen.org

will be open sourced from the start, and communities around the globe will be actively encouraged to follow the project's steps. The tools we will expand can be used independently and there already are communities feeling responsible for their maintenance. By engaging with them we will secure long term use of our software outputs.

Concerning our educational resources, the student training will be included in the normal curriculum of the TU and FU. In addition, the material can suit a variety of needs, according to different audiences: from university teaching to research training to school lessons, citizen science projects or even entrepreneurial activities. We therefore expect to see open hardware training flourish both inside and outside academia during this grant period.

The project can also serve as a catalyst for addressing social issues, particularly in fostering collaborations with the Global South. Ingenieure ohne Grenzen e.V. (IOG) together with OHO e.V. and TUB (through Robert Mies) are starting a working group within IOG to explore the potential benefits of open hardware documentation and sharing for international development cooperations. Dr. Julieta Arancio, our incoming researcher, is actively engaged in the Latin American open science hardware landscape and is settling in Berlin. The Global Innovation Gathering (GIG) network, based in Berlin, will play a vital role in informing the development of Open.Make II. Through their connections with maker spaces in Africa and South Asia, we aim to leverage these networks to enhance the platform and training materials, as well as explore another avenue for future exploitation potential.

Partners and target groups in Berlin

As described earlier, significant efforts will be dedicated to search and connect with local hubs and BUA expertise. In particular, we will seek a closer relation with university libraries for the development and implementation of the publication platform. This will start later this year inside the Open.Make project. Similarly, we will reach to intellectual property officers, open access and research data management offices in this platform design phase. We will also network with Berlin graduate schools to foster the teaching of open hardware (and open science practices) at the PhD level. We engage in inactive exchanges with neuroscientist of the CRC1315, which define the publication of FAIR hardware documentation as one objective of their infrastructure project[20].

During Open.Make II, we will collaborate with institute workshops (for instance the Feinwerktechnik, a workshop service at FUB) inside WP1. Service facilities like these build a significant part of the hardware used in research groups. FUB's Feinwerktechnik has agreed to work with us and implement the Open.Make guidelines in future constructions. We will find other interested parties inside the four partner organisations, such as the TU-based workshop of the excellence cluster "Science of intelligence". This network will then be leveraged to foster the adoption of hardware training and publication inside the BUA. This work will provide the ground knowledge and practical recommendation for a future implementation of an open hardware strategy in Berlin and beyond.

Concept for collaboration with project partners

Open.Make II will involve all four partner institutions of the BUA. The team that made Open.Make (I) a success, will be extended by Prof. Dr. Petra Ritter (CUB) for an additional focus point on open hardware in the health space. We have extensive expertise in hardware evaluation (TUB), academic OS hardware & software development (FUB, CUB), scholarly communication and data management at (HUB), and

[20] https://www.sfb1315.de/research/inf/

medical applications (CUB). While Dr. Julien Colomb will continue to work part-time on this project (about 15%) inside his contract in the infrastructure project of the SFB1315, both Robert Mies and Moritz Maxeiner will be dedicating their full attention on open Make II. Prof. Tim Landgraf has a number of hardware-related projects that will serve as example use-cases for the publication platform demonstrator. He is also mentoring an active startup in the digital health space and is interested to explore open hardware options with them. Prof. Dr. Petra Ritter is the coordinator of TEF-Health, a consortium of 51 European groups tasked with validating new testing protocols for AI and robotics solutions in the healthcare sector. This field is particularly interesting as regulations on how to document medical hardware throughout development might be translated to non-medical hardware. TEF-Health will stimulate the transfer from research to clinical practise and will be a powerful addition to the Open.Make network.

The team remains committed to achieve the long-term objectives we have set for ourselves to foster open hardware in academia from Berlin. In particular, the work planned for WP1 and WP2 will require high levels of collaboration to ensure the contents of the workshops and training programs are well-rounded. With regards to individual responsibilities, the TUB will take the lead in project coordination and overall organisation of WP1 and WP2, while the HUB will head data management tasks and international networking (WP4). The FUB and TUB will have shared responsibilities for cooperation with OH communities with the TUB focusing on national groups. As mentioned previously, the FUB will furthermore lead the task of software development (WP3), on top of their role as research hardware engineer (WP1).

Robert Mies (TUB), Dr. Julien Colomb (HUB), and Moritz Maxeiner (FUB) are foreseen as the main resources during the whole grant period. The current work organisation and data sharing habits will be kept. The TUB HiDrive will be used for internal data exchange, while public data will be pushed on GitHub. All partners will share relevant files in the consortium and prepare their documentation to be released and published. Where legally possible, we will work in the open, so that putative partners can follow in progress in real time, see www.openmake.de.

This will explicitly be the case for the publication system software, which will be open source and developed in a public git repository. For this, we will use the GitLab development and operations platform, unless we expand a project that is hosted elsewhere. The platform has been used successfully and heavily by FUB for software project management, development, and continuous integration. We believe this open approach will foster adoption of the system. Bi-weekly team meetings have proven invaluable in monitoring the progress of the current project and we will thus keep with that process. We will also continue organising a whole team meeting at least once every six months, with the agenda being prepared by TUB.

Research data management

As for Open.Make (I), all outputs of the project will be available with open access as soon as possible for the community. We will continue to use our website (www.openmake.de) as a blog platform to share grey literature. Hardware and software will be build in the open using one or several Git platform(s) and published (on Zenodo for software) once ready. The RDA platform will be used to publish our community-created outreach document, in particular our work on the application of FAIR principles for hardware. Publications will be gold open access under Creative Commons license and additionally published in university long-term archiving repositories, such as DepositOnce (TUB).

Financial plan

- Total estimated costs: **465 012 EUR** (2024: 222 453 EUR + 2025: 209 002 EUR + 2026: 31 557 EUR)
- Personnel costs: **413 012 EUR** (2024: 188 953 EUR + 2025: 193 502 EUR + 2026: 30 557 EUR)
- Other costs **52 000 EUR** (2024: 34 000 EUR + 2025: 15 500 EUR + 2026: 2 000 EUR)

The budget plan slightly exceeds the maximum amount allowed. We hope this is acceptable as the objectives of the project are very ambitious and all partner institutions of the BUA are playing a vital role in Open.Make II.

Personal costs

- TUB: One postdoc 24 months 100% + 6 months 50%: **235 662 EUR** (2024_12 months 100%: 103 015 EUR + 2025_12 months 100%: 105 590 EUR + 2026_6 months 50%: 27 057 EUR)
- FUB: 24 person months for one doctoral researcher 100%: **151 831 EUR** (2024_12 months: 74 978 EUR + 2025_12 months: 76 853 EUR)
- HUB: One student assistant 30 months 40 h per month: **17 500 EUR** (2024_12 months: 7 000 EUR + 2025_12 months: 7 000 EUR + 2026_6 months: 3 500 EUR)
- CUB: One student assistant 12 months 40 h per month: **8 019** EUR (2024_6 months: 3 960 EUR + 2025_6 months: 4 059 EUR)

Note: HUB and CUB, via the SFB1315 INF project, provide a senior post doc 15% (Dr. Julien Colomb) as existing staff for the 30 months.

Publications, travels, conference fees, events, server hosting/maintenance

- TUB: **5 000 EUR** (2024: 2 000 EUR + 2025: 2 000 EUR + 2026: 1 000 EUR)
- FUB: **5 000 EUR** (2024: 2 500 EUR + 2025: 2 500 EUR)
- HUB: **5 000 EUR** (2024: 2 000 EUR + 2025: 2 000 EUR + 2026: 1 000 EUR)
- CUB: **2 000 EUR** (2024: 1 000 EUR + 2025: 1 000 EUR)

Workshop tools and consumables (WP1)

TUB: **20 000 EUR** (2024_16 000 EUR for 2x machine tools & 2 000 EUR for materials and consumables: 18 000 EUR + 2025_materials and consumables: 2 000 EUR)

External services (WP3)

FUB: **15 000 EUR** (2024_software development: 9 000 EUR + 2025_ web and user experience design: 6 000 EUR)