Open Know-How and An Open Source Hardware Registry As a Unifying Discoverability Mechanism for Open Source Hardware Humanitarian Engineering Projects

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***Abstract*—At least five organizations maintain libraries of open source humanitarian engineering projects designed to support rapid distribution and manufacturing, with the potential to alleviate suffering globally. However, these projects are described using various data formats, making them difficult for the general public to discover and access. Additionally, only the leadership of these disparate libraries can add new projects, further limiting accessibility. To address these challenges, we present the Open Source Hardware (OSH) registry modeled on the Arduino Library system. This unified registry endeavors to standardize project metadata, enhance discoverability, and improve the global response to humanitarian crises.**

***Index Terms*—Open source, humanitarian engineering, discoverability, metadata standard**

I. Introduction

A. Value Proposition

The open hardware community currently lacks the community awareness and adoption seen in the open source software and open science communities. Open hardware is often developed within an isolated nodal system, and organizations form around hardware developed for specialized niches such as medical, laboratory, humanitarian, and disaster response. These organizations create directories to catalog specific hardware, but in a directory format specific to the niche, which fails to communicate and integrate with the broader open hardware community. This heterogeneous operation of current open hardware directories and lack of standardization prevents potential stakeholders and users from adopting open hardware and associated open access principles.

Organizations that curate valuable humanitarian projects that cannot presently be searched in a unified way include:

- Open Source Medical Supplies (OSMS) (247 projects) [1]
- Library of Open Source Hardware (LOSH) (17129 projects) [2]
- Gathering of Open Source Hardware (GOSH) [3]
- Appropedia (3036 projects) [4]
- Field Ready (96 projects) [5]
- NIH 3D COVID Response Collection [6]

We intend to improve the discoverability of these curated project libraries.

Some large collections that are not focused on humanitarian technology do contain useful and humanitarian-adjacent projects:

- Thingiverse [7]
- Prusa Printables (has a category for healthcare-related hardware) [8]
- Open Source Hardware Association (OSHWA) (2778 projects) [9]
- Wikifactory [10]

A homogeneous search for open hardware would centralize the assets produced by the community and create the following potential impact.

B. Broad Discoverability

Just as there are currently targeted browser search options for video and image, a hardware search option would allow buildable open hardware projects to be discovered by any searcher, especially those unfamiliar with open hardware. Disparate results and unclear licensing from random searches would be reduced or eliminated. Designs verified as “good”

by organizations in the research and regulatory sector would be more visible, thereby assuring a maker that what they are making is safe.

As evidenced by the February 2024 proposal [11] from the Federation of American Scientists, the United States Patent Office(USPTO) searches open source hardware for prior art, such as those certified by OSHWA [9], a broad hardware search function would create a prior art database for Patent Offices to prevent patents that are not novel, thus preserving the licensing and intellectual property of the open hardware design.

C. Improved Crisis Response

Open hardware designs can positively impact manufacturing timelines for crisis and disaster response [12]. Pre-existing designs save time. Maximizing manufacturing speed results in reduced costs and faster distribution to crisis areas. An OSH registry search for those pre-existing designs would allow a maker to quickly determine how many open hardware designs existed, their licensing status, and their relevance to the present emergency. If a manufacturer iterated the design, that iteration could be found via the exact search where it was discovered, thereby creating a knowledge base for the next crisis response maker. By allowing the registry to list potential design manufacturers, a maker or manufacturer can make their ability to manufacture an item discoverable—an opportunity that does not exist today.

D. Community Growth

Some open hardware projects, such as the self-replicating RepRap 3D printer [13], have become so socially and commercially popular that tracking their lifecycle and design evolution is easy. However, many other projects never achieve wide interest simply because users do not know they exist, leading to the constant question of "Who is using open hardware?" The inability to show consistent, wide-ranging adoption data outside of niche projects hampers the community's ability to achieve economies of scale, grantmaking, design iterations, and far-reaching social and humanitarian change.

With enough open hardware organizations participating in the OSH directory, a broad new cataloging culture would be created. For the first time, the ability to capture data on who was observing, iterating, designing, manufacturing, and scaling open hardware would lead to greater visibility, greater adoption, and, thus, a more impactful life cycle.

II. Open Know-How (OKH)

Open Know-How (OKH) is an open, proposed metadata format [14] for representing buildable projects. Its stated purpose is:

> . . . to improve the openness of know-how for making hardware by improving the discoverability, portability, and translatability of knowledge.

```
title: VentMon v0.5T
description: The VentMon is basically a cloud-enable spirometer
with an FiO2 sensor.
  It can simply be plugged into a standard 22mm airway
  and provides a rich stream of
  pressure, flow, and Oxygen sensor, with
  humidity and temperature sensing as
  well. The primary use of the VentMon
  is by engineering teams developing
  pandemic response ventilators and other respiration tools.
intended-use: The original purpose of the VentMon was to support
  pandemic response
  teams creating emergency ventilators.
keywords:
  - ventilation
  - spirometry
  - pandemic response
  - arduino
  - open source
  - free software
project-link: https://github.com/PubInv
/ventmon-ventilator-inline-test-monitor
image: https://user-images.githubusercontent.com/5296671/
113649478-1e9da800-9654-11eb-934b-7e8a9a5c5bfe.JPG
made: true
made-independently: false
license:
  hardware: CERN-OHL-1.2
  documentation: CC0-1.0
  software: GPL-3.0-only
licensor:
  name: Robert L. Read
  affiliation: Public Invention (https://www.pubinv.org/)
  email: read.robert@gmail.com
okh-manifest-version: 1.0.0
date-created: 2021-06-01
date-updated: 2021-06-01
manifest-author:
  name: Robert L. Read
  affiliation: Public Invention (https://www.pubinv.org/)
  email: read.robert@gmail.com
manifest-language: en-US
contact:
  name: Robert L. Read
  affiliation: Public Invention (https://www.pubinv.org/)
  email: read.robert@gmail.com
contributors:
  - name: Lauria Clarke
    affiliation: Public Invention
  - name: Geoff Mulligan
    affiliation: Public Invention
  - name: Ben Coombs
    affiliation: Public Invention
version: v0.3T and V0.4T
development-stage: product
documentation-home: https://github.com/PubInv/
    ventmon-ventilator-inline-test-monitor
archive-download: https://github.com/PubInv/
    ventmon-ventilator-inline-test-monitor/releases/tag/v0.3.1T
schematics:
  - path: https://github.com/PubInv/ventmon-ventilator-inline-test-
  monitor/blob/master/design/pcb/ventmon_T0.4/ventmon_t0.42.sch
    title: T0.4 PCB schematics (look for complete Eagle files)
bom: https://github.com/PubInv/ventmon-ventilator-inline-test-
monitor/blob/master/design/pcb/ventmon_T0.4/VentMon%20T0.4%20BOM.csv
manufacturing-files:
  - path: https://github.com/PubInv/
    ventmon-ventilator-inline-test-monitor/
    tree/master/design/3dparts
    title: 3d printed files can be found here
operating-instructions:
  - path: https://github.com/PubInv/vent-display
    title: VentDisplay explanations, including useful video
software:
  - path: https://github.com/PubInv/vent-display
    title: VentDisplay
  - path: https://github.com/PubInv/PIRDS-pubinv-respiration-data-standard
    title: Public Invention Respiration Data Standard
    title: PIRDS docker instance
health-safety-notice: This is not intended to be used on live patients.
standards-used:
  - standard-title: https://github.com/PubInv/
  PIRDS-pubinv-respiration-data-standard
    publisher: Public Invention
```

Fig. 1. An example OKH File (abridged)

An example OKH file is shown in Fig. 1. Like every attempt to create a standard from a format, aspects of the OKH are debatable and deserve an open, iterative process for the format itself to evolve. However, it is already the basis of the Open Knowledge Resilience Framework (OKRF) [15] proposed to increase supply chain resilience. Like other metadata standards such as "Dublin Core" [16], [17], it is a meta standard for describing data, not a standard for describing open hardware directly.

The wider adoption of the OKH standard builds incrementally on the idea of the OSH registry. Using the OKH is unnecessary, yet we intend to make the OSH registry implementation able to exploit the OKH data fields if an OKH is registered. In this way, we allow a gentle path to increasing the usage of the OKH over time. OKH documents can be created easily for projects that do not currently have them, and URLs to those OKHs are added with the same simple git "pull request" mechanism that allows registry entries to be created in the first place.

III. OSH Registry based on the Arduino Library Registry

The Arduino Library Manager [18] and the Arduino Library Registry [19] provide a useful model for an approach to implementing an Open Source Hardware Registry (OSH Registry) that is OKH-aware. This system allows:

- the public to submit new projects via one-line git "pull requests."
- software to be written to search project libraries.

The basic concept is maintaining a public file containing a set of entries. Most of these entries will be URLs to OSH projects. Call such a file an *OSH registry*. By allowing a registry to contain a URL reference to a registry, the system becomes recursive, implementing the so-called Composite Design [20]. There are, however, some differences. The Arduino registry contains only URLs and, by convention, expects there to be a file called "library.properties." [19], which defines valuable metadata about the project. This system works well for the Arduino environment, but it is highly dependent on the projects stored in a repository that has added the library.properties file. This is possible with the cooperation of many Arduino programmers who have grown up around the Arduino framework using git and GitHub. GitHub is a service for supporting the source control system git [21]. Together, these tools automatically provide security for the repository itself, allowing anyone to propose an addition, but only the authorized owners of the repository to approve and enact those changes.

Unfortunately, the open source hardware community does not have this cohesiveness. We, therefore, propose that every hardware entry in the OSH registry have more information in the entry:

1) A URL to the single source of truth for the project. If this is a quoted string, it is some other instruction assumed not to be machine-readable, like "call Alice Cooper at 555-1212". A descriptor of the URL which describes the kind of information you will find at the URL. These might assert the URL is:
   a) An OKH URL
   b) A Git repo
   c) None of the above
2) An optional license descriptor
3) An optional set of keywords for searching
4) An optional list of "makers"

Some entries will refer to other OSH entries, but they can be a single URL or distinguished differently. Of course, it is valuable to establish a semi-official entry point for the top of the registry tree. However, nothing prevents multiple initial starting points.

Our initial, live, minimal implementation of the OSH-registry can be found here: https://pubinv.github.io/osh-registry [22]

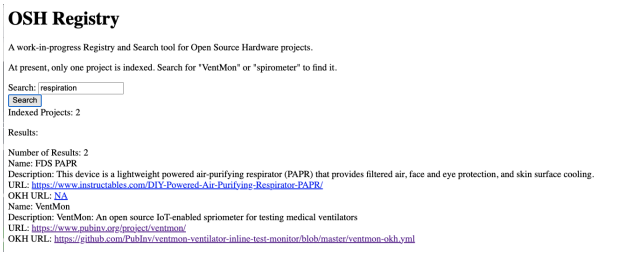

Fig. 2. A screenshot of the OSH Registry showing two projects found

A screenshot of this MVP is shown in Fig. 2

The OSH registry file is in the JSON format. The top-level file has the JSON entry in Fig. 3, allowing the VentMon [23] project to be searchable.

The registry file shown in Fig. 3 includes a field titled "maker," which adds links to organizations capable of rapidly building and distributing items during a crisis. This feature enhances the practical utility of open source designs by ensuring that they can quickly and effectively be deployed when needed. Open source designs legally empower anyone to manufacture the item so long as they obey the license. Although there may be important privacy concerns raised by the use of a manufactured item, in particular a medical device, there are, by definition, no privacy concerns for the registry of device designs itself. However, beyond the legal right to manufacture, actual empowerment requires the technical, financial, and organizational capacity to do so. In disaster scenarios, such as earthquakes, the affected population is often the least equipped to undertake manufacturing tasks. By establishing a publicly accessible database of makers or manufacturers who are prepared to produce and deliver items swiftly in crises, the registry can significantly mitigate human suffering.

This creates the possibility of a profit for makers or manufacturers, whether small or large, who are prepared to use OSH

```
{
    "name": "VentMon",
    "projectOrRegistry": "project",
    "keywords": "spirometer, respiration,
    Arduino, ESP32",
    "description": "VentMon: An open source
    IoT-enabled spirometer for testing
    medical ventilators,"
    "okhURL": "https://github.com/PubInv/
    ventmon-ventilator-inline-test-monitor
    /blob/master/ventmon-okh.yml",
    "browseToUrl": "https://www.pubinv.org
    /project/ventmon/",
    "repository": {
        "type": "git",
        "url": "https://github.com/PubInv/
        ventmon-ventilator-inline-test-monitor"
    },
    "hardwareLicense": "CERN-OHL-S",
    "authors": [
    {
      "name": "Robert L. Read",
      "email": "read.robert@gmail.com",
      "url": "https://github.com/RobertLRead",
      "maintainer": true
    },
    { "name": "Ben Coombs"},
    { "name": "Lauria Clarke"}
    ],
    "makers": [
        { "name" : "Public Invention",
          "url" : "https://www.pubinv.org/"}
    ],
    "version": "0.5",
}
```

Fig. 3. A sample registry file JSON entry

designs to make and distribute goods rapidly. The Internet of Production Alliance other standards, such as the Open Know-Where [24] for the geographic location of manufacturing capabilities and the People and Skills standard [25] for maker capabilities are intended to further augment these business opportunities. Although more cultural change is required than the OSH registry, which is a simple catalog of goods that includes potential makers, it is a step toward creating a vast corps of rapid responders in the supply chain. Imagine a world where every disaster is countered by an immediate action by hundreds of small and large manufacturers and distributors empowered by legally unencumbered open source hardware designs!

Although the proposed OKH search mechanism is a metadata format and not a new standard for classifying hardware, we imagine the search mechanism to be part of a broader quality assurance hardware ecosystem. As mentioned previously, the OKH would create more discoverability for designs in the regulatory-compliant and peer-reviewed niche. Additionally, hardware registrants would have the opportunity to incorporate Global Distributed Tracking (GDT), a product of the Global Open Source Quality Assurance System (GOSQAS) [26], in their metadata. Designed to assist hardware manufacturers in tracking documentation for FDA/ISO compliance [27], a unique GDT identifier could be created, attached to a manufactured object, shared, and updated in real-time throughout the hardware manufacturing or research process.

IV. Encouraging Incremental Use of the OKH Format

Projects described with an OKH document would have a greater chance of their design being discovered, built, marketed, and distributed. When published to a proprietary database, such as Thingiverse, the chance of profit is low. However, listing to an OKH-based search function would increase the probability that a manufacturer would be discovered and, therefore, marketed.

A practical approach to implementing a search mechanism involves creating a serverless website using simple tools. This website would allow users to search for Open Source Hardware (OSH) projects based on keywords. By utilizing JavaScript to run in the browser, the website can read the registry, follow registry links, and build a full-text search index dynamically. This approach enables efficient searching of OSH projects without requiring a dedicated server, thereby simplifying maintenance and reducing costs.

To promote the adoption of the Open Know-How (OKH) format, the OSH Registry Search Engine and indexable OSH file should be designed to recognize and utilize OKH metadata. As the website incorporates more data fields from the OKH metadata files, users will experience enhanced search capabilities and richer information.

As more JSON entries in the OSH registry reference OKH files, the overall index becomes increasingly valuable. This gradual evolution allows project curators to add projects to the discoverable index seamlessly without requiring significant changes to their processes. The OKH format, being open and adaptable, will continue to evolve based on usage and community feedback, ensuring it meets the needs of the open hardware community effectively.

Although nascent at the time of writing, GitHub traffic analytics tools will allow us to monitor (hopefully) increasing usage. Like all new technologies, the usage of the OKH metadata format itself and the usage of the OSH registry will depend on a summation of the usefulness they provide and the energy we expend in promoting them.

V. Future Work

As an alternative to our implemented search mechanism, a non-selective approach to maintaining a live search engine, a simple file can be generated and hosted, for example, as a nearly free service such as GitHub via GitHub Pages or a `README.md`. We call such a file a *Search Engine Optimized Indexable OSH Registry File*. This file can explicitly invite search engines to index the page. This would typically be done

as an HTML file but could be done in Markdown. The entries can contain not only the metadata but links to the project. In this way, multiple libraries can be discoverable in a single file. As the use of the OKH is increased, this file will automatically become richer, both for the search engines and the user.

Our live implementation is very preliminary and needs significant GUI design and expansion of the data fields rendered to be useful to most users. GitHub has a built-in feedback mechanism called *i*ssues. Normally, these are used for bug reports on the software, which is version-controlled in the repository. However, as part of our effort to promote systematic quality assurance for open source hardware, we intend to use the *i*ssues feature to provide trust through transparency through feedback on open source hardware projects themselves in the registry.

VI. Conclusion and Call to Action

The OSH Registry project needs volunteer programmers, marketers, technical writers, and videographers. Email read.robert@pubinv.org to volunteer.

Realizing the vision of a unified and comprehensive OSH registry requires the cooperation of curators from existing libraries. While it is technically possible to index public libraries independently, collaboration will yield better results. Specifically, it is advantageous for each organization to maintain its own OSH registry files. This approach ensures that new projects are promptly included and accurately described, maintaining the integrity and utility of the registry.

We encourage project curators to adopt the OSH-registry format and add their entries to the top-level index. Additionally, contributions from volunteer programmers to enhance the searchable, serverless index are crucial, and by undertaking these actions, the community can significantly amplify its impact, by creating a robust, searchable index that spans multiple independent and heterogeneous collections of humanitarian technology projects. This collaborative effort will greatly enhance the discoverability and utility of open source hardware in addressing global humanitarian challenges.

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