DAPSI Programme: 3rd Open Call (Round 3)

OKH P&I Phase I: Use Case Analysis

Owning your own work, no matter where you publish: portability and interoperability of hardware designs through new Open Know-How standards and tools

NGI DAPSI

IoP Alliance

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Introduction

Project Summary

The objective of the Open Know-How (OKH) specification is to improve the open-ness of know-how for making physical goods by improving the discoverability, portability and translatability of knowledge. The intent is that a maker, designer, or platform can choose to adopt the OKH specification, rather than an over-prescriptive approach that deters adoption. The mandatory aspects of this specification are kept to a minimum, to lessen the barriers for those who want to make their know-how discoverable. The OKH standard aligns with the Open Source Hardware Definition [cite] and other efforts to standardise approaches for documenting how to make things. Version 1 specifies the approach to Open Know-How Level 1 by providing a schema for providing metadata in a consistent format and a mode of information exchange enabling indexing and discovery of open hardware by stakeholders.

To progressively mature this standard, the Internet of Production Alliance (IOPA) and stakeholders in the Alliance will build on the proven OKH standard for the discoverability of hardware designs. This will be accomplished by researching uses of online hardware platforms, investigation of new options for decentralised data storage, and the development of tools for data interoperability and portability. Makers will be able to publish their creative work across many platforms at once, share their work with wider audiences, easily keep their designs up to date, build on each other's work and contributions (no matter what software they use) and secure their livelihoods and work in perpetuity. Specifically concerned by the data and content created by 'makers' (designs and documentation for hardware, together referred to as "works"), the IOP continues the exploration of tools to re-establish the boundary between makers and service providers hosting this data.

Outcomes/KPIs

Research (Phase 1): Use-case analysis, development of further OKH standards. Research implementations of the specification documentation standard, within the OKH community and investigate use-cases beyond, by:

- Conduct(ing) research towards developing a standard for portability & interoperability[1].

Primary Purpose of the Research

The primary purpose of this study was to conduct research toward developing a standard for portability and interoperability, to lend to increasing discoverability of works between platforms through better data validation. This research will aid in the further development of portability tools to transform data hosted on specific platforms into the OKH data standard for Open Hardware designs and frame investigation of the possible use of decentralised data-storage for project data.

The experiences and feedback of open manufacturing and open data stakeholders were captured via semi-structured interviews to help move to the next phase of OKH interoperability, with a focus on discoverability, adoption, and usability of the OKH standard. Document analysis across open community platforms, unpublished/grey literature, white papers and open publications related to open hardware was additionally conducted to inform the research.

Grounded theory and constant comparative analysis were chosen for this case analysis because it is inductive and provides an approach to understanding, particularly in studies regarding software engineering and development (Adolph & Hall, 2011; Hoda, 2021; Shannak & Aldhmour, 2009; Stol, Ralph, & Fitzgerald, 2016).

[1] Original proposal authors, researcher and study support contributor information located in Acknowledgements section of Appendix.

Intended audience:

- Designers and makers who publish their documentation in self-hosted or generic file repositories.
- Platforms that provide tools for designers to publish their documentation online.
- Platforms that aggregate, index or link to open hardware designs.

Research Methodology

Study Participant/Stakeholder Characteristics

Study Participants were purposefully Selected on the basis of intersection with one or more of the three primary stakeholder categories:

1 Previous or current involvement with initial and ongoing development of the Open Know-How (OKH) or Open Know-Where (OKW) standard(s).

2 Previous or current use of the Open Know-How (OKH) or Open Know-Where (OKW) standard(s) for individual production or mass manufacturing.

3 Identified as a stakeholder in the development of open manufacturing standards, with recognized involvement in open hardware use, design, or manufacturing.

Participant/Stakeholder Organisation Representation and Characteristics

Study participants were selected from a broad range of organisations identified as stakeholders in open hardware and manufacturing, including private and publicly held organisations, for profit, NGO/NFP, academic and research organisations, and community research forums and associations. The contact information and characteristics of all organisations included in the study are reflected in Table 1: Characteristics of Identified Stakeholder Organisations[2].

Research Questions for Semi-Structured Interviews[3]

1. What is your understanding of the purpose and intent of the OKH standard?
2. Does this purpose and intent match your needs to accomplish your goals in manufacturing?
3. What is the current awareness of generated manifests and their utility?
4. What do we mean by data portability?
5. What, in your view, are the next steps to make progress?

Each interview was scheduled for 45 minutes, though many conversations stretched beyond that time marker. There were several emergent themes that came from the resulting data; the focus of this report is on data interoperability and use cases for the OKH standard and implications for further development or branching of the standard.

Research Findings

Use Cases

While there are multiple examples of individual users and organisations using okh v1.0.0 to generate project manifests, three use cases are being highlighted as those with the greatest maturity and highest adoption rate.

[2] Table 1: Characteristics of Identified Stakeholder Organizations located in Appendix.

[3] Questions grow and shift during semi-structured interviews; full list of questions resulting from iterative process, including interviewer script, provided in Appendix.

Use Case 1: OKH Specification v1.0.0 for OKH Search Ingest

Open Know-How v1 is an open data model for sharing hardware designs and documentation online, to know how something can be made. The discoverability standard is in use, and the next phases of its development are portability and interactivity. In okh-manifest-version: 1.0.0, there are 4 required fields of 40 in the standard. Manifests generated with the minimum required 4 fields are ingested into OKH search for discoverability. There are 490 YML files to date in the dataset, with varying levels of information present in the product manifest.

Use case: Makers in the field; low number of required fields, platform interoperable for discoverability and ease of use. Limitations: health and safety standards, requirements and certifications not required. Validation of production and success of standard not required. High number of optional fields complicates use for lay people.

Use Case 2: Appropedia

Appropedia.org provides infrastructure for making connections between individuals, organisations and free content, toward sustainability and climate preservation which includes project design files for manufacturing to scale. Appropedia has adopted the OKH standard with amendments reflected in version 15:13, 2 June 2021 by Felipe Schenone.

Appropedia-specific field:

Fieldname: sustainable-development-goals

Purpose: Indicates which UNESCO SDGs are addressed by the project that has been produced/the thing that has been made.

Format: SDG ##: Text

User-defined fields" . ($sdg ? " sustainable-development-goals: $sdg" : ")

Use case: Makers in the field; low number of required fields in manifest generator, platform interoperable for discoverability and ease of use. Mapping to SDGs helpful for mapping to funding opportunities. Limitations: health and safety standards, requirements and certifications not required. Validation of production and success of standard not required.

Use Case 3: OPEN-NEXT/OKH-LOSH

LOSH is a library of open source hardware, with technical documentation in an open graph database. Based on OKH v1.0.0, OKH-LOSH features the specification for representative metadata of open source hardware (OSH) modules.

Data Mapping

OPEN-NEXT LOSH-Appropedia-Scraper	Wikifactory	OSHWA Certified Projects List
Scrapes project metadata on the appropedia.org Wiki and converts it to manifest files.	Platform URL Data mapping specification crawler code	Platform URL Data/Ontology mapping

Main specification differences: Source for mapping OKHv1 Section 4.5 ff/Ontology mapping main differences:

specification	**OKHv1 Section 4**	**OKH-LOSHv1**
Manifest file format	YAML v1.2	TOML
Manifest file name	Anything containing “okh”	Anything containing “okh,” but preferable just okh.toml
declaration	Via %Open Know-How Manifest 1.0 in line 1, and 3 dashes in line 2	Specification of the version used in the data field okhv

Use case for OKH manifest file: when metadata for the thing/project cannot be accessed via the platform API (GitLab or GitHub, for example).

Location and Naming Convention: YAML vs TOML. Ontology is written in TURTLE; fields pre-filled by the crawler = 50. Template for manifest files is available at okh-TEMPLATE.toml. Justification for removal of optional fields is that many are not used in practice. Data from study supports this.

Mandatory Field Requirements (manual entry)

- Complete legal information (name, license, licensor)
- Unambiguous reference to its repository, where source files are available
- Specific version
- Language in which the documentation is written
- Functional description

Helpful Engineering version of OKH: https://github.com/helpfulengineering/template-project/

Recommendations for Future Versions of OKH

Develop a shared understanding amongst all stakeholders and Working Groups: OKH specification intent/audience and conduct additional community research.

A shared vocabulary amongst stakeholders is a necessary baseline prior to further development of the OKH specification to a subsequent version. Multiple stakeholders have indicated that the following categories require clear definition:

1. User story/audience: who is the standard for?

   Clear parameters need to be set surrounding user stories for the OKH specification, with the two recommended categories:
   a. Independent Maker/Designer;
   b. Manufacturer (small to large scale).

   By first developing the user story for each category, the definition of portability and the fields required for adoption shift. For example, several study participants who are either currently or have previously worked in private industry or manufacturing to scale indicated that health and safety protocol and standards for safety certification are a must and impact OKH adoption rates[4], whereas independent makers are impacted more by field data related to localised health and safety concerns, maintenance and making instructions. There is the recognition that compliance and public safety tend to be so jurisdictionally specific that there cannot be a universal standard. ISO is the closest and it has served as a starting point for many who have tried to implement discoverability/portability. It has been found to be lacking in several areas, which warrants further discussion.

Develop a shared ontological understanding amongst all stakeholders and Working Groups: OKH specification metadata schema, manifest fields, and data format.

1. Determine minimum required fields for manifest viability and reduce optional fields.
2. Look to LOSH-OKH ontology mapping for recommendation on required fields once it becomes available for review[5].
3. Metadata ontologies: when generating specification outside of pre-existing metadata standards, there will be multiple discrepancies in vocabulary. Mapping OKH specification fields, where appropriate, to a pre-existing/known metadata standard, such as DublinCore or a format such as Resource Description Framework (RDF) (preferred, for evolution of

[4] https://www.nist.gov/nist-research-library

[5] Utilizing visual mapping software such as the VMF help develop shared visual vocabulary and understanding; the visual vocabulary under development (Miro) by LOSH is currently pre-pub.

schema), which will limit discrepancies in vocabulary agreement in future development. RDF as a standard format for data interchange is recommended over StictYAML or TOML, as it will enable smooth portability between platforms. Parse/dump converters can be used for pre-existing YAML/TOML forms.

4. Research supports superfluous optional fields to be a deterrent in adoption; simplification of required fields and pre-fill by crawlers are recommended for end user ease of access and use.

Develop a shared validation and feedback system for built objects and projects.

1. Multiple study participants voiced concerns surrounding the lack of rigorous testing of the standard producing a successful build; this includes testing of necessary field data for completion of project and testing of the object itself with a community feedback mechanism in place to verify viability of design.
2. **Validation of manifest fields** is a necessary step prior to being able to discuss portability.
    a. Work on a manifest field validator is currently in development, to crawl and validate for the following:
        i. Title
        ii. Description
        iii. Project Link or Documentation Home
        iv. License
    b. Applying the following three statuses for validation:
        i. Ok [field complete/verified]
        ii. Not found [field empty]
        iii. Error [field problematic/incorrect data]
3. **Validation of built objects/completed projects** requires further community engagement and platform development. While beyond the scope of this study's remit, the development of a community feedback forum for the successful build and use of built objects has been identified as a critical need in support of broader community adoption of the OKH standard.

Recommendation for additional research related to data portability

Conduct focus groups and extensive UX testing of the OKH specification fields with stakeholders for two groups: [1]manufacturing/industry and [2]independent designers/makers; run diff on okh-manifest.yml; generateOpenKnowHowManifest.yml; losh[proposed].tml, isolating core similarities for required and optional fields and rigorously assess in the field with practitioners.

Emergent Themes for Further Exploration and Research

Grounded theory and constant comparative analysis as a research methodology produced several emergent themes for further research. They will be mentioned briefly here but not explored in depth in this report, as it is beyond this study's remit:

Governance	Communication	Community	Funding
Shared Values Cohesion Open Governance Models Signaling	Continuity Organizational Structure Strategy	Membership Participation Inclusion	Non-Profit Foundation Model Grant Support Growth models

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Appendix

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- Max Wardeh
- Barbara Schack
- Andrew Lamb
- Robin Vobruba

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The IOPA gratefully acknowledges the principal authors/contributors:

- Sarah Hutton, Research and Technical Author, IOPA
- Max Mahmoud Wardeh, Technical Coordinator, IOPA

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- Barbara Schack, Coordinator, IOPA
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- Raisa Ismaily, Communications and Operations, IOPA

Methodology

Characteristics of Identified Stakeholder Organizations

Table 1

Characteristics of Identified Stakeholder Organizations

Participant Affiliation	Organization Website	Org Classification
Appropedia	https://www.appropedia.org	Foundation/501c(3) EIN: 20-8982657
FabCity	https://fab.city	Foundation/NPO or MTÜ VAT: EE102339491

Field Ready	https://www.fieldready.org	501c(3) EIN: 61-1725201 DUNS: 079360197
Habitat for Humanity	https://www.habitat.org	501c(3) EIN: 91-1914868
Hackaday	https://hackaday.io	Subsidiary of Supplyframe Inc. Privately Held EIN: 20-0073122
Helpful Engineering	https://helpfulengineering.org	501c(3) EIN: 85-0673635
Jacobs	https://www.jacobs.com	Charitable Foundation EIN: 20-3975531
Kijenzi	https://www.kijenzi.com	Privately Owned/For Profit
Kitspace	https://kitspace.org	Privately Held
Gathering for Open Science Hardware [GOSH]	https://openhardware.science	Community/Forum
Library of Open Source Hardware [LOSH]	https://losh.opennext.eu	Community/Forum; subsidiary of OpenNEXT!
Makernet	https://makernet.org	Privately Held
Massive Small Manufacturing	http://www.massivesmallmanufacturing.com	Private Limited Company (Ltd.) Company No:12177978
Open Instruments Group	http://www.openinstruments.com	Private Limited Company (Ltd.)
OPEN NEXT!	https://opennext.eu	Funding from the European Union's Horizon 2020 research and innovation programme under grant agreement no. 869984
Open Source Ecology [OSE]	https://www.ose-germany.de	Community/Research
Open Source Hardware Association [OSHWA]	https://www.oshwa.org	Community/Research
Tzoumakers	https://www.tzoumakers.gr	NPO/NGO

Wikifactory	https://wikifactory.com	Privately Held/For Profit Company No: 09421115

Interview Questions

Introduction

As the Standards Researcher and Technical Author for the Internet of Production Alliance, I am currently conducting research focusing on further developments of the Open Know-How standards for portability and interactivity.

The purpose of this use-case analysis is to aid in the further development of the OKH standards, taking a look at the discoverability standard and what is needed to move to portability; I am speaking with the stakeholder working groups who are dedicated to developing portability & interoperability standard(s), and conducting research on how the platforms treat data, including IP, encoding and data structure.

This research is being conducted to provide a use-case analysis of the original OpenKnowHow (OKH) **Discoverability** standard, or the "Level 1" of OKH, which allows know-how to be discovered, indexed and linked to using meta-data about the *thing* and the location of *know-how*.

This hope is that this research will lend to achieving **Level 2**, or the **Portable** Know-How, which will provide a format and structure for know-how so that it is represented in a consistent format and can be easily moved between platforms.

Establishing portability will lend to achieving **Level 3**, or **Distributed** KnowHow, which supports interoperability, creation and aggregation of know-how about a thing by different designers and makers without centralised control of the know-how.

The current understanding is that:

- The OKH manifest should be a list of things that could be found in a directory structure - that should be templatized, and should be versioned, and openly available for use by a decentralized manufacturing network/ecosystem of makers.

Participant Affiliation/Background

1. Could you provide me with a bit of background/context regarding your current or previous work in manufacturing, open hardware or affiliated work, including involvement with the IOP Alliance?

Over the course of preliminary conversations, there is a recognition that we could be looking at v2 of OKH to be a connection between OKH v1 and the work LOSH, and these conversations with stakeholders and community members are ultimately seeking to address the overarching research questions:

1. What is your understanding of the purpose and intent of the OKH manifest?
2. Does this purpose and intent match your needs to accomplish your goals in manufacturing?

3. What is the current awareness of generated manifests and their utility?
4. Considering the structure of the OKH manifest as a file:
    a. Format
        i. YAML v1.2
        ii. Encoding - UTF-8.
        iii. Character - Unicode.
    b. Filename
        i. Example: “okh.yml”
    c. Declaration
        i. %Open Know-How Manifest 1.0
    d. Absolute vs Relative links
    e. Location of the manifest - linked from project homepage (where is?)
        i. To declare OKH schema: open-know-how v0-1

5. Discussion/review of manifest fields

Manifest fields - categorical discussion

Date Created Fieldname: date-created	Purpose: Indicates the date the manifest was originally created. Format: YYYY-MM-DD
Date last updated Fieldname: date-updated	Purpose: Indicates the date the manifest was last edited. Format: YYYY-MM-DD
Content Originator Fieldname: manifest-author	Purpose: States the person who has created and is responsible for the content in the manifest. Manifest-author: name: [value] # Text affiliation: [value] # Text email: [value] # Email address *Name field required, others optional*

Descriptive Properties

Title Fieldname: title	Purpose: A title to identify the thing. Format: Text. Rules: Required.
Description	Purpose: Describes the thing.

Fieldname: description

Format: Paragraph.

Rules: Required.

Intended Use

Fieldname: indended-use

Purpose: Informs the maker for what purpose the designer intends the thing to be used. In particular, make reference to the context and type of users.

Format: Paragraph.

Rule: Recommended.

Keywords

Fieldname: keywords

Purpose: Provides a small number of terms that can be used to help identify.

Format: Array of text.

Rule: At least one keyword is recommended.

Project Homepage

Fieldname: project-link

Purpose: Where the thing or associated project has a web presence that is separate from the documentation (e.g. a marketing page), links to the web resource.

Format: Absolute path.

Rules: At least one of the project-link or documentation-home fields is required.

Health and Safety Notice

Fieldname: health-safety-notice

Purpose: Highlight health and safety risks and/or necessary precautions that the maker should be aware of as part of the decision to make the thing.

Format: Paragraph

Rules: Not an exhaustive list of all risks associated with the thing, but a summary of the most important risks and hazards associated with making, using, maintaining or disposing. Knowledge of such issues could influence the decision to make the thing.

Primary Contact

Fieldname: contact

Purpose: Provides a point of contact for people who wish to discuss the thing.

Format:

```
contact:
  name: [value]            # Text
  affiliation: [value]     # Text
  email: [value]           # Email address
  social:                  # Lists other web-presences through which contact can be
made
    - platform: [value]    # Text
      user-handle: [value] # Text
```

Rules: Where used, provide at least one email address or social media user handle.

Contributors

Fieldname: contributors

Purpose: Credits the contributors to the know-how. May include people who designed, produced documentation, tested the documentation by making, reviewed and/or edited documentation, or made another contribution as deemed valued by the project or manifest-author.

Format: List of contributors

```
contributors:
  - name: [value]         # Text
    affiliation: [value]  # Text
    email: [value]        # Email address
```

Rules: Recommended. A name is required for each contributor listed.

Image

Fieldname: image

Purpose: Provides a graphical representation of the thing.

Format: Absolute or relative path to image file.

Rule: Recommended.

Thing Version

Fieldname: version

Purpose: Defines the version of the thing that is represented by this manifest.

Format: Text.

Stage of Development

Fieldname: development-stage

Purpose: Indicates the maturity of the design and documentation development.

Format: Text

Note: The Open Know-How Working Group intends to develop recommended values for this field to support commonality across manifest files. This is likely to be made by reference to a external standard.

Has Been Made

Fieldname: made

Purpose: Indicates whether the thing has been made and verifies that it is makeable.

Format: Boolean – “true” or “false“

Has Been Made Independently

Fieldname: made-independently

Purpose: Indicates whether the thing has been made using the documentation by someone who was not a contributor to the design or documentation and, therefore, verifies that the documentation is sufficient to make the thing.

Format: Boolean – “true” or “false“

Standards Used

Fieldname: standards-used

Purpose: Indicates any standards that have been used in developing the design or documentation.

```
standards-used:
  - standard-title: [value]      # Required where used | Title of the standard used in
                                 developing the design or documentation
    publisher: [value]           # Publisher of the standard
    reference: [value]           # Reference indentifier of the standard (e.g. ISO 9001)
    certification:               # If certification has been granted confirming
```

Format: Array of arrays.

```
compliance
                                        with the standard
    - certifier: [value]          # Individual or organisation granting the
certification. Use
                                        "Self" for self-certification
      date-awarded: [value]    # Date certification was granted
      link: [value]                 # Link to evidence of certification (e.g.
certificate). Use an
                                        an absolute path to an external resource or
an absolute
                                        or relative path to evidence within the
documentation.
```

Rules: Do not list standards to be used by the maker or user, instead these should be referenced in the relevant documentation.

Derivative Of

Fieldname: derivative-of

Purpose: Where the thing is a derivative of a different thing (e.g. the documentation has been forked), links to the original thing.

Format:

```
derivative-of:
  title: [value]       # text | Title of the original
  manifest: [value]    # URL - Absolute path | OKH manifest location
  web: [value]          # URL - Absolute path | web presence location
```

Rules: Where derivative-of used, the title sub-field is required.

Variant Of

Fieldname: variant-of

Purpose: Where the thing is a variant, links to the original.

Format:

```
variant-of:
  title: [value]          # text | Title of the original
  manifest: [value]   # URL - Absolute path | OKH manifest location
  web: [value]          # URL - Absolute path | web presence location
```

Sub-thing

Fieldname: sub

Purpose: Where the design uses sub-components, sub-assemblies etc that are also available as open know-how, links to the documentation.

Format: List of sub-things

```
sub:
  title: [value]         # text | Title of the original
  manifest: [value]  # URL - Absolute path | OKH manifest location
  web: [value]         # URL - Absolute path | web presence location
```

License

Fieldname: License

Purpose: States the licenses under which the thing is made available.

Format:

```
license:
  hardware: [value]
  documentation: [value]
  software: [value]
```

Rules: At least one license is required. All three license types are recommended. The format should be an SPDX identifier [3]. See https://spdx.org/licenses/

Licensor
Fieldname: licensor

Purpose: States who is licensing the thing.

Format:

licensor:

```
name: [value]          # text
affiliation: [value]   # text
email: [value]         # email address
```

6. Dcoumentation - review
    a. Entry point to documentation
    b. Documentation archive
    c. Design files
    d. Schematics
    e. Bill of materials
    f. List of tools
    g. Assdembly instructions
    h. Manufacturing files (such as 3D print) - what's the difference between this and design files?
    i. Risk assessment - define assessment
    j. Tool settings and documentation
    k. Quality control instructions
    l. Operating instructions
    m. Maintenance instructions
    n. Disposal instructions
    o. Software

7. Documentation language
    a. ISO
    b. BCP/IETF (language tag)

8. If you have used the manifest generator in your work, how has this process been beneficial? What could be improved?

9. If the intended goal of discoverability and interoperability are not a match for your goals, why is that the case?

10. What do you see as next steps, and what is needed to make progress?

What is Our Success Criteria in this Research? Discussion.

- Building consensus about the nature and details of the problem. This is important as it will help us validate what a sample of makers consider to be the common issues around project portability between platforms
    - What success means in context: >80% of the group agrees that this is a problem, and a big enough problem that it should be solved.

- Generating a list of must-have features that a solution would have. This will enable us to use the input of the focus group into prioritising the development of features that will best meet their needs and therefore increase the chance of early adoption of the solution.

- What success means in context: participants of the focus group can identify at least 2 specific needs that make this a problem, which a solution should address.
- What success means in context: 50% of participants of the focus group declare that they are interested in “signing-up” to participate in designing the product. As an open project, one of the ways to measure product fit is the degree of community participation in the design and development of the solution

OKH v1+ goals (original)

Validation

Improve the manifest generator to provide better validation of data

- Building on the outputs of the user research, the improved OKH manifest validation tool will result in better inter-platform compatibility and interoperability for makers to use the standard as a basis for enabling inter- platform portability

Portability Tools (Building on LOSH work)

- Data transformation tools to generate different data formats for data stored on different platforms to the OKH standard, including the use of linked-data such as RDF
- Outcome: Increased interoperability for makers

Decentralized Data Storage

- Investigate the use of decentralized data storage protocols and tools, such as those developed by Solid, to allow makers to have more control of the data related to their projects
- Outcome: The use of these protocols and tools will enable much greater service portability than alternative methods of transfer of project data between platforms