



Open Science Plan-Track-Assess Pathways

Deliverable 3.4

Deliverable Number	D3.4
Deliverable Title	Disciplinary and Thematic Community based Evaluation Extensions for Compliance Assessment V1
Version n°	1
Status	Final
Type	R - Document, report
Dissemination Level	Public
Work Package	WP3
Lead Beneficiary	UOXF
Delivery Date	31/07/2025
Author(s)	Susanna-Assunta Sansone, Allyson Lister, Mark Wilkinson, Daniel Garijo, Renaud Duyme, Baptiste Cecconi, Maud Medves
Editor(s)	Susanna-Assunta Sansone (UOXF), Allyson Lister (UOXF)
Reviewers	Natalia Manola (OPENAIRE), Paolo Manghi (OpenAIRE), Wim Hugo (KNAW), Tomasz Miksa (TU Wien).
Approved by	Natalia Manola (OPENAIRE)

This project has received funding from the European Union's Horizon Europe framework programme under grant agreement No. 101130187. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the European Research Executive Agency can be held responsible for them.



Revision History

VERSION	STATUS	DATE	DESCRIPTION	AUTHOR(S)
0.0	Draft	15/05/2025	Agreement on structure & References	Susanna-Assunta Sansone (UOXF), Allyson Lister (UOXF)
0.1	Draft	28/05/2025	First Draft	Susanna-Assunta Sansone (UOXF), Allyson Lister (UOXF), Mark Wilkinson (UPM), Daniel Garijo (UPM), Renaud Duyme (ESRF), Baptiste Cecconi (ObsParis), Maud Medves (INRIA), Miguel Rey Mazón (TU Gaz), Katja Moilanen (TAU), John Shepherdson (CESSDA), Oana Claudia Dragomir (SOCIB), Andres Tabima (TU Wien).
0.2	Review		Intermediate version	Natalia Manola (OPENAIRE), Paolo Manghi (OpenAIRE), Wim Hugo (KNAW), Tomasz Miksa (TU Wien).
1.0	Final		Comments Addressed	Susanna-Assunta Sansone (UOXF), Allyson Lister (UOXF), Mark Wilkinson (UPM), Daniel Garijo (UPM).

Author List

ORGANISATION	NAME	CONTACT INFORMATION
UOXF	Susanna-Assunta Sansone, Allyson Lister	susanna-assunta.sansone@oerc.ox.ac.uk allyson.lister@oerc.ox.ac.uk
UPM	Mark Wilkinson Daniel Garijo	mark.wilkinson@upm.es daniel.garijo@upm.es
ESRF	Renaud Duyme	renaud.duyme@esrf.fr
ObsParis	Baptiste Cecconi	baptiste.cecconi@obsparis.fr
Inria	Maud Medves	maud.medves@inria.fr

Contribution List

ORGANISATION	NAME	CONTACT INFORMATION
TUGraz	Miguel Rey Mazón	m.reymazon@tugraz.at
TAU	Katja Moilanen	katja.moilanen@tuni.fi
OpenAIRE	Natalia Manola Paolo Manghi	natalia.manola@openaire.eu paolo.manghi@openaire.eu
CESSDA	John Shepherdson	john.shepherdson@cessda.eu
TU Wien	Tomasz Miksa Andres Tabima	tomasz.miksa@tuwien.ac.at andres.romero@tuwien.ac.at
SOCIB	Oana Claudia Dragomir	odragomir@socib.es
KNAW	Wim Hugo	wim.hugo@dans.knaw.nl

Table of Contents

Disclaimer	6
Abbreviations list.....	7
Executive Summary.....	8
1. Context and Introduction	9
2. Methodology	12
2.1. Survey of the Thematic Clusters.....	12
2.2. Continuous Refinement with Clusters	13
3. Results and Ongoing Activities.....	14
3.1. DOs, Including Repositories and Standards.....	14
3.2. Generic and Extendable Assessment-IF	15
3.3. DOs Type and Discipline Specific Examples of Metrics	17
3.3.1. Research Software Source Code	18
3.3.2. Datasets and Repositories	19
3.4. Discoverability and Sharing	23
3.4.1. Standards and Repositories	23
3.4.2. Dimensions, Metrics, Benchmarks.....	25
3.4.3. Tests and Algorithms.....	26
4. Conclusions and Next Steps.....	27
5. References	30

List of Figures

Figure 1. DO types, by frequency, that Clusters would like to assess for FAIRness. Note that 'document' includes publications.	15
Figure 2. The components and inter-component relationships in the Assessment-IF, along the two exemplar registries where the components will be made discoverable, searchable and reusable by humans and machines.....	15

Figure 3. A snippet of the graph of the "ESRF - Resources for FAIR Assessment" Collection. The arrows starting at the central red dot) highlight the example given in the main text.	24
Figure 4. The in-development FAIRassist registry landing page, its filtering options and navigation, from Dimensions, via a visualisation tree.....	26
Figure 5. The homepage of the FDP available in the OSTRails reference implementation shows a list of known metadata records corresponding to Tests and Algorithms, along with some quality metadata about them.	27

List of Tables

Table 1. Example of a Metric for research software licensing.	18
Table 2. Example of Metric for dataset and its compliance with community terminologies.	20
Table 3. Example of Metric for datasets and its association with an IVOA Catalogue Resource.....	21
Table 4. Example of Metric for checking compliance of a dataset's service with IVOA specifications.	23

Disclaimer

This document contains a description of the OSTrails project findings, work, and products. Certain parts of it might be under partner Intellectual Property Right (IPR) rules so, prior to using its content please contact the consortium head for approval.

In case you believe that this document harms in any way IPR held by you as a person or as a representative of an entity, please do notify us immediately.

The authors of this document have taken any available measure to ensure that its content is accurate, consistent, and lawful. However, neither the project consortium as a whole nor the individual partners that implicitly or explicitly participated in the creation and publication of this document hold any sort of responsibility that might occur as a result of using its content.

The publication herein was produced in the framework of the EU-funded OSTrails project (Grant Agreement No 101130187). Views and opinions expressed are however those of the OSTrails consortium and do not necessarily reflect those of the European Union or the European Research Executive Agency.



**Funded by
the European Union**

Abbreviations list

API	Application Programming Interface
DO	Digital Object
DCAT	Data Catalog Vocabulary
DMP	Data Management Plan
ENVRI	Environmental Research Infrastructures
ERINHA	European Research Infrastructure on Highly Pathogenic Agents
EOSC	European Open Science Cloud
ESRF	European Synchrotron Radiation Facility
ESFRI	European Strategy Forum on Research Infrastructures
FAIR	Findable, Accessible, Interoperable, Reusable
FAIR4RS	FAIR Principles for Research Software
FAIR-IF	FAIR Interoperability Framework
FDP	FAIR Data Point
GBIF	Global Biodiversity Information Facility
IVOA	International Virtual Observatory Alliance
JSON	JavaScript Object Notation
LSRI	Life Science Research Infrastructure
PaNET	Photon and Neutron Experimental Techniques
RDA	Research Data Alliance
SKG	Scientific Knowledge Graph
UOXF	University of Oxford
UPM	Universidad Politécnica de Madrid

Executive Summary

A broad diversity of resources exists to help researchers and data stewards measure, evaluate, and improve the FAIRness of datasets, repositories and other Digital Objects (collectively – DOs). However, several unresolved issues continue to challenge the credibility of the results produced and transparency of the methods used. Firstly, the wide variety of tools produces a correspondingly disparate set of results for the same DO. Secondly, existing FAIR evaluation and assessment tools often test only a limited set of DO typologies. Finally, some of these tools are “domain-agnostic”, testing only those FAIR features that can be expected across most/all specialist domains.

In OSTrails we address these challenges by developing an Assessment Interoperability Framework (hereafter Assessment-IF) that is both generic and extendable and helps to harmonise how FAIR testing tools behave. Ultimately this allows the production of results that are more transparent, and are technically consistent and comparable, regardless of the tool used, the specific discipline and/or research community, or the type of DO. In this context, the two objectives of Deliverable 3.4 are to ensure that (i) DOs type and research discipline needs are taken in account in the development of this Assessment-IF, illustrated in this document through concrete examples; and (ii) exemplar services are in place to assist with the sharing and reuse of the assessment components and their implementation by FAIR testing tools.

To collect these requirements, we used two complementary strategies. The first step was to design and run a short survey on DOs to collect requirements from the scientific disciplines represented in OSTrails by the five ESFRI Thematic Clusters: ENVRI, Life Science RIs, ESCAPE, PANOSC, and SSHOC. The second step was to engage representatives from these partners in the existing FAIRsharing Community Champion Programme to continuously refine their needs with regards to DO typologies and disciplines.

The collected requirements enabled us to design a generic and extendable Assessment-IF, used to form a suitable framework for the DO types and specialisations identified for the cases we evaluated. We are confident that the framework is adequately modular and generic to be extended to all DO types and any discipline or thematic community needs. Moreover, we ensured that all relevant information on repositories and standards is available and correctly classified in FAIRsharing according to DO types (e.g. GBIF database and *dataset*; CodeMeta format and *software code*) and disciplines (e.g. PaNET terminology for *physics*).

Furthermore, we launched beta versions of the FAIRassist registry and the FDP Index, complementary exemplar services to showcase: (i) registration and sharing the components of the Assessment-IF, (ii) assistance with their discoverability (based on DO

types, discipline specificity or generic), and (iii) delivery information to guide and assist during the FAIR assessment process.

This is a technical deliverable, and the intended audience is mainly technical partners and other infrastructure developers. The FAIRassist and FDP Index have been developed as exemplar registry services that allow partners to be transparent about the functionality of their tools, and these registries are currently being tested by some of the thematic early-adopter Cluster partners. While registration of assessment tool behaviour/functionality is strongly recommended for transparency, and for FAIRness, the use of these registries by the pilots and their existing tools for the purpose of lookup – i.e. integration of these registries into existing workflows - is optional but complements the Interoperability Framework. This approach allows ease of adoption and transparency while encouraging, and providing clear guidance for producing, the formality and consistency expected in an Interoperability Framework. This approach will be further tested and refined by additional Pilots and partners in the next phase of the project (version 2 of this deliverable).

1. Context and Introduction

We have identified at least 30 tools¹ whose goal is to help users understand how to achieve a state of FAIRness for their DOs, and how that FAIRness can be measured (assessed and/or evaluated) and improved. However, claims such as “my data is FAIR” or my “repository enables FAIR data” cannot currently be trusted, a challenge documented by a report of the former EOSC FAIR Metrics and Data Quality Task Force², and still addressed by the current EOSC FAIR Metrics and Digital Objects Task Force³. Currently, the use of these tools presents the following challenges:

- The same assessment and/or evaluation by different tools often exhibits different results⁴ due to the flexibility with which the FAIR Principles⁵ may be interpreted.

¹ FAIRassist – signposting tools. <https://fairassist.org/tools>

² EOSC FAIR Metrics and Data Quality Task Force. <https://eosc.eu/advisory-groups/fair-metrics-and-data-quality>

³ EOSC FAIR Metrics and Digital Object Task Force: <https://eosc.eu/advisory-groups/fair-metrics-and-digital-objects-task-force>

⁴ Wilkinson, M. D., Sansone, S.-A., Grootveld Marjan, Nordling, J., Dennis, R., & Hecker, D. (2022). FAIR Assessment Tools: Towards an "Apples to Apples" Comparisons. Zenodo. <https://doi.org/10.5281/zenodo.7463421>

⁵ Wilkinson, M. D., et al. The FAIR Guiding Principles for scientific data management and stewardship. Sci Data, 3(1):160018 (2016). <https://doi.org/10.1038/sdata.2016.18>

- Some tools can test only a limited set of DO types⁶, and usually when such DO is already shared or published. For example, the FAIR Champion⁷ (formerly FAIR Evaluator) and F-UJI⁸ tools are primarily aimed at testing traditional datasets stored and shared in repositories; the OpenAIRE Validator⁹ focuses on content providers such as repositories themselves; FOOPS!¹⁰ is intended to test semantic artefacts like ontologies; and howfairis¹¹ is designed to test software.
- Tools are usually domain-agnostic, testing only FAIR features that can be expected across most/all disciplines; in particular, when checking for the use of community-standards, the tools cannot easily adhere to the thousands of discipline- and DO-specific standards¹².

One of the aims of OSTRails¹³ is to contribute towards these challenges, by designing and implementing an Assessment-IF that is both generic (works for all DO types and is domain-agnostic) and extendable (meets the needs of different DO typologies and disciplines). By adopting a common framework, we can achieve harmonisation in the behaviour of FAIR assessment and evaluation tools. This, in turn, will foster trust in the results they produce, as these tools will become more transparent, technically consistent, and comparable. The Assessment-IF is summarised in this Deliverable for context, however it is the focus of Deliverable 1.2¹⁴ and Deliverable 1.4¹⁵.

This Deliverable 3.4 focuses on describing the work we have done to:

- Identify the requirements on DOs typologies and disciplines-specific needs from the five ESFRI Thematic Clusters (ENVRI – Environmental Science; Life Science RIs – Life Science; ESCAPE – Astronomy; PANOSC – Photon Neutron Science; SSHOC – Social Sciences and Humanities)¹⁶, to inform the development of the Assessment-IF.

⁶ Digital object types in OSTRails. <https://fairsharing.gitbook.io/fairsharing/record-sections-and-fields/general-information/object-types>

⁷ FAIR Champion. <https://tools.ostrails.eu/champion/>

⁸ F-UJI. <https://www.f-uji.net/>

⁹ OpenAIRE Metadata Validator.

https://catalogue.openaire.eu/service/openaire.metadata_validator/overview

¹⁰ FOOPS! https://foops.linkeddata.es/FAIR_validator.html

¹¹ howfairis. <https://github.com/fair-software/howfairis>

¹² FAIRsharing Standards registry. <http://fairsharing.org/standards>

¹³ OSTRails project website: <https://ostrails.eu>

¹⁴ OSTRails D1.2 FAIRness Reference Model for Digital Objects V1.

<https://doi.org/10.5281/zenodo.14794900>

¹⁵ D1.4 OSTRails Interoperability Reference Architecture V1.

<https://doi.org/10.5281/zenodo.14794999>

¹⁶ ESFRI Thematic Clusters. <https://science-clusters.eu>

- Start to illustrate the generic and extendable nature of the Assessment-IF through concrete examples with several DO types and disciplines.
- Launch of two exemplar services (as beta versions), the FAIRassist registry¹⁷, within FAIRsharing¹⁸, and the FDP Index¹⁹ to support the discovery, sharing and reuse of Assessment-IF components by humans (e.g., tools developers) and machines (e.g., the FAIR assessment and/or evaluation tools).

This is a technical deliverable, and the intended audience is mainly technical partners and other infrastructure developers.

This Deliverable contributes to several Tasks in WP3 *Assessment tools & services* and WP 4 *Pilots for adoption*:

- Task 3.1 - *FAIR assessment metric services - Harmonizing legacy tools and services*, and Task 3.2 - *Beyond FAIR - domain-specific and digital-object-specific assessment services*, require the Assessment-IF²⁰ components to be described according to their specificity or genericity to disciplines and DO types, as well as being searchable by and shared with the wider community outside OSTRails.
- Task 3.4 - *Enhancing "assessment" with "guidance"*, concerned with providing domain-specific guidance to interpret and improve the results of the tests.
- Task 4.2 - *National Pilots*, and Task 4.3 - *Thematic pilots*, including a cross-Clusters pilot to identify discipline-specific standards and repositories.

We present Deliverable D3.4 in two stages. In this first version (V1) we report on the initial results covering the period from Month 1 to Month 18 (February 2024 to July 2025); V2 (Deliverable 3.5) is due at month 30 will report on more examples of the extendibility of the Assessment-IF.

Deliverable D3.4 V1 is organised in the following sections:

- Methodology: summarising two complementary strategies used to collect the requirements on DOs typologies and disciplines-specific needs, and ensuring their continuous refinements with the Clusters.
- Results and Ongoing Activities: covering the requirements collected, an overview of the Assessment-IF, illustrated through an initial set of concrete examples, and the exemplar services launched, as beta versions, to support discoverability, sharing and reuse of Assessment-IF components by humans and machines; and

¹⁷ The FAIRassist registry. <https://w3id.org/fair-assist>

¹⁸ FAIRsharing: <https://fairsharing.org>

¹⁹ FDP Index. <https://w3id.org/fdp-index>

²⁰ Assessment-IF (formerly FAIR-IF). https://docs.ostrails.eu/en/latest/architecture/fair_if.html

- Conclusions and Next Steps.

2. Methodology

This section summarises the two complementary strategies we employed to collect Cluster requirements on DO typologies and disciplines-specific needs and ensure continuous refinement of their requirements.

2.1. Survey of the Thematic Clusters

The goal of our survey was to gain a more complete understanding of the following requirements:

- **Types of DOs:** identify the DO typologies the Clusters considered important to assess, without making any distinction between data/payload and metadata (as the definitions varies across communities).
- **Repositories for DOs:** indicate where these DOs are stored and made available to humans and machines.
- **Community standards for DOs:** detail those community reporting guidelines, models/formats, terminologies, and identifier schemas used, if any, to identify, describe, and structure these DOs; and
- **Community FAIRness criteria:** get an early indication of the features of those DOs of interest to their community with regards to quality assurance.

The information we requested in this DO survey is listed below:

- Type(s) of DO.
- Formats used for the DO.
- Specialist repositories where the DO would commonly be made accessible.
- Generalist repositories where the DO would commonly be made accessible.
- Example URLs for typical repository records for this type of DO.
- Community standards for this type of DO in terms of reporting guidelines, models/formats, terminologies, and identifier schemas.
- Requirements for the assessment of this DO.
- Preferred modality for the results of the FAIR test on this DO (e.g. pass/fail plus guidance).

The responses, along with the questions, are described and referenced in subsection [3.1.](#)

2.2. Continuous Refinement with Clusters

To iteratively refine and extend the results of the survey, we engaged representatives of the Clusters via the FAIRsharing Community Champions programme²¹. Launched in 2022 and supported by the RDA FAIRsharing WG²² and the RDA/EOSC-Future Ambassadorship Programme²³, this programme shows the importance of cultivating and sharing collective knowledge on standards (terminologies, models/formats, guidelines, identifier schema) and data resources for all types of DOs (databases, repositories and knowledgebases) to map their complex landscape and understand their maturity status (e.g., ready for use, in development, superseded). The programme provides our Cluster representatives with an observation point on the wider ecosystem of standards and data resources within and beyond the disciplines they represent. Cross-cluster communication and sharing is essential to meet both domain-agnostic and discipline specific needs for FAIR assessment.

This iterative engagement with Clusters helps us to ensure that domain-agnostic, disciplinary standards and data resources are made available in FAIRsharing, the curated resource of standards, data resources and data policies, provided by the UOXF partner and endorsed by RDA. FAIRsharing exposes its content according to the OSTRails SKG-IF and shows how standards are related to each other (e.g. which terminology is required by a given discipline-specific format), which repositories implement them, what their maturity statuses are, and which data policies recommend them. FAIRsharing content is also tagged with DO types and disciplines or labelled as subject and/or DO type agnostic.

Since the Assessment-IF describes the types of standards and DOs as of primary importance, Cluster representatives use FAIRsharing to:

- Identify the disciplinary standards and repositories both used/recommended by their Clusters and community practices, and necessary to power their assessment process.
- Curate those resources, focusing on those attributes most relevant to their Clusters as highlighted by the survey, such as the types of DOs and discipline relevance, and

²¹ FAIRsharing Community Champions Programme.

https://fairsharing.org/community_champions

²² RDA FAIRsharing WG: <https://www.rd-alliance.org/groups/group-fairsharing-registry-connecting-data-policies-standards-databases-rda-wg/>

²³ RDA/EOSC Future Ambassador Programme. <https://www.rd-alliance.org/disciplines/rda-europe-ambassadors-2022/>

- Create Collections of those resources, and a grouping function that facilitates their discovery and use by humans and machines (as described in subsection 3.4.1).

3. Results and Ongoing Activities

In this section we report on the results achieved to date as well as our work in progress, organised in four subsections. The first (3.1) summarises the Clusters' requirements in terms of DO typologies and discipline-specific needs, as well as standards and repositories; these requirements have informed the development of the Assessment-IF. The second subsection (3.2) provides an overview of the Assessment-IF structure. Subsection 3.3 illustrates the framework is generic and extendable through an initial set of concrete examples from the Clusters that span over different DO types and disciplines; therefore, we can assume that the Assessment-IF will allow extension to other cases, and this will be reported in the Deliverable 3.5 (the V2 of this Deliverable) due at month 30. The final subsection (3.4) introduces the exemplar services launched to support discoverability, sharing and reuse of Assessment-IF components by humans and machines.

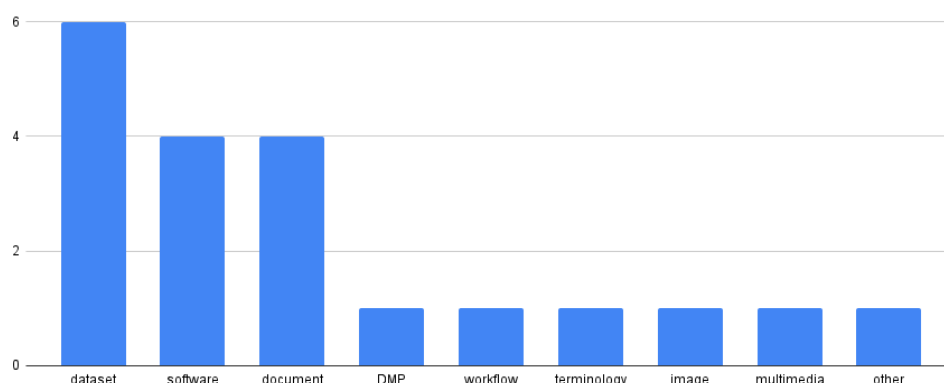
3.1. DOs, Including Repositories and Standards

Four Clusters (ESCAPE, PaNOSC, SSHOC and ENVRI) provided a total of six responses, with three responses coming from SSHOC partners in OSTRails. The combined file with the results is available in Zenodo²⁴. Because the UOXF partner also represents LSRI, the Life Science Cluster, their requirements were: (i) extracted from the final Achievement report for EOSC-Life²⁵, the most recent EOSC project that included all members of the LSRI, and (ii) verified in collaboration with other LSRI experts. The collated resulting DO types, in **Figure 1**, indicated that all Clusters find both traditional DO (such as datasets) as well as less traditional types (such as software and workflows) important for assessment.

²⁴ Lister, A., Wilkinson, M., & Sansone, S.-A. (2025). OSTRails - Digital Object Survey Results. Zenodo. <https://doi.org/10.5281/zenodo.15721706>

²⁵ Populating EOSC-Life: Final Achievements. <https://www.eosc-life.eu/wp-content/uploads/2023/11/EOSC-Life-Achievements-FINAL-1.pdf>

Figure 1. DO types, by frequency, that Clusters would like to assess for FAIRness. Note that ‘document’ includes publications.



The identification of relevant DO types²⁶ is an iterative process that we began with the survey and will continue across the entire OSTRails timeline. The community standards and repositories that structure and store the DO types are also being listed and described by the Cluster Champions (as described in Section 2.2) using FAIRsharing Collections (detailed in subsection 3.4.1).

3.2. Generic and Extendable Assessment-IF

The Assessment-IF²⁷ describes the components, their interactions, and the APIs required to create a modular environment for executing automated assessments. During the authoring of the Assessment-IF, there was an attempt to align with the work done in FAIRCORE4EOSC - the Compliance Assessment Toolkit (CAT) - where a similar conceptual model was derived based on a variety of case studies²⁸, and this alignment was largely accomplished with respect to the subset of CAT components that were required for this IF. While originally intended for FAIR assessment, the architecture

Figure 2) is sufficiently generic that it can be applied to all types of assessment in the OSTRails project pathways – FAIR, DMP, and SKG; as such, we now refer to it as the Assessment-IF rather than the FAIR-IF, as originally defined in the OSTRails grant proposal. Nevertheless, in this Deliverable 3.4 V1 we focus on providing examples of FAIR assessment (subsection 3.3).

²⁶ The DO types in OSTRails are being mapped to others, including schema.org.

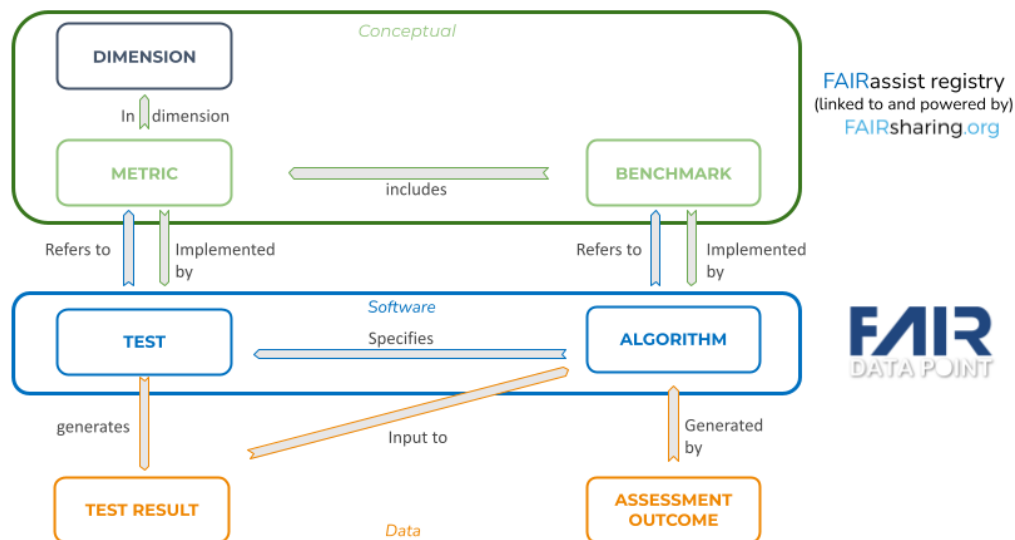
<https://github.com/OSTrails/digital-object-commons/tree/main>

²⁷ Assessment-IF (formerly FAIR-IF). https://docs.ostrails.eu/en/latest/architecture/fair_if.html

²⁸ FAIRCORE4EOSC D2.1 Compliance Assessment Specification.

<https://doi.org/10.5281/zenodo.10067253>

Figure 2. The components and inter-component relationships in the Assessment-IF, along the two exemplar registries where the components will be made discoverable, searchable and reusable by humans and machines.



The Assessment-IF architecture has been designed with three "layers":

- a conceptual layer of **Benchmark** expectations that can vary between disciplines and communities in general; **Dimensions** which act as general Principles²⁹ (e.g. the FAIR Principles) that are often hierarchical; and **Metrics** which define and categorize at a narrative level what is being measured.
- a software layer of **Tests** and **Algorithms** that are the specific implementations of the Metrics and Benchmarks (respectively), and define what specific aspects are being checked and how FAIR scores are calculated; and
- a data layer of **Test** and **Algorithm** inputs and outputs that provide the assessment results for a given DO.

In the OSTRails implementation of the Assessment-IF, the conceptual and software layers are catalogued in two searchable registries (detailed in subsection 3.4) (i) FAIRsharing, through its FAIRassist registry, to hold conceptual objects such as **Dimensions/Principles**, **Metrics** and **Benchmarks**, interlinked to standards and repositories, and (ii) a FDP Index, instantiated for OSTRails, used to hold implementations of the software components such as **Tests** and **Algorithms**.

We have designed the Assessment-IF to be generic and expandable, guided by the results of the survey and the continued engagement with the Clusters, as shown by a first set of examples in subsection 3.3. These who that the framework can be used for all DO

²⁹ Although the Assessment-IF uses the term 'Dimensions' within their specification, some resources such as FAIRsharing uses 'Principles'; these are equivalent concepts. Specifically, FAIRsharing uses Principles as it is a record type that existed within FAIRsharing prior to this work, and because the user community is more familiar with this term.

typologies, e.g., *software source code* with the FAIR4RS³⁰ Principles, an extended version of the original FAIR Principles for research software; and an example is provided in subsection 3.3.1. The framework can also be used beyond the FAIR Principles, e.g., for the evaluation of DMP; this use, however, will be detailed in later Deliverables.

Metrics are flexible and can be agnostic or specific of the DO type, discipline/community, or related standards. As an example, a generalist **Metric** might indicate that an open licence is required without specifying DO types, each of which will carry that licence in distinct locations. The **Metric** may be applicable over a wide range of DO types, while its linked **Tests** may be tagged as being applicable only to, e.g., ontologies. In such a general example, the **Tests** must then specify which terminologies should be used in each specific circumstance. A community with more specific requirements may create **Metrics** that are tailored to their needs; see also subsection 3.3.2. As an example, a community-specific **Metric** might be requiring the use of formats for the *proteomics* subject area, and as such would have that subject area as well as the DO types of *datasets* and *image*, and link to appropriate community formats. Each **Test** would implement this **Metric** with one or more of these DO types and formats.

Each component (except for **Dimensions**, which are authored by broader community agreements) is defined using a metadata template based on the Data Catalog (DCAT) standard. Specifically, **Metrics**, **Benchmarks**, **Algorithms**, and **Tests** all have a distinct DCAT Application Profile that extends the core metadata (authorship, title, description) with additional, specific metadata elements such as the kind of digital object that a **Metric** is applicable to (e.g. software), or its domain of interest (e.g. Astronomy), if any. These DCAT descriptors are intended for machine-readability and primarily use references to controlled vocabulary terms to build unambiguous records; however, in Section 3.3 we provide worked examples of **Metrics** using the human-readable labels in place of the Web addresses that would appear in the ‘raw’ DCAT record. Creation of such templates is also work in progress.

3.3. DOs Type and Discipline Specific Examples of Metrics

This subsection illustrates the **Metrics** component of the Assessment-IF through an initial set of concrete examples from two Clusters’ representatives. The example of **Metric** in subsection 3.3.1 is discipline-agnostic and focuses on software as DO type, whilst the

³⁰ Barker, M., Chue Hong, N.P., Katz, D.S. *et al.* Introducing the FAIR Principles for research software. *Sci Data* **9**, 622 (2022). <https://doi.org/10.1038/s41597-022-01710-x>.

examples in subsection 3.3.2 are discipline-specific and focused on datasets, as DO types. The latter examples also illustrate the importance of identifying standards and repositories, used or recommended by each Cluster (based on their community practice), and show the role FAIRsharing Collections play (as described in subsection 3.4.1).

The **Metrics** examples are provided in a narrative form, using the human-readable labels, following the metadata fields defined in the Assessment-IF **Metric** specification³¹. Overall, these first set of examples also show the Assessment-IF as both generic (suitable for any DO type or domain) and expandable (e.g. using the FAIR4RS **Dimensions** for software).

3.3.1. Research Software Source Code

Simultaneously discipline agnostic and DO type specific, this **Metric** exemplifies the generic and flexible nature of the Assessment-IF **Metric** specification. It was created by ESRF, a partner in OSTRails and a member of the PaNOSC Cluster. As the DO typology is *software source code*, we use **Dimensions** from the FAIR4RS Principles. This **Metric** expects either a `licence.md` or `codemeta.json` file at the root of a software repository to align with FAIR4RS Principle R1.1. This **Metric** is described in **Table 1**, and registered in FAIRsharing³², the service that underpins the FAIRassist registry.

Table 1. Example of a **Metric** for research software licensing.

TITLE	FAIR METRIC - SOFTWARE SOURCE CODE HAS A LICENCE HTTPS://FAIRSHARING.ORG/6451
Acronym	FM - SOFT_SRC_LI
Definition	This Metric ensures that a software application has a license defined within its source code files (e.g., a license file, <code>codemeta.json</code> or similar)
Subject type	<i>Subject Agnostic</i>
DO type	<i>Software source code</i>
Measures Principle	FAIR Principles for Research Software - R1.1. Software is given a clear and accessible license (FAIR4RS - R1.1) https://fairsharing.org/6438
Related to	CodeMeta: https://doi.org/10.25504/FAIRsharing.TS3gpY
Example	Positive examples: <ul style="list-style-type: none"> https://github.com/github-linguist/linguist (licence) https://github.com/BM32ESRF/lauetools (<code>codemeta.json</code>) https://github.com/cds-astro/cds-moc-rust (licence and <code>codemeta.json</code>)

³¹ FAIR Test Results (FTR) Metric specification.

https://ostrails.github.io/FAIR_assessment_output_specification/release/1.1.0/index-en.html#Metric

³² FAIR Metric – software source code has a licence. <https://fairsharing.org/6451>

This **Metric** showcases the richness of relationships that **Metrics** have within the Assessment-IF:

- Each **Metric** may be linked to one or more **Dimensions** hierarchies via the *measures_principle*³³ relationship. Links may point to any Principle³⁴ registered in FAIRsharing. In this example, the linked **Metric** is “FAIR Principles for Research Software - R1.1. Software is given a clear and accessible license (FAIR4RS - R1.1)”³⁵.
- Each **Metric** may relate to existing records in FAIRsharing. In this example, the **Metric** is linked to the “CodeMeta”³⁶ standard to show that this format is relevant to understanding the intent of the **Metric**. This relationship can be used by FAIR assessment and tool developers to inform the creation of **Tests** related to this **Metric**.
- Each **Metric** relates to a DO type, used by both humans and machines to understand the intended type(s) in scope for a **Metric**. In the example, the DO type is *software source code*.
- Each **Metric** relates to a subject, providing the research area the **Metric** is intended for. In the example, this **Metric** can be used by communities from all research areas and is therefore tagged with *Subject Agnostic*.

The ESRF partner also created the FAIRsharing Collection “ESRF - Resources for FAIR Assessment”³⁷, which contains those repositories and standards relevant to **Metrics** defined by ESRF to aid discovery and potential reuse by others. This value of the FAIRsharing Collections, and the details of this specific ESRF Collection are described in subsection 3.4.1.

3.3.2. Datasets and Repositories

Many communities, e.g., Astronomy or Heliophysics from the ESCAPE Cluster^{38,39}, have an extended ecosystem of FAIR-enabling tools and protocols to find, access, interoperate

³³ Note that this relationship is equivalent to *inDimension* from the Assessment-IF. It is relabeled in FAIRsharing to align with how Dimensions are represented as Principles within the registry.

³⁴ Principles records in FAIRsharing. <https://fairsharing.org/search?recordType=principle&page=1>
³⁵ <https://fairsharing.org/6438>.

³⁶ <https://doi.org/10.25504/FAIRsharing.TS3gpY>.

³⁷ <https://fairsharing.org/ESRF-FAIR>.

³⁸ Fung, S. F., A. Masson, L. F. Bargatze, T. King, R. Ringuette, R. M. Candey, C. Wiegand, L. K. Jian, D. De Zeeuw, K. Muglach, R. M. McGranaghan, D. Aaron Roberts, B. Cecconi, N. André, V. Génot, J. Vandegriff, & M. A. Reiss (2023). SPASE metadata as a building block of a heliophysics science-enabling framework. *AdSpR*, 72(12), 5707-5752. <https://doi.org/10.1016/j.asr.2023.09.066>

³⁹ O'Toole, Simon & Tocknell, James. (2022). FAIR standards for astronomical data. <https://doi.org/10.48550/arXiv.2203.10710>

and reuse data. Three examples of **Metric** ([Table 2](#), [Table 3](#), [Table 4](#)) for astronomy datasets and repositories defined by the ObsParis partner (a member of the ESCAPE Cluster) are detailed below using standards and protocols defined by IVOA⁴⁰, reflecting the importance of community-based tools and protocols. The IVOA data ecosystem is organised around a resource registry used to retrieve the capabilities (i.e., the protocols and their endpoints) of each registered resource. The resources registered therein are mostly data access services as well as catalogues of datasets. The data access services do not provide access to datasets in the form of data files, but rather as a standardised protocol response containing data. This interoperability-driven infrastructure permits consistent integration of databases into visualisation tools, abstracting the datasets so that users don't have to care about the original data formats.

Table 2 shows the richness of the relationships **Metric FM - DATA_ASTRONT** has within the Assessment-IF, as curated using content from FAIRsharing and the FAIRassist registry, as described in sections [3.4.1](#) and [3.4.2](#). This table shows the relationship from *FM - DATA_ASTRONT* to FAIR I2 via *measures_principle*, and to terminologies and the IVOA identifier as core parts of the **Metric** description. In contrast to the ESRF example **Metric** in [Table 1](#), this **Metric** is specific to *datasets* and to the *Astronomy and Astrophysics* subject area. Finally, note that this **Metric** should be evaluated differently depending on the source of the dataset, with IVOA-rendered UAT for IVOA data, and standard UAT for other data sources.

Table 2. Example of **Metric** for dataset and its compliance with community terminologies.

TITLE	FAIR METRIC - DATASET - SUBJECT TERMS FROM AN APPROPRIATE ASTRONOMY ONTOLOGY HTTPS://FAIRSHARING.ORG/6547
Acronym	FM - DATA_ASTRONT
Definition	Subject terms must be taken from an appropriate community ontology for astronomy. Within the astronomy subject area generally, the main community ontology is the Unified Astronomy Thesaurus (UAT) or the IVOA-rendered UAT ontology. However, if the Metric is applied to the subject terms of IVOA registry records (for instance, if a dataset is related to an IVOA identifier in its metadata), then one must use the IVOA-rendered UAT ontology terms as defined in the IVOA registry resource specification.
Subject type	<i>Astronomy and Astrophysics</i>
DO type	<i>Dataset</i>
Measures Principle	FAIR Principles I2: (meta)data use vocabularies that follow FAIR principles (FAIR I2) https://doi.org/10.25504/FAIRsharing.96d4af
Related to	Unified Astronomy Thesaurus (https://doi.org/10.25504/FAIRsharing.998c4c)

⁴⁰ International Virtual Observatory Alliance. <https://ivoa.net>

	IVOA Vocabulary: Unified Astronomy Thesaurus (IVOA rendering) (https://doi.org/10.25504/FAIRsharing.f50cc0) IVOA Identifier (https://doi.org/10.25504/FAIRsharing.L4Q3H9)
Example	Positive examples: <ul style="list-style-type: none"> Use of IVOA-rendered UAT term to describe an IVOA dataset: Example of IVOA resource metadata record (web rendering), see the content/subject section: <pre><subject>radio-astronomy</subject> <subject>saturn</subject></pre> Use of a UAT term to describe a dataset outside the IVOA registry: https://doi.org/10.25935/1sxh-aq56, see JSON-LD content, "subjects" section: <pre>"keywords": [{ "@type": "DefinedTerm", "name": "Radio astronomy", "inDefinedTermSet": "https://astrothesaurus.org/uat/", "url": "https://astrothesaurus.org/uat/1338", "termCode": "1338" }, { "@type": "DefinedTerm", "name": "Saturn", "inDefinedTermSet": "https://astrothesaurus.org/uat/", "url": "https://astrothesaurus.org/uat/1426", "termCode": "1426" }]</pre>

An IVOA catalogue resource is a specific IVOA registry record for catalogues of products. An IVOA dataset is usually composed of several (or many) data products (usually files), with the catalogue resource as a metadata table allowing for the selection of data products inside a dataset. Hence, such associated resources are a key asset for findability. There are two main types of catalogue resources, namely "*Observation Data Model Core*" and "*Europlanet Core Data Model*", respectively dedicated to celestial astronomy and solar system datasets. **Metric FM - DATA_IVOACR** in **Table 3** states that **Tests** must check that: a resource is associated with an IVOA identifier; the associated IVOA registry record must be a catalogue resource; and its type (or data model) should be one of "*Observation Data Model Core*" or "*Europlanet Core Data Model*".

As with the previous examples, **Table 3** shows the richness of the relationships this **Metric** has within the Assessment-IF. The table shows the relationship from *FM - DATA_IVOACR* to FAIR F4 via *measures_principle*, and to the catalogue resource and relevant data model records as well as the IVOA identifier record. As with the example in **Table 2**, this **Metric** is specific to *datasets* and to the *Astronomy and Astrophysics* subject area.

Table 3. Example of **Metric** for datasets and its association with an IVOA Catalogue Resource.

TITLE	FAIR METRIC - DATASET - ASSOCIATION WITH IVOA CATALOGUE RESOURCE HTTPS://FAIRSHARING.ORG/6548
-------	---

Acronym	FM - DATA_IVOACR
Definition	This metric requires the association of an IVOA 'Catalogue Resource' to the dataset being evaluated.
Subject type	<i>Astronomy and Astrophysics</i>
DO type	<i>Dataset</i>
Measures Principle	FAIR Principles F4: (meta)data are registered or indexed in a searchable resource (FAIR F4) https://doi.org/10.25504/FAIRsharing.0c0d21
Related to	EPN-TAP: Publishing Solar System Data to the Virtual Observatory (EPNcore) (https://doi.org/10.25504/FAIRsharing.fba4ef) Observation Data Model Core Components and its Implementation in the Table Access Protocol (ObsCoreDM) (https://doi.org/10.25504/FAIRsharing.rYgXhw) VODataService: a VOResource Schema Extension for Describing Collections and Services (https://doi.org/10.25504/FAIRsharing.TVImPv) IVOA Identifier (https://doi.org/10.25504/FAIRsharing.L4Q3H9)
Example	<p>Positive examples:</p> <ul style="list-style-type: none"> Use of IVOA identifier and the evaluated dataset has a Catalogue Resource that uses the EPNcore data model: https://doi.org/10.25935/fwtq-v202, see JSON-LD content, "IncludedInDataCatalog" part: <pre>"includedInDataCatalog": { "@id": "ivo://padc.obspm.maser/juno_waves/epn/epn_core", "@type": ["DataCatalog", "vs:CatalogResource"], "identifier": "ivo://padc.obspm.maser/juno_waves/epn/epn_core", "name": "MASER Juno/Waves EPNcore catalogue", "abstract": "Juno/Waves database at LESIA. This collection contains L3 data products. This collection is maintained by the MASER team.", "url": "http://voparis-tap-maser.obspm.fr/tableinfo/juno_waves.epn_core" },</pre> <ul style="list-style-type: none"> Use of IVOA identifier and the evaluated dataset has a Catalogue Resource that uses the ObsCoreDM data model: (this is a more abstract positive example, as no implementation is ready yet)

Table 4 provides summary information regarding several key features of **Metric FM – DATA_IVOA_SERV**. This **Metric** measures FAIR F3 and is specific to *datasets* and to the *Astronomy and Astrophysics* subject area. When a dataset is related to an IVOA registry record, the level of FAIRness increases. However, the services declared may not be fully compliant with protocol specifications, in which case the FAIRness decreases. Each IVOA registry record is monitored using the *voparis-validation-reports*⁴¹ service that queries all endpoints of all capabilities for every record of the IVOA registry daily.

Depending on the score of the validation report, the associated pass/fail result of a **Test** implementing the **Metric** in **Table 4** can be adjusted. In the worst-case scenario, the dataset declares a related IVOA registry record, with capabilities, but the server hosting

⁴¹ PADC IVOA Services Validation Portal. <https://voparis-validation-reports.obspm.fr/>

the capabilities has been down for some time. In this case, the validation report will contain this information, and the **Test** will return an appropriately lower result.

Table 4. Example of **Metric** for checking compliance of a dataset's service with IVOA specifications.

TITLE	FAIR METRIC - DATASET - ASSOCIATED IVOA SERVICES ARE COMPLIANT WITH IVOA PROTOCOL SPECIFICATIONS HTTPS://FAIRSHARING.ORG/6549
Acronym	FM – DATA_IVOA_SERV
Definition	This Metric ensures that IVOA services associated with a dataset are compliant with IVOA protocol specifications.
Subject type	<i>Astronomy and Astrophysics</i>
DO type	<i>Dataset</i>
Measures Principle	FAIR Principles F3: Metadata clearly and explicitly include the identifier of the data they describe (FAIR F3) https://doi.org/10.25504/FAIRsharing.820324
Related to	n/a
Example	Positive examples: <ul style="list-style-type: none"> The service declared by a dataset is fully compliant with protocol specifications as determined by the <i>voparis-validation-reports</i> service The output from the selected IVOA service access point (found in the IncludedinCatalog metadata, see previous example) should show no error (not the case on this example). Note: This example is preliminary, as we should use the API rather than the web rendering.

3.4. Discoverability and Sharing

In this section we introduce the exemplar and complementary services we have used or launched to publish, and make accessible to humans and machines, the following information: the disciplinary standards and repositories used/recommended by the Clusters and necessary to power their assessment process (described subsection 3.4.1); the Assessment-IF conceptual components (described subsection 3.4.2); and its software components (described subsection 3.4.3).

3.4.1. Standards and Repositories

We leveraged the Collection functionality of the existing RDA-endorsed FAIRsharing service to transparently declare the standards and data resources used and/or recommended by the Clusters. The selection of standards and data resources is based on each community's best practices and is necessary to power each Cluster's assessment process. Collections are branded slices of FAIRsharing records selected for a variety of

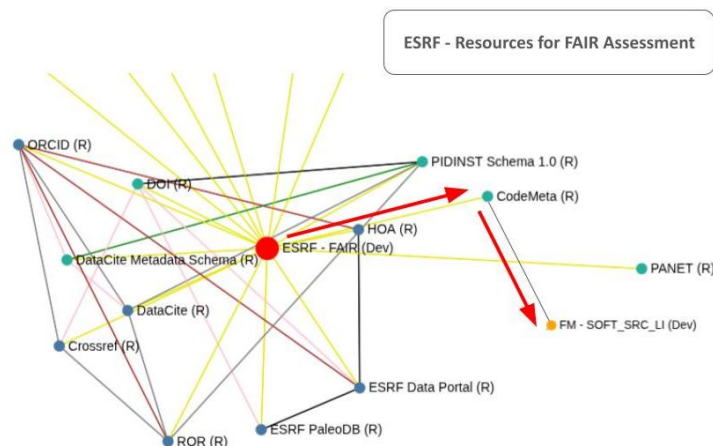
purposes^{e.g42,43}. In the context of OSTrails these FAIRsharing Collections specifically serve to:

- Provide a shortlist of acceptable standards and repositories that are used within relevant **Tests**, **Metrics** and **Benchmarks** in the FAIR assessment process.
- Visualise this shortlist in graphical form to show the relationships among standards and repositories, e.g. which terminologies are required by specific formats, or which identifier schemas a repository uses, and
- Foster reuse of common standards and repositories, across Clusters, disciplines and communities, where relevant.

We have started to create the Cluster's Collections, and we provide here a summary of the work to-date. The ESRF partner, a member of the PaNOSC Cluster, is working with UOXF to provide expert curation for (i) the standards and repositories records relevant to the **Metrics** and **Benchmarks** for the ESRF use case, and (ii) the in-development ESRF FAIR Assessment Collection *ESRF - Resources for FAIR Assessment*⁴⁴, and (iii) iteratively developing a number of **Metrics** linked to an ESRF **Benchmark**⁴⁵ as the first step in the creation of a complete Assessment-IF workflow.

Figure 3 shows navigation of the ESRF Collection's graph⁴⁶ to the *CodeMeta* standard and then on to the "*FAIR **Metric** - software source code has a licence*", a **Metric** that requires compliance with *CodeMeta* standard.

Figure 3. A snippet of the graph of the "ESRF - Resources for FAIR Assessment" Collection. The arrows starting at the central red dot) highlight the example given in the main text.



The ObsParis partner, a member of the ESCAPE Cluster, is working with UOXF to (i) provide extensive curation of Astronomy repositories and standards (ii) refresh curation

⁴² International Virtual Observatory Alliance - Document Standards. <https://fairsharing.org/IVOA>

⁴³ RDA MOMSI Working Group Collection. <https://fairsharing.org/MOMSI>

⁴⁴ <https://fairsharing.org/ESRF-FAIR>.

⁴⁵ Example in-development ESRF Benchmark. <https://fairsharing.org/6477>

⁴⁶ <https://fairsharing.org/graph/6443>.

of IVOA records⁴⁷ and begin curation of IVOA-related **Metrics**⁴⁸, and (iii) iteratively develop two ESCAPE-related Collections. The *ESCAPE - Resources for FAIR Assessment*⁴⁹ Collection contains resources relevant to FAIR Assessment within IVOA. The second Collection, *ESCAPE - Astronomy Resources*⁵⁰, is a broader, discipline-specific collection that can be used as a curated set of recommended resources as well as input for additional **Benchmarks** by the wider astronomy community. This work also includes the co-development of a new release of the FAIRsharing Subject Ontology⁵¹ to enhance coverage/completeness of Astronomy disciplinary terms and enable more precise searches of records in FAIRsharing.

The UOXF partner, a member of ELIXIR (a leading RI of the LS Cluster), worked with an ERINHA representative to extract the requirements from the final EOSC-Life Achievement report (and its corresponding FAIRsharing Collection⁵²) to create a new, broader, Collection (the *LSRI Cluster Resources Collection*⁵³) of Cluster-associated resources. Furthermore, each standard and database in this Collection is associated with an organisation or RI that is part of the LSRI (for example, all records linked to ELIXIR⁵⁴).

This information in FAIRsharing is also provided in machine-actionable format, using DCAT⁵⁵ and JSON⁵⁶, and accessible via the FAIRsharing API⁵⁷ for advanced queries.

3.4.2. Dimensions, Metrics, Benchmarks

Registries of Assessment-IF components aid discoverability and transparency; in OSTRails, the reference registry for conceptual components is being built and will aid discoverability as well as test the newly developed framework. As shown in

Figure 4 the FAIRassist registry (beta version), part of FAIRsharing, will hold records (with DOIs) describing the conceptual components of the Assessment-IF, namely:

⁴⁷ IVOA Collection. <https://fairsharing.org/IVOA>

⁴⁸ New IVOA-related Metrics added by the ESCAPE FAIRsharing Champion. <https://fairsharing.org/6547>, <https://fairsharing.org/6548>, <https://fairsharing.org/6549>

⁴⁹ <https://fairsharing.org/ESCAPE-FAIR>.

⁵⁰ <https://fairsharing.org/ESCAPE-Resources>.

⁵¹ FAIRsharing Subject Ontology. <https://github.com/FAIRsharing/subject-ontology>

⁵² EOSC-Life Collection. <https://fairsharing.org/EOSCLife>

⁵³ <https://fairsharing.org/LSRI>.

⁵⁴ ELIXIR Organisational page in FAIRsharing. <https://fairsharing.org/organisations/841>

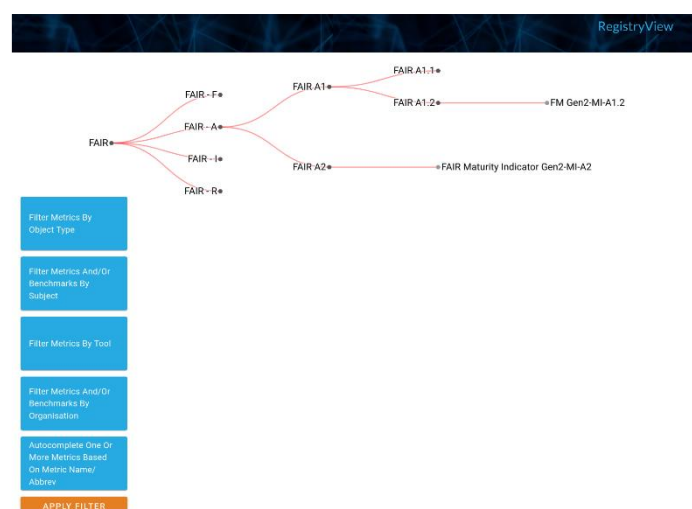
⁵⁵ DCAT FAIRsharing record. <https://doi.org/10.25504/FAIRsharing.h4j3qm>

⁵⁶ JSON FAIRsharing record. <https://doi.org/10.25504/FAIRsharing.5bbab9>

⁵⁷ FAIRsharing REST API. https://fairsharing.org/API_doc

Dimensions⁵⁸, **Metrics**⁵⁹, and **Benchmarks**⁶⁰. The FAIRassist registry is still in development, therefore not all its functionalities are operational; when completed it is set to: (i) show how registration and discoverability of these components can occur (via filters, including DO types, discipline specificity or generality), and (ii) contribute to guidance and transparency during the FAIR assessment process. The FAIRassist registry will assist the operationalisation of the Assessment-IF and become a resource for tool developers and FAIR doers who create or search for FAIR **Metrics**, **Benchmarks** and **Tests** (the latter within the FDP Index, see section 3.4.3).

Figure 4. The in-development FAIRassist registry landing page, its filtering options and navigation, from **Dimensions**, via a visualisation tree



To create **Dimensions** for software, following FAIR4RS, UOXF and UPM are in discussion with EOSC EVERSE⁶¹. FAIRassist has been built with inherent flexibility with regards to **Dimension** hierarchies and will initially contain both the FAIR and FAIR4RS hierarchies, displaying the appropriate one upon selection of the DO type.

3.4.3. Tests and Algorithms

Assessment-IF components that represent concrete implementations of the concepts registered in FAIRassist – in particular, **Tests** and **Algorithms** – also require registration to be discoverable based on their metadata. In the OSTRails reference implementation,

⁵⁸ Metrics registered in the FAIRassist registry.

<https://fairsharing.org/search?page=1&recordType=principle>

⁵⁹ Metrics registered in the FAIRassist registry.

<https://fairsharing.org/search?page=1&recordType=metric>

⁶⁰ Benchmarks registered in the FAIRassist registry.

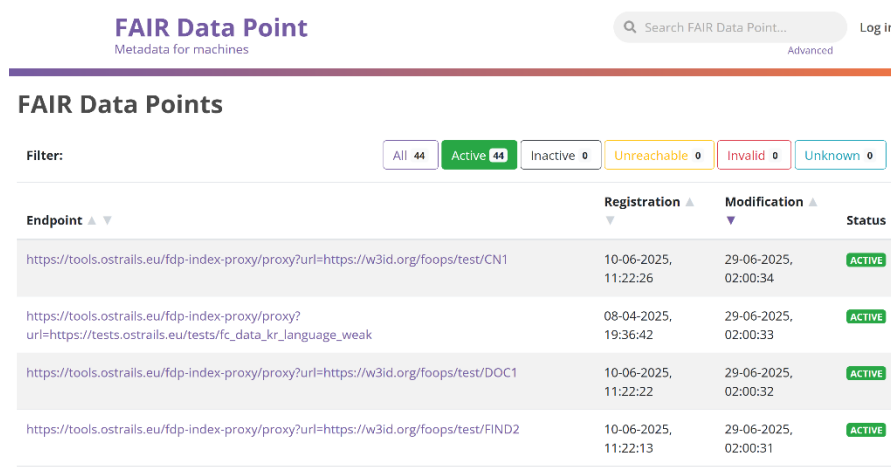
<https://fairsharing.org/search?page=1&recordType=benchmark>

⁶¹ ELIXIR EVERSE. <https://everse.software>

FDP⁶² was selected because it provides native DCAT application profile support for **Tests** and **Algorithms**, thus was straightforward to deploy for OSTRails. Importantly, since **Tests** and **Algorithms** are anticipated to be highly distributed (over multiple third-party servers, authored by the community members themselves, independent of the OSTRails project) the FDP also provides a degree of quality-of-service in the form of automated auditing of the ongoing existence of these artefacts, and their correct publication.

Figure 5 below shows the FDP Index containing 44 currently registered artefacts, all of which are valid and active. The OSTRails FDP provides an open SPARQL endpoint to allow for arbitrary queries but also provides pre-canned queries that can be accessed via URLs; these URLs will be used by FAIRassist to achieve real-time lookups for implementations (**Tests**) of their conceptual (**Metrics**) records. Within the DCAT records in the FDP are cross-references to the **Metrics** and **Benchmarks** in FAIRassist, such that metadata can be extracted in a federated manner from both registries through straightforward queries.

*Figure 5. The homepage of the FDP available in the OSTRails reference implementation shows a list of known metadata records corresponding to **Tests** and **Algorithms**, along with some quality metadata about them.*



The screenshot shows the 'FAIR Data Point' homepage. At the top, there is a search bar labeled 'Search FAIR Data Point...' and a 'Log in' button. Below the header, the title 'FAIR Data Points' is displayed. A filter section shows 'All 44', 'Active 44', 'Inactive 0', 'Unreachable 0', 'Invalid 0', and 'Unknown 0'. The main table lists four records with columns for 'Endpoint', 'Registration', 'Modification', and 'Status'. All records are marked as 'ACTIVE'.

Endpoint	Registration	Modification	Status
https://tools.ostrails.eu/fdp-index-proxy/proxy?url=https://w3id.org/foops/test/CN1	10-06-2025, 11:22:26	29-06-2025, 02:00:34	ACTIVE
https://tools.ostrails.eu/fdp-index-proxy/proxy?url=https://tests.ostrails.eu/tests/fc_data_kr_language_weak	08-04-2025, 19:36:42	29-06-2025, 02:00:33	ACTIVE
https://tools.ostrails.eu/fdp-index-proxy/proxy?url=https://w3id.org/foops/test/DOC1	10-06-2025, 11:22:22	29-06-2025, 02:00:32	ACTIVE
https://tools.ostrails.eu/fdp-index-proxy/proxy?url=https://w3id.org/foops/test/FIND2	10-06-2025, 11:22:13	29-06-2025, 02:00:31	ACTIVE

4. Conclusions and Next Steps

To improve the trustworthiness of claims of FAIRness, OSTRails developed an Assessment-IF that makes transparent and ideally harmonises the way the assessment process is done, and the way tools will behave. Ultimately the goal is to ensure that results of these testing processes are consistent and reliable, regardless of the choice of tool. In turn this harmonisation will enable improved FAIRness of DOs, as well as the

⁶² da Silva Santos, L.O.B, Burger, K., Kaliyaperumal, R., et al.: FAIR Data Point: A FAIR-Oriented approach for metadata publication. Data Intelligence 5(1), 163-183 2023.
https://doi.org/10.1162/dint_a_00160

operationalization of the wider uptake of and compliance with FAIR principles and practices.

Our work to date, described in V1 of this Deliverable, broadly addressed the above-mentioned challenges, but focused on:

- 1) the collection of the requirements to inform the definition of a generic and extendable Assessment-IF, suitable for the DO types and specialisations identified for the cases we evaluated; activity led by UPM and UOXF.
- 2) the creation of an initial set of exemplar **Metrics** (and related **Benchmarks** and **Tests**) tailored to different types of DOs and rooted discipline specific needs (to show the generic and extendable nature of the framework); activity led by ObsParis, ESRF, UPM, and UOXF.
- 3) the enrichment of the description of standards and repositories of DOs in FAIRsharing, to support relevant **Metrics**, led by ObsParis, ESRF, and UOXF, and
- 4) the launch of the beta versions of the FAIRassist registry, led by UOXF, and the FDP Index, led by UPM, as exemplar services to describe, register and discover the Assessment-IF components.

Based on work in point 1 and 2 above, we can conclude that the Assessment-IF is a suitable framework for the DO types and specialisations identified for the cases we evaluated, and we are confident that the framework is also adequately modular and generic to be extended to all DO types and any discipline.

The next steps foresee several streams of work to fulfil Task 3.2 (testing framework is applicable to a wider range of DO types, and extendable to disciplines), and Task 3.4 (enhance guidance in the assessment), and contribute to Task 4.3 (cross-Clusters pilot set to identify discipline-specific needs).

- Create common guidance to define **Metrics, Benchmarks, Algorithms** and **Tests** so that they are at the appropriate granularity level. This will also include templates with human-readable labels for the DCAT descriptors are intended for machine-readability. The guidance will be used to define a core set of **Metrics, Benchmarks, Algorithms** and **Tests** for several DO types, both domain-agnostic and discipline-specific, that can be reused by other tool developers; alternatively, these components may be created independently but consistent with the Assessment-IF and then shared.
- Continue to work with the Clusters to ensure that all relevant information on repositories and standards used to power the FAIR assessment is available in FAIRsharing and correctly classified according to the DO types (e.g. standard for workflow) and disciplines relevant to them (e.g. repository for astronomy datasets).

- Finalise the development of the exemplar services: FAIRassist registry, focusing on functionalities such as registration, filtering and visualisation to aid navigation and discovery of **Dimensions, Metrics, Benchmarks**, connected to **Tests** stored in the FDP Index. Additional services may emerge, to fit different needs, and these will be described in V2 of this Deliverable, as relevant.
- Test the use of the FAIRassist registry as a service that runs over records of repositories in FAIRsharing (since the two systems share the same backend) to check the degree of FAIR compliance of these repositories, and improvements they may need.
- Connect the information in FAIRsharing and FAIRassist registry to the guidance component in the FAIRCORE4EOSC CAT that will serve as assistance during the FAIR assessment process.

5. References

Assessment-IF (formerly FAIR-IF). OSTRails Project Documentation. Retrieved from https://docs.ostrails.eu/en/latest/architecture/fair_if.html

Barker, M., Chue Hong, N. P., Katz, D. S., et al. (2022). Introducing the FAIR Principles for research software. Scientific Data, 9, 622. <https://doi.org/10.1038/s41597-022-01710-x>

da Silva Santos, L. O. B., Burger, K., Kaliyaperumal, R., et al. (2023). FAIR Data Point: A FAIR-oriented approach for metadata publication. Data Intelligence, 5(1), 163–183. https://doi.org/10.1162/dint_a_00160

EOSC FAIR Metrics and Data Quality Task Force. EOSC Association. Retrieved from <https://eosc.eu/advisory-groups/fair-metrics-and-data-quality>

EOSC FAIR Metrics and Digital Objects Task Force. EOSC Association. Retrieved from <https://eosc.eu/advisory-groups/fair-metrics-and-digital-objects-task-force>

Example in-development ESRF Benchmark. FAIRsharing. Retrieved from <https://fairsharing.org/6477>

FAIR Metric – software source code has a licence. FAIRsharing. Retrieved from <https://fairsharing.org/6451>

FAIR Test Results (FTR) Metric Specification. OSTRails. Retrieved from https://ostrails.github.io/FAIR_assessment_output_specification/release/1.1.0/index-en.html#Metric

FAIRassist. Signposting Tools. Retrieved from <https://fairassist.org/tools>

FAIRassist Registry. Principles Records. Retrieved from <https://fairsharing.org/search?page=1&recordType=principle>

FAIRassist Registry. Metrics Records. Retrieved from <https://fairsharing.org/search?page=1&recordType=metric>

FAIRassist Registry. Benchmarks Records. Retrieved from <https://fairsharing.org/search?page=1&recordType=benchmark>

FAIRCORE4EOSC. (2023). D2.1 Compliance Assessment Specification. Zenodo. <https://doi.org/10.5281/zenodo.10067253>

FAIRsharing. Retrieved from <https://fairsharing.org>

FAIRsharing. CodeMeta. <https://doi.org/10.25504/FAIRsharing.TS3gpY>

FAIRsharing. FAIR Principles for Research Software - R1.1. Retrieved from <https://fairsharing.org/6438>

FAIRsharing. Graph Entry: Benchmarking Metadata. Retrieved from <https://fairsharing.org/graph/6443>

FAIRsharing. DCAT Record. <https://doi.org/10.25504/FAIRsharing.h4j3qm>

FAIRsharing. JSON Record. <https://doi.org/10.25504/FAIRsharing.5bbab9>

FAIRsharing. REST API Documentation. Retrieved from https://fairsharing.org/API_doc

FAIRsharing Community Champions Programme. Retrieved from https://fairsharing.org/community_champions

FAIRsharing Collection. ESRF - Resources for FAIR Assessment. Retrieved from <https://fairsharing.org/ESRF-FAIR>

FDP Index. Retrieved from <https://w3id.org/fdp-index>

Fung, S. F., Masson, A., Bargatze, L. F., King, T., Ringuette, R., Candey, R. M., ... & Reiss, M. A. (2023). SPASE metadata as a building block of a heliophysics science-enabling framework. *Advances in Space Research*, 72(12), 5707–5752. <https://doi.org/10.1016/j.asr.2023.09.066>

International Virtual Observatory Alliance. Retrieved from <https://ivoa.net>

International Virtual Observatory Alliance – Document Standards. FAIRsharing. Retrieved from <https://fairsharing.org/IVOA>

Lister, A., Wilkinson, M., & Sansone, S.-A. (2025). OTrails – Digital Object Survey Results. Zenodo. <https://doi.org/10.5281/zenodo.15721706>

O'Toole, S., & Tocknell, J. (2022). FAIR standards for astronomical data. arXiv preprint. <https://doi.org/10.48550/arXiv.2203.10710>

Populating EOSC-Life: Final Achievements. EOSC-Life Project. Retrieved from <https://www.eosc-life.eu/wp-content/uploads/2023/11/EOSC-Life-Achievements-FINAL-1.pdf>

RDA FAIRsharing Working Group. Research Data Alliance. Retrieved from <https://www.rd-alliance.org/groups/group-fairsharing-registry-connecting-data-policies-standards-databases-rda-wg/>

RDA MOMSI Working Group Collection. FAIRsharing. Retrieved from <https://fairsharing.org/MOMSI>

RDA/EOSC Future Ambassador Programme. Research Data Alliance. Retrieved from <https://www.rd-alliance.org/disciplines/rda-europe-ambassadors-2022/>

The DO types in OSTRails are being mapped to others, including schema.org. Retrieved from <https://github.com/OSTrails/digital-object-commons/tree/main>

Wilkinson, M. D., Sansone, S.-A., Grootveld, M., Nordling, J., Dennis, R., & Hecker, D. (2022). FAIR Assessment Tools: Towards an "Apples to Apples" Comparisons. Zenodo. <https://doi.org/10.5281/zenodo.7463421>

Wilkinson, M. D., Dumontier, M., Aalbersberg, I. J. J., Appleton, G., Axton, M., Baak, A., ... & Mons, B. (2016). The FAIR Guiding Principles for scientific data management and stewardship. Scientific Data, 3, 160018. <https://doi.org/10.1038/sdata.2016.18>