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M4.2 DRAFT MATURITY MODEL BASED ON EXTENSIONS AND/OR ADDITIONS TO CORETRUSTSEAL REQUIREMENTS

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X	PU: Public
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Abstract

Aligning the CoreTrustSeal Requirements with an assessment of repositories' ability to enable FAIR data is an important part of delivering an EOSC. Trustworthy Digital Repositories which enable FAIR data are a dependency for many components of modern, open, distributed research. This paper sets the work within the wider context of data infrastructures, describes the co-dependencies between (meta) data objects and their repository environment, and presents the developing mapping between requirements and principles. The evolving capability/maturity approach is explained and the design of a governed assessment and certification process is defined. This work will iterate alongside the wide range of ongoing data infrastructure initiatives to support a range of stakeholders on their journey towards trustworthy repository services that enable FAIR data. Extensive engagement and feedback are planned to allow us to reach this goal. The CoreTrustSeal+FAIR overview itself is published and managed as a separate document[1].

[1] CoreTrustSeal+FAIR Overview

Versioning and contribution history

Version	Date	Authors	Notes
0.1	2020-08-24	Hervé L'Hours (UKDA), Ilona von Stein, Frans Huigen, Mustapha Mokrane, Jerry de Vries, Linas Cepinskas (DANS), Anusuriya Devaraju, Robert Huber (UniHB), Joy Davidson, Patricia Herterich (DCC)	Draft for internal review.
1.0	2020-08-31	Hervé L'Hours (UKDA), Ilona von Stein, Frans Huigen, Mustapha Mokrane, Jerry de Vries, Linas Cepinskas (DANS), Anusuriya Devaraju, Robert Huber (UniHB), Joy Davidson, Patricia Herterich (DCC)	As published

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Abbreviations and Acronyms

FAIR	Findable, Accessible, Interoperable, Reusable
TDR	Trusted Digital Repository
OAIS	Open Archival Information System
ISO	International Organization for Standardization
CMMI	Capability Maturity Model Integration
RDA	Research Data Alliance
WG	Working Group
EOSC	European Open Science Cloud
DDI	Data Documentation Initiative
PID	Persistent Identifier

Executive Summary

This paper, milestone 4.2 of FAIRsFAIR task 4.1 (Capability Maturity Models towards FAIR Certification, is an updated version of deliverable 4.2[2] and a number of its component documents (see section 8), including a CoreTrustSeal+FAIR Overview[3]. The task will develop a practical and sustainable approach for repositories to self-assess their capability levels and identify target levels for 'enabling' FAIR data. This is the third step in aligning the characteristics of FAIR digital objects with the repositories that enable FAIRness, through the CoreTrustSeal Trustworthy Data Repository Requirements[4] and the application of a capability/maturity approach: CoreTrustSeal+FAIR. Outcomes will include an overall improvement of repository practice and a pathway to certification.

The community-driven CoreTrustSeal is an effort to identify best practices, support improvement, and deliver improved repository service outcomes to data users. The requirements and associated process are endorsed by the RDA[5] and have been explicitly recommended as the basis for certification of repositories by the Turning FAIR into Reality Report[6]. Certification offers recognition and demonstrates trustworthiness to data depositors, users and funders. However it is through the process of self-assessment and peer review that practices are shared and data infrastructures are improved. FAIRsFAIR follows that spirit of open inclusivity. The goal is to share and improve rather than to exclude repositories or digital objects. Gaps in trustworthy practice or objects' FAIR status are opportunities for discussion and targeted improvement.

The CoreTrustSeal, FAIR principles, and European Open Science Cloud (EOSC) align through a shared goal to maximise the quantity of FAIR data under trustworthy curation. Achieving this mission depends on working together to ensure that digital objects are technically managed to ensure their protection and integrity, and preserved in a manner relevant to the user community and the types of objects and their. Ideally, research data and metadata also benefit from specialist preservation, e.g. by domain/subject experts such as disciplinary repositories.

This alignment of requirements and principles must have operational value and be sustainable. Though there is no formal CoreTrustSeal role or certification process within the project timeframe the project is liasing with the Board. CoreTrustSeal+FAIR will support the evaluation of Trustworthy Data Repositories (TDR), including their ability to offer an environment that enables FAIR data and metadata for the long term.

A synopsis is provided, followed by the wider scope and context surrounding the work package, project, FAIR data and trustworthy data repositories. The methodology is described and the design principles of the proposed approach are outlined. Issues and dependencies are presented. The conclusion and next steps explain how the approach will be opened to feedback and testing before a round of iterative updates.

[2] D4.2 Repository Certification Mechanism: a Recommendation on the Extended Requirements and Procedures
[3] CoreTrustSeal+FAIR Overview
[4] CoreTrustSeal Trustworthy Data Repositories Requirements: Extended Guidance 2020–2022
[5] All Recommendations & Outputs | RDA
[6] Turning FAIR into Reality

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1. Synopsis

The fifteen FAIR principles seek to set an expectation that digital objects (data and their associated metadata) become more findable, accessible, interoperable and re-usable. The RDA indicators[7] for the principles have made it clear that a (digital) object cannot be made FAIR or evaluated for FAIRness in isolation from its context. Here, the relevant context is a data repository.

Maintaining FAIRness over the long term depends on the preservation of an object. The CoreTrustSeal+FAIR work examines the alignment between the FAIR Data Principles with the CoreTrustSeal Trustworthy Digital Repository Requirements and considers how increased tiers of FAIRness and Trust can be described through capability/maturity levels.

The CoreTrustSeal is a community-driven foundation offering a certification process against sixteen core Trustworthy Data Repository (TDR) requirements. The FAIR and CoreTrustSeal approaches are complementary and well-aligned. The FAIR principles are statements about digital objects that also reflect the long-standing mission of repositories. Trustworthy Data Repository standards can enable FAIRness over time as they address changes to data assets and their users. A combination of FAIR and TDR offers an assurance that data will retain its value through preservation.

We are elaborating more specific requirements around the 'Core' of the CoreTrustSeal (see *5. CoreTrustSeal+FAIR Model Design*).The ideal outcome of this work is a CoreTrustSeal process which certifies repositories as FAIR-enabling trustworthy data repositories. But an alignment between object FAIRness and trustworthy repository standards provides benefits to funders, depositors, repository data services and their users either with, or without full formal certification.

The clear alignment of CoreTrustSeal+FAIR has immediate benefits in addressing the relationship between data and users via repository data services. The challenge is to develop an approach which offers both an assessment/certification mechanism and a useful tool that has operational value repository practices.

An assessment usually involves some evaluation/scoring method. In this case, we are using both the CoreTrustSeal compliance levels and a capability maturity approach. CoreTrustSeal scores from 'not considered' to 'fully implemented' while CMMI[8] scores from incomplete to optimising (see *CoreTrustSeal, Compliance, Capability & Maturity* below). We will evolve capability/maturity tiers for CoreTrustSeal+FAIR alongside the evolving FAIR indicators and metrics.

Both defining and achieving FAIR are a journey. This aligns well with the CoreTrustSeal goal of providing clear expectations, with an assumption of improved repository practice over time. A transparent, supportive community of practice is best-placed to deliver a European Open Science Cloud (EOSC).

The users of data are implied but not directly addressed by FAIR. For example, the FAIR Reusable principle 1.3 "meet domain-relevant community standards" connects objects to users through repositories. TDR standards directly address the need to serve a defined community (see *6. Open Issues for Integration: Designated Community and Other Users*).

[7] FAIR Data Maturity Model WG | RDA
[8] Capability Maturity Model Integration

In developing CoreTrustSeal+FAIR, a direct mapping of Requirements to the FAIR acronym is not sufficient. To align digital objects and the repository context, we must analyse the FAIR principles and the repository approach to data and metadata. This is also dependent on evidence for compliance provided by repository process metadata and other business information (see *FAIR Object and FAIRenabling Environments* below). We must also consider the indicators of FAIRness which are still under development. These are necessary to identify metrics and to apply tests for FAIRness (See *5. CoreTrustSeal+FAIR Model Design*).

The agreement of indicators and the development of tests for FAIRness, including the degree of 'machine-actionable FAIRness' sit alongside the need to clarify FAIR concepts (e.g. the richness of metadata) and contexts (e.g. community standards). These issues have been identified and will be monitored throughout the project (see 2. *Scope and Context*, *FAIR Principles: Baseline*)

Despite the clear alignment, there are two key challenges in designing CoreTrustSeal+FAIR:

1: Concepts that are implicit assumptions rather than explicit requirements in CoreTrustSeal.

2: Concepts in FAIR that align with more than one part of the CoreTrustSeal.

Broadly speaking a repository may evaluate, curate and communicate for FAIRness at three points during the sequential repository phases (R8. Appraisal, R11. Data Quality and R14. Data ReUse). Together these create the environment for data discovery (R13) by the user. In CoreTrustSeal 'access' is assumed and implied through delivering a mission (R1) in line with licence conditions (R2). But all of the CoreTrustSeal Requirements remain critical to ensuring that organisations and objects are sustainable over time (preservation). See *3.1. CoreTrustSeal Requirements in Brief* and *4. CoreTrustSeal+FAIR* below.

Clear, accountable assessment, evaluation and certification depends on a transparent and well-governed process. A recommended approach to CoreTrustSeal+FAIR in practice, for assessment/evaluation and eventual certification will be proposed (see *5.3 A Governed Assessment and Evaluation Process*).

As we iterate and collaborate with a wide variety of stakeholders the CoreTrustSeal+FAIR work will also integrate with the broader vision of an interoperable European Open Science Cloud (see 2. *Scope & Contex*t: *Wider EOSC Components*).

Recommendations for integration are being shared and discussed with the CoreTrustSeal Board. The Board has provided a statement of support for this work (Appendix 3), but no direct alignment with the CoreTrustSeal or its processes is currently in place. In the project timeframe, there is no formal process of FAIR enabled certification through CoreTrustSeal. This would require adoption through the periodic CoreTrustSeal community review of requirements and processes.

2. Scope & Context

The primary focus of this work is to align the CoreTrustSeal Requirements with FAIR to identify how repositories can enable FAIR data. Provision of a capability maturity approach is central to this work, but the application of capability and maturity levels will not be prescriptive at this stage. These will be developed iteratively through interaction with ten supported repositories and more extended engagement, for example in the emerging European Network of Trustworthy Data Repositories enabling FAIR data.

The format of a single large deliverable is not best suited to addressing the complex content and varied stakeholder audiences. At this stage, the content is directed primarily at those designing and developing FAIR and EOSC related standards and infrastructures. These standards need to be streamlined and updated over time to provide clear direction to repositories and their key stakeholders: depositors, users and funders. The 'component documents' (section 8) will also evolve independently over the course of the project. This will lead to a final deliverable that proposes a standard, process and governance model that incorporates CoreTrustSeal+FAIR.

The outputs are not only directed at an operational repository audience, but also aimed at those designing interoperable infrastructures of people, processes and technologies. Making CoreTrustSeal+FAIR simpler and more usable for a wider range of stakeholders will form part of the FAIRsFAIR iteration process.

Within the FAIRsFAIR project work package 4 will: offer support for FAIR-enabling Repositories (T4.3), develop a network of FAIR-enabling Trusted Digital Repositories (T4.2), improve registries for FAIR-enabling repositories (T4.4) and undertake several FAIR Data assessment pilots (T4.5). These pilots and other work to formalise metrics and tests against the FAIR Principles will be used to consider the practicalities of integrating the FAIR 'scores' of repositories collections into FAIR-enabling repository assessment.

The FAIR Data Principles: Baseline

The detailed clarification of each FAIR principle and its application is beyond the immediate scope, though highly relevant to any final recommendations.

All current FAIR work can be traced back to the original 2014 Force 11 Principles and the subsequent Nature paper[9] which we use as our reference point. The numerous ongoing efforts around FAIR often question the meaning and intention of the original principles at different points in their work. We need to address these issues of FAIR interpretation without allowing them to delay our progress. We have annotated the Principles to develop a 'baseline' of potential issues (see Component Documents)[10] that impact the definition and evaluation of digital object FAIRness or the ability of repositories to enable their FAIRness. Future versions of the baseline document will identify whether these issues have been addressed.

[9] The FAIR Guiding Principles for scientific data management and stewardship
[10] FAIR Principles: Baseline Comments

Repository Interoperability

Interoperability between repositories and with other components of the EOSC is essential. This particularly applies to technical standards for repository interoperability. Full details of the FAIRsFAIR work in this area are presented in *D2.3 Set of FAIR data repositories features*[11]. We will engage with this work and outcomes will be integrated into future iterations of CoreTrustSeal+FAIR.

Object Assessment

Among the many rapidly evolving areas of FAIR and EOSC is the ongoing development of indicators and metrics to enabling testing for objects' compliance with the FAIR principles. Project interactions with the RDA FAIR Data Maturity Working Group (now in a maintenance phase), are available in the deliverable *4.1 Draft Recommendations on Requirements for Fair Datasets in Certified Repositories*[12] and the outcomes were integrated into *FAIRsFAIR Data Object Assessment Metrics*[13]. These FAIR indicators and metrics have been included in the work to align CoreTrustSeal with FAIR.

Object & Repository Data

The CoreTrustSeal+FAIR alignment of repository practice with FAIR object assessment supports FAIRsFAIR task 4.4 in identifying necessary extensions to descriptive metadata about repositories. This sets the foundation for streamlining assessment and certification through improved organisational and data collection metadata.

Service Assessment

Repositories are part of a wider data service ecosystem. The FAIRsFAIR work in this area is available in the *Assessment Report on FAIRness of Services*[14]. We will engage with this work and outcomes will be integrated into future iterations of CoreTrustSeal+FAIR.

Human Mediated and Machine-Actionable Assessment

The minimum expectations for machine-actionability will become more apparent as different aspects of the EOSC ecosystem mature. Future interactions of this work will take into account the expected balance of machine-actionability, including assessments across repositories, objects and services, partnerships and policies. This includes the evolving goals for semantic interoperability of repositories and machine-actionable policies.

Wider EOSC Components

The final recommendations from this work depend on repository interactions with the wider components of the EOSC Ecosystem. *FAIR Ecosystem Components: Vision*[15] is being iterated in response to external feedback and internal results. We will engage with this work and outcomes will be integrated into future iterations of CoreTrustSeal+FAIR.

[11] Set of FAIR data repositories features
[12] Draft Recommendations on Requirements for FAIR Datasets in Certified Repositories
[13] FAIRsFAIR Data Object Assessment Metrics
[14] Assessment report on 'FAIRness of services'
[15] FAIR Ecosystem Components: Vision

Policy and Practice Integration and Enhancement

The FAIRsFAIR Project provides a number of recommendations for policy enhancement[16] that will be considered as we develop repository assessment proposals. The key findings are structured in terms of the Turning FAIR into Reality report: define, implement, embed and sustain. Policy enhancements relevant to CoreTrustSeal+FAIR include "Efforts are needed to raise general awareness about the FAIR principles and how to implement them in a practical sense" (#1), "Clearer definitions of data and expectations around sharing are needed. Definitions and expectations should be harmonised across stakeholders" (#6-8), and "Requirements for research data management (RDM) and data management plans (DMPs) should be harmonised across stakeholders" (#14-18). CoreTrustSeal+FAIR will also consider the Recommendations on practice to support FAIR data principles[17]

Assessment & Evaluation Modelling

The outcome of an assessment/evaluation of an object or other entity (such as a repository or service) is a defined status, e.g. Trustworthy, FAIR, Open. There are several existing and in development evaluation approaches for us to examine. A structured typology of relevant concepts facilitates the design, review and comparison of standards and processes[18]. Future iterations of the CoreTrustSeal+FAIR outcomes will be benchmarked against this model.

3. FAIR Objects & FAIR Enabling Environments

Different scientific communities and their repositories work with different assumptions about what is a 'digital object' and different approaches to 'data' and 'metadata'. In *Turning FAIR Data into Reality*, the following overview object model is presented.

[16] Policy Enhancement Recommendations
[17] Recommendations on practice to support FAIR data principles
[18] Generic Assessment & Evaluation Reference Model

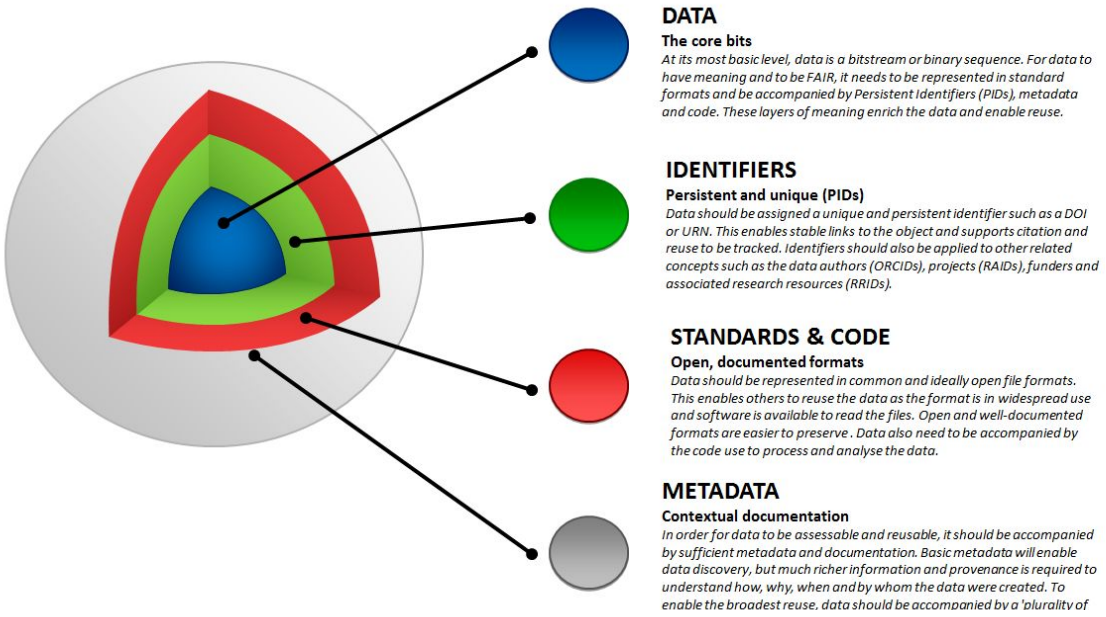


Diagram 1: ***Rec. 3****: **A model for FAIR Data Objects***

This division between the data (as the original target for collection/creation) and its supporting metadata is not always clear and consistent in practice. For example, some standards support data and associated metadata contained within a single file (e.g. DDI[19], ABCD[20]). Repositories also create their own 'business information' which include policies, procedures and other documentation, and its own 'process metadata' (ranging from 'policy review/approval' to 'format risk updated'). Some of this repository 'process' metadata might be stored and managed with the object metadata (e.g. 'validation of a checksum' or 'file format migration completed'). All of these (meta) data types are important as either they enable FAIRness directly or they provide supporting evidence for enabling FAIRness.

The diagram below presents the potential overlaps between object data, object metadata, repository process metadata and other repository business information.

[19] Data Documentation Initiative: Specification
[20] ABCD: Access to Biological Collection Data

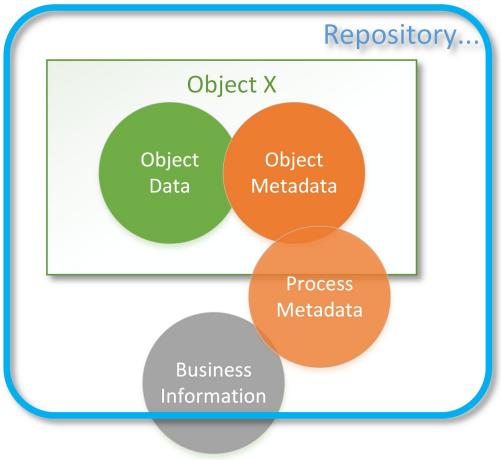


Diagram 2: ***Repository & Object Metadata***

In the development and implementation of CoreTrustSeal+FAIR, we must take into account repositories and their collections of heterogeneous digital objects. But we must also remain general enough for the approach to be applicable to a broad range of repositories. The diagram below demonstrates a mapping from objects to the FAIR principles that takes account of the repository context and some wider dependencies.

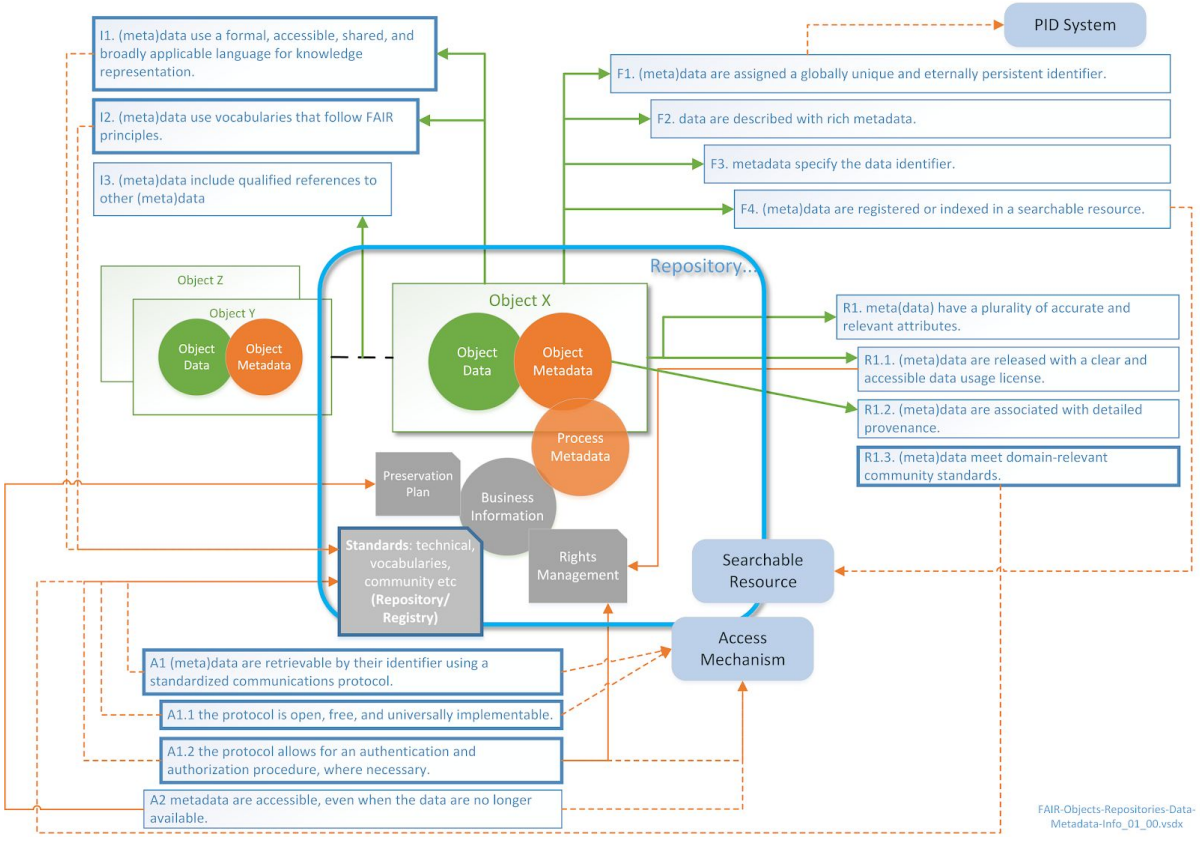


Diagram 3: ***FAIR Objects, Repositories, Dependencies*** *(FAIR Principles abbreviated)*

In the diagram above (full version see Appendix 1) the green arrows represent FAIR Principles that are most closely associated with object characteristics. However, delivering FAIRness remains

dependent on the data curator. In this case, the repository is the data curator, but from a full lifecycle perspective FAIRness depends on data creators/researchers/depositors to provide FAIR data at source, and on data re(users) to follow FAIR principles. Orange arrows represent cases where compliance with the FAIR Principles has dependencies, for example, on internal repository business information like rights management or preservation plans. Dotted orange arrows represent dependencies on functionality (PID systems, searchable resources, access mechanisms) or information (technical/community standards for data or metadata vocabularies) which might be outside direct repository control (e.g. held in a registry or provided as a third-party service).

Principles with a bold border indicate the (minimum number of) cases where there is a dependency on some wider clarification or contextualisation (e.g. “what is acceptable as ‘rich’ metadata?”, or “how must a vocabulary meet FAIR principles?”).

Defining the alignment between objects and their repository environments allows us to identify dependencies. It also helps us to identify cases where repositories might depend on outsource partners to provide supporting evidence for CoreTrustSeal+FAIR status.

3.1. CoreTrustSeal Requirements in Brief

The diagram below presents the CoreTrustSeal requirements. Context (R0) provides information to support the overall assessment. Organisation Infrastructure (R5), supports: internal expertise and governance, achieving the mission (R1), business continuity (R3), rights management (R2), confidentiality and ethical issues (R4) and access to appropriate external expertise (R6).

Digital Objects are preserved (R10) for ongoing access after selection and appraisal of deposits (R8), assurance of quality (R11) during curation and measure to enable discovery (R13) and reuse (R14) through managed workflows (R12).

The integrity and authenticity (R7) of data and their storage (R9) are primarily addressed from the curator perspective in CoreTrustSeal, but they also depend on the Technical Infrastructure (R15) and Security (R16).

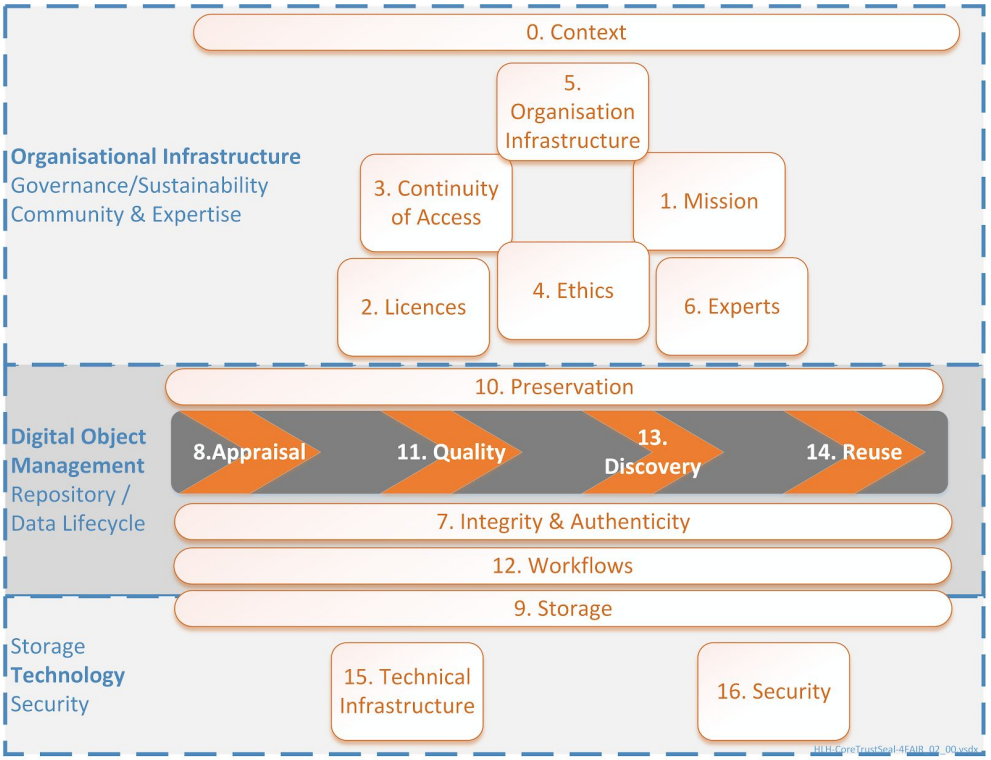


Diagram 4: ***CoreTrustSeal Requirements in Brief***

Broadly speaking a repository may evaluate/curate for FAIRness at three points

- R8. Appraisal
- R11. Data Quality
- R14. Data Reuse

Objects may be evaluated for FAIRness at *appraisal*. Curation to ensure *data quality* may apply missing elements of FAIRness. At the point of *data reuse,* the FAIRness of data should be assured, or any lack of FAIRness communicated to data users.

4. CoreTrustSeal+FAIR

The FAIRsFAIR CoreTrustSeal to FAIR alignment builds on previous work by CoreTrustSeal Board Members[21] at iPres and the OpenAIRE workshop on Services to support FAIR data[22]. The second iteration of the CoreTrustSeal to FAIR alignment mapping were reviewed and responded to by the ten FAIRsFAIR Repositories supported within this FAIRsFAIR work package and more widely through comments on the FAIRsFAIR Data Object Assessment Metrics[23]. The final versions of the FAIR indicators[24], and the latest version of the FAIRsFAIR metrics with the updated mappings have been

[21] Enabling Findable, Accessible, Interoperable, and Reusable (FAIR) Data
[22] How CoreTrustSeal enables FAIR data
[23] FAIRsFAIR Data Object Assessment Metrics
[24] FAIR Data Maturity Model: specification and guidelines

integrated into the third iteration of the CoreTrustSeal+FAIR Overview[25] which remains open for comment.

The supported repositories have now completed their first self-assessments against the CoreTrustSeal Requirements (without FAIR elements). The support process will provide guidance on how best to improve self-assessment statements and supporting evidence. Future self-assessments will be used to re-integrate FAIR into the requirements evaluation and consider the relationship between capability, evidence and ultimately overall organisational (repository) maturity.

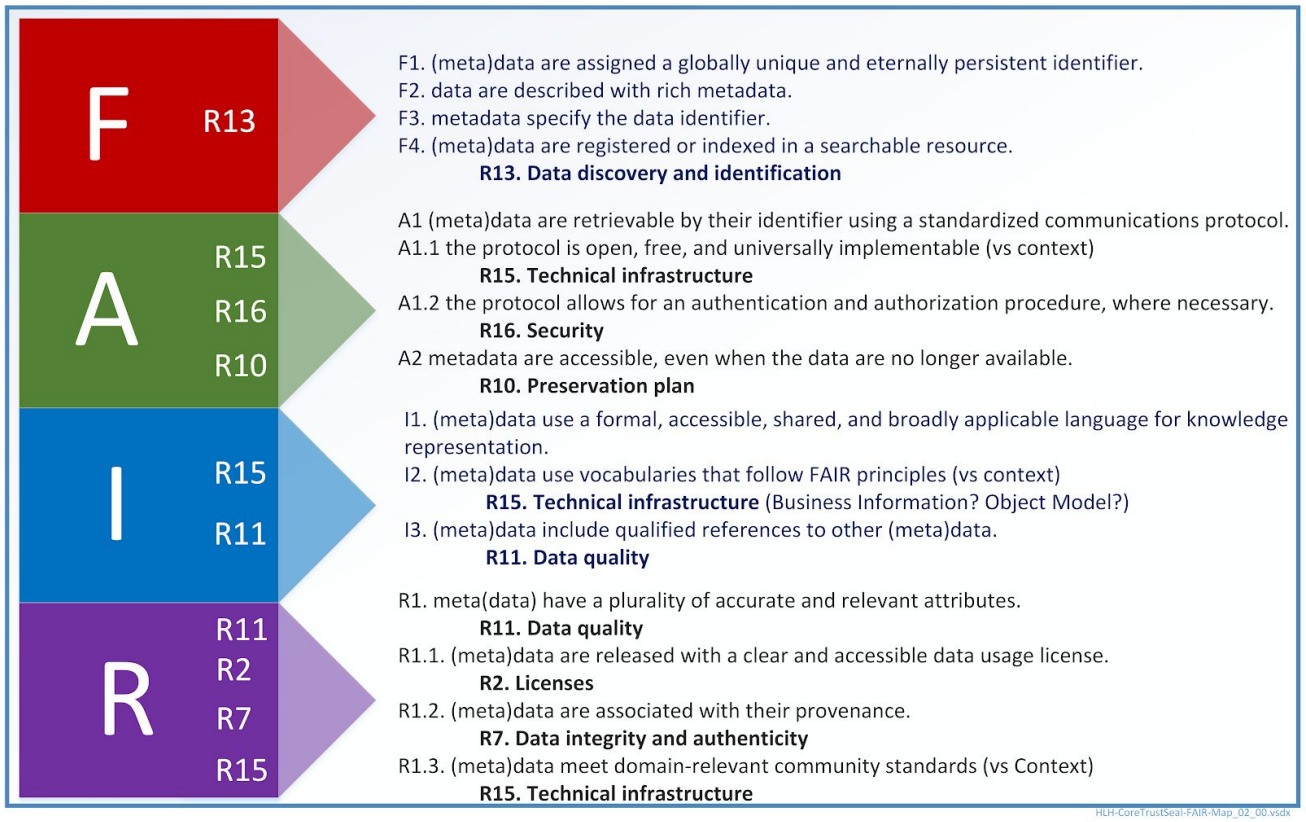


Diagram 5: ***FAIR to CoreTrustSeal***

A more detailed mapping from the Requirements to the Principles is provided in Appendix 2.

5. CoreTrustSeal+FAIR Model Design

In setting up an approach for FAIR enabled repositories, we need to consider where we can elaborate on the existing CoreTrustSeal requirements and whether some additional features are required. The design methodology is to use the CoreTrustSeal Requirements as a baseline and to elaborate them in ways which demonstrate that a repository enables FAIRness.

The overall goal is to integrate the CoreTrustSeal requirements with repository approaches to enabling FAIR data. A capability/maturity approach will be used to support repository assessment

[25] CoreTrustSeal+FAIR Overview

and improvement. This will be aligned with parallel work to test the FAIRness of curated digital objects.

The repositories supported by FAIRsFAIR are the initial audience, but much more extensive feedback is sought as we iterate and test the approach. There are several logical mappings from FAIR into various parts of the requirements. However, we need to select the most intuitive and practical alignment, so repositories have clear locations to provide self-assessment statements and associated evidence for FAIR enabling.

The challenge of mapping to CoreTrustSeal and evaluating capability and maturity goes beyond the FAIR acronym. The acronym contains 15 principles, each of which has a number of associated indicators, metrics, and tests. The RDA FAIR Data Maturity Working Group have also classified each indicator as one of: essential, important or useful.

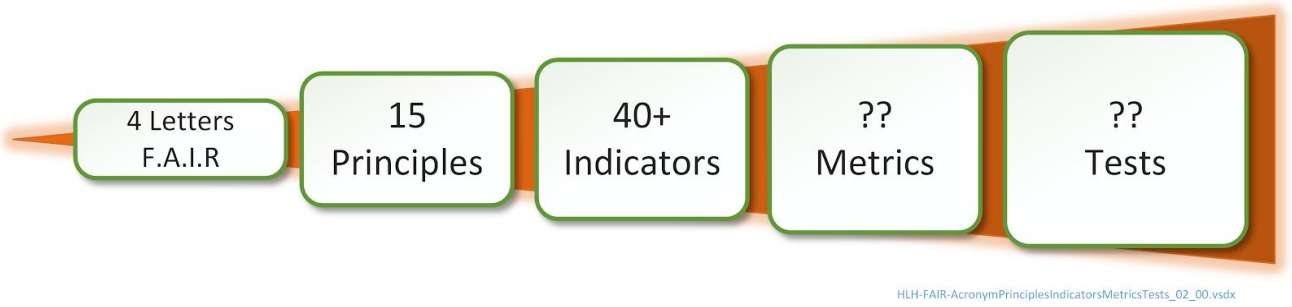


Diagram 6: ***FAIR acronym, principles, indicators, metrics & tests.***

Indicators clarify how the Principles apply in practice. Metrics define how that practice can be measured. A range of tests could be designed/coded to apply these metrics.

For example: "*R1.2: (Meta)data are associated with detailed provenance*." is supported by the indicator[26] "R1.2-01M Metadata includes provenance information according to community-specific standards". Metrics could include the presence or absence of provenance information and whether this met an agreed community standard. The test could involve a search for provenance-related metadata elements which comply with a provenance schema approved as community-specific and recorded in a registry, e.g. FAIRsharing[27].

Discussions with another group working on relationships between repository-related standards including CoreTrustSeal to FAIR[28] raised some issues around the purpose and scope of the mapping or crosswalk process. Even mappings between more structured standards like XML schema may result in different proposed crosswalks. This has implications for confidence in the alignments and strand of subsequent work may diverge as result. For this reason we have worked to provide a basic definition of the intended purpose and outcomes which guide the FAIRsFAIR alignment process.

In addition to directly mapping each FAIR Principle we have also considered the RDA FAIR Data Maturity Working Group Indicators in our mapping. These add some more specific interpretations

[26] FAIR Data Maturity Model: specification and guidelines
[27] https://fairsharing.org, an RDA WG, and RDA-endorsed output
[28] Peng, G., W. S. Gross, and R. Edmunds, 2020: Crosswalks Among Stewardship Maturity Models Promoting Trustworthy FAIR Data and Repositories, in preparation

of the Principles that can influence the mapping. The FAIRsFAIR Data Object Assessment Metrics propose specific testable metrics against some of the indicators which, again, can influence the mapping. For example the principle: "*A1 (meta)data are retrievable by their identifier using a standardized communications protocol*" and all indicators are mapped to R15. Technical Infrastructure, but the metric "*FsF-A1-01M Metadata contains access level and access conditions of the data*" has a clear association with R2. Licences (rights management).

We have taken an A/B approach rather than trying to note all of the (many) conceptual relationships between CoreTrustSeal and FAIR. The revised FAIRsFAIR mapping (Appendix 2) presents a two-tier alignment where 'A' indicates primary mapping for self-assessors to provide their responses and evidence while 'B' acknowledges other relationships. This practical need to consider the completion of a 'CoreTrustSeal+FAIR' assessment within the project impacts our mapping approach.

Another reason for variances in crosswalks is that we have not mapped directly into the R0 context areas. Even though a principle may be conceptually related to a R0 Context item this does not necessarily provide a location for a respondent to add their evidence information. In some cases we have noted "A vs Context". These indicate areas where some changes to the CoreTrustSeal R0 section would allow us to map into R0 e.g. the inclusion of a 'relevant standards' list.

At this stage of the alignment betweenCoreTrustSeal requirements and the FAIR principles, we have some open issues. These include the need for feedback from repositories about their perception of FAIR enabling and a more extensive set of contextual questions than those currently requested by CoreTrustSeal. There are also some FAIR concepts, including the use of standards and the provision of access functionality, which are implied by several CoreTrustSeal Requirements rather than being explicitly defined.

5.1. Supporting the Journey Towards Trust & FAIR

Both Trustworthy Data Repository status and FAIR data may be conceived as a journey. The application of a scoring mechanism such as capability/maturity may support repositories at lower levels of maturity in defining and achieving their goals. This approach can also be aligned with the work of the EOSC Secretariat working groups[29] including Rules of Participation[30] and FAIR which have resulted in *Interim recommendations for FAIR metrics and service certification to apply within EOSC*[31] and "Interim recommendations on certifying the services required to enable FAIR research outputs within EOSC"[32].

[29] EOSC Secretariat: EOSC Working Groups
[30] EOSC Secretariat: Draft Rules of Participation
[31] EOSC Secretariat: Recommendations on FAIR Metrics in the EOSC
[32] EOSC Secretariat: Recommendations on Certifying Services that enable FAIR research output in the EOSC

5.2. CoreTrustSeal, Compliance, Capability & Maturity

An assessment usually involves some evaluation/scoring method. In this case, we are using both the CoreTrustSeal compliance levels and a capability maturity approach.

CoreTrustSeal Self-Assessment Compliance Levels

0 – Not applicable

1 – The repository has not considered this yet

2 – The repository has a theoretical concept

3 – The repository is in the implementation phase

4 – The guideline has been fully implemented in the repository

CMMI Levels

0: Incomplete	1: Initial	2: Managed	3: Defined	4: Quantitatively Managed	5: Optimizing

Rather than pre-defining expectations against each aspect of CoreTrustSeal+FAIR, we will evolve our approach to these tiers over time. This will happen through interactions with the ten FAIRsFAIR supported repositories, the emerging European network of trustworthy data repositories enabling FAIR data, and the global FAIR and CoreTrustSeal stakeholders.

There are two reasons for taking an iterative and evidence-based approach. The first is that neither CoreTrustSeal nor FAIR are designed with capability/maturity tiers in mind. They do not apply the practice areas which are mapped to assess practice capability and overall institutional maturity. The second is that metrics and tests against the FAIR Principles and indicators are still under development. Outcomes of that activity will change the ‘minimum' capability-maturity expectations and CoreTrustSeal+FAIR interactions more broadly.

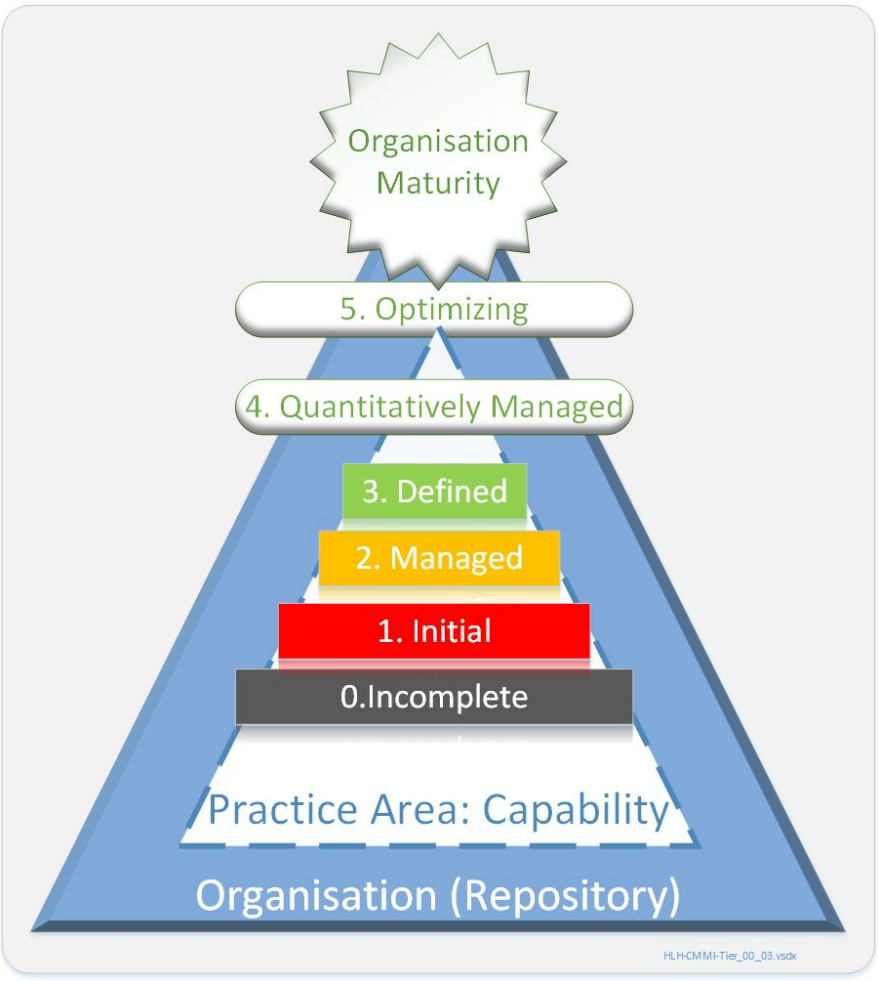


Diagram 7: ***Tiered Capability/Maturity***

For capability/maturity our working assumption is that capability levels of defined (3) can deliver FAIRness, though we will consider the validity of level 2 (managed). Maturity level 4 (quantitatively managed) may be a dependency for sustainable complex partnerships between data service providers. CMMI is an operational tool and not a marketing device; achieving level 5: Optimising should be seen as desirable, but resource-intensive. It is valuable to support data services in defining where they need to focus resources on improvement. For further detail, see *Capability-Maturity Modeling and Landscape* in *Component Documents* below.

5.3. A Governed Assessment and Evaluation Process

5.3.1. Assessment Methods & Outcomes

It seems inevitable that there will be a debate on what constitutes a level 3 maturity (defined) vs level 5 (quantitatively managed) and on what outcome is required for a given set of circumstances (e.g. 3 for low value, low cost/easy to recreate data, 5 for high value or sensitive data). We expect community expectations to evolve. We also need to be sure the measurement/metric (e.g. CMMI scale) is appropriate to the object characteristics or repository features being analysed.

This assessment and evaluation must be applied through a governed and transparent review process.

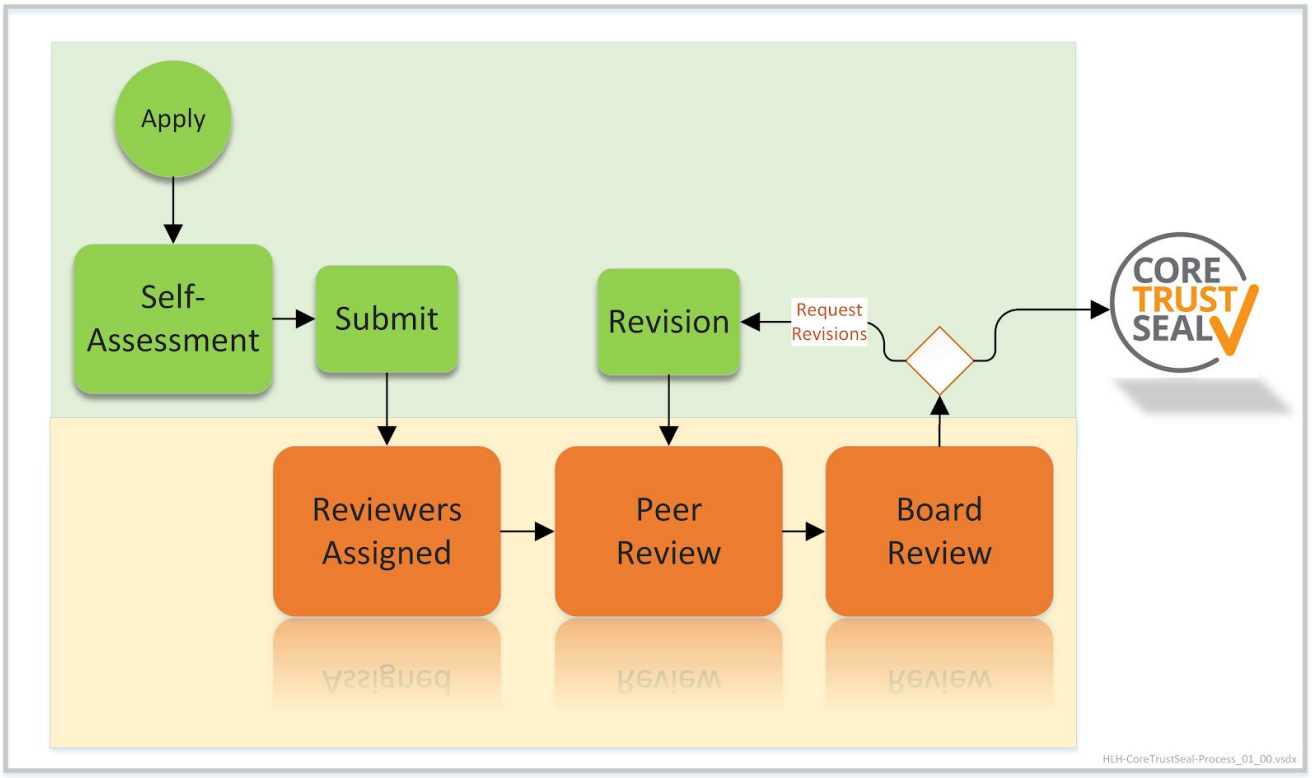


Diagram 8: ***CoreTrustSeal Process***

The diagram above presents the applicant activities in green and the CoreTrustSeal review process in orange. The self-assessment process feeds into an assessment method which will result in agreed outcomes, including the defined 'status' of a repository, i.e. as a CoreTrustSeal Trustworthy digital repository. The diagram below presents the addition of FAIRsFAIR repository support into the CoreTrustSeal process.

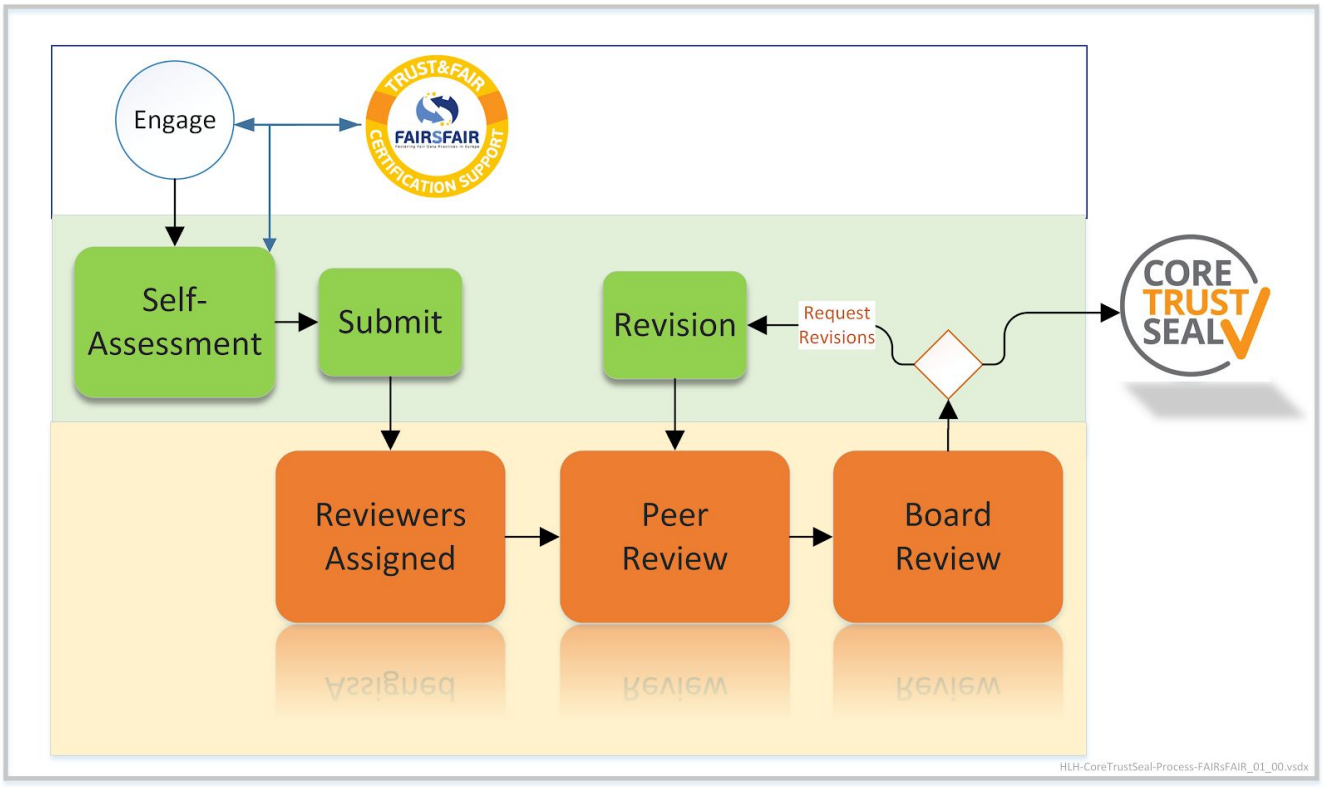


Diagram 9: ***FAIRsFAIR Project Repository Support***

This work takes place in parallel to efforts to test and 'badge' individual digital objects as 'FAIR'.

Repository support in FAIRsFAIR will enable applications for CoreTrustSeal which integrate evidence for FAIR enabling, but during this work there is no 'pass/fail' outcome within the project or a formal process of FAIR enabled certification through CoreTrustSeal. Recommendations for integration are being shared and discussed with the CoreTrustSeal Board. The Board has provided a statement of support for this work (Appendix 3).

In designing evaluations and outcomes, we must also consider how to avoid unfairly penalising objects or repositories, especially in the design and testing phase of FAIR assessments, e.g. restrictions on access to protect sensitive data should not lead to a lower score.

5.3.1.1. Certification and Badging

Beyond the design and implementation of indicators and tests for the FAIR principles, we will consider how best to recognise successful outcomes through formal certification and badging of FAIR entities and FAIR enabling repositories. Certification and badging options have dependencies on the final structure of the approach and the different 'certification' actors that will be involved. The evolving consensus is that achieving FAIR data and FAIR enabling repositories and data services is a journey that will require evaluation and support. In addition to monitoring the demand for a binary pass/fail view of datasets' FAIRness we will consider the implications of providing 'badges' as a visual summary of the FAIRness of a data object alongside guidance on how practice can be improved. Given the challenges of moving from principles to metrics we must be careful not to rely too much on a subset of metrics just because they are easier to test. Any 'tiered' scoring outcome

must also be clearly communicated. The logical and technical route from high-level 'badge' to more granular information and evidence must be defined.

5.3.1.2. Change, Periodicity & Validity Terms

CoreTrustSeal repository certification lasts for three years. However, digital objects might change at any time. The period and terms under which a FAIR evaluation remains valid are important design considerations.

5.4 CoreTrustSeal+ Integration, Elaboration & Extension

The final issue in the design of CoreTrustSeal+FAIR is to deliver a standardised user-friendly presentation that aligns well with the 16 CoreTrustSeal Requirements while being clearly separated from them. In seeking to design CoreTrustSeal+FAIR there are three possible options.

1. **Integration**. A key expectation in the vision for the CoreTrustSeal, as identified by the Research Data Alliance[33], is the provision of a single, sustainable 'core' level trustworthy digital repository standard for the community. The proliferation of baseline repository data service standards was considered undesirable, and this is further reflected in the Turning FAIR into Reality[34] report which notes in rec. 13 that "Existing frameworks like CoreTrustSeal (CTS) for repository certification should be used and adapted rather than initiating new schemes". If FAIRsFAIR or other actors identify a possible candidate for 'core' status and this is supported by the community it should be proposed for integration into the CoreTrustSeal Requirements themselves.
2. **Elaboration**. Where a strong alignment exists between trustworthy digital repository requirements and some other environment requiring standards definition this can be achieved by adding details and specifications to requirements that go beyond the 'Core'.
3. **Extension**. There may be cases where the 'Core' of CoreTrustSeal provides the foundations required, but additional standards which don't directly align with one or more of the 16 requirements have been identified. In this case an extension model with a CoreTrustSeal Core could be developed.

[33] https://www.rd-alliance.org/
[34] Turning FAIR into Reality

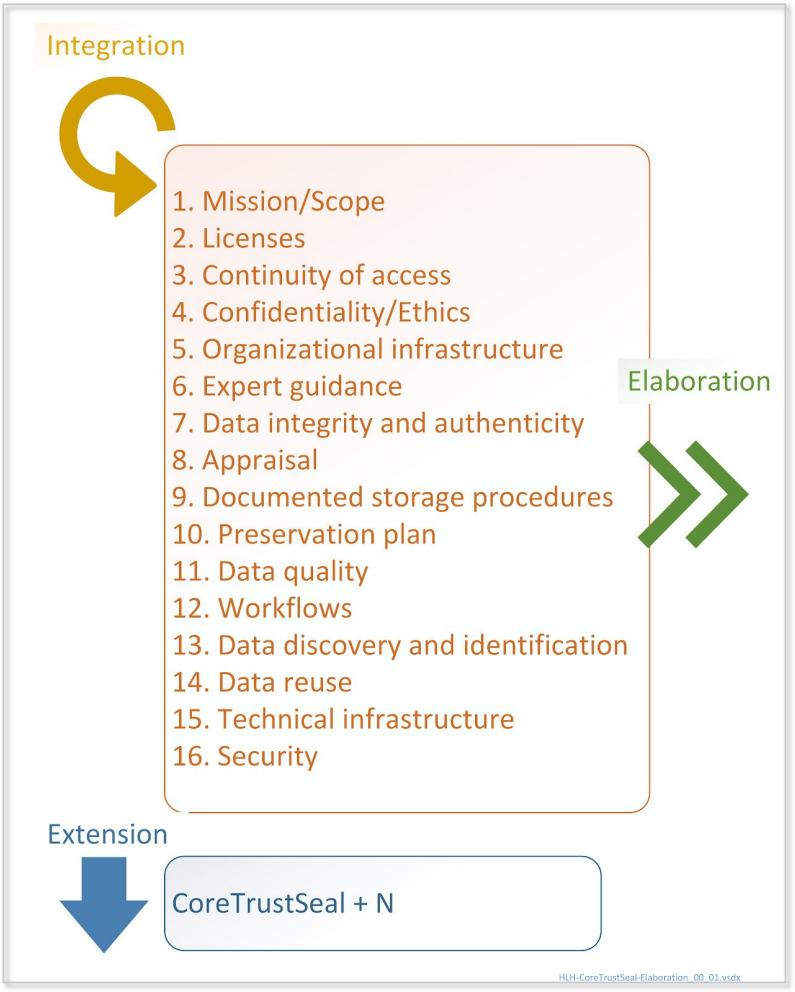


Diagram 10: ***FAIRsFAIR Project Repository Support***

An example of an extension would be the setting of terms and conditions for organisational membership in addition to achieving the CoreTrustSeal, as in the example of the World Data System[35]. In the CoreTrustSeal+FAIR work to date the strong dependencies between data objects and repositories mean we have mapped solely through elaboration. Other examples where elaboration of stricter or more detailed requirements than set at the 'core' level might be applied include the expectation that data be 'open', or the application of discipline-specific norms.

6. Open Issues for Integration

Our work to date has raised a number of issues, a selection of these are briefly outlined below. The issues will be considered in a future deliverable and further iterations of the CoreTrustSeal+FAIR approach. We would welcome feedback and input on each of these areas.

[35] Regular Members — World Data System: Trusted Data Services for Global Science

Iteration through Support and Wider Engagement

We are evaluating and testing a range of support approaches, including those used within the CESSDA Trust Support programme[36] also referenced by the SSHOC Project. Support and other engagement will help to define a flexible iteration schedule of design, implementation and evaluation throughout the project. Towards the end of the project, clear recommendations for the maintenance phase will be proposed.

Boundaries and Scope

Insourcing, outsourcing and complex partnerships can make repository boundaries hard to define. Complex, heterogeneous data collections can make it hard to evaluate overall collectionFAIRness at the repository level. The ability to clearly define the entity (object or organisation) under review is critical to any assessment, evaluation and certification process. A recent CoreTrustSeal consultation[37] included the issue of Technical Repository Service Providers (TRSP) and how they can play a role in the certification of their client repositories. We will monitor the outcomes of this process.

Registries

Registries will be a critical part of any future FAIR ecosystem. In addition to repository and object registries, the FAIR principles and indicators imply the need for other types. For example, do we need a clear registry of 'approved' PID systems, or disciplinary-specific data standard registries to help us evaluate 'rich' metadata?

Best, Minimal and Ideal Practices

The existence of standards like CoreTrustSeal, OAIS, ISO16363, ISO27001 and others does not mean there is always a community consensus on minimal levels of service quality and necessary supporting evidence. The CoreTrustSeal is the only current effort generating a publicly available body of work which could be used to support discussion on the often-used phrase 'best practices'. For formal assessment of object or repository characteristics, it is necessary to move from general assumptions of what 'best practice' means to SMART (specific, measurable, achievable, realistic, time-bound) objectives. We might also usefully differentiate between 'minimal practice' and 'ideal practice'. Some levels of practice might be defined purely from a 'technical perspective', e.g. a minimal number of data copies, while others will be dependent on local context including the needs of the data users.

Designated Community & other Users

"Designated Community: An identified group of potential Consumers who should be able to understand a particular set of information. The Designated Community may be composed of multiple user communities. A Designated Community is defined by the Archive and this definition may change over time". Definition from the OAIS reference model as used by the CoreTrustSeal glossary[38].

[36] CESSDA Trust Group: Overview of Support Approaches
[37] Request for Feedback – Specialists, Generalists, and Technical Repository Service Providers
[38] CoreTrustSeal Trustworthy Data Repositories Requirements: Glossary 2020–2022

For any real-world evaluation of an object, a repository or another FAIR entity, there must be a mixture of agreed practices and clear responsiveness to the changing needs of users. Whether this is a formally defined designated community, a broader mission to the public or a commercially driven approach based on supply (depositor) and demand (user). Some aspects of the evaluation must be based on who a repository (or object, or service, etc.) is intended to serve.

The Science Europe Practical Guide to the International Alignment of Research Data Management states "In some disciplines, researchers work with discipline-specific repositories which already have certain policies and standards in place that meet the needs of the specific community. Other repositories serve a more general research public, and their policies and standards are necessarily more generic as well"[39], noting that "It is always recommended to refer to broadly recognised discipline-specific or certified repositories in the first place"

The CoreTrustSeal identified that both discipline-specific 'specialists' and more generalist repositories were seeking recognition as trustworthy repositories for their own more or less specific designated communities. To meet the needs of the academic recommendations that disciplinary repositories should be selected where possible it is important to differentiate these from more generalist repositories while continuing to recognise the significant role this latter group plays in the data lifecycle. The results of the recent CoreTrustSeal consultation[40] on 'Specialists, Generalists, and Technical Repository Service Providers' will be monitored for its input into the subject of disciplinary designated communities. The requirements for European Open Science Cloud integration broadly reflect those of the wider research data community: that certification is associated with an actor that has direct responsibility for the data, that it remains clear if a repository serves particular domains or disciplines (and which ones) and that trust certification provides an assurance that the data retain their value over time. We will seek more precise approaches to defining designated communities and agreement on expectations of how a repository should interact and respond to their needs.

[39] Science Europe Practical Guide to the International Alignment of Research Data Management
[40] Request for Feedback – Specialists, Generalists, and Technical Repository Service Providers

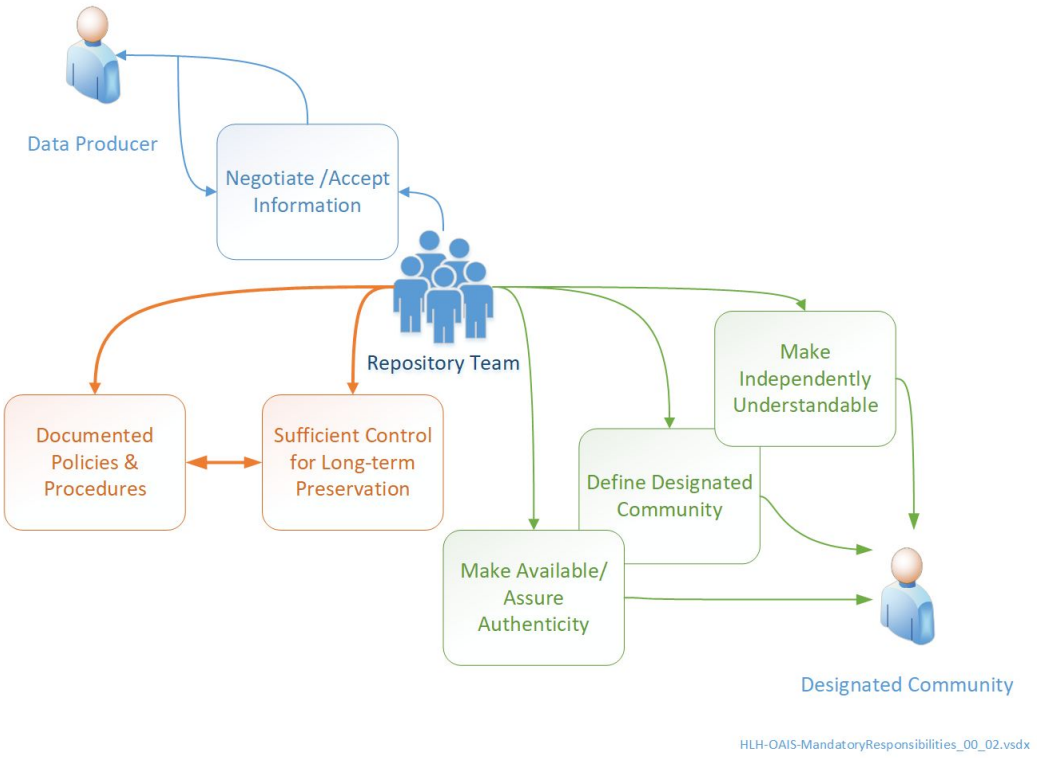


Diagram 10: ***OAIS Responsibilities Diagram***

The Full (FAIR) Data Lifecycle & Ecosystem

In line with the wider vision for FAIR, the FAIR-enabling repository work must align with a vision of the full FAIR data ecosystem and data lifecycle. This includes identifying how to integrate with work on research data management plans.

Non-(Meta) Data Artefacts as Evidence

Apart from a few cases where an entity (repository, object) is being directly inspected during a review there is always some dependency on evidence to support assessment. Evidence could range from mission statements, policies, procedures and workflows, to granular outcomes of fixity checks. This evidence is another type of 'digital object' generated as a result of running any infrastructure (people, processes, technology) which curates digital objects.

A key high-level indicator of maturity is the ability to design, implement, manage and change these evidence 'artefacts'. Without a business information management approach, there will always be a risk to maintaining a consistent level of FAIRness over time.

'Core' Level Technical & Security Standards

In seeking to define a CoreTrustSeal+FAIR model which keeps to the goal of 'Core' certification but also allows for alignment with and interoperability between repositories, data services, and other infrastructure components the technical and security factors may be the most challenging. The Trustworthy Repository ISO standard[41] references the ISO27001[42] security standards within its

[41] ISO 16363 Certification of Trustworthy Digital Repositories
[42] ISO/IEC 27001 — Information security management

metrics, but this is impractical at a 'core' level. One item of feedback received noted that technical requirements might need to integrate or align with IT Service Management certification as a crucial part of service quality. One of the more 'core' CMMI-compliant approaches suggested was FitSM. We will investigate the maturity approach in place and consider whether, at a minimum, terminological alignment would support improved interoperability.

7. Conclusions and Next Steps

At this stage of the iterative process, we have an alignment between the FAIR Principles and the CoreTrustSeal Requirements. We have outlined the capability and maturity approach, which will be applied to the CoreTrustSeal+FAIR alignment. As we apply capability criteria to CoreTrustSeal+FAIR, we will address the calculation of overall repository maturity.

The vision is to develop a practical and sustainable approach for repositories to self-assess their current capability levels, identify target levels and define where they need to focus resources on improvement. Integration of these processes into operational practice will provide a common approach to assessing and evaluating a data repository's ability to enable FAIR data. The outcomes will be an overall improvement of repository practice and a pathway to certification.

A wide range of interactions and dependencies will influence this iterative work, including internal testing with supported repositories, external feedback and integration of ongoing developments. These include cooperation with the CoreTrustSeal Board and community. FAIRsFAIR supported repositories will be seeking to certify against the current version of the requirements, while the outcome of the project may recommend future directions for the structure, content and process of the CoreTrustSeal.

Influences on theCoreTrustSeal+FAIR mapping include a number of ongoing activities both within and beyond the FAIRsFAIR project work. These include FAIRsFAIR *D3.3 Policy Enhancement Recommendations*[43] and *D3.4 Recommendations on practice to support FAIR data principles*[44]. We will consider the degree to which policy and practice recommendations can or should be integrated into the CoreTrustSeal+FAIR and whether they can inform more detailed statements on what we expect at each capability level.

Along with direct feedback from ten supported repositories FAIRsFAIR is developing a wider range of repository support approaches. The text of, and emerging feedback to *M3.5 Description of Transition Support Programme for Repositories*[45] raises a number of issues relevant to CoreTrustSeal+FAIR including clarification of standards in place at a repository, long term preservation definitions, repository types and data types . These also reflect some of the issues implied by the recent CoreTrustSeal consultation on specialist (e.g. domain/disciplinary) repositories vs more generalist repositories and the outsourcing of repository functions to technical repository service providers (TRSP).

[43] D3.3 Policy Enhancement Recommendations
[44] D3.4 Recommendations on practice to support FAIR data principles
[45] M3.5 Description of Transition Support Programme for Repositories

We are seeking comments, feedback and information about related efforts so that we can ensure cooperation, alignment and improvement of this crucial area of research data infrastructure.

8. Component Documents

8.4. CoreTrustSeal+FAIR Overview

This document represents the third alignment of CoreTrustSeal to FAIR requirements to inform repositories seeking to enable FAIR data. This version has been revised to align with the indicators and associated tests documented in *FAIRsFAIR Data Object Assessment Metrics*[46].

https://doi.org/10.5281/zenodo.4003630

8.1. Capability-Maturity Modeling and Landscape

This discussion paper provides an overview of the FAIRsFAIR project approach to evaluating Capability Maturity Modelling for use alongside the alignment of the CoreTrustSeal Requirements with the FAIR Data Principles.

https://doi.org/10.5281/zenodo.3862587

8.2. FAIR Principles: Baseline Comments

It is noticeable in various FAIR-related work that the same comments and questions related to the original Principles are repeatedly referenced. Rather than do the same thing for FAIRsFAIR WP4 we will retain the baseline issues and comments in this document and refer back to them periodically to see if they have been addressed either by our work or by others.

This text seeks to consider the issues around the FAIR Data Principles, particularly as they apply to the notion of a Trustworthy Digital Repository. Issues here must be answered (or at least acknowledged) for us to provide an aligned approach to FAIR-enabled Trustworthy Digital Repositories. We can progress without all of these questions being addressed, but clarifying them will ensure a better overall solution.

https://doi.org/10.5281/zenodo.3728131

8.3. FAIR Ecosystem Components: Vision

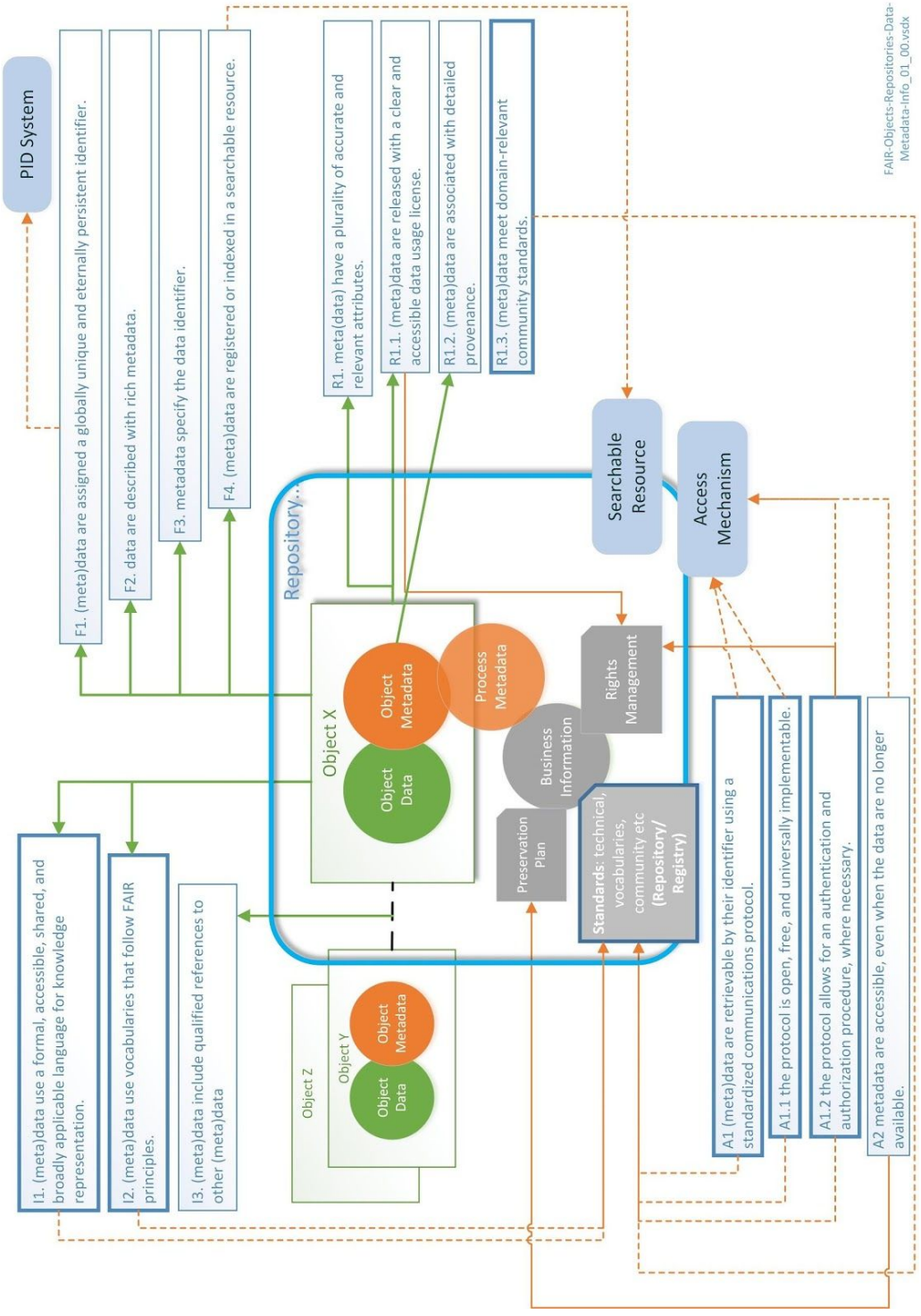
The primary focus of work package four in FAIRsFAIR is (trusted) repositories that enable the curation of (FAIR) objects. However, to be integrated into an operational European Open Science Cloud, a wider vision of FAIR ecosystem dependencies and interconnections is required. Data users and stewards of all kinds must be empowered to find, store and access data and metadata designed for interoperability and reuse. This draft presents a vision for the FAIR ecosystem components required to ensure FAIRness across the full data lifecycle.

https://doi.org/10.5281/zenodo.3734273

[46] FAIRsFAIR Data Object Assessment Metrics

Appendix 1: FAIR Objects, Repositories, Dependencies

Objects and Repository characteristics are mapped to the FAIR Principles.



Appendix 2: CoreTrustSeal to FAIR: Quick Reference v03.00

CoreTrustSeal to FAIR Quick Requirement v03.00	F1. (meta)data are assigned a globally unique and eternally persistent identifier.	F2. data are described with rich metadata.	F3. metadata specify the data identifier.	F4. (meta)data are registered or indexed in a searchable resource.	A1 (meta)data are retrievable by their identifier using a standardized communications protocol.	A1.1 the protocol is open, free, and universally implementable.	A1.2 the protocol allows for an authentication and authorization procedure, where necessary.	A2 metadata are accessible, even when the data are no longer available.	I1. (meta)data use a formal, accessible, shared, and broadly applicable language for knowledge representation.	I2. (meta)data use vocabularies that follow FAIR principles.	I3. (meta)data include qualified references to other (meta)data.	R1. meta(data) have a plurality of accurate and relevant attributes.	R1.1. (meta)data are released with a clear and accessible data usage license.	R1.2. (meta)data are associated with their provenance.	R1.3. (meta)data meet domain-relevant community standards.
Quick Map >>>	13. Data discovery and identification	13. Data discovery and identification	13. Data discovery and identification	13. Data discovery and identification	15. Technical infrastructure	15. Technical infrastructure	16. Security	10. Preservation plan	15. Technical infrastructure	15. Technical infrastructure	11. Data Quality	11. Quality	2. Licenses	7. Data integrity and authenticity	15. Technical infrastructure
1. Mission/Scope	Enables FAIR	Enables FAIR	Enables FAIR	Enables FAIR	Enables FAIR	Enables FAIR	Enables FAIR	Enables FAIR	Enables FAIR	Enables FAIR	Enables FAIR	Enables FAIR	Enables FAIR	Enables FAIR	Enables FAIR
2. Licenses				B	B								A		
3. Continuity of access	FAIR over Time	FAIR over Time	FAIR over Time	FAIR over Time	FAIR over Time	FAIR over Time	FAIR over Time	FAIR over Time	FAIR over Time	FAIR over Time	FAIR over Time	FAIR over Time	FAIR over Time	FAIR over Time	FAIR over Time
4. Confidentiality/Ethics															
5. Organizational infrastructure															
6. Expert guidance															
7. Data integrity and authenticity														A	
8. Appraisal	FAIRness Evaluated	FAIRness Evaluated	FAIRness Evaluated	FAIRness Evaluated	FAIRness Evaluated	FAIRness Evaluated	FAIRness Evaluated	FAIRness Evaluated	FAIRness Evaluated	FAIRness Evaluated	FAIRness Evaluated	FAIRness Evaluated	FAIRness Evaluated	FAIRness Evaluated	FAIRness Evaluated
9. Documented storage procedures															
10. Preservation plan	FAIR over Time	FAIR over Time	FAIR over Time	FAIR over Time	FAIR over Time	FAIR over Time	FAIR over Time	A	FAIR over Time	FAIR over Time	FAIR over Time	FAIR over Time	FAIR over Time	FAIR over Time	FAIR over Time
11. Data quality	FAIR Action	FAIR Action	FAIR Action	FAIR Action	FAIR Action	FAIR Action	FAIR Action	FAIR Action	FAIR Action	FAIR Action	A	A	FAIR Action	FAIR Action	FAIR Action
12. Workflows															
13. Data discovery and identification	A	A	A	A											
14. Data reuse	FAIR Information								B			FAIR Information	FAIR Information	FAIR Information	B
15. Technical infrastructure					A	A vs context			A	A vs context					A
16. Security							A	A							

Appendix 3: CoreTrustSeal Board Statement

"FAIR data and other ongoing research data development have raised several key issues of relevance to CoreTrustSeal. We are actively engaging with FAIRsFAIR and a range of other FAIR-related projects and working groups. CoreTrustSeal-certified Trustworthy Data Repositories are vital components in enabling the realization of the Findable, Accessible, Interoperable, and Reusable (FAIR) Data Principles, both ensuring and enhancing the 'FAIRness' of data over the long term.

The mission for CoreTrustSeal endorsed by the Research Data Alliance and the wider community is to provide a single sustainable 'core' route for repository data service requirements and certification. The Board exists to manage and maintain that core route over time, and in response to community needs. As the FAIR Principles are clarified through indicators and evaluated through (ideally automated) tests against digital objects, CoreTrustSeal will continue to integrate 'core' best practices into the Requirements. We also recognise there may be more explicit FAIR requirements that may be elaborated around the foundation of the CoreTrustSeal. The CoreTrustSeal+FAIR work may be a case where we can integrate a FAIR-enabling assessment into the CoreTrustSeal process.

The CoreTrustSeal Board will continue to follow and engage in the work carried out by FAIRsFAIR and other FAIR-related initiatives around the world to ensure that CoreTrustSeal certification continues to address community needs for core-level certification."