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An Institutional Federated Readiness Assessment Framework for Multidisciplinary Research Organisations

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ABSTRACT

Research organisations increasingly need to access and use data held across institutions and research infrastructures. Federated research environments support this by allowing data and resources to be accessed across organisational boundaries while remaining under the responsibility of the organisations that hold them. In Europe, these environments have developed around different scientific communities, types of data and purposes. A multidisciplinary research organisation may therefore need to consider different federated environments across its research activities, together with their requirements for data management, interoperability, governance, security and access. Assessing readiness for a single environment may give only a partial view of what is needed across the organisation. This study presents the Institutional Federated Readiness Assessment Framework (IFRAF) to address this problem. We reviewed scientific literature, standards and documentation from European federated research environments and compared the requirements identified from these sources. The analysis resulted in six areas of institutional capability. It also showed that some requirements are common across several environments, while others depend on the data, the environment and the role of the organisation. Systems engineering principles were used to organise the requirements and maintain traceability to their sources. We initially applied IFRAF at the Department of Chemistry and Biotechnology (KBI) at Tallinn University of Technology by mapping its scientific and data domains to potentially relevant European federated environments. The mapping showed that different research areas within the same organisation may be associated with different federated environments. This represents an initial application of IFRAF rather than a validation of its assessment capability. The next stage of the work covers the evidence-based capability assessment and gap analysis, followed by further validation of the framework.

Keywords: Federated research environments, Institutional readiness, Research data, Interoperability, Research infrastructures, IFRAF

INTRODUCTION

Research increasingly depends on data, computational resources and digital services that are distributed across universities, research infrastructures and other organisations. Large-scale studies often require researchers to discover, access and combine resources held by different institutions and,

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increasingly, across national borders. This has increased the need for research environments that can connect distributed resources without requiring them to be transferred to or managed by a single organisation (European Commission, 2016). Federated research environments have developed around this approach, allowing participating organisations to retain responsibility for their resources while supporting their discovery, access and reuse across organisational boundaries.

In Europe, the European Open Science Cloud (EOSC) provides a federated environment for research data and services across scientific disciplines. More specialised research infrastructures (RIs) have developed around particular research communities and types of data, including the European Life Sciences Infrastructure for Biological Information (ELIXIR), the Biobanking and BioMolecular Resources Research Infrastructure – European Research Infrastructure Consortium (BBMRI-ERIC) and the Genomic Data Infrastructure (GDI). The ability to find, access and reuse data across such distributed environments depends in part on how the data are described and managed. The Findable, Accessible, Interoperable and Reusable (FAIR) principles provide an important basis for this and have influenced research data management and sharing practices (Wilkinson et al., 2016). At the same time, participation in a federated environment places requirements on the organisations responsible for data and services, including governance, metadata, access management, security and interoperability. The EOSC Interoperability Framework, for example, considers interoperability at technical, semantic, organisational and legal levels (European Commission, 2021).

The requirements for working in these environments are not necessarily the same across scientific disciplines. Research fields differ in the types of data they produce, how those data are managed and the conditions under which they can be shared and reused. Akers and Doty (2013) found significant disciplinary differences in research data management practices and needs. Khan, Thelwall and Kousha (2023) similarly reported differences in data production, sharing and reuse across 20 disciplines. For multidisciplinary research organisations, different areas of research may therefore connect to different federated environments and face different requirements. Genomics research, for example, may involve GDI or ELIXIR, while biobanks and associated data may involve BBMRI-ERIC. EOSC has a broader cross-disciplinary scope. Research involving health data also needs to consider specific legal and governance requirements. In the European Union, the European Health Data Space (EHDS) establishes a common framework for the secondary use of electronic health data for purposes including research (European Parliament and Council, 2025). A research organisation working with health data may therefore need to consider both the requirements of the research infrastructure in which it participates and those arising from the EHDS.

Research readiness has been examined at different levels, including individual datasets, repositories and technical environments. The FAIR Data Maturity Model assesses digital research objects against the FAIR principles, while the TRUST Principles focus on the trustworthiness and stewardship of digital repositories (RDA FAIR Data Maturity Model Working Group, 2020; Lin et al., 2020). More recently, Luong et al. (2026)

developed a maturity model for assessing the governance, operational and technical readiness of Trusted Research Environments to participate in federated networks. However, these approaches address different aspects of readiness and provide limited support for assessing the requirements of multiple federated environments together from the perspective of a multidisciplinary research organisation. Such organisations need to identify which environments are relevant to their research and data, understand the requirements associated with participation and determine whether they have the institutional capabilities to meet them. This paper addresses this gap through the development of the Institutional Federated Readiness Assessment Framework (IFRAF). The framework uses systems engineering principles to relate an organisation's scientific and data domains to relevant federated environments and their requirements. IFRAF combines six institutional capability domains with a structured assessment process. The assessment begins with an examination of the institutional context and its scientific and data domains, followed by the identification of relevant federated environments and the roles the organisation may have within them. The requirements associated with these environments are then examined against institutional capabilities and available evidence to identify gaps, dependencies and priorities for institutional development. The framework was initially applied at the Department of Chemistry and Biotechnology at Tallinn University of Technology (KBI), where research covers biomedicine, gene technology, neuroscience, biotechnology, food science and analytical chemistry. The initial application focused on mapping the department's scientific and data domains to potentially relevant European federated environments. The evidence-based capability assessment, gap analysis and further validation of the framework are ongoing. The study addresses the following research question, *"How can a multidisciplinary research organisation assess the institutional capabilities required to participate in different European federated research environments and use the identified gaps to guide institutional development?"*.

RELATED WORK AND RESEARCH GAP

González-García et al. (2021) examined the development of a federated health research infrastructure and identified legal, organisational, semantic and technical interoperability as areas that need to be addressed across participating organisations. Luong et al. (2026), comparing maturity models from ELIXIR, Federated European Genome-phenome Archive (EGA) and Beyond 1+M Genomes, found both common areas and differences in how readiness is assessed across federated networks. The models covered areas such as governance, data management and security, infrastructure and operations, but their structure and emphasis reflected the objectives of the individual networks. This is relevant for multidisciplinary research organisations, where different research and data domains may involve different federated environments and therefore different combinations of institutional requirements.

Table 1: Approaches relevant to federation readiness.

Approach	Focus	Level Considered	Relevance to Institutional Readiness
FAIR Data Maturity Mode	Assessment of FAIR indicators	Digital research object	Examines characteristics of data rather than the wider institutional capabilities
TRUST Principles	Trustworthiness and sustainable stewardship	Digital repository	Addresses responsibilities and capabilities associated with trustworthy repositories
EOSC Interoperability Framework	Technical, semantic, organisational and legal interoperability	Federated resources and services	Identifies interoperability requirements relevant to organisations participating in federation
Federated Trusted Research Environment (TRE) maturity model (Luong et al., 2026)	Governance, operational and technical readiness	TRE and federated TRE network	Assesses readiness for participation in a particular type of federated network
IFRAF	Capabilities required to work across relevant federated environments	Multidisciplinary research organisation	Brings requirements from different environments into a common institutional assessment

The studies reviewed above address readiness at different levels, but they do not fully capture the situation of a multidisciplinary research organisation working across several federated environments. Some requirements may be shared across these environments, while others depend on the research domain, the type of data and the role of the organisation. Bringing these requirements together would allow an institution to see which capabilities are already in place, where gaps remain and where the same capability could support participation in more than one federated environment.

RESEARCH METHOD

This study draws on the Design Science Research methodology described by Peffers et al. (2007), which provides a structured process for developing and evaluating artefacts designed to address an identified problem. The approach was used to guide the definition of the institutional readiness problem, the development of IFRAF and its initial application. The evaluation of the framework is still ongoing.

Systems engineering principles were also applied to organise the requirements and maintain traceability between the requirements of federated environments and the institutional capabilities needed to address them

(INCOSE, 2023). Scientific literature, standards and documentation from the selected European federated environments were reviewed to identify requirements relevant to research organisations. The identified requirements were recorded together with their sources and the institutional functions they addressed. Requirements addressing similar institutional responsibilities, resources, processes or controls were compared and grouped into six capability domains. For example, requirements concerning common metadata standards and semantic interoperability in the EOSC Interoperability Framework were assigned to the Interoperability and Standards domain, while requirements concerning metadata documentation and management were assigned to the Data and Metadata domain (European Commission, 2021). Requirements specific to individual federated environments were retained within the relevant domains rather than removed through consolidation. This allowed common institutional capabilities to be identified while preserving differences in the requirements associated with particular environments. Traceability between the original requirements, their sources and the resulting capability domains was maintained throughout the process.

The initial application was carried out at the Department of Chemistry and Biotechnology at Tallinn University of Technology. The work included mapping the main scientific domains and associated research data, followed by an initial mapping to potentially relevant European federated environments. The mapping was used to identify the requirements to be considered in the subsequent institutional capability assessment.

The application presented in this paper covers the initial stages of IFRAF. The full evidence-based capability assessment, gap analysis and institutional development roadmap have not yet been completed. The results are therefore presented as an initial application rather than a final assessment of institutional federation readiness. The study does not yet validate the assessment capability of IFRAF or its relationship with federation outcomes. Further evaluation of the capability domains and the assessment process through expert review and institutional stakeholder assessment forms part of the continuing work.

INSTITUTIONAL FEDERATED READINESS ASSESSMENT FRAMEWORK

IFRAF was designed to examine federation readiness from the perspective of the research organisation. It starts with the organisation's scientific activities and the data associated with them and then considers the federated environments relevant to this work. Readiness is therefore assessed in relation to the requirements that apply to the organisation rather than against a single predefined set of requirements.

Institutional Capability Model

The requirement analysis described in the previous section resulted in six institutional capability domains. Table 2 presents the scope of each domain and the previous work that informed its development.

Table 2: IFRAF institutional capability domains.

Capability	Scope	Previous Work Informing the Domain
Governance and organisation	Institutional roles and responsibilities, policies, decision-making and coordination	González-García et al. (2021); European Commission (2021); Luong et al. (2026)
Data and metadata	Data management, metadata, documentation, provenance, quality and lifecycle management	Wilkinson et al. (2016); RDA FAIR Data Maturity Model Working Group (2020); Luong et al. (2026)
Technical infrastructure	Computing, storage, data services and mechanisms for accessing data and services	González-García et al. (2021); European Commission (2021); Luong et al. (2026)
Interoperability and standards	Technical and semantic standards, data models, vocabularies and interfaces	González-García et al. (2021); European Commission (2021)
Security, compliance and trust	Information security, access control, legal and ethical requirements, consent and trusted use of data	Lin et al. (2020); European Commission (2021); Luong et al. (2026)
Operations and stewardship	Data stewardship, operational support, monitoring and maintenance	Lin et al. (2020); Luong et al. (2026)

The six domains bring together requirements identified across the different sources. Requirements specific to a particular federated environment are retained under the relevant domain rather than treated as requirements for all environments. The same institutional capability may therefore support participation in several federated environments, although the specific requirements to be met may differ depending on the environment, the research data and the organisation's role.

ASSESSMENT PROCESS

The assessment is organised into six phases. The first phase defines the institutional context and the scope of the assessment. The second maps the scientific domains and the research data associated with them. Based on this mapping, the third phase identifies the federated environments that are relevant to the organisation and the role the organisation may have in each environment. The fourth phase examines the applicable requirements against the six capability domains and the available institutional evidence. The fifth phase identifies gaps and dependencies. The final phase uses the findings to define actions for institutional development.

Table 3: IFRAF assessment process.

Phase	Main Activity	Output
1. Institutional context analysis	Define the organisation, research activities and scope of the assessment	Institutional context
2. Scientific and data domain mapping	Map scientific domains, data types and digital resources	Scientific and data map
3. Federated infrastructure alignment	Identify relevant federated environments and the organisation's role	Environment and role mapping
4. Capability assessment	Compare applicable requirements with institutional capabilities and available evidence	Capability assessment
5. Readiness and gap analysis	Identify gaps and dependencies	Gap analysis
6. Institutional development planning	Define development actions based on identified gaps and dependencies	Prioritised institutional development roadmap

Within IFRAF, readiness is intended to be assessed against the requirements that apply to the organisation in a particular federated environment and the evidence available for the corresponding institutional capabilities. It may therefore differ across research domains and federated environments.

INITIAL APPLICATION AT KBI

IFRAF was initially applied at the Department of Chemistry and Biotechnology at Tallinn University of Technology. The first stage examined the research carried out within the department and the types of data associated with it. The mapping covered research in biomedicine, gene technology, neuroscience, biotechnology, food science and analytical chemistry. Across these areas, the data landscape included different forms of experimental, molecular and computational data, with differences in sensitivity, structure, standards and conditions for access and reuse.

The next step was to examine which European federated environments could be relevant to these research and data domains. EOSC was considered across the broader research landscape, while ELIXIR and GDI were particularly relevant to life science and genomic data. BBMRI-ERIC was considered where research involved biological samples and associated data. For research involving health data, the EHDS was included because of the additional requirements associated with the secondary use of electronic health data. The EHDS was considered as a regulatory framework rather than a federated research infrastructure. These mappings indicate potential relevance rather than existing participation or eligibility.

Table 4: Initial mapping of KBI research domains to potentially relevant federated environments and applicable regulatory frameworks.

KBI Research Domain	Examples of Data Considered	Potentially Relevant Federated Environment or Regulatory Framework
Biomedicine	Molecular, omics, experimental and health-related data	EOSC, ELIXIR, BBMRI-ERIC, EHDS where applicable
Gene technology	Genomic and other molecular data	EOSC, ELIXIR, GDI, EHDS where applicable
Neuroscience	Experimental, imaging, molecular and computational data	EOSC, ELIXIR where applicable
Biotechnology	Experimental, molecular and process-related data	EOSC, ELIXIR where applicable
Food science	Experimental, analytical and human-related research data	EOSC, EHDS where health data are involved
Analytical chemistry	Analytical and experimental data	EOSC

The mapping showed that a single department may need to consider more than one federated environment. It also provided a basis for identifying which requirements should be taken forward to the capability assessment. The requirements analysis identified common areas, including metadata, data management, interoperability, access management, security and governance, while other requirements remained specific to particular data, environments or institutional roles. The KBI application covered the institutional context, scientific and data domain mapping and the initial identification of relevant federated environments. The evidence-based assessment of institutional capabilities, gap analysis and identification of development priorities are ongoing.

DISCUSSION

The initial application of IFRAF at KBI illustrates why federation readiness needs to be considered at the level of the research organisation. The research areas examined at KBI differ in the types of data they produce and in the federated environments that may be relevant to them. Assessing the department against the requirements of only one infrastructure would therefore give an incomplete picture of the capabilities needed across the organisation.

The requirements analysis identified several areas of institutional capability relevant across different federated environments, including metadata management, access control, interoperability, security and governance. The initial application at KBI showed how these requirements could be

considered in relation to the department's different scientific and data domains. Some requirements may be addressed through common institutional capabilities, while others depend on the type of data involved, the federated environment and the organisation's role. IFRAF allows these requirements to be examined together without treating all research domains or federated environments as having the same requirements.

This differs from approaches that assess an individual digital object, repository or technical environment. IFRAF does not replace FAIR assessment, repository trust frameworks or infrastructure-specific readiness models. Instead, it uses their requirements, together with those of relevant federated environments, to examine what is required from the organisation responsible for the research data and services.

The present study has limitations. The application at KBI is still in progress and does not yet include a complete evidence-based capability assessment, gap analysis or institutional development roadmap. The findings therefore concern the design and initial application of IFRAF rather than validation of its assessment capability. The study does not establish predictive validity or whether use of IFRAF leads to improved federation outcomes. The six capability domains and the assessment process also require further evaluation with researchers, data stewards, technical specialists and other institutional stakeholders. The next stage of the work will examine whether the domains adequately cover the requirements encountered in practice and whether the assessment produces information that can be used to define institutional priorities.

CONCLUSION

This study introduced the Institutional Federated Readiness Assessment Framework (IFRAF), designed to support the assessment of the capabilities a multidisciplinary research organisation needs to participate in different European federated research environments. IFRAF combines six institutional capability domains with a structured assessment process that relates an organisation's scientific and data domains to relevant federated environments and their requirements. The framework brings common institutional requirements together while retaining those specific to particular data, environments and institutional roles.

The initial application at the Department of Chemistry and Biotechnology at Tallinn University of Technology demonstrated how different scientific and data domains within a single organisation can be mapped to potentially relevant European federated environments. The application covered the initial stages of IFRAF rather than a completed assessment of institutional readiness. The subsequent work will assess institutional capabilities against available evidence, identify gaps and development priorities, and further validate the framework with institutional stakeholders.

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