

FAIR Runtime Environments

1. Working Group Charter

Since the seminal FAIR principles for research data publication were introduced in 2016 [1], considerable effort has been devoted to making datasets and data repositories findable, accessible, interoperable, and reusable. In 2020, the FAIR envelope was broadened to include research software [2]. However, in a practical sense, there is still a large gap between the first half of the acronym, FA (findability and accessibility), and the last half, IR (interoperability and reusability). While data and software repositories are in everyday use by researchers, offering findability and accessibility to proliferating research data and software, interoperability and reusability depend on a critical additional factor. This element is often referred to as the run-time environment (RTE), which comprises the operating system, applications, software dependencies, and hardware drivers. The RTE provides a compatible environment to couple the data and software components. To build a model or execute an analysis, a reusable, interoperable system must integrate data and software in the appropriate runtime environment.

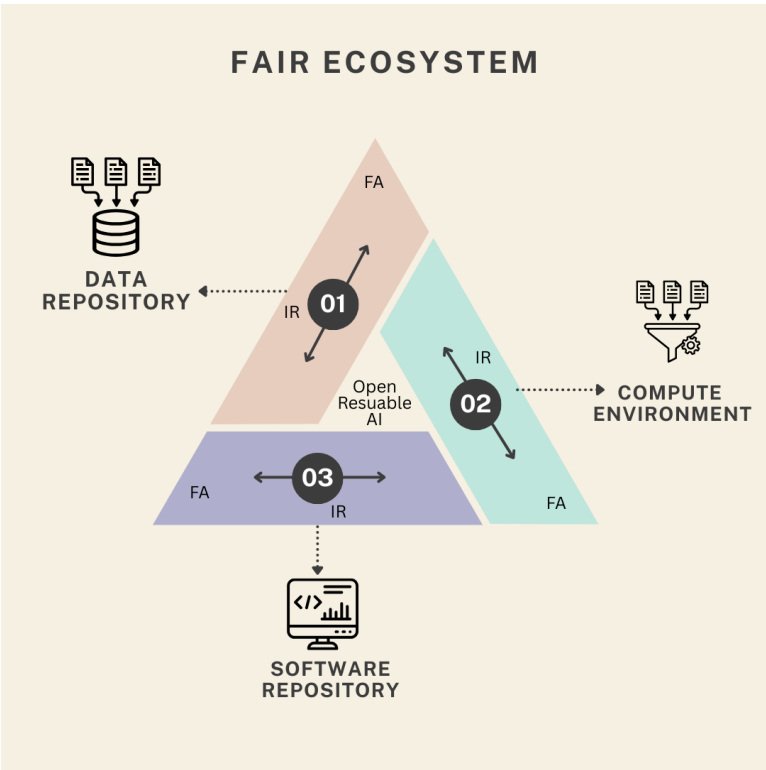


Figure 1: End-to-end FAIR Ecosystems - Data, Software, and RTE must be described to reach functional reusability

Data, software, and container (pre-packaged RTE snapshots) repositories are standard and, with varying degrees of success, address the Findable and Accessible aspects of the FAIR principles. However, the complex relationships that allow the Interoperability and Reusability principles are much more challenging to accomplish, as shown at a high level in Figure 1. Nowhere is this more apparent than with AI data and software. The RTE needed to build AI models or compare new data to AI-generated models is a crucial ingredient often overlooked in the AI ecosystem. This includes considering rapidly evolving processors such as GPUs, TPUs, and FPGAs, which are critical to many AI applications.

While findability and accessibility solutions (some more FAIR than others) have been proposed and are in place in some systems, represented by the vertices of Figure 1. Interoperability and reusability, however, happen along the edges. To achieve interoperability and, ultimately, reusability, there are three requirements: a) software must be paired with data it understands and can use; b) the runtime environment must meet the software's dependencies; and c) the runtime environment must have access to the data and be executable on hardware available to the user. This presents challenges, especially for AI-dependent research. A recent paper on the difficulties in reusing AI algorithms examines 75 published AI algorithms. It was concluded that only 25.3% of open software in the AI sub-domains of computer vision, audio analysis, and natural language processing is typically reusable by researchers without a deep understanding of cyberinfrastructure [3].

The FAIR-RTE working group will coordinate community-led discussions on how to define and effectively apply FAIR principles to runtime environments. To accomplish this, the proposed working group will:

- Provide a community-developed document defining the FAIR principles for Runtime Environments
- Provide guidelines on how to apply the FAIR principles to Runtime Environments
- Provide a document describing the implementation guidelines and adoption examples for FAIR Runtime Environments.

2. Value Proposition

The value proposition for the FAIR-RTE WG is primarily centered on **bridging the significant and often-overlooked gap between the Findable and Accessible (FA) aspects and the Interoperability and Reusability (IR) aspects of the FAIR principles**, particularly in the context of AI-based scientific research. The project recognizes that while data and software are increasingly findable and accessible, their practical reuse is hindered by a **critical additional factor of the run-time environment (RTE)**, which includes operating systems, applications, software dependencies, and hardware drivers.

The working group offers value by:

- **Empowering Researchers to Adopt New Tools.**

- By providing FAIR-RTE recommendations, the working group will establish a framework for adopting FAIR Data and FAIR Software into their computing environment.
- **Enabling End-to-End Reusability and Portability of AI Resources.**
 - The interoperability and reusability (IR in FAIR) depend on having an environment to execute analysis tasks. By defining and documenting FAIR principles in the RTE context, the working group will guide FAIR to the analysis execution point.
- **Delivering Concrete, Actionable Recommendations for FAIR RTEs**
 - By documenting implementation guidelines and adoption examples, the WG will be able to provide actionable recommendations for researchers looking to adopt FAIR Data and FAIR software into their institutional computing environments.

3. Engagement with existing work

The working group is inspired by previous work within the RDA and ReSA. This includes but is not limited to the following groups:

- FAIR4RS WG - Completed working group that facilitates knowledge discovery by assisting humans and machines in their discovery of, access to, integration, and analysis of data and their associated research objects.
- FAIR Mappings WG - Aims at working with the various communities and the RDA WGs that have generated mappings to converge toward standard guidelines to make different types of mappings FAIR.
- FAIR Principles for Research Hardware IG - Group geared toward the redefinition of FAIR principles for the domain of research hardware.
- FAIR Instrument Data IG - Currently in planning.
- CURE-FAIR WG - Establish standards-based guidelines for curating for reproducible and FAIR data and code.

4. Work Plan

Below is a table outlining the Milestones, Deliverables, and timelines required to complete the work within the 18-month life of the RDA Working Group.

Milestone	Deliverable	Timeline
Define FAIR for Run Time Environments informed by the work done with FAIR Data and FAIR Research Software. This definition would include comparing and contrasting the needs of data, software, and RTEs.	Document identifying the definition of FAIR RTEs and the similarities and differences to FAIR Data and FAIR RS.	0-6 Months
Seek community feedback and use cases for FAIR RTE	Finalize document defining FAIR principles for RTEs.	6-12 Months

Milestone	Deliverable	Timeline
definition document.		
Draft implementation and adoption plans, which include robust use cases.	Draft document.	12-18 Months
Produce a community-informed and vetted implementation and adoption document.	Finalize the implementation and adoption document for FAIR RTEs.	18- Months

5. Adoption Plan

This plan outlines a strategy for adopting FAIR (Findable, Accessible, Interoperable, and Reusable) principles for runtime environments, aiming for their widespread integration into research practices. The initiative, led by the FAIR-RTE (WG), leverages international co-chairs to provide a community-informed approach to completing true reusability of digital research artifacts. It details a phased approach to defining, disseminating, and embedding these principles across the global research community.

Phase 1: Principle Definition and Community Endorsement

Initially, the FAIR-RTE WG will focus on defining the core principles for computing run-time environments. This involves a collaborative process to ensure the principles are not only technically sound but also practical and aligned with the needs of diverse research disciplines. The WG will draft the principles and then seek broad community feedback and endorsement. This approach will ensure that the principles are built on a foundation of consensus and are perceived as a community-driven effort, which is essential for successful adoption.

Phase 2: Guideline Development and Practice Dissemination

Following the formalization of the principles, the WG will develop a comprehensive set of guidelines and best practices. These materials will serve as a practical guide for researchers, developers, and institutions on how to implement the FAIR principles in their computing environments. These resources will be disseminated through various channels, including workshops, webinars, and dedicated online platforms. The goal is to make the application of FAIR principles accessible and straightforward, moving from theoretical concepts to tangible actions.

Phase 3: Systematic Promotion and Engagement

A key component of this plan is the systematic promotion of the outcomes. The RDA FAIR-RTE WG will utilize RDA communication channels, such as newsletters, conferences, and social media, to raise awareness within its respective communities. This targeted approach will facilitate the direct engagement of researchers, policymakers, and funding agencies. Furthermore, the WG will proactively engage with other organizations focused on FAIR principles to encourage the application of these principles to research outputs beyond the scope of the RTE. This will not only broaden the reach of the initiative but also foster a more interconnected ecosystem of open and reusable research outputs.

Phase 4: Long-Term Integration and Impact Assessment

In the final phase, the focus will shift to facilitating the long-term adoption of the principles. The WG will support existing and emerging initiatives in integrating the FAIR principles into their workflows, thereby institutionalizing the practices. The collaborating organizations will continuously monitor the adoption rate and gather feedback to assess the real-life impact of the principles. This ongoing evaluation will allow for the refinement of guidelines and strategies, ensuring the long-term sustainability and relevance of the FAIR-RTE principles. Ultimately, the success of this plan will be measured by the degree to which FAIR workflows become a standard and expected practice within the global research community.

6. Initial Membership

Co-chair - Rob Quick (Indiana University, RDA-US)

Co-chair - Hugh Shanahan (Royal Holloway, University of London)

Co-chair - Raphael C be (Universidade Estadual Paulista, UNESP)

References

[1] Mark D Wilkinson, Michel Dumontier, IJsbrand Jan Aalbersberg, Gabrielle Appleton, Myles Axton, Arie Baak, Niklas Blomberg, Jan-Willem Boiten, Luiz Bonino da Silva Santos, and Philip E Bourne. The fair guiding principles for scientific data management and stewardship. *Scientific data*, 3(1):1–9, 2016.

[2] Anna-Lena Lamprecht, Leyla Garcia, Mateusz Kuzak, Carlos Martinez, Ricardo Arcila, Eva Martin Del Pico, Victoria Dominguez Del Angel, Stephanie Van De Sandt, Jon Ison, Paula Andrea Martinez, Peter McQuilton, Algonso Valencia, Jennifer Harrow, Fotis Psomopoulos, Josep Gelpi, Neil Chue Hong, Carole Goble, and Salvador Capella-Gutierrez. Towards fair principles for research software. *Data Science*, 3(1):37–59, 2020.

[3] Rob Quick and Mohith Kasula. Ai readiness: A reusability study of popular ai algorithms. Hawaii International Conference on System Science, 2025.