IJDC | *Conference Paper*

Global Open Research Commons: enabling curation for the next 20 years

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Abstract

This paper addresses the requirements for long-term preservation through a system lens. That is, rather than just focussing on specific technical elements that are needed for curation, the paper considers all the system elements that need to be put in place, and intentionally maintained, in order to ensure curation for the long term.

The paper begins by making the argument that curation requires attention to preservation over time. The need for preservation in turn requires both sustainable data contents and sustained infrastructures. These infrastructures consist of many elements, both social and technical, all of which need attention.

The paper then briefly introduces the concept of the open research commons as a way of conceptualising these elements, before examining in some detail the Global Open Research Commons (GORC) typology of essential elements. This work was developed through a Research Data Alliance Working Group, which started with a definition of a commons as "a global trusted ecosystem that provides seamless access to high quality interoperable research outputs and services". The essential elements in the typology include ICT infrastructure, services and tools, research objects, human capacity, rules of participation and access, governance, engagement, and sustainability.

This general approach was then extended by the GORC International Model Working Group to "review and identify attributes or features currently implemented by a target set of GORC organisations". The GORC approach has already been used in designing the creation of new commons, characterising existing research infrastructures, and analysing interoperability between commons. Future work, to commence in 2025, will clarify how the commons might be used and adopted, as well as improving how it is presented.

Our researchers need to have ongoing access to sustainable aggregations of data. These will need to be curated for reuse and interoperability over the long-term to support the integrity of the scholarly record. The GORC groups are working towards an interoperable set of platforms that together build on both the advances of the internet and the consensus and strengths of the research community.

Submitted date 2024 ~ *Accepted* date 2025

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This paper was presented at the International Digital Curation Conference IDCC25, 17-19 February 2025

The *International Journal of Digital Curation* is an international journal committed to scholarly excellence and dedicated to the advancement of digital curation across a wide range of sectors. The IJDC is published by the University of Edinburgh on behalf of the Digital Curation Centre. ISSN: 1746-8256. URL: http://www.ijdc.net/

Curation implies preservation

The CODATA RDM vocabulary (CODATA , 2024) defines data curation as a "managed process throughout the data lifecycle, by which data/data collections are cleansed, documented, standardised, formatted and inter-related. This includes versioning data, or forming a new collection from several data sources, annotating with metadata, adding codes to raw data (e.g., classifying a galaxy image with a galaxy type such as "spiral"). Higher levels of curation involve maintaining links with annotation and with other published materials. … The goal of curation is to manage and promote the use of data from its point of creation to ensure it is fit for contemporary purpose [*sic*] and available for discovery and re-use…"

Implicit in this definition's reference to "available for discovery and re-use" is the need to ensure the ongoing nature of this availability and reusability over the data lifecycle. This need must extend to all interlinked digital objects, whose lifecycles may well last for decades, particularly in the case of observational datasets or foundational software libraries. In that sense, digital curation implies the need for digital preservation, which is defined as "Series of managed activities necessary to ensure continued access to digital materials for as long as necessary. All of the actions required to maintain access to digital materials beyond the limits of media failure or technological change …" (CODATA, 2024).

Preservation requires sustainability

If we consider this preservation requirement, it becomes clear that this will require both sustainable and sustained **data contents** and sustainable and sustained **data container infrastructure**. Without the former, the contents will become unusable by future generations of scholars. Without the latter, the contents will become lost or forgotten. This means that a focus on sustainability of the entire ecosystem is needed.

Sustainability is often reduced to a focus on ongoing funding, but if one zooms out a little it becomes clear that true sustainability for data infrastructures also requires a commitment to a number of critical non-financial aspects:

- **Human capacity** needs to be maintained and adapted to the changing demands of the commons. Indeed, people are critical for the operation and maintenance of research infrastructures. They are the holders of tacit knowledge about how to operate and maintain the infrastructures, and their lived experience is essential in informing infrastructure enhancements, both in terms of what is lacking and what is possible.

- The **rules of participation and access** need to guard against services and data being exploited in a way that damages the long-term sustainability or reputation of the commons. This could include fake data being uploaded in support of research that was not carried out, existing data being changed by malicious state actors, services being taken offline through cyberattacks, or non-authentic services attempting to intercept login credentials.

- **Governance structures** need to be appropriate to the organisational demands of the commons, and need themselves to be sustainable over the long term (or designed in such a way as to enable transition to different governance structures as needed). This need for governance evolution is critical for infrastructures (such as those accumulating observational records) that need to persist for decades.

- **Engagement with users** needs to be active and to evolve as their needs change over time in order to ensure a user base that justifies ongoing investment. The best argument for sustaining a commons is the number of researchers who will be affected by its termination.

- **Use of standards** (and conventions) will reduce wasted effort through wheel re-invention and ensure that the data contents are more accessible to standards-based tools, rather than requiring bespoke solutions. This in turn will reduce the costs of maintenance and the overall cost burden over time.

- The underlying **storage, network and compute technologies** need to be aligned with the use patterns, as well as being upgraded as equipment ages and new more cost-effective technologies become available. Infrastructure elements that are allowed to age will need the investment of an increasing proportion of the available funding for the commons over time, causing a challenge for ongoing funding.

- The **research objects** themselves that include data should be stored in standard formats, and migrated over time as needed. Standard formats enable research infrastructures to rely on libraries of existing tools for shared functions, thus enabling funding to be allocated to rarer bespoke functionality. Migration over time will reduce the barriers to access for new users, and increase the potential value of the commons as a whole.

- The **services and tools** should provide standards-based APIs to enable easier creation of new tools and easier maintenance over time. This also makes it easier to recruit developers for the commons as they are more likely to have experience with those APIs.

Re-use requires FAIRness

The reference to "discovery and re-use" also needs to be unpacked. Indeed, enabling the ongoing ability to discover and re-use datasets requires a commitment to all aspects of FAIR (Wilkinson et al. 2016):

- unless the data is findable, it can't be discovered

- unless the data is accessible, discovery will only serve to frustrate

- unless the data is interoperable, it can't be combined with existing data

- and unless its licensing makes it re-usable, the previous three characteristics are irrelevant.

Importantly, ongoing availability for re-use requires an ongoing commitment to maintaining these FAIR characteristics.

Commons enable both sustainability and re-use

So, how to construct data infrastructures that enable sustainable data curation in support of re-use?

One approach that has been gaining ground over the last 20 years has been the idea of an open research commons. The term "commons" derives from the English idea of land held in

common and was popularised in the modern sense as a way of referring to shared resources by the ecologist Garrett Hardin in his influential 1968 article "The Tragedy of the Commons" (Hardin 1968). The Nobel laureate Elinor Ostrom revisited this idea and demonstrated instead that there do exist practical algorithms for the collective use of a limited common resource (Ostrom 1990). The idea of the commons has since been taken up and applied to a wide range of domains, including fisheries (Berkes et al. 1989), urban planning (Colding et al. 2013) and genomic data (Grossman 2019). Grossman (2023) lists a number of reasons as to why research projects might find commons a useful approach.

A research commons can be defined as a research-focused version of a digital commons, where "informational resources are created and shared within voluntary communities of varying size and interests", are held as communal, and management is "oriented towards use within the community, rather than exchange in the market". (Stalder 2010). Commons are emerging as an important tool for enabling the reuse of different types of data at the national and global levels. As more commons are developed, the need for coordination of these infrastructures on various levels (country, continent, discipline, sector) and focus (for all or some of the research artefacts) is increasing. Examples include the European Open Science Cloud[1], the Australian Research Data Commons[2], the International Virtual Observatory Alliance[3], and the African Open Science Platform (Participants of African Open Science Platform Stakeholder Workshop September 2018 et al. 2018; AOSP n.d.).

The GORC typology defines the necessary elements for a commons

Typology

The Global Open Research Commons Interest Group (GORC-IG) grew out of a Birds of a Feather meeting held as part of the 11th Research Data Alliance plenary in Berlin in March 2018 (Bicarregui 2018). The goal of the IG was to provide a neutral place where people could coordinate the development of a typology to describe what are referred to as "Open Science Commons" or "Data commons" within the research commons umbrella (Treloar et al. 2019). The creation of the IG was a response to growing interest in, and creation of, various kinds of research commons. It was also a response to a recognition among digital research infrastructure providers that national and discipline solutions needed a common language with which to address the challenges of interoperability.

As a first step, the GORC-IG examined a range of existing research commons architectures to review current practice. As a subsequent step, the GORC-IG generated this definition of a commons: "A global trusted ecosystem that provides seamless access to high quality interoperable research outputs and services." Lastly, it developed a typology of the essential elements in a commons (Fig. 1) and a set of definitions for each of the essential elements.

[1] EOSC Portal. Available at https://eosc-portal.eu/about/eosc [Last accessed 26 February 2024].
[2] Australian Research Data Commons 2024. ARDC. Available at https://ardc.edu.au/ [Last accessed 26 February 2024]
[3] IVOA. Available at https://www.ivoa.net/index.html [Last accessed 26 February 2024].

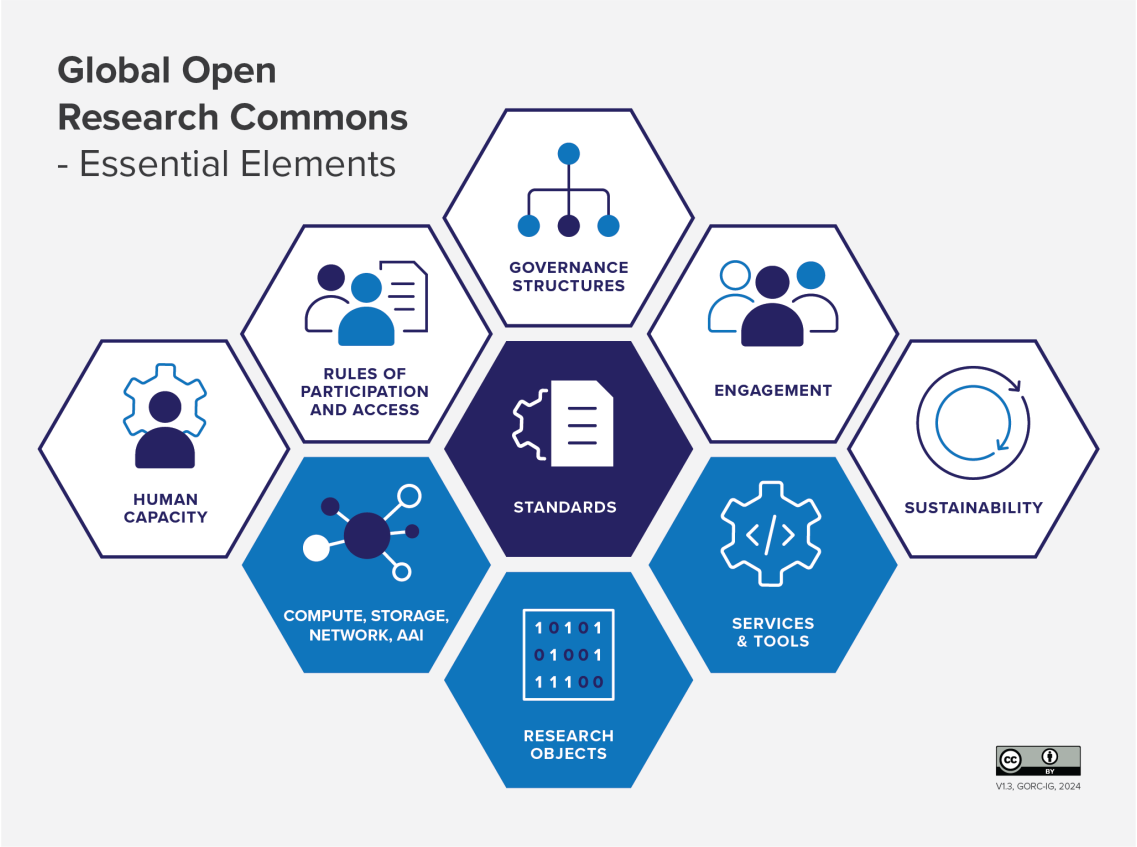

Figure 1: Essential elements of a research commons.

The three elements in blue are the underpinning elements that constitute the parts of the commons with which people interact:

- ICT Infrastructure: the physical components that a computer system requires to function and are necessary to conduct research
- Services & Tools: Service (as defined by IVOA) A service is any Commons element that can be invoked by the user to perform some action on their behalf. Services are usually intended for use by machines. Tools enable researchers to perform one or more operations, typically on data, and often with data as the output. Tools are usually intended for use by humans. In this context we are explicitly excluding physical instruments.
- Research Objects: These are the outputs of the research process, but they can also be inputs to later processes. Here, we limit our scope to digital research objects.

The five elements in white are the social or human elements that are needed to make the commons succeed:

- Human Capacity: The ability of the Commons to create a human-friendly environment for all stakeholders and community members in all aspects.
- Rules of Participation & Access: the set of policies defining a minimal set of rights, obligations and accountability governing the activities of those participating in the Commons.

- Governance: defining the organization's purpose and the development of the strategies, Typically the governance processes will be operated via a series of steering groups or boards, involving key stakeholders for the commons such as funders, national services and community representatives. Note that data governance is classified under the Rules of Participation and Access element.

- Engagement: Methods used to interact with the broad stakeholder community to involve them in activities.

- Sustainability: Models and agreements made on how to ensure the viability and continued or transitioned operations of the Commons, including funding and resourcing activities, in a way that can be sustained over the long-term.

The central element in dark blue represents the central importance of Standards at the core of any commons. Originally, this element was Standards and Interoperability, indicating that Interoperability was a core goal, and Standards a key enabler. As we have explored some of the usecases described below, we have come to recognise that Interoperability needs to be considered in all of the elements, particularly as this applies to interoperability between commons. We plan to explore this in future work.

This typology was presented to the RDA community as a draft supporting output in early 2023, revised in July 2023 to respond to community comments, and accepted as a supporting output in August 2023 (Jones et al. 2023). In addition to the typology and providing a forum for conversations about commons, the GORC-IG is now working towards a roadmap for global alignment and integration of research commons.

Feedback on the typology to date indicates that this is a complete list of the essential elements needed by a commons and that this representation is a very useful way of considering the infrastructure decisions that need to be made to ensure ongoing sustainability, as well as an agreed set of elements that can be used when considering questions of interoperability.

International Model

The GORC International Model Working Group (GORC-WG) worked under the auspices of the GORC-IG in support of the development of an interoperability roadmap. The mission of the GORC-WG was to "generate a set of pertinent attributes to identify common features across commons" and "review and identify attributes or features currently implemented by a target set of GORC organisations and when possible identify how they measure their user engagement with these features." (Payne, Leggott & Treloar 2021). This International Model (IM), the realisation of that mission, can be thought of as an organisational structure or framework that captures observations of commons elements, attributes, and key performance indicators (KPIs) from real world implementations currently in use or expected in research commons. One of us (Woodford) led the development of the IM.

The model is based on the GORC-IG typology outlining the essential elements of a commons (Jones et al. 2023), shown in Figure 1. The model further refines these essential elements by defining categories and subcategories of the essential elements as well as attributes and features of these entities. The items in the model were identified from a range of sources including a speaker series and related documentation, a literature review, and a community consultation process. The model was endorsed by RDA as a supporting output in October 2023 (Woodford et al. 2023) and as an RDA recommendation in November 2024 with adoption use cases.

In its current version (V1.1) the model is represented as a spreadsheet available in static and online formats that are open for comments and suggestions from users. It is divided across tabs based on the GORC-IG essential elements in addition to a glossary and a set of KPIs and metrics. Each item in the model has a main statement or label, an extended description, examples, consideration level, and primary sources. The consideration level is intended as a

guide for users of the model, allowing the items to be filtered based on whether they are "core" considerations that every commons should consider, "desirable' considerations that should be considered by established commons or those looking to expand, and 'optional' considerations that may be considered by commons with particular interest in those areas.

Sustainability is both a dedicated essential element in the model as well as considerations throughout the model. In the essential element, sustainability is focused into three main categories of plans, schemes, and implementations for: resourcing and capacity building on the medium and long term, including business models, human management, and knowledge retention; medium and long term stewardship, contextualization, usability, and accessibility of research objects, services & tools, such as through transition and scalability plans with consideration for ICT infrastructure, human resources, and operations; and building community trust and maintaining it in the long term. This last category emphasises sustainability in other elements of the commons, and is evident in the model through:

- Governance & Leadership, where considerations are spread across five categories: commons intent and definition; commons strategic planning, which includes the development of roadmaps, risk and financial frameworks, and community relations; organizational structures, designs, ways of working, and capability maturity level for the aims and context of the commons, which includes iterative review and improvement considerations; internal commons policy development, implementation, and review, including internal documentation management and preservation; and governance rules, principles, and enforcement of quality for research objects and services & tools, including adherence to principles such as FAIR (Wilkinson et al. 2016), CARE (Carroll et al. 2020) and TRUST (Lin et al. 2020). TRUST in particular emphasizes sustainability, with FAIR and CARE emphasizing aspects of preservation.
- Rules of Participation and Access, which is characterized by the definition of the commons community, with two main categories of: a set of policies defining a minimal set of rights and obligations for the commons community; and a set of policies defining minimal accountability for the commons community.
- Engagement, which is characterized by structured, coordinated, and implemented communication and engagement plans and mechanisms, media, or channels as well as documented and public processes of the commons maintain a high level of transparency with stakeholders and the community applied to four categories: community input and feedback; active promotion to intended audiences to participate in the commons; incentivisation to intended audiences to participate in or with the commons, such as through consultations, events, and funding competitions; and engagement with other research commons, research infrastructure hosts, research institutions, and research funders such as through active research projects.
- Human Capacity, where considerations are spread across six categories: internal capacity, including accounting for turnover, backfill, and maintaining a high level of transparency for internal operations through documentation; skills for planning, managing and assessing service delivery, namely to ensure commons future-proofing and relevance as technology and research needs change; skill requirements for the commons community, namely through documentation such as user guides and wikis; ease of use for the commons community; and training and education hosted, provided, and/or contributed to by the commons for individuals and groups in the commons community, which may focus on curation procedures and practises.
- Interoperability, where the main categories of technical, organizational, and legal interoperability require ongoing sustainability of the commons.
- Standards & Conventions, characterized by sustainability of these practises and applications including community-supported standards and conventions for: research objects content, format, and access method; metadata content, format, and access method; semantic object content, format, access methods, and mappings; applications, software, and services & tools such as reproducible builds; quality, such as for appraisal decisions and quality assessments; adding and maintaining persistent identifies (PIDs);

authentication and authorization protocols; catalogues of digital objects; regulatory and ethical compliance; and for supporting and describing mechanisms, infrastructure and plans for specific workflows, use cases, and types of interexchange within the commons.

- ICT Infrastructure, which is characterized by web interfaces, scaling, and regular reviews and updates, including consideration for environmental sustainability as well as maintenance, upgrades, and replacements for hardware and software addressing: network; compute; storage; foundational operating system(s); and authorization and authentication infrastructure.
- Services & Tools, characterized by their sustainability such as via review, maintenance, and FAIR assessments. Services & Tools includes: research object repositories; discovery services; services and tools for direct research tasks, such as consultations and platform as a service for analysis, research data management, and acquisition; workflow and middleware services and tools; PIDs; vocabularies and semantic objects; data management; catalogues of services and tools such as a registry of repositories; authentication and authorization; and helpdesk.
- Research objects, characterized by the accessibility and (re)usability of: publications and research documentation; research data; research software; semantic objects; and collections. The accessibility and (re)usability of research objects is directly tied to curation, preservation, and of indirectly to the sustainability of the hosting commons.
- KPIs & Metrics, specifically metrics for budget change and operations cost-efficiency within the theme of commons governance and policy. Additional themes of KPIs & metrics include engagement with stakeholders; feedback and satisfaction of stakeholders; infrastructure and technology; and stakeholder engagement with commons infrastructure and technology.

GORC typology supports three classes of use case

So, how can the GORC Typology and International Model assist with designing sustainable open research commons that support ongoing curation of FAIR research objects for interoperability and re-use? Here are three different kinds of use cases, with illustrative examples. The examples are chosen from those known to the authors, and should not be assumed to be a complete list.

Creation of new commons: REASON & BioFAIR

The ResEArch CommonS fOr Norway (REASON) is a funding proposal submitted to the Research Council of Norway in November 2023 (Conzett & Macneil 2023). REASON is a proposed generalist research infrastructure for Norway, that complements and supplements existing domain-specific / specialized infrastructures. It involves five Norwegian and nine international partner organisations across Europe, US and Canada. This proposal was explicitly structured around the 10 essential elements of the IM (Conzett & Macneil 2024), which provides for the first time a globally accepted template for research commons. Aligning with GORC demonstrates alignment with a larger international agenda. The GORC IM was stated by the proposers to be an essential reference model to use in structuring the proposal. REASON proposes to make comprehensive use of the GORC elements and to build out a range of services and tools within these elements. The proposers also see an essential role for REASON in a future national EOSC node in Norway.

BioFAIR is a UK Research and Innovation (UKRI) funded data commons for biological and biomedical sciences based in the United Kingdom (UKRI 2024). Originally proposed by ELIXIR-UK in 2020, BioFAIR aims to enable access to life science data across research institutions and existing data infrastructures by providing end-to-end FAIR research data management and analysis capabilities (BioFAIR 2023). At the 20th Research Data Alliance

plenary in Gothenburg, Sweden, there was a call for publication of intermediate GORC outputs so that the typology of essential elements and the international model drafts could be used ahead of their official endorsement to strengthen the BioFAIR funding and business proposals specifically. With funding secured, BioFAIR is aiming to structure their development around the GORC international model and would provide the first test case for ground-up development using the model.

Characterisation of existing infrastructure: SURF

SURF is a cooperative for research institutions in the Netherlands and the major provider of research data infrastructure (SURF n.d.). Since 2023 they have used GORC to promote a commons approach to enhance coordination of existing infrastructures, provide a point of connection to European and international initiatives, and shape alternatives to commercial providers. SURF was considering how best to connect national initiatives to EOSC and saw the IM as a way of taking an inventory of current activities using a common language. They derived topics and questions from the model to be used in semi-structured dialogs. They found the IM was helpful as a way to identify common activities and challenges among different national initiatives and nodes. The model helped to unveil attributes that had not yet been considered. They also found that the model exposed ways in which all elements of the activities were related.

Analysis of interoperability: EOSC

The ambition of the European Open Science Cloud (EOSC) is to create a federated and open multi-disciplinary environment where researchers, industry and members of the public can publish, find and reuse data, tools and services for research, innovation and educational purposes. In pursuit of this, the European Commission has been considering how to construct an interoperability framework (European Commission 2021) and how to construct an EOSC EU Node[4]. The EOSC interoperability framework and related publications were key resources for the development of the IM. Recently, EC staff in the Open Science unit have been using the GORC elements as a way of breaking down the larger interoperability challenges into discrete aspects. The beginnings of this two-way relationship between GORC and EOSC was furthered in the FAIR-IMPACT workshop at the 23rd Research Data Alliance Plenary in San José, Costa Rica focusing on interoperability challenges and solutions in a global context (RDA 2024).

In related activity, a recent EGI discussion paper (EGI 2024) uses the GORC elements to consider both the EOSC contribution to an Open Research Commons, as well as how to characterise the contribution of the EGI as an EOSC Node.

In the same spirit, the German National Research Data Infrastructure (NFDI[5]), refers to GORC as an important element in their strategy towards interoperability and connection to EOSC (Bernard et al. 2024): "The Global Open Research Commons (GORC) is emerging as a model that other international infrastructures are using to shape their activities at policy, technical, interoperability and monitoring level." (p. 24) and "The GORC can provide a framework to ensure interoperability of Base4NFDI with international infrastructures." (ibid).

Future work

In the dynamic world of digital research infrastructure, there cannot be a static or definite model of all possible considerations for research commons. Further landscape and literature analyses are needed as well as supporting outputs to assist in the use of the model and how it may be used in conjunction with other existing models and frameworks.

[4] https://open-science-cloud.ec.europa.eu/
[5] https://www.nfdi.de/association/?lang=en

One strand of work relates to the typology and model itself. The GORC-WG will restart in 2025 within RDA to begin tackling new avenues of work and support existing and new adopters of the model. Clear initial needs are revisions to the IM such as consistent wording and descriptions, adoption support, mapping with relevant frameworks, and moving the IM into a more visual, interactive container. Developing the analysis from the GORC-WG that was not included in the model is another priority, including work on identifying types of commons, how the speaker series participants were represented in the IM, and thematic subsections of the model. Thematic subsections of the IM, or "slices", would provide only the relevant items across the model for that particular theme, such as research data management and curation, which have already been determined to have relevant representations across essential elements. This will also lead into creating discipline and commons-type specific profiles of the model, which in turn will lead into creating implementation maps (i.e. how did research commons implement items in the IM). These goals are addressed in the developing charter for the GORC International Implementations WG (GORC II WG), which will address:

1. identifying and defining implementations of the GORC IM that may then be referenced as examples for commons development (D1), specifically profiles;
2. Improving usability by creating an interactive container for the GORC IM that includes documentation, thematic subsets of the model (slices), and mappings with existing frameworks, models, vocabulary, and principles (D2); and
3. Ensuring updated relevance to current literature and community considerations on commons and research infrastructure by continuing our literature analysis and subsequent updates to the IM (D3)

Setting a maturity level on the adoption of considerations or implementations within the model is also of interest, but is currently a future priority.

Another relates to extending the model. As we develop these various supporting outputs, we will consistently reevaluate the model and will aim to release future versions, in particular a version 2.0 including research hardware (Miljković et al. 2024) and physical instruments. As we develop profiles and new versions of the model, special attention will also be paid to addressing emerging topics in digital research infrastructure, including the use and misuse of artificial intelligence, data security, big data, and equity, diversity, inclusion, and accessibility (Pérez-Jvostov, Sahrakorpi & Zhang 2023).

The third strand of work relates to using the model to work towards the ultimate goal of truly global open research commons. Here, the discussions within the EOSC will be a very useful testbed. One idea being explored is what would it mean to define adapters between the same element in two different existing commons. As the essential elements are drawn from both social and technical domains, the adapters will need to be varied in scope and approach. Identifying or creating adapters between the technical elements, will be a non-trivial exercise, but one where existing solutions could be re-used or re-configured. For the social domains we anticipate the need for what might call "conceptual adapters', with different compliance levels for each element. The RDA-CODATA Legal Interoperability of Research Data: Principles and Implementation Guidelines (RDA-CODATA Legal Interoperability Interest Group 2016) are an example (although at the level of data objects, rather than entire commons) that could be used as a starting point. These are still very nascent ideas and will receive both further exploration and testing against real world examples in planned future work.

Conclusion

The GORC IM provides a list of commons components (entities) and characteristics to be considered when undertaking the development or assessment of a commons of any kind, at any stage. The model does not mandate what should be implemented, or in what way; the decisions on what is relevant, and where resources should be invested will vary depending on the

environment and priorities of the implementer. Our hope is that the model will provide actionable information for organisations as they make their decisions about what and how to focus and develop their infrastructure.

While the work supports the development of individual commons, it also supports the work necessary to make the commons interoperable. The GORC-WG outputs provide an agreed language and model to describe commons components and a firm foundation for the GORC-IG as it seeks to create a roadmap for commons integration. Increasing interoperability between commons will increase their individual as well as collective value. But this move towards increased value from connecting multiple commons also emphasises the need for ongoing curation at the level of each commons and an intentional focus on sustainability.

In order to address current and future challenges, especially at the accelerated pace necessitated by the multiple global crises facing humanity, our researchers will need to have access to sustainable aggregations of data. These will need to be curated for reuse and interoperability over the long-term to support the integrity of the scholarly record. This work envisions an interoperable set of platforms that build on both the advances of the internet and the consensus and strengths of the research community. It learns from the past, is grounded in the present, and looks to the future.

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