The Global Open Research commons International Model, version 1.1

Model Overview

Context

In response to the global movement to implement national and cross-national or global commons, a Research Data Alliance (RDA) Interest Group was formed to work towards a community-developed typology for describing research commons. This Interest Group created a Working Group to develop an International Model describing the attributes of Global Open Research commons. This document supports the release of this RDA Global Open Research commons (GORC) International Model (IM) v. 1.1, presented as a spreadsheet[1]. An accompanying narrative report[2] provides background information about the initiative, describes its intent and intended audience, the method used to create it, its structure and content. It also provides brief descriptions of communities and activities that have proposed to, or are currently, utilising the model in different contexts, as well as next steps for work in this area. This document is a relatively short narrative summary of the public release of the model version 1.1, which is presented in detail in the GORC IM spreadsheet and more fully discussed in the report.

It is important to recognise that the model is aspirational in nature and not prescriptive, drawing on existing good practice and promoting inclusive approaches. The GORC IM Working Group (WG) consolidated a large range of resources and expert feedback to generate the model, which consists of a number of elements, with associated categories, subcategories, attributes and features, to be considered when undertaking the development of a commons of any kind, at any stage. Although the categories, subcategories, attributes and features are marked as core, desirable or optional, 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. The model is already being used in several contexts that are adapting and testing the model in real world situations. In some cases, the work is being used in the development of commons, while in other cases it is being utilised in other research infrastructure projects. Further details about how the model was derived are available in the report[2].

The purpose of the GORC-WG International Model (IM) is to provide a framework and common language to stakeholders around the world who are committed to developing interoperable research services for the public good. The target audience for the model is anyone that is involved in the planning, development, operation, funding or use of a research commons. It is not intended as a prescriptive model, but rather to define and establish a common basis of attributes and features of

[1] GORC IM WG Commons Model V1.1, https://docs.google.com/spreadsheets/d/1tyFpCEbLvHRE2BKy0EDyPc1Gz5w6jm9Q5RVYx2XETkM/edit?usp=sharing

[2] GORC IM WG Commons Model V1 report, https://doi.org/10.15497/RDA00097

research commons that users of the model can consider in the context of their own commons as it evolves.

Model Structure

The model is based on the GORC-IG typology[3] outlining the **essential elements** of a commons, as shown in figure 1. Essential elements are high-level concepts that are essential to the composition of an Open Research commons.

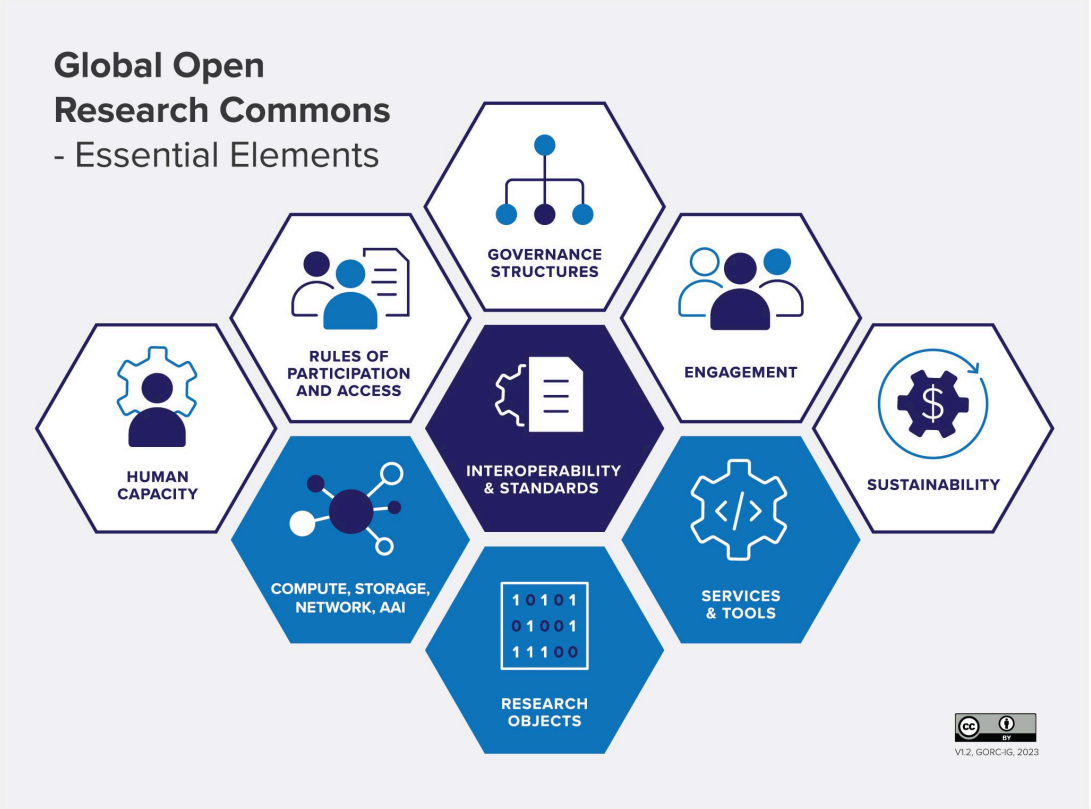

Figure 1: Essential elements of a research commons.

The three elements in blue are the underpinning elements that constitute the parts of the commons with which people interact. The five elements in white are the social/human elements that are needed to make the commons succeed. The central element in dark blue represents the central importance of standards at the core of a commons. The above diagram was used as an organising principle for the model creation. Each essential element in the diagram above is represented as a tab in the model spreadsheet[4], with the exception of *Interoperability and Standards*, which has been split into two separate tabs. While these are central to the diagram, it was conceptually easier to discuss them separately.

[3] Jones, S., Leggott, M., Lopez Albacete, J., Pascu, C., Payne, K., Schouppe, M., Treloar, A., & Global Open Research Commons IG. (2023). GORC IG: Typology and Definitions (1.01). https://doi.org/10.15497/RDA00087

[4] GORC IM WG Commons Model V1.1, https://docs.google.com/spreadsheets/d/1tyFpCEbLvHRE2BKy0EDyPc1Gz5w6jm9Q5RVYx2XETkM/edit?usp=sharing

The categories and attributes in the model are grouped by essential elements, as defined by the GORC Typology: Governance & Management Structures, Rules of Participation & Access, Engagement, Human Capacity, Sustainability, Interoperability, Standards & Conventions, Services & Tools, and Research Objects. The model also includes an alphabetical glossary of terms. Every attempt was made to make the definitions more inclusive rather than exclusive.

Each row in the model spreadsheet represents a single category, subcategory, attribute or feature that has been identified as something that is worthy of consideration in the planning, development, management, or operation of an Open Research commons. The model breaks down each essential element into a set of **categories** that provide scope for the broad concepts that each element represents. For example, the Interoperability essential element is broken down into the three categories: *Technical Interoperability, Organisational Interoperability, and Legal Interoperability.* Categories are in turn sometimes broken down into **subcategories** that provide a more granular scoping and definition for the concept being described. For example, *Technical Interoperability* has subcategories of *Syntactic Interoperability, Semantic Interoperability,* and *Other Technical Interoperability.* Not all categories have subcategories, in keeping with the complexity of the concept being considered.

Each category or subcategory has associated with it one or more **attributes.** An attribute is a standard, characteristic, functionality or point of reference about an essential element, category or subcategory from which information can be documented, or measurements or comparisons may be made. For example, *Syntactic Interoperability* has attributes that relate to a research commons *planning for interoperability* as well as attributes that consider a research commons implementation of syntactic interoperability in the form of *file and data formats for syntactic interoperability* and *APIs that support syntactic interoperability.* For concepts that are sufficiently complex, attributes can be further subdivided into sets of **features.** Attributes and features can be defined for essential elements, categories, and/or subcategories, and are inherited from parent to child in all cases.

For each row in the model spreadsheet, we have also provided an **extended description**, **examples**, **consideration level (i.e., core, desirable, optional)**, and the **primary sources** that were used to define the category, subcategory, attribute or feature. The model is not intended to be prescriptive or indicate how any one commons should be structured or operate, and so the consideration level is intended as a guideline for prioritising the implementation or refinement of commons' attributes. Items with the *Core* consideration level do not have to be implemented but should be considered by all commons. *Desirable* items may be less critical for all commons to consider and may be more suited to established commons, and *Optional* items may be suited to commons of specific type.

The model is accompanied by a set of related **key performance indicators** (KPIs) and **metrics** that can be used as a starting point for commons to measure uptake, engagement, or use of the essential elements, attributes, and features of a commons and progress in the development of the commons. KPIs can be used to measure performance against indicators of importance to the commons, while metrics can measure a wider range of indicators. Similarly to the model itself, this set of KPIs and metrics are intended as a guide for what a commons could consider using as a starting point for their own set of success indicators and metrics.

Model elements

As noted above, each essential element in the diagram is represented as a tab in the model spreadsheet[5], with the exception of *Interoperability and Standards*, which has been split into two separate tabs. The rest of this document provides an overview for the content of each tab.

Governance & Leadership

Governance is focused on defining the commons purpose and the development of the strategies, objectives, values, and policies that frame how that purpose will be pursued by management and internal personnel of the commons. It includes the development of such things as strategic plans including mission statements, values, organisational performance metrics, risk management frameworks; policies and guidelines for financial and operational matters such as commitments to community endorsed principles and frameworks like FAIR and data ethics ; and the creation and maintenance of governance structures, their interactions with stakeholders, and the ways of working with management. Unless they are part of very small teams, there is a boundary between governance and management. Governance is responsible for strategy and direction, while management is the coordination of day to day activities and implementation of policies set by the governing body. 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. It is likely that the model will be adapted differently for different types of commons, in particular large monolithic commons will have different governance structures than more distributed or federated commons. The model developers also note that the lack of a culture and structure for effective lobbying that drives appropriate regulatory change is challenging.

The FAIR, CARE, and TRUST principles are community-developed, widely implemented principles for data reuse resources. As such they should play a central role in multiple areas of a commons, including governance and have implications for all aspects of the commons.

Rules of Participation & Access

Rules of participation and access refer to the policies that define the rights, obligations, and accountability for commons' stakeholders. The rules of participation and access define how different stakeholder groups interact with the commons and each other. These rules are designed to ensure that the principles of open research, collaboration, and transparency and other commons-defined values are upheld while promoting responsible and ethical interactions with commons' resources and community members. All commons users and resources are governed by rules of participation and access but the rules and their application may vary by commons and by resource within each commons. In keeping with Elinor Ostrom's framework for the sustainable management of collective resources[6], rules of participation and access should be informed by local values, knowledge, and

[5] GORC IM WG Commons Model V1.1, https://docs.google.com/spreadsheets/d/1tyFpCEbLvHRE2BKy0EDyPc1Gz5w6jm9Q5RVYx2XETkM/edit?usp=sharing

[6] https://www.onthecommons.org/magazine/elinor-ostroms-8-principles-managing-commmons/

practices. The rules of participation and access will include policies for access, allocation of resources, privacy, preservation of resources, attribution, and acceptable use. The commons community should develop consequences for research objects not meeting quality standards and for the misuse of commons research objects, services, tools, or infrastructure. This enforcement may be conducted internally, by the commons' community and externally, as needed. The commons should include deterrents or sanctions to promote accountability and prevent the misuse of commons' resources.

Sustainability

Sustainability includes models and agreements made on how to ensure the viability and operations of the commons. It includes funding and resourcing activities that ensure the commons can be sustained over the long-term. This may include mixed streams of investment and cost recovery through subscriptions, service payment models to ensure operation of the commons, and in-kind contributions in the form of effort/time by contributors to both maintainers of commons infrastructure and interactions with stakeholders. Sustainability should also include defining and developing a strategy for long-term sustainability for all operations and holdings, as well as keeping issues of sustainability in mind when choosing or building commons components. For instance, reuse of existing components is an effective strategy for more sustainable commons infrastructures. Research infrastructure managers and developers have often remarked that brittle policies make it difficult to create a sustainable set of services. In particular, Time-limited funds are used only for time-limited activities, and organisations which define sustainability based on recovering costs can become stagnant.[7] While understandable, in the context of a national commons, funding can be difficult if services are only available to national stakeholders, thus preventing global research. Similarly, new mechanisms should be developed that support multinational funding streams that support international, interoperable services.

Sustainability is approached in the model from three aspects, with each requiring suitable plans, schemes, and implementations to demonstrate sustainability. Sustainability of resourcing and capacity building in the medium and long term includes development of business models, the management of human resources (including retaining accumulated knowledge), and management of any other types of resources required by the commons. Sustainability for Research Objects, Services and Tools includes their stewardship, contextualisation (i.e. metadata, documentation), usability and accessibility over the medium and long term. This requires considerations for ICT infrastructure, human resources and commons operations, as well as the use of transition plans and scalability plans. The third aspect of sustainability is for building and maintaining community trust, which sits more clearly in the domain of the social elements required to sustain the commons, including the social agency to operate and the overall mindset of the commons.

Developers of the model have also noted that infrastructure providers - particularly those in an early phase of development - need to plan for the enterprise to scale and for contingency plans in the event of failure. This will affect their cost and funding structures as well as their use of and ability to migrate between commercial and open services and software. The WG is aware that smaller and

[7] https://openscholarlyinfrastructure.org/?ref=investinopen.org

newer projects often look towards commercial cloud offerings to help with these issues, but this also has risks of vendor lock-in; extraction may be difficult as the project continues.[8]

Engagement

Engagement is one of the social/human elements that is needed to make the commons succeed, and it refers to the interaction between the commons and the commons' broadly defined community of stakeholders. Engagement activity should be seen as an iterative cycle, which includes requirements gathering exercises, consultations, usability testing, communications, events and training amongst others. A core attribute of this element is an efficient and effective engagement plan to structure, coordinate and share the relevant level of information (what), to the right target audience (to whom), addressing specific requirements (why), at the right time and with the appropriate frequency (when), and via the most suitable mechanisms (how). An engagement plan is key to ensure the development, maintenance and evolution process is transparent to users and contributors, and that they are aware and involved in the activities, as needed. Also depending on the individual circumstances, the engagement plan should include culturally appropriate materials as well as translations in more than one language. Building community trust, and creating connections to the communities that are being served, is imperative. If that trust is lost, then the mandate for the commons organisation is also lost.

In the model the engagement element is defined by four categories, based on the intended scope/outcome of the engagement process. Community input and feedback, the first category, requires use of methodologies that attract contributors, providing them with credit and incentives, as well as explanation for why a suggestion or requirement was accepted and implemented, or parked, modified, or rejected. Active promotion of and participation in the commons, the second category, requires addressing a multi-level diverse audience, using the means familiar to them: from presentations and training sessions, to ambassadorship programmes, and citizen science events. Incentivize the participation in and use of the commons, the third category, recommends targeting the intended audience offering consultations and events tailored to provide solutions for their needs, e.g. fund meta-research projects set to contribute to the scholarly ecosystem, technical hackathons to enable co-development. Interoperability with other commons, research institutions, and other potential partners is the fourth category that recommends considering a strategic collaboration and alignments with neighbouring and related efforts, to amplify the impact, or share experience and expertise.

Human Capacity

The ability of the commons to create a human-friendly environment for all stakeholders and community members in all aspects, specifically for users, providers, and intermediaries, so that the commons can set and achieve objectives, perform functions, solve problems, and continue to develop the means and conditions required to enable this process (adapted from https://www.fao.org/3/y5613e/y5613e08.htm).

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8 https://a16z.com/2021/05/27/cost-of-cloud-paradox-market-cap-cloud-lifecycle-scale-growth-repatriation-optimization/

The human capacity of a commons should be viewed in the context of a community which includes all human individuals and entities that could be considered stakeholders, users, providers, members of the commons, and intermediaries (i.e., those who do not interact directly with the commons, but use information about or provided by the commons, e.g., policy makers, journals, funders) in the past, present, and future as well as all research communities that the research commons is a part of in a regional, national, and global context. Depending on the structure of the commons, stakeholders may include funding and government bodies as well as related commercial entities; these may be in scope through the provision of related services or an association with related research communities.

The model divides human capacity into five main categories:

Internal Capacity includes human resources required to provide services and to plan for growth required by future services, succession and labour turnover planning, and mechanisms for enacting EDII[9] commitments to personnel and the commons. As part of the support for internal capacity, personnel processes need to be documented and shared for a high level of transparency, with regular reviews of working conditions and requirements in place.

The model articulates as an additional category the skills required for planning, managing and assessing service delivery. This includes the development of use cases for services and platforms, the prioritisation of identified needs and derived requirements of users, assessing plans and deployments, and the implementation of continuous improvement mechanisms.

Skill requirements for the commons community focuses on the capacity of individuals interacting with the commons, which includes documentation to facilitate that use and lower the skill requirement to ensure that the commons is an effective choice for its users.

Ease of use for the commons community focuses on the capacity enabled by the commons, including considerations for effective user-centred design employed to make the commons easier to use.

Training and education, the fifth category, requires design (structure, content, target audiences and levels), development, and delivery of the material, including mechanism (e.g., modules, summer schools) and means (e.g., online, in person), as well as an evaluation and assessment phase also to measure impact. A specific subcategory of training that commons may consider is an ongoing training program for internal personnel, with the goal of increasing internal capacity.

Finally, the model developers note that increasing internal and external documentation in all of these areas is a mechanism for increasing the sustainability of a commons.

ICT Infrastructure

By “ICT infrastructure” we mean the hardware and base software components that a computer system requires to function and are necessary to conduct research. These need to be designed to scale with increasing volume, complexity and velocity of projects and expectations. To aid this, a review and update of ICT infrastructure should be scheduled to happen on a regular basis. For all of

[9] EDII stands for Equity, Diversity, Inclusion, and Indigenization. Similar representations may be EDIA (Equity, Diversity, Inclusion, and Accessibility) and DEI.

the infrastructure categories listed below, a knowledge of, and ability to manage, the infrastructure is required by commons operators.

A number of infrastructure categories were identified through the review. Network infrastructure encompasses both the internal network infrastructure (for passing messages within the commons) and external network infrastructure (to facilitate connections to external services and other commons). Compute infrastructure encompasses both the base computing infrastructure (the essential hardware components required for stable and robust minimum viable operation of the commons) and add-on computing infrastructure (components that enable advanced or specialised operations, such as GPUs for ML computing). Compute may be delivered via on-premise hardware or off-premise cloud services. Storage infrastructure encompasses both direct-attached storage in the data centre and network-based storage in the cloud. Base software infrastructure includes the underlying OS elements upon which different applications depend. Authentication and authorization infrastructure refers to services and procedures that enable members of different institutions to access protected information that is distributed on different servers. This includes both base AAI infrastructure and add-on infrastructure.

Interoperability

Interoperability is the ability of data or tools from non-cooperating resources to integrate or work together with minimal effort[10] and is arguably the most difficult part of implementing the FAIR principles. It can also enable a wider range of cross-commons use-cases. Interoperability enables cross-commons reuse of data and is of central importance to the commons. Types of interoperability include: Technical interoperability (how artefacts are exchanged), Syntactic interoperability (how to structure information), Semantic interoperability (data are interpreted the same way) and Pragmatic interoperability (agreements between organisations)[11].

Interoperability in many ways is at the heart of the work of the GORC IG and the WG. The IG is working to coordinate infrastructures “as they work to build interoperable resources necessary to enable researchers to address societal grand challenges”. The model divides the issues into technical, organisational and legal interoperability.

Technical interoperability in turn has two main foci: syntactic interoperability and semantic interoperability. Syntactic interoperability means that plans and mechanisms exist to create and maintain Interoperability and compatibility at the syntactic level over time, the commons uses file/data formats that support Syntactic Interoperability, and provides APIs that support Syntactic Interoperability. Semantic interoperability means that plans and mechanisms exist to create and maintain Interoperability and compatibility at the semantic level over time, and that metadata, data, and other Research Objects use standardised community-endorsed vocabularies, and FAIR-compliant community-endorsed vocabularies where possible. In addition to these two main dimensions, commons may offer other Other Technical Interoperability plans, infrastructure, and mechanisms,

[10] Wilkinson, M., Dumontier, M., Aalbersberg, I. et al. The FAIR Guiding Principles for scientific data management and stewardship. Sci Data 3, 160018 (2016). https://doi.org/10.1038/sdata.2016.18

[11] Janssen, M., Estevez, E., & Janowski, T. Interoperability in Big, Open, and Linked Data--Organizational Maturity, Capabilities, and Data Portfolios. Computer 47,10, pp. 44-49 (2014).https://doi.org/10.1109/MC.2014.290

such as following API search standards, and having a security framework that is shared between Services and Tools, from backend to frontend.

Because commons infrastructure is operated and managed by organisations, it is important to also consider organisational interoperability. This includes ensuring that plans and mechanisms exist to create and maintain organisational Interoperability and compatibility over time. For non-domain specific commons, it also requires ensuring that domain-specific needs are addressed and considered so that the commons remains interoperable with other domain-specific commons and services over time.

The whole point of a commons is to provide access to research objects for use/re-use. This requires attention to a cluster of legal interoperability issues. Access to and reuse of Research Objects should be open and unrestricted as a default rule, or otherwise granted with the fewest limitations possible; ideally a licence for reuse is required for all Research Objects and Tools in the commons. Licences used should be enumerated and harmonised to allow seamless exchange between actors within the commons and outside of the commons. The entities with rights to Research Objects should be specified appropriately via licences and Research Object documentation and identified before dissemination, to ensure no surprises. As an increasing amount of access to commons will be via software, it is important that legal aspects are encoded in a Machine Actionable format that enables automated provision of Services and data.

Standards & Conventions

A standard is a repeatable, harmonised, agreed and documented way of doing something[12].
Standards can be either *de jure* or *de facto*. *De jure* standards, or standards according to law, are endorsed by a formal standards organisation, such as the ISO. The organisation ratifies each standard through its official procedures and gives the standard its stamp of approval.

De facto standards, or conventions, are adopted widely by a community. These standards arise when they become part of the accepted way of doing things within a community. *De facto* standards can become *de jure* standards if they are submitted to a formal standards organisation and approved.

Within the commons context, standards and conventions may cover various things:

- Community supported Research Object standards and conventions
- Community supported Semantic Object standards and conventions
- Applications, Software, Services & Tools standards and convention
- Quality standards, conventions, and/or guidelines
- Standards and conventions for adding and maintaining PIDs for managed assets
- Authentication and Authorization protocols
- Standards and conventions for the commons catalogue of digital objects
- Standards and conventions supporting and describing mechanisms, infrastructure and plans for specific workflows, use cases, and types of interexchange within the commons
- Standards and conventions for regulatory and ethical compliance.

[12] https://inspire.irena.org/Pages/standards/whatarestandards.aspx

Services & Tools

Service (as defined by IVOA[13]) 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, and mostly invoked by software. 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 as tools. Services and tools overlap with users who create processes.

The following categories of services and tools were identified:

1. Research object repositories
2. Discovery service
3. Services and tools for direct research tasks
4. Services and tools that enable workflows and middleware
5. Persistent identifier services
6. Vocabulary and semantic object services
7. Data management services and tools
8. Commons catalogue of all services and tools
9. Security and identification services
10. Helpdesk service

These categories include tools and services used by researchers in their primary research, e.g services and tools for direct research tasks; tools and services used to support or connect tools and services, e.g. tools and services that enable workflows and middleware; tools and services focussed on research data management, e.g. research object repositories and dedicated research data management services and tools; tools and services focussed on discovery; persistent identifier services; vocabulary and semantic object services; and miscellaneous other tools.

The context for these definitions is the emerging and complex intersection of tools, disciplines, services, platforms, hardware, resources, and the people (users, researchers, developers, stakeholders, personnel and communities, etc.) who use and contribute to them.

As research infrastructure, services and tools are often made available through research platforms (variously referred to as virtual science labs, virtual research environments (VREs), or Science Gateways,) that are deployed to support both the research workflows and the communities of practice engaged in collaborative research. Typically, a research platform's capabilities include data acquisition and management, processing and visualisation, storage and preservation, sharing and discovery; platforms may provide the full spectrum or a subset of components. Science Gateways may be discipline-specific, and may support and enhance scientific collaboration and scholarly communication by facilitating citizen science engagement as well.Processes, services, and tools all overlap with each other in ways that complicate the discussion. Some particular issues to be considered are these:

- Services can be both internal and external, where some of the layers are invisible to users but identifiable as services that sit between ICT and user-oriented services

[13] https://ivoa.net/documents/WD/ResMetadata/RSM-20021011.html

- Commons need to have a range of services that reflect and support the processes in the other essential elements
- Every commons shouldn't need to do everything; over time there should arise a range of global services offered to everyone that are needed by every commons. (e.g. citation information could come from Crossref or DataCite)
- Globally the community should be targeting the services and tools that make a commons attractive. It is also the case that different commons will have different histories, funding sources, and business drivers, and that this may lead to parallel service offerings. Looking at specific attributes and services and evaluating them individually might not aggregate up to the big picture.
- Given that the ever changing and fast developing landscape/ecosystem of services and tools used in research is extraordinarily rich, varied and dynamic, the categorisation described above is best understood as a snapshot which attempts to capture the current situation, and will evolve over time with significant changes. Moreover, full blown categorisation of tools and services was not the remit of the GORC WG.

Specific tools and services may overlap more than one subcategory and categories, especially if it is a larger system with multiple functionalities. Categories and their subcategories are not disjoint.

Research Objects

Research Objects are the outputs of the research process, but can also be inputs to later processes. Like ICT Infrastructure and Services & Tools, they are the underpinning digital elements that people interact with in the commons. The scope here is limited to digital research objects, and research hardware itself is out of scope; the model developers understand that this is a challenging perspective, since research cannot occur without specially designed hardware. However, it was necessary to contain the scope of the model and the project more broadly. The digital outputs *from* hardware are of course in scope (e.g. calibration data are research data, user manuals are publications/documentation, software endpoints are research software).

The research object approach is primarily motivated by a desire to improve reproducibility of scientific investigations. Central to the proposal is a need to share research artefacts commonly distributed across specialist repositories on the Web including publications, lab notebooks, blog entries, supporting data, software executables, source code, presentation slides, and presentation videos.

The model identifies five main categories of research objects:

- Publications and Research Documentation include any digital, textual, visual, audio, or tactile representations that describe or discuss any aspect of the research project and activities in human or machine readable formats.
- Research Data are a collection of data that is identifiable and has the potential to be curated or published by a single actor and is the result or focus of research activities. Research data can digitally represent a group of observations, a data product from a specific version of a processing algorithm based on observations, output of numerical model(s), or outcomes of laboratory experiments.

- Research Software includes any software component created during the research process or for a research purpose that is implementable or executable by a computer or machine (actionable research documentation that describes protocols, workflows, algorithms etc. is included in the above category of Research Documentation)
- Semantic Objects are a named grouping of descriptive elements that sufficiently describe a distinct identity. Semantic Objects may be in the form of documentation, Research Software, or research data. They may also be referred to as Semantic Artefacts, defined as groups of entities with unique identifiers where entities include subjects, predicates, and objects that can be linked together to form a network that describes a dataset. In this model, Semantic Objects/Artefacts are not considered as collections, since collections are comprised of research objects and not entities.
- Collections are a combination or bundle of research objects that are of the same kind or different kinds that share a relationship and are treated as a digital object which likely bears a PID. Collections consist of a finite number of digital object identifiers and metadata associated with each referenced identifier.

KPIs & Metrics

KPIs are qualitative or quantitative measures that the commons, commons' stakeholders, and community of commons can use to measure the uptake, engagement, or use of commons attributes and features. In contrast, metrics are quantitative measures used to assess the evolution or performance of specific processes, and likely feed into or contribute to the monitoring of KPIs. While the model includes suggested KPIs and metrics for every essential element, most KPIs and metrics relate to engagement with the commons and to human capacity. Broad themes of KPIs and metrics are apparent and provide some organisation for the KPIs and metrics, namely: commons governance and policy, commons engagement with stakeholders, feedback and satisfaction of stakeholders, commons infrastructure and technology, and Stakeholder Engagement with technology and infrastructure. KPIs and metrics use data generated from the commons (e.g., number of registered users), data generated outside of the commons (e.g., number of publications produced using commons-derived datasets), and data generated by other commons (e.g., the number of commons that implement a given standard to facilitate interoperability across related data in separate commons). Most KPIs and metrics are quantitative measures that could be externally verified. In a few cases, the model suggests qualitative measures, as in adherence to commons' policies. While some quantitative measures can be uniformly applied across commons (e.g., number of registered users), others, like measures of research impact, will vary in their application across commons. As evidenced in the speaker series, KPIs and metrics can be internal to the commons or openly available. It should be noted that the KPIs and metrics are not nearly as comprehensive as the IM itself and should be considered as observations of success and engagement metrics that we observed in the existing commons. These metrics could be developed further as part of future work, and currently provide a starting point for commons to consider what their own set of KPIs and metrics may be.