CatRIS

Catalogue of Research Infrastructures Services

Horizon 2020 CSA

WP3 User needs and requirement elicitation

Deliverable 3.1 “Working note on typology of research infrastructure services”

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Definitions

Short name	Definition
Core Facility (CF)	Core Facilities are shared and typically physical resource infrastructures for scientific research of a smaller scale than Research Infrastructures.
Research Infrastructure (RI)	'Research Infrastructures are facilities that provide resources and services for research communities to conduct research and foster innovation. They can be used beyond research e.g. for education or public services and they may be single-sited, distributed, or virtual' (https://ec.europa.eu/info/research-and-innovation/strategy/european-research-infrastructures_en).

Acronyms

Abbreviation	Meaning
CF	Core Facility
DOI	Digital object identifier
EOSC	European Open Science Cloud
ESFRI	European Strategy Forum on Research Infrastructures
RI	Research Infrastructure
SDT	Service description template

Summary

This Working Note focuses on the definition of Research Infrastructures' (RIs) service and on an RI services typology applicable across scientific disciplines and geographic levels, placing these in the context of the CatRIS catalogue. In order to fulfil the task, the project team has: a) carried out a review of existing service descriptions and service catalogues, including the existence of service level agreements; b) drafted a preliminary typology of services as the framework for the consultation on user needs; c) conducted a Survey on requirement elicitation for the CatRIS catalogue; d) conducted 29 interviews with members of CF and RI community; e) organised a Validation Workshop with RI managers, selected users and funders (policy-makers) to discuss and refine the typology. The result of this elicitation process was a modification of an initial typology and suggestions for the final one, with a view to aligning the typology, to the extent possible, with the EOSC (https://catalogue.eosc-portal.eu) catalogue.

The definition of RI service that emerged from the survey and the interviews is centred around its immaterial qualities, to make it distinguishable from physical resources (facilities, instruments, equipment). As a pre-defined unit of work, it requires a range of specifications (attributes) that correctly describe it and let the users pick the right service. These would typically include cost, time of usage, technical information and other variables. A service incorporates technological knowledge and scientific expertise, using other resources in the process in order to deliver benefits to a user. The definition of RI service in the catalogue should combine a choice of attributes to inform user of the services they are getting.

The final typology proposed for the CatRIS classification of services is as follows, with the second level of services' classification in brackets: 1) Access service (access to data, access to software, access to central infrastructure for IT resources and digital services, access to aggregators, access to facilities, and access to equipment); 2) Analysis service (data analysis service and sample analysis service), 3) Expertise (consultancy) service, 4) Data management (maintenance service, and data storage service), 5) Material processing service (material maintenance and modification, material production service, and material storage service), 6) Support service (project development, development of models and tools, development of solutions, certification and benchmarking, and knowledge and technology transfer), 7) Training and education service, and 8) Logistics service (financial service, transport service, and other logistics services).

Introduction

Work-package 3 (WP3) of the CatRIS project reached out to users via a broad-based consultation and user needs' elicitation process. The aim was to gather a well-balanced set of opinions on the required content of the service catalogue and the design and functionalities of the future gateway. To support the process, this deliverable defines Research Infrastructure (RI) 'service' and scopes out a typology of services. The latter should be applicable across a range of RIs of different types, from various scientific fields or geographical regions (regional, national macro-/inter-regional, European, international). The definitions and the typology are equally applicable to physical RIs[1] and Core Facilities (CFs)[2]. Hence, no difference is made between the types of RIs when discussing the typology of RI/CF services.

Moreover, the aim was to align the typology, to the extent possible, with the EOSC (https://catalogue.eosc-portal.eu) catalogue. Consequently, the outcome presented here should be considered as an input for the further development of the EOSC classification of services. The final typology should be modular, with certain 'common services' being accompanied by other types of services, specific for certain types of RIs/CFs and scientific fields. This deliverable deals with the first two levels of the services' classification.

In order to carry out these tasks the project team has:

- Carried out a review of existing service descriptions and service catalogues, including the existence of service level agreements.
- Drafted a preliminary typology of services as the framework for the consultation on user needs.
- Conducted a Survey on requirement elicitation for the CatRIS catalogue;
- Based on a representative sample of RIs (drawing on MERIL, ESFRI cluster projects, thematic &/or inter- and macro-regional RI networks and other relevant databases of RIs) interviewed: 15 RI (service) managers; 4 representatives of cross-border, regional networks of RIs; 8 RI users and 2 policy makers/funders;
- Organised a Validation Workshop with RI managers, selected users and funders (policy-makers) to discuss and refine the typology.

This deliverable provides a summary of the results gathered by the aforementioned process. It concludes by suggesting a typology of services that shall be further tailored in the course of the project. The typology seeks be simple to understand and apply yet allow for modularity and

[1] 'Research Infrastructures are facilities that provide resources and services for research communities to conduct research and foster innovation. They can be used beyond research e.g. for education or public services and they may be single-sited, distributed, or virtual' (https://ec.europa.eu/info/research-and-innovation/strategy/european-research-infrastructures_en).

[2] Core Facilities are shared and typically physical resource infrastructures for scientific research of a smaller scale than Research Infrastructures.

growth. It is applicable to all areas of CFs and RIs thereby laying the foundations for the catalogue of RI services.

This Working Note is structured as follows: The first section addresses the question of what constitutes a RI service. It is followed by a section analysing the current practices of RIs service listings. The third section proposes a baseline typology of RI services that was further developed and checked through the survey, interviews and the Validation Workshop (documented in the fourth section). The concluding section outlines the suggested typology.

1 What is a Research Infrastructure service?

In line with the definition of Research Infrastructures (RIs), the core of their activity is to provide resources and services for researchers to conduct research. Indeed, RI managers consider it essential for the long-term sustainability of the RI to: '[e]nsure the reliability of the Research Infrastructure in terms of access (number of hours of operation offered to users) and services; provide services and assistance to scientific users, notably regarding technical support and data management' (OECD, 2017: 17). In this context, various definitions of RI services have been proposed (see Table 1).

Table 1: An overview of some definitions of services

Definition of service	Source
'Main types of services provided to users (e.g., access[3], analysis, data, testing, training, user support, archiving, etc.)'.	MERIL (https://portal.meril.eu/meril/downloads/MERIL_definitions.pdf)
'[A] means or a method that organisations use to deliver results that end-users/customers value and wish to achieve. These results are usually intangible although they may also include tangible elements. A service is the result of a process that includes at least one activity that is carried out at the interface between the supplier (provider) and the end-users/customers'.	eInfraCentral project (Sanchez et al., 2018: 12)
'A planned process carried out by a person or organization with the objective of performing a technique, providing training, providing storage of data or physical resources, or providing access to instruments for another person or organization.'	Eagle-I catalogue (search.eagle-i.net/model/#t=http://purl.obolibrary.org/obo/ERO_0000005&of=score=)

Source: authors.

Based on the aforementioned definitions, RI services may be defined, in the simplest terms, as the assistance provided to users that offers them certain benefits. Hence, services differ from the 'facilities', 'equipment' or 'instruments' that are used to provide those services as they are physical objects that serve certain purposes[4]. Defined like this, a service of e.g. provision of access to a 'facility', piece of 'equipment' or 'instruments' would include a permission from a RI for a third party to access aforementioned objects and use them for the purposes of experimentation, analysis or similar.

[3] In the European Charter for Access to Research Infrastructures access is defined as follows: 'the legitimate and authorised physical, remote and virtual admission to, interactions with and use of Research Infrastructures and to services offered by Research Infrastructures to Users. Such Access can be granted, amongst others, to machine time, computing resources, software, data, data-communication services, trust and authentication services, sample preparation, archives, collections, the set-up, execution and dismantling of experiments, education and training, expert support and analytical services' (European Commission, 2016: 9).

[4] In that sense, the MERIL project (cordis.europa.eu/project/rcn/96986/reporting/en) distinguishes 'resources, services and facilities'.

This general definition of a ‘service’ was tested with respondents of the survey, interviewees and in the Validation Workshop (see below) to allow them to suggest modifications to the proposed definition. The final definition developed in this Working Note will be used as a basis for the future catalogue of services.

2 Current practices of Research Infrastructures services' listings

This section reviews the most noteworthy examples of current practices of RIs' services catalogues in and outside Europe, covering both scientific field-specific examples and those covering a range of scientific fields. The review suggests that catalogues of services available on RIs' websites is not yet widespread. For example, the European Strategy Forum on Research Infrastructures (ESFRI, 2018) lists a total of 55 ESFRI Projects and Landmarks[5], some of which have not yet started their operations. Nevertheless, out of 54 that have a website, 25 (or 46.3%) have no mention of services. Very few of the ESFRI Projects and Landmarks have service level agreements regulating the use of their services (see Table 4 in Annex 1).

The most developed example of a European-wide catalogue of RI services is that for e-infrastructures[6] developed by the eInfraCentral project (www.einfracentral.eu). It classifies services with the help of a Service Description Template (SDT) providing detailed information for each service[7]. In June 2019, the eInfraCentral catalogue covered 21 providers (providing access to 325+ services and resources). The eInfraCentral catalogue (www.einfracentral.eu/browseCategories) – in consultation with the major e-Infrastructure providers – developed the following categorisation: 1) aggregator, 2) analytics, 3) application, 4) compute, 5) consulting, 6) data, 7) networking, 8) operations, 9) other, 10) security, 11) software, 12) storage, 13) training. Each registered service[8] is allocated to one of the previous categories. This classification was also adopted by the EOSC Hub marketplace (which has 61 providers from different scientific fields offering 70+ services to the community). The two initiatives are working jointly to develop the EOSC portal. While this classification applies to e-infrastructures there are certain commonalities with physical RIs as well (e.g. in the domain of training, analytics and consulting services).

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[5] 'The ESFRI Projects are RIs in their Preparation Phase which have been selected for the excellence of their scientific case and for their maturity…They are included in the Roadmap to point out the strategic importance they represent for the European Research Area (ERA) and to support their timely implementation as new RIs or major updates of existing RIs… The ESFRI Landmarks are RIs that were implemented or reached an advanced implementation Phase under the Roadmap and that represent major elements of competitiveness of the ERA' (ESFRI, 2018: 12).

[6] These 'address the needs of European researchers for digital services in terms of networking, computing and data management' (ec.europa.eu/digital-single-market/en/e-infrastructures).

[7] Service description template is divided into the following categories: 1) basic service information, 2) service classification information, 3) service support information, 4) service contractual information, 5) service level targets and performance information, 6) service operations information, 7) other service provider service information and 8) other stakeholder service information (Sanchez et al., 2018: 49-64).

[8] As they are quite numerous and relatively specific, they will not be listed here. Interested readers may see them online at beta.einfracentral.eu/browseCategories.

A specific example of a European-wide service provider is OpenAIRE-Advance, with currently (June 2019) a catalogue with six main categories of services (catalogue.openaire.eu/search): 1) analytics, 2) training, 3) aggregator, 4) operations, 5) data and 6) application numbering a total of 18 services. OpenAIRE-Advance together with four other e-Infrastructures, namely GEANT, PRACE, EGI and EUDAT were the core contributors to the initial filling out of the EOSC catalogue of services under coordination of EFIS, JNP and UoA (via eInfraCentral). Though it is still specific for e-infrastructures, this catalogue does give a sense of how simple a typology could be.

A case of a Europe-wide science area-specific catalogue is provided by CORBEL (Coordinated Research Infrastructures Building Enduring Life-science Services), a Horizon 2020 project. It covers the sphere of life sciences and classifies services of all 13 European RIs in the area of biological and medical sciences. There are five main types of services that are further broken down into subcategories, as follows (www.corbel-project.eu/services.html):

1. Samples (a) access to / deposit of human biological samples (biobanks), b) access to / deposit of non-human biological samples (microorganisms, animals) and c) access to / management/ deposit of chemical compounds);
2. Data and databases (a) data repositories (access/management/deposition), b) management of clinical trial data and c) work with patient cohorts);
3. Technologies and facilities (a) accredited/certified facilities (ISO certified, GLP, GMP, GCP), b) adaptation / development of assays (compounds etc.), c) adaptation / development of assays (human/non-human samples), d) high-throughput screening, e) imaging (biological), f) imaging (medical), g) isolation / cultivation / characterisation of microorganisms, h) -omics technology platforms, i) plant phenotyping technologies/facilities, j) production of high-quality protein samples, k) structural biology technologies/software);
4. Models and tools (a) biological system modelling, b) in-vivo modelling in high containment environment, c) marine model organisms, d) repositories for model/modelling standards and SOPs, e) rodent models (e.g. custom-made or axenic mouse lines), f) specialised pre-clinical models and tools (in vitro/in vivo);
5. Expertise and support (a) assessment of projects' impact and innovation potential, b) biomarker validation, c) biosecurity / biosafety (incl. regulatory) issues, d) data management expertise, e) development of project towards a medical application, f) ethical / legal issues, informed consent, g) mouse model generation, phenotyping and cryopreservation, h) multinational clinical trial (establishment / management / monitoring), i) outbreak / emergency response / epidemiology, j) support to submit a project proposal, k) systems biology expertise, l) training courses).

An in-depth catalogue of European RIs and their services in multiple scientific disciplines is represented by the MERIL project (portal.meril.eu), most recently financed through the Horizon 2020 programme. It provides a listing of RIs' services[9] but does not catalogue the services in

[9] At the time of writing, end January 2019, 1 032 infrastructures from multiple scientific disciplines and 2 807 services are listed online.

a harmonised way as it is not built on a service classification or SDT. The MERIL database covers eight scientific fields 1) biological and medical sciences, 2) chemistry and material sciences, 3) earth and environmental sciences, 4) engineering and energy, 5) humanities and arts, 6) information science and technology, 7) physics, astronomy, astrophysics and mathematics, 8) social sciences (MERIL, n.d.). The full list of services of the MERIL project[10] has been extracted and analysed in a word cloud in a raw form (i.e. without additional modifications). The result can be seen in Figure 1.

Figure 1: Word cloud analysis of the services of the MERIL project

Note: the list of services has not been modified.

Source: Samantha Alex Gordine of the MERIL team (ESF) for the data. Authors' own analysis.

As shown in Figure 1, the most frequent words occurring in the MERIL's catalogue of services (the words in large light-blue letters and/or if they show up two times, in the order of appearance) are: 1) processing, 2) training, 3) service(s), 4) support, 5) data, 6) access, 7) research, 8) analysis, 9) user, 10) testing, 11) measurement(s). Rather than being conclusive in itself, this analysis actually gives a sense of what services are listed in the MERIL catalogue and hence which services could be considered in a typology.

An example from the United States is a catalogue of online biomedical resources financed by the US National Institutes for Health (www.eagle-i.net). It classifies 20 categories of resources[11] that in that case include services, of which there are 3,577. It comprises the

[10] The list of services in a tabular form has been kindly provided by Samantha Alex Gordine of the MERIL team (ESF) 23 January 2019.

[11] These are: 1) algorithms and software, 2) antibodies, 3) biological specimens, 4) cell lines, 5) chemicals, 6) Core Facilities, 7) human studies, 8) instruments, 9) microarrays, 10) nucleic acid reagents, 11) organisms, 12) plasmids, 13) proteins, 14) protocols, 15) reagents, 16) reagent libraries, 17) research opportunities, 18) services, 19) stem cells and 20) viruses (www.eagle-i.net/browse).

following types of services (including subtypes, in brackets): 1) access service, 2) analysis service (data analysis service and material analysis service), 3) maintenance service (data maintenance service and material maintenance service), 4) material processing service (material modification service and material production service), 5) storage service (data storage service and material storage service), 6) support service, 7) training service and 8) transport service.

Another example of a catalogue is called Labs Explorer (www.labsexplorer.com/services). The company behind it is based in Paris and provides a search engine for research and development (R&D) services on a worldwide scale. There are many providers and some RIs (e.g. ECRIN and EATRIS – see Table 1 in the Annex) also list their services on the website. While Labs Explorers' classification nominally includes physical facilities (lab equipment, Core Facility, library), software (research software) and even lab supplies (consumable lab supply) these may nevertheless be understood as services, inasmuch there are essential elements of a service involved in the process. Moreover, among the services it includes there are some that are not typically provided by RIs to external clients: financial and business service, R&D management support as well as communication and dissemination service. The latter could be understood in a broad sense as logistics services. Labs Explorer provides the following services and expertise ordered into categories:

- Contract research (analysis service, measurement service, custom solution development, synthesis service, certification test, extraction and purification service and labelling service)
- Lab supplies and software (Consumable lab supply, Lab equipment, Research software and Program development)
- Technical support (Modelling and simulation, Prototype development, Material engineering, Calibration service and Biobank),
- Supporting activities (Financial and business service, R&D management support, Education and training and Communication and dissemination service)
- Facilities (Core Facility and library)

A review of the classification of services applied by individual RIs provides additional hints about a potential services classification. Three RIs offer interesting examples. ALBA Synchrotron (2016) provides services of magnetic measurements laboratory, radiofrequency laboratory, optics and metrology laboratory, vacuum laboratory and electronics laboratory. Each of these different facilities provides a set of services, e.g. electronics laboratory offers the following ones: 1) characterisation of semiconductor devices, 2) low level current and voltage measurements, 3) high impedance characterization, 4) high accuracy synchronization timing systems (sub nanosecond range), 5) FPGA programming: high speed digital bus, embedded data processing and 6) full-custom electronics design. ELIXIR (https://elixir-europe.org/services) offers a listing of services by scientific domain, type of service or key service collections. EMBL (www.embl.de/services/index.html) provides an overview of bioinformatics services as well as of IT services, with an additional catalogue under the listing

of its Core Facilities. These examples are scientific area-specific and are thus not all-encompassing. However, they may show a way for the CatRIS gateway, as services' classification may be combined with other attributes for finding the right service more easily.

Classifications reviewed in this section provide examples for a typology of services that could be in use in CatRIS. There are certain similarities emerging in these typologies and/or possibilities to find common denominators for some categories of services. This is going to be elaborated on in the next section that introduces a baseline typology.

3 Baseline typology of RI services

Based on the review of existing classifications of services, this section proposes a general typology of CFs' and RIs' services. The eagle-i online biomedical resources catalogue is used as a basis, although the services and subcategories are modified in order to accommodate a larger variety of services. The suggested first level (numbered) and second level classification (marked with letters) is given below[12] in Table 2:

Table 2: CatRIS baseline classification of services of physical RIs and CFs

1)	Access service
	a) access to data
	b) access to aggregators
	c) access to facilities
	d) access to equipment
2)	Analysis service
	a) data analysis service and
	b) material analysis service
3)	Expertise (consultancy) service
4)	Data management
	a) maintenance service
	b) data storage service
5)	Material processing service
	a) material maintenance and modification
	b) material production service
	c) materials testing and validation
	d) material storage service
6)	Support service
	a) project development
	b) development of models and tools
	c) development of solutions
7)	Training and education service
8)	Transport service

Source: authors, based on www.eagle-i.net, modified.

The categories have been designed in such way that they accommodate the ones identified in the previous section. They can be used across scientific fields but are represented here only at the first and second levels of disaggregation. Hence this classification does not reflect on a potential third level of services, which may be more specific to science fields.

The next section presents the findings from the survey, interviews and the Validation Workshop on how the typology could be modified to make it fit with the needs of RI/CFs.

[12] An aggregator may be a repository, a hub or a similar catalogue of resources. For example eInfracentral (see einfracentral.eu/browseCategories) is an aggregator of all services of eInfrastructures.

4 Towards typology of Research Infrastructures' services

The typology discussed in this chapter develops the initial typology, based on the desk research, presented in the previous chapter.

4.1 Conclusions from the Survey

The full survey results are provided in a separate deliverable[13]. The Survey collected 207 responses from all scientific disciplines and across the CF and RI community. The intent here is to draw on the analysis of responses[14] in order to adapt the definitions of services and the typology as commented and/or modified by survey respondents.

Regarding the definition of a service, the majority of respondents agreed with the provided definition ('RI assistance to the users that provides them certain benefits')[15]. However, some modifications were suggested, notably by broadening the scope of the initial definition. In particular, the respondents suggested considering the following specifications for a 'service':

- Predefined unit of work;
- Working with specific technological knowledge and scientific expertise;
- Facilitate access to advanced scientific technologies, resource collections or technical expertise; computational capabilities;
- Use of instruments, use of resources and use of services should be considered
- Providing added value to the research, scientific expertise and technical state of the art technologies.

A definition using the above elements would be the following one: RI service is a predefined unit of work with specific technological knowledge and scientific expertise that facilitates access to advanced scientific technologies, resource collection, technical expertise and/or computational capabilities and that uses instruments and resources hence providing added value to the research, scientific expertise and state of the art technologies. It follows that a RI service is multidimensional in that it is a unit of work which incorporates or may incorporate many different elements of a RI or a CF.

[13] See Deliverable D3.2 Survey form for requirement elicitation for the form and Deliverable D3.3 Report on the results of the Survey on requirement elicitation.

[14] All 'raw' Survey results in this chapter are taken from D3.3 Report on the results of the survey on requirement elicitation. The comments are additional.

[15] That was question 4 in the Survey.

Another important input came from respondents' answers on type of RI services they use or look for, which cover a range of types of RI services[16]: 1) Access to facilities / instruments, 2) Access to data, 3) Access to samples, 4) Analysis service, 5) Material processing service, 6) Data management, 7) Software and applications, 8) Storage service, 9) Support service, 10) Training and education service, 11) Expertise (consultancy) service, advice, 12) Infrastructure management service and 13) Transport service.

For the fourteenth option ('other'), helpful answers from current and potential users/customers of RI services included 'statistics about RI usage' and 'certification – benchmarking'. In addition, there was one answer from RI service managers/providers to a similar question[17] to include 'e-infrastructures'. All of the latter can be taken as 'horizontal' services in that they may be provided for users with a wide range of scientific backgrounds, i.e. scientific disciplines.

As regards the need for a catalogue of RI services users did report encountering problems when trying to find the right service. A majority of them found it difficult to find a particular service and complained that services are described in an incomplete or unclear way (both options receiving 62.5% of responses). Moreover, such difficulties may logically be connected to some of the challenges that RI service managers/providers face regarding an increase in uptake of the services. Some of the latter mentioned services not being easily discoverable on their website (28% of respondents). Since the RI service managers/providers also think that being listed in a service catalogue would translate into better visibility/outreach it shows that there is a clear advantage of a well organised and accessible service catalogue. Furthermore, 81% of responses from the latter group indicate that an 'easy and understandable process of publishing services' is either very or extremely important. The need for 'alignment of service definition across different RIs' is also quite important, receiving a weighted average of 3.45 out of the maximum 5[18]. Hence, a clear definition of service(s) and an understandable typology of services together with a well organised catalogue would bring about the needed benefits.

A standardised typology and construction of a catalogue would be beneficial to policy makers as well, as a majority of them would be interested in data on the 'use of RI's services' when they assess RIs' progress or performance. For policy makers, the added value of a RI service catalogue would follow from a number of criteria that would allow for comparison among RIs

[16] This classification of RI services was used for the Survey. It was based on initial desk research as well as the discussion by consortium partners.

[17] Question 19: What type of RI services do you provide? (multiple answers possible).

[18] Respondents were asked to grade the responses on an ordinal scale (from not important to extremely important, i.e. on a scale of 1, 2, 3, 4 to the maximum of 5). Results are weighted by percentage of responses given for each rank.

(e.g. ‘to understand the potential impact of funded RI services’, ‘to automatically collect information about service performance (i.e. KPIs)’, etc.).

The survey results therefore offer important building blocks for the RI services definition and the typology to be developed, especially in terms of the functionalities of the future gateway.

4.2 Lessons from the interviews

4.2.1 Interviews’ design and methodological notes

A total of 29 semi-structured interviews (undertaken based on structured interview guides, see Annex 2) with 1) RI users (8 interviews), 2) RI managers / service providers (15 interviews) and representatives of RI networks (4 interviews)[19] as well as 3) RI policy makers and funding agencies (2 interviews) have been done in the period March – May 2019 by the consortium partners[20]. Anonymised interview responses have been used as an input to derive conclusions.

Questions were grouped in several thematic categories and were adapted to the profile of each of the target groups. While some of the interviews or some parts of the interviews were done in writing, the majority were done orally. For the purposes of the analysis here, whenever interview notes are copied quotation marks are used (or it has otherwise been so noted), with small language corrections. Whenever interviews’ results are used it is clearly marked so.

4.2.2 Analysis of the interviews

The focus in this section is on analysis of the responses divided into core thematic areas (see below) so that the results are clearly organised and presented. Responses that stand out and offer a more detailed picture of the RI service definition and RI services’ typology vis-à-vis the gateway have been analysed and commented below. Some other responses, directly concerning activities of WP 4 and WP5 (e.g. the question on whether interviewees know of any well-functioning examples of such catalogues) have already been taken account of elsewhere (see D4.1 and D4.4 for the status and assessment of catalogues for important thematic aggregators in Europe), so they will not be repeated here.

The definitions of RI service suggested varied much more than in the survey. In one of the RIs ‘the terms ‘services’ and ‘resources’ are used extensively…, often interchangeably’. There were similar definitions mentioned, sometimes specific for certain scientific disciplines, e.g.

[19] Most of the RI managers/service providers and representatives of RI networks (10/19) unambiguously said that their RI’s mission included provision of services and that their RIs provided a listing or a catalogue of services.

[20] One of the interviewees was interviewed both in her capacity as s RI manager and in her capacity as a RI user. Some of the interviews were done with 2 interviewees at the time.

- ‘Mainly bioinformatics service, e.g. a database, a tool, a training course, a data standard. Or even a possibility to provide computational power’.
- ‘Source of data for contextualisation of research, source of information made in the user-friendly way that you can adjust to your needs’.
- ‘A service to a researcher in the area of language tech can have the following incarnations: i. software, applications that are offered over a web API, these could be anything. If I receive a mail that I don’t want to translate through Google, for security reasons, I may want a more reliable application; ii. data: there are already implemented algorithms, deep learning frameworks. We need to train them through data. This is why people are searching for data; iii. Computing infra: if you want to train a deep learning model you need hardware. These are quite expensive. Ideally here I would like to use computing infra that offers CPU etc for data that I have retrieved from a RI or anywhere in the web; iv. Storage infra’.

However, predominantly there was a definition of service that makes clear distinction from physical resources, with some users underlining integral definitions:

- ‘The scientific community (end-user) go-to place for the expertise and competence (knowledge-based resources), for conducting top-level research in their respective fields, and this, of course, covers major scientific equipment or sets of instruments as well.’
- ‘A service of a Research Infrastructure is based on necessary resources, equipment and instruments but does not coincide with them. In our facilities a service in the result of human work exploiting the resources/equipment/instrument available.’
- ‘The “equipment” is a device for generating the data; “resources” is the actual process for making data better and more useful; “instruments” it’s the platform. Service is the whole package we offer (which is composed by all these components)’.
- ‘A service is an action provided to users, giving them tools that can be hard/soft infrastructures, human resources, equipment, instruments, supporting the use of them. For example: a vessel is a service as it is a research platform combined with expertise provided by the service provider’,
- ‘The operation of the wind tunnel is our service. That includes equipment and human resource. It also includes a software model of a company that we use to perform wind tunnel testing’.

Two of the interviewees made an important distinction to better define a RI ‘service’. One of them suggested that if instruments are accessed by users with help of someone from RI, that is a service; Otherwise, without this assistance, it would be called ‘equipment time’. A further

opinion highlighted the need to think about the phases of a service – 'introduction, consultations, measurement and interpretation'.

As can be seen, the definitions of a 'service' from the interviews ranged from the services as being the same as resources - a service being inextricably linked with material resources - to a service as would be typically be defined in business ('service' as immaterial assistance to customers and hence as something different from a 'product'). As already mentioned, the latter perspective has been predominantly present among interviewees' opinions and is therefore taken as a baseline in adopting a definition for the CatRIS project.

Taking further suggestions from the interviews into account bring us closer to the desired definition of service to be used for the CatRIS catalogue. In that respect the most important elements suggested to describe a service are the following:

- 1) The way this service can be obtained (peer review, collaboration, projects, applications, contracts); 2) The right people to get in contact with and discuss about the service; 3) It may be useful to give the possibility to different users (such as non-experts) to access the possibility of support services in terms of: supports in performing experiments, support in data analysis, support in sample preparation; 4) It may be useful to enrich the catalogue with a series of "case studies" in an indexable and usable way.
- First of all, the unit of access that is available (e.g. someone using the ship for a certain number of days). Costs that might be involved in it. Planning is a must – whether the facility can be opened. Financial constraints are very important. And then, depending on infrastructures a certain description of capacity.
- The costs of accessing, the cost of IP (intellectual property)
- The instrument that is used is important. Then the application, experience, expertise of the staff.
- Time/place/some other parameters and the platform used to collect data
- Service description, Location, Contacts, Access modalities
- Things like limitations, support you can get for a service, training materials to use a service, who should you call when something…. A knowledge base and a support desk are always something that can be of use for end user. Discoverability is very important.
- Logistics
- I should get an immediate reply from the catalogue to the possible question whether I can use this service. Is this service for me? Authentication, and immediate info on if and how I can use it, URL, technical details, etc; Legal issues are also very important, whether I can use it and work on it to create something new. This is the famous issue of licensing.

- Should be very precise, to know how to deposit your project, the delay of answer (very important), exactly the type of equipment, the person in charge. It shouldn't be very extensive.
- Name the service, Equipment specifications, Technique description, Sample specifications, required use, how long a typical experiment would take – duration, sample recovery, remote user capability, user experience, user feedback, access policy, pricing issues; software should be described, usage period
- Listing technical information and making some examples of other provided services would be also useful
- 3 core elements that work the best; laboratories must have these elements; what type of service, what equipment, contact
- Provide the basics and then make sure that this catalogue becomes richer as it grows in time; Make it dynamic

Such responses cannot be easily filtered without an overall concept on how the whole catalogue should look like. The interviewees emphasised a flexible, user-friendly and grid-like structure of a catalogue, without users being forced to browse too many levels of services until they reach what they are interested in. Tagging and a search function may be practical to have and so would modularity and the use of key words and attributes. Furthermore, some interviewees argued against too many levels in the catalogue, to reduce the level of complexity. Whether a catalogue should be structured in scientific areas is something that was not resolved clearly from the interviews (10 out of 19 interviewees who responded were in favour of that option). Such an option also has to be viewed from the angle of the overall complexity of the catalogue. Rather, standardisation of the information in the catalogue was underlined, as well as the importance of being found in search engine results. Hence, the future catalogue needs to provide a possibility to characterise a service through a range of searchable attributes.

When it comes to the varieties of RI services (that are not scientific discipline-related), the main findings that may be important both for the main category and for subcategories were:

- Training and support
- Full service (including sample preparation, imaging acquisition, imaging process and analysis; operating a machine, etc.)
- Access to instruments and sampling tools, access to ship time, access to experimental facilities, access to marine robotics, e-Infrastructure services; Access to marine data, access to metadata catalogues related to the process of collecting marine data, Provision of standards: common vocabularies, formats…, Software available for data managers and data users; access to datasets; Access, guesthouse for staying, canteens, scientists to help set up the instruments to get started, workshop and labs

- Data treatment, curation and analysis as well as training and instrumentation development
- Developing the whole project together with just an idea of the project
- Sample preparation, data management and data analytics
- Differentiate services in terms of technical and scientific nature; have logistics services, and possibly financial services likewise.

The services mentioned were mostly pre-identified in the desk research phase (training and support, access services, data management, sample preparation). Nevertheless, certain additions can be suggested based on the answers, namely.: provision of standards[21], software, accommodation and canteen services, workshop and labs. 'Full service' is similar in scope and scale to the approach of 'integrating the services' (see below, under horizontal services) in that in concerns a combination of several services. Furthermore, logistics and financial services need to be considered under a new category.

In addition, there are horizontal services that some interviewees singled out: central infrastructure for IT resources; digital services; knowledge transfer; training for users; linking open data, about to integrate datasets on micro-level, that takes standardising the data; and integrated approaches integrating the services provided. In short, interviewees mentioned four main groups of horizontal services: 1) digital/e-services, 2) knowledge transfer, 3) training and 4) integrating the services.

4.3 Results of the Validation Workshop

On 15 May 2019, in Brussels, the CatRIS team organised a Validation Workshop, targeted at RI managers, users of RIs as well as RI funders (policy makers). It gathered 16 participants as well as 5 representatives from the consortium partners. The purpose was to discuss and refine the CatRIS concept and the typology of RIs' services[22] (see agenda in Annex 3). While discussions mostly focused on concept for and requirements of the gateway the second part of the workshop predominantly concerned the typology of services.

Participants underlined the need for a clear definition of RI service and also the necessity that a user understands what service they are getting. They thought that it would be good to inform a user about which other similar services the service is linked with. It was argued that an important information to be included in the catalogue concerns background about service,

[21] This potential service may be considered in a description of another service, e.g. of support service.

[22] We are thankful to Lavanya Premvardhan for her comments on and input to notes circulated to Validation Workshop participants after the workshop.

competencies and the facility. Some participants underlined a need to introduce different users'/customers' classifications (e.g. a new user and an experienced user) for the gateway. There was a suggestion to let users themselves order choices/collections of services that are visible to everybody. This is all the more important as industry users may have different needs than other users; researchers from some fields may have a better idea of where to find services than researchers in other fields. Furthermore, the basic knowledge of what an RI is may be lacking in certain scientific disciplines (like humanities and social sciences).

Participants were asked to comment and discus an initial typology of RIs' services, as laid out in chapter 3. The following ideas have had a direct importance on the proposed typology:

- Subcategory 2b: to rename the material analysis service to sample analysis service
- to differentiate training as a separate service from training as connected to a specific service;
- Category 4: could 4c – curation of data and 4d – DOI (digital object identifier) attribution be added?;
- The difference between subcategories 2b – material analysis service and 5c – materials testing and validation was not clear;
- Transport service could be included under material management or logistics service; it was unclear what it entailed;
- Make distinction between physical, remote and online access;
- Category 6: include technology transfer;
- For industry users readiness level for access may be important;
- Services need to fit into different categories;
- There is a need for a vocabulary;

5 Conclusion

This Working Note focused on the definition of RI service and on an RI services typology, placing these in the context of the CatRIS catalogue.

The definition of RI service that emerged from the survey and the interviews is centred around its immaterial qualities, thereby distinguishing a service from physical resources (facilities, instruments, equipment). As a pre-defined unit of work, it requires a range of specifications (attributes) that correctly describe it and let the users pick the right service. These would typically include cost, time of usage, technical information and other variables. It incorporates technological knowledge and scientific expertise, using other resources in the process in order to deliver benefits to a user. The definition of RI service in the catalogue should combine a choice of attributes to inform user of the service they are getting.

As to the typology of RI services, the findings laid out above suggest the introduction of some changes into the preliminary baseline typology. Table 3 sets out the final typology proposed for the CatRIS classification of services.

Table 3: New typology of services

1) Access service
a) access to data
b) access to software
c) access to central infrastructure for IT resources and digital services
d) access to aggregators
e) access to facilities
f) access to equipment
2) Analysis service
a) data analysis service and
b) sample analysis service
3) Expertise (consultancy) service
4) Data management
a) maintenance service
b) data storage service
5) Material processing service
a) material maintenance and modification
b) material production service
c) material storage service
6) Support service
a) project development
b) development of models and tools
c) development of solutions
d) certification and benchmarking
e) knowledge and technology transfer
7) Training and education service
8) Logistics service
a) financial service
b) transport service
c) other logistics services

Source: authors

The following changes have been introduced. Category 1 (‘Access service’) is modified by adding ‘access to software’ and ‘access to central infrastructure for IT resources and digital services’. Category 2b (‘Analysis service’ / ‘material analysis service’) is renamed to ‘sample analysis service’. Category 5c (‘Material processing service’ / ‘materials testing and validation’) is considered redundant and has been deleted; while category 5a (‘Material processing service’ / ‘material maintenance and modification’) includes sample preparation. Under category 6 (‘Support service’) two new subcategories are introduced: ‘certification and benchmarking’ and ‘knowledge and technology transfer’. One new category, ‘Logistics service’ is included with subcategories including ‘financial service’, ‘transport service’ (the former category 8) and ‘other logistics services’. As to other suggestions by the interviewees they may be covered by third level subcategories, e.g. Category 1c (‘Access service’ / ‘access to facilities’) could encompass access to guesthouse and canteen, workshop and labs. Category 4a (‘Data management’ / ‘maintenance service’) could comprise data treatment, curation, DOI attribution and analysis.

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Annex 1: The ESFRI RI list with services offered and service level agreements

Table 4: The ESFRI Research Infrastructures list with services offered and service level agreements (when applicable)

RI No.	ESFRI PROJECTS	NAME	WEBSITE	SERVICES AND SERVICE LEVEL AGREEMENTS
1	ENERGY	EU-SOLARIS	http://www.eusolaris.eu/Home.aspx	N/a
2		IFMIH-DONES	N/a	N/a
3		MYRRHA	https://myrrha.be/	N/a
4		WindScanner	http://www.windscanner.eu/	N/a
5	ENVIRONMENT	ACTRIS	https://www.actris.eu/	"ACTRIS-2 offers free of charge access to 18 observational facilities to: Comprehensive measurement programmes using state-of-the art equipment and expertise within any of the ACTRIS domains: Aerosol vertical profiles, near-surface aerosol properties, trace gases, cloud-aerosol observations. Scientific measurement campaigns, calibration and intercomparisons, instrument testing, data analysis. High level of services and support to users incl. training to young scientists and new users." (link) "LiCal is the official Lidar Calibration Centre offering a wide range of services to test and calibrate lidars and ceilometers, starting from the characterization and optimization of single components, to the assessment of the whole system's performance, and training of instrument operators." (link) "AERONET-Europe provides free calibration and standard maintenance services for CIMEL sun/lunar photometers involved in AERONET Network. Calibration is also offered to other types of sun/lunar-photometer" (link) "European Center for Aerosol Calibration (ECAC)… offers the following services to all users of the scientific community, including SMEs: Inter-comparisons and hands-on capacity building of operators for instrument operation and data processing at ECAC installations for Condensation Particle Counters, Aerosol Electrometers, Mobility, Aerodynamic and Optical Particle Size Spectrometers, Extinction monitors, Integrating Nephelometers, Absorption Photometers, Cloud Condensation Nuclei Counters (including reference instruments) at the WCCAP and Aerosol Chemical Speciation Monitors at the ACMCC

				Inter-laboratory comparisons of OC and EC measurements based on synthetic standards and ambient test samples provided by the ERLAP facility (remote access). On-site intercomparisons with reference instruments of physical and optical in-situ aerosol instruments, including station audits Hands-on capacity building of fundamentals in aerosol physics, physical and optical aerosol in-situ instruments, and aerosol in-situ sampling" (link) Agreements are foreseen for stakeholders or customers (see link).
6		DANUBIUS-RI	http://www.danubius-ri.eu/	N/a
7		DiSSCo	https://dissco.eu/	N/a
8		eLTER	http://www.lter-europe.net/	"What will eLTER RI offer? Filling a critical gap for top-class, continental scale science Access to integrated research sites and local expert teams Easy access to long-term data, data products, models and analysis tools Support for research project design Support for ground-truthing and remote sensing service development Support for development and testing of new observation technologies and approaches Education and training programmes for RI providers, RI managers, researchers, other data users and students Information on the state of European ecosystems and impacts of pressures." (link)
9	HEALTH & FOOD	AnaEE	https://www.anaee.com/	Services for researchers, national stakeholders and for European policy makers and industry are to be found at link
10		EMPHASIS	https://emphasis.plant-phenotyping.eu/	N/a
11		EU-IBISBA	https://www.ibisba.eu/	"IBISBA 1.0 Transnational Access (T.N.A.) offers external users free access to the IBISBA 1.0 specialised research structures and facilities, including a contribution to users' travel and subsistence costs." (link)
12		ISBE	http://project.isbe.eu/	"Infrastructure for Systems Biology Europe (ISBE) is a knowledge-based Research Infrastructure that adds value to national and European investments by empowering European researchers across academia, clinics and industry to implement systems biology approaches. It will enable easy access to expertise, resources and training and offer hands-on support in building and using computational models based on model-compliant high quality data." (link) "Services and modalities ISBE's services are offered in various modalities, fitting the full range of needs of diverse life science communities.

				Web-based access to repositories and archives ISBE will offer curation of models and data, tools and protocols linked to them, throughout the life-time of the projects and beyond. This will make data, tools and models re-usable over prolonged periods of time; in other projects and by other researchers. Consultancy Users may contact ISBE to get information and advice from experts about the use systems biology and how to implement it in (small or large) research programmes. Contract activities National SBCs, individually or in groups (depending on the requested service), will offer to guide or to carry out those components of research projects that require specific expertise. This includes the following activities. design of experimental approaches and efficient workflows that allow the development of quantitative and predictive models of complex biological systems acquisition of data that are fit for modelling model-driven integration of diverse data sets development of quantitative and predictive models validation and analysis of models model simulation to gain insight into the behaviour of complex systems" (link)
13		METROFOOD-RI	https://www.metrofood.eu/	N/a
14		MIRRI	http://mirri.org/	"MIRRI offers its users shortcuts to the participating microbial domain Biological Resource Centres (mBRCs)" (link) Some services listed under 'Infrastructure objectives' (link). Microbiological services offered (link): 1) consultancy, training and contract research, 2) data management, 3) deposit, 4) idenfitication, molecular typing and phylogenetic/community analysis, 5) isolation, preservation and cultivation, 6) phenotypic and molecular characterisation, 6) screening, tests and bioassays and 7) miscellaneous.
15	PHYSICAL SCIENCES & ENGINEERING	EST	http://www.est-east.eu/est/index.php	N/a
16		KM3NeT 2.0	https://www.km3net.org/	The RI provides an open access to the facilities and the data it produces.
17	SOCIAL & CULTURAL INNOVATION	E-RIHS	http://www.e-rihs.eu/	N/a
18		EHRI	https://www.ehri-project.eu/	N/a

Ri No.	ESFRI LANDMARKS	NAME	WEBSITE	SERVICES AND SERVICE LEVEL AGREEMENTS
19	ENERGY	ECCSEL ERIC	http://www.eccsel.org/	N/a
20		JHR	http://www-rjh.cea.fr/index.html	N/a
21	ENVIRONMENT	EISCAT_3D	https://www.eiscat.se/eiscat3d/	N/a
22		EMSO ERIC	http://emso.eu/	There is a list of services: "Access to the Infrastructure Services, Climate Change Services, Marine Ecosystem Services, Geo-hazards Services, Training & Best Practices Services, Technology & Engineering Services, Data Management Services, Communications & Branding Services, Lobby & Policy Services, International Relations & Partnering Services" (link). In the case of "transnational access" 'A written contract or agreement between the "Access Provider" or the "Infrastructure Operator" and the "End User" will delineate the actions to be undertaken, the resources that will need to be allocated, the length of planned user stays (if any), and the period of use. It will also define the rights and obligations of all the Parties involved, including data sharing and eventual provisions for early termination of the conferred access' (link).
23		EPOS	https://www.epos-ip.org/	There is a list of services: seismology, near-fault observatories, GNSS data and products, volcano observations, satellite data, geomagnetic observations, anthropogenic hazards, geological information and modelling, multi-scale laboratories, geo-energy test beds for low carbon energy (link)
24		EURO-ARGO ERIC	https://www.euro-argo.eu/	Apparently no explicit mention of services – aside from the provision of data from the research.
25		IAGOS	https://www.iagos.org/	Apparently no mention of services. However, it is underlined that the RI does something for the users: "IAGOS provides a data base for users in science and policy, including near realtime data provision for weather prediction and air quality forecasting. IAGOS data are being used by researchers world-wide for process studies, trend analysis, validation of climate and air quality models, and the validation of space borne data retrievals."
26		ICOS ERIC	https://www.icos-ri.eu/	N/a
27		LifeWatch ERIC	https://www.lifewatch.eu/	There is a catalogue of services online, encompassing alien species thesaurus, biodiversity partitioning, BioMaS (Bioinformatic analysis of Metagenomic AmpliconS), data services, endemisms thesaurus, fish traits thesaurus, ISS Benthos, ISS Phyto, LW Toponyms IGM, MSA-PAD, Niche Filtering, Phytoplankton Size Distributions, Phytoplankton Traits

				Computation, Phytoplankton Traits Thesaurus, Taxonomic Rarefaction (link). 'The Statutory Seat and the ICT e-Infrastructure Technical Office… coordinate procurement and IPR matters, formal agreements with external data and e-Services suppliers, and Service Legal Agreements (SLA) with local, regional, national and international entities, including decision-makers and environmental managers.' (link)
28	HEALTH & FOOD	BBMRI ERIC	http://www.bbmri-eric.eu/	Quality management services for basic and applied research; the ethical, legal and social issues (ELSI) knowledge base, the ELSI helpdesk, the ethics check (link).
29		EATRIS ERIC	https://eatris.eu/	"EATRIS services are built along technology pipelines and supporting services. For any product class, we can build the project team to meet your needs, covering: Advanced Therapy Medicinal Products (ATMP) and biologics Small Molecules Vaccines" (link) "EATRIS helps you de-risk and add value to your drug, vaccine or diagnostic development programme. We do this by providing fast, tailored access to cutting-edge enabling technologies in translational research." (link)
30		ECRIN ERIC	https://www.ecrin.org/	"ECRIN's main activity is the provision of support for the management of multinational clinical trials. Support is primarily provided during implementation, but also for preparation and protocol evaluation… ECRIN is also involved in activities to enhance the ability of European institutions to successfully conduct multi-country clinical research. This can include, for example, the creation and maintenance of tools or databases, or the recognition/certification of high-quality data centres. (Note that these activities may also be done as part of trial management services for specific trials.) Moreover, ECRIN is involved in capacity building projects that aim to further develop the European clinical research community and to facilitate multinational trials." (link)
31		ELIXIR	https://www.elixir-europe.org/	Services are ordered into 5 types: 1) compute, 2) data resources, 3) interoperability and standards, 4) software tools, 5) training. There is a long list of services. (link) ELIXIR Node and ELIXIR Hub regulate their relationships by collaboration agreements that are 'service level agreements which specify which activities ELIXIR Nodes will carry out and which services they will provide to the ELIXIR Hub' (link)

32		EMBRC ERIC	http://www.embrc.eu/	There is a long list of services under each of the following categories: 1) biological resources, 2) ecosystem access, 3) experimental facilities, 4) technology platforms, 5) training and education, 6) e-infrastructure, data and services, 7) supporting facilities, 8) expert advice. Furthermore, "EMBRC-ERIC offers a range of high-level services to support basic and applied marine biology and ecology research. The services are provided by the EMBRC-ERIC Operators in EMBRC-ERIC member countries". (link) '"Service Level Agreement(s) (SLA)" means agreements between EMBRC-ERIC and legal entities operating the Nodes regulating the provision of services and resources to support the high-level ambitions of the Research Infrastructure' (link, p. 8)
33		ERINHA	https://www.erinha.eu/	It provides transnational access to BSL4 and complementary facilities through CCU, high quality scientific project management and implementation as well as advice and scientific expertise. Furthermore, it provides training and also other services (eg. Access to pathogen specimens. (link) Erinha node is defined as '[a] national or international research institute or a network of institutes located in a Member country that enters into a Service Level Agreement with ERINHA, upon the fulfilment of the conditions and procedures established by the ERINHA General Assembly, to provide services with European dimension and that have an added value for ERINHA'. (link)
34		EU-OPENSCREEN ERIC	https://www.eu-openscreen.eu/	Services include screening, compound collection, database, medicinal chemistry and project funding. Each of these comprise further services. Service-level agreements are mentioned in the context of EU-OPENSCREEN partner sites, defined as 'entities with scientific and technological capabilities and with service level agreements with EU-OPENSCREEN ERIC. They provide services to the researchers like screening, assay development or chemical optimisation of biologically active compounds (medicinal chemistry)'. (link)
35		Euro-BioImaging	http://www.eurobioimaging.eu/	"The comprehensive services Euro-BioImaging will provide are: · Open physical access to imaging infrastructure (Chapter 3.1) · Advanced expertise and services for technology users (Chapter 3.1) · Training of technology users (Chapter 3.2) · Advanced training of facility staff/technology experts (Chapter 3.2) · Data analysis support for user image data (Chapter 3.3) · Data storage capacities for user image data (Chapter 3.3) · Open access to data of public interest (Chapter 3.3) · High-quality control standards of its services (Chapter 3.4) · European-level

				coordination and integration activities for its scientific communities (Chapter 6)" (link, p. 12) Service-level agreements are signed 'between the EuBI Hub and each EuBI Node, enabling the opening of the full-fledged Nodes' services to EuBI users'. (link)
36		INFRAFRONTIER	https://www.infrafrontier.eu/	Archiving service, access to EMMA mouse resources, axenic service and training and consulting services (link)
37		INSTRUCT ERIC	https://instruct-eric.eu/	Access to infrastructure, training courses, R&D pilot research award, internships, Instruct Structural Biennial Conferenced. (link) Instruct-ERIC provides industry users with service-level agreements (link). More generally, '[t]he cost of a standard Unit of Access for each machine/method for academic users from member countries will stated in the appendix to the Service Level Agreement'. (link)
38	PHYSICAL SCIENCES & ENGINEERING	CTA	https://www.cta-observatory.org/	N/a
39		ELI	https://eli-laser.eu/	N/a
40		ELT	https://www.eso.org/sci/facilities/eelt/	N/a
41		EMFL	https://emfl.eu/	N/a
42		ESRF EBS	https://www.esrf.eu/home.html	(Users and science) beamtime (link); (Services for industry) Proprietary research (full service, mail-in, on-site access and remote access), peer reviewed research, collaborations, specialised laboratory services (long trace profiler, the crystal laboratory, the multilayer laboratory, scientific and engineering expertise), structural biology services (macromolecular crystallography services – with several different services – different beamlines, humidity control device (HC1)) (link)
43		European Spallation Source ERIC	https://europeanspallationsource.se/	N/a
44		European XFEL	https://www.xfel.eu/	N/a
45		FAIR	https://fair-center.eu/	N/a
46		HL-LHC	http://hilumilhc.web.cern.ch/	N/a
47		ILL	https://www.ill.eu/	N/a
48		SKA	https://www.skatelescope.org/	N/a
49		SPIRAL2	https://www.ganil-spiral2.eu/	There are collaboration agreements and services for industry (link) and a specification for work with scientists, but services as such are not explicitly mentioned.
50	SOCIAL & CULTURAL INNOVATION	CESSDA ERIC	https://www.cessda.eu/	(Tools and services) CESSDA vocabulary service, social science multilingual thesaurus, social sciences multilingual question bank, CESSDA quality assurance, CESSDA self-archiving, single sign on / easy

				access, CESSDA access to sensitive data, social sciences data discovery tools, social sciences research data management, CESSDA data tags. (link) 'The organisation formally defines all appropriate aspects of a service it provides (e.g. scope, quality, responsibilities, availability, performance) in written form as service level agreements (SLA) with relevant service users (Designated Community or other key stakeholders)'. (link)
51		CLARIN ERIC	https://www.clarin.eu/	CLARIN portal, depositing services, virtual language observatory, easy access to protected resources, language resource switchboard, virtual collections, language resource inventory (link)
52		DARIAH ERIC	https://www.dariah.eu/	Isidore, Collection Registry, DARIAH Wiki, DARIAH Etherpad, Generic Search, TaDiRAH – Taxonomy of Digital Research Activities in the Humanities, DARIAH AAI (link)
53		ESS ERIC	https://www.europeansocialsurvey.org/	N/a
54		SHARE ERIC	http://www.share-project.org/	Access services to data produced. (link)
55	DATA, COMPUTING AND DIGITAL RIs	PRACE	http://www.prace-ri.eu/	Access to high performance computing resources and services. (link)

Source: ESFRI (2018) and own research based on RIs' websites.

Annex 2: Questionnaires for the interviews

Questions for RI managers / service providers and RI networks

What is the nature and role of the institution the interviewee represents and its relationship with RIs?

UNDERSTANDING RESEARCH INFRASTRUCTURE AND ITS USERS

Questions:

1. Please describe a mission of your RI / Core Facility and its main activities.
2. Does your RI's mission include provision of services to users?
3. Even if you don't have a provision of services to users as part of your mission statement, do you offer services?
4. What are your RI's / Core Facility's key users or user groups? Do you differentiate between your users, e.g. internal vs external, individual vs groups, by scientific domains?

YOUR RI SERVICES IN MORE DETAIL

5. Please describe what kind of services does your RI offer to users.
6. How do you define / describe a 'service' of a Research Infrastructure? How does "a service" differ from "resources", "equipment", "instrument"? How is "a service" linked to "resources", "equipment", "instrument"?
7. Are there any 'horizontal' services in your RI which can be offered to a wide user group regardless of their thematic field? What are these 'horizontal' services?
8. Are there services you are thinking of offering in the near future, on top of your current offer?

CATALOGUES OF RI SERVICES

9. Do you have a listing or a catalogue of services? If so, how is it structured?
10. What feedback have you received about the services/resources that users would like to see in your catalogue?
11. Do you think it will be useful / practical to list all available services in one catalogue?
12. Why not?

13. What about a catalogue of catalogues principle, i.e. various RIs have their own catalogues but all of these will be linked together like in the field of hospitality where through Trivago a user can find various hotel chains?
14. How should such a catalogue be structured? E.g. based on the type of RIs, a region they operate in? Why do you think so?
15. A service catalogue can have multiple levels of services. For example, 1st level: non-scientific area-specific services that may be common to all RIs (e.g. storage service); 2nd level: non-scientific area-specific services branching out from the 1st level, that serves the purpose of defining the exact object of the service in question, e.g. data storage vs. material storage; 3rd level: scientific area-specific services branching out from the 2nd level).

    In your opinion, what are the pros and cons of such levels and/or other possibilities of listing / grouping services?

16. Should such a catalogue be thematic (i.e. according to disciplinary areas)? If yes, how could / should it fit / align with the efforts of the ESFRI cluster projects in building their catalogues?
17. Do you know of any well-functioning examples of such catalogues? If yes, in your opinion, what makes them good? What are (if any) drawbacks / weaknesses in these catalogues?

DESIGN OF A CATALOGUE OF RI SERVICES

18. Focusing on the design of a catalogue, in your opinion what are the most difficult aspects to capture? For example, a unified way of describing a service, differences in application of a particular service in different scientific domains, geographical limitations in the provision of a service.
19. From a perspective of your RI, what are the 'must ingredients' in describing a service in a catalogue? For example, a level of detail each service should be described in. What would you suggest to list in the catalogue?
20. What other information your RI might want to include in the catalogue alongside services? For example, is there any essential information about an RI itself that needs to be included in the catalogue of services in order to be able to understand this RI services?

STRATEGIC RELEVANCE

21. How would you suggest involving current and potential users in building a catalogue of services that benefits them?

22. From the perspective of your RI / from your experience, what are the benefits of a common catalogue?
23. Which actions might be required by the different stakeholders (e.g. RIs, national and regional policy makers, funding agencies) to develop and make systematic use of a catalogue of RI services? For instance, in terms of legislative requirements, cross-border access etc.

CONCLUDING QUESTION

24. Would you be interested in receiving the news from the CatRIS projects and in getting involved in our events (e.g. focus groups, workshops, etc.)?

Thank you for taking your time and for sharing your thoughts and experience!

Questions for RI users

What is the nature and role of the institution the interviewee represents and its relationship with RIs?

1. We have chosen you for this interview on the assumption that you require Research Infrastructure facilities and services for your research. Please describe which RIs do you use most frequently and why.
2. How do you define / describe a 'service' of a Research Infrastructure? How does "a service" differ from "resources", "equipment", "instrument"? How is "a service" linked to "resources", "equipment", "instrument"?
3. What kind of RI services do you need for your research?

RI SERVICES IN MORE DETAIL

4. Are these services available anywhere else / provided by other RIs?
5. In case you need other services not offered by your usually preferred RI, how would you go about finding these services?

CATALOGUES OF RI SERVICES

6. Do you use any catalogues of services when looking for a RI service you need? If 'YES', which ones?
7. What are (if any) drawbacks / weaknesses in these catalogues? What are the advantages?
8. Do you think it will be useful / practical to list all available services in ONE catalogue?
9. Why not?
10. What about a catalogue of catalogues principle, i.e. various RIs have their own catalogues but all of these will be linked together like in the field of hospitality where through Trivago a user can find various hotel chains?
11. How should such a catalogue be structured? E.g. based on the type of RIs, a region they operate in? Why do you think so?
12. A service catalogue can have multiple levels of services. For example, *1st level: non-scientific area-specific services* that may be common to all RIs (e.g. storage service); *2nd level: non-scientific area-specific services* branching out from the 1st level, that serves the purpose of defining the exact object of the service in question, e.g. data storage vs. material storage; *3rd level: scientific area-specific services* branching out from the 2nd level). **In your opinion, what are the pros and cons of such levels and/or other possibilities of listing / grouping services?**
13. Should such a catalogue be thematic (i.e. according to disciplinary areas)? If yes, how could / should it fit / align with the efforts of the ESFRI cluster projects in building their catalogues?
14. Do you know of any well-functioning examples of such catalogues? If yes, in your opinion, what makes them good? What are (if any) drawbacks / weaknesses in these catalogues?

DESIGN OF A CATALOGUE OF RI SERVICES

15. Focusing on the design of a catalogue, in your opinion what are the most useful elements from a user perspective? For example, a unified way of describing a service, differences in application of a particular service in different scientific domains, geographical limitations in the provision of a service.

16. From a user perspective, what are the ‘must ingredients’ in describing a service in a catalogue? For example, a level of detail each service should be described in. What would you suggest to list in the catalogue?
17. What other information you – as a user of RI services – might want to see in the catalogue alongside services? For example, is there any essential information about an RI itself that needs to be included in the catalogue of services in order to be able to understand this RI services?

CONCLUDING QUESTION

18. Would you be interested in receiving the news from the CatRIS project and in getting involved in our events (e.g. focus groups, workshops, etc.)?

Thank you for taking your time and for sharing your thoughts and experience!

Questions for RI policy makers

What is the nature and role of the institution the interviewee represents and its relationship with RIs?

1. Which aspects to you look into when assessing performance or progress of a Research Infrastructure / Core Facility? Do you look into the provision of services? If ‘YES’, please describe from which angles.
2. Actually, how do you define / describe a ‘service’ of a Research Infrastructure / Core Facility? How does “a service” differ from “resources”, “equipment”, “instrument”? How is “a service” linked to “resources”, “equipment”, “instrument”?

CATALOGUES OF RI SERVICES

3. What do you think about the catalogues of RI services?
4. Which catalogues do you mean - please provide some examples.
5. In your opinion, what makes them good? What are (if any) drawbacks / weaknesses in these catalogues?
6. What is an added value of a RI service catalogue from your perspective as a policy maker or funder?
7. Do you think it will be useful / practical to list all available services in ONE catalogue?

8. Why not?
9. What about a catalogue of catalogues principle, i.e. various RIs have their own catalogues but all of these will be linked together like in the field of hospitality where through Trivago a user can find various hotel chains?
10. How should such a catalogue be structured? E.g. based on the type of RIs, a region they operate in? Why do you think so?
11. A service catalogue can have multiple levels of services. For example, 1st level: non-scientific area-specific services that may be common to all RIs (e.g. storage service); 2nd level: non-scientific area-specific services branching out from the 1st level, that serves the purpose of defining the exact object of the service in question, e.g. data storage vs. material storage; 3rd level: scientific area-specific services branching out from the 2nd level). **In your opinion, what are the pros and cons of such levels and/or other possibilities of listing / grouping services?**
12. Should such a catalogue be thematic (i.e. according to disciplinary areas)? If yes, how could / should it fit / align with the efforts of the ESFRI cluster projects in building their catalogues?
13. Do you know of any well-functioning examples of such catalogues? If yes, in your opinion, what makes them good? What are (if any) drawbacks / weaknesses in these catalogues?

DESIGN OF A CATALOGUE OF RI SERVICES

14. Focusing on the design of a catalogue, in your opinion what are the most useful elements from a policy-maker perspective? For example, a unified way of describing a service, differences in application of a particular service in different scientific domains, geographical limitations in the provision of a service.
15. From a policy-maker's perspective, what are the 'must ingredients' in describing a service in a catalogue? For example, a level of detail each service should be described in. What would you suggest to list in the catalogue?
16. What other information you – as a policy-maker – might want to see in the catalogue alongside services? For example, is there any essential information about an RI itself that needs to be included in the catalogue of services in order to be able to understand this RI services?

STRATEGIC RELEVANCE

17. Which actions might be required by the different stakeholders (e.g. RIs, national and regional policy makers, funding agencies) to develop and make systematic use of a catalogue of RI services? For instance, in terms of legislative requirements, cross-border access etc.

CONCLUDING QUESTION

18. Would you be interested in receiving the news from the CatRIS projects and in getting involved in our events (e.g. focus groups, workshops, etc.)?

Thank you for taking your time and for sharing your thoughts and experience!

Annex 3: Agenda of the Validation Workshop

Objective

CatRIS project answers the needs of physical Research Infrastructures (RIs) in Europe by making available information on RI services via a future catalogue. This Validation Workshop gathers RI managers, selected users as well as RI funders (policy makers). It serves the purpose of discussing and refining the CatRIS concept including the typology of RIs' services that will be circulated to participants as a summary prior to the meeting.

Key questions for participants:

- Do you agree with the proposed typology of Research Infrastructures' (RIs') services, i.e. is it:
    - Comprehensive (covering broad range of RIs and scientific disciplines)?
    - Modular (can it be expanded to include further subfields)?
    - Simple to use (can it be easily operationalised in a catalogue)?
- To which extent or to which level of detail can a typology be designed in order to be useful now? Can it be useful in the near future as well, given that interdisciplinary fields are expanding, and technology is developing?
- What further improvements would be needed?

Date	**15 May 2019**
Time	**8:30 – 13:45**
Location	**THON hotel Brussels city centre** **Avenue du Boulevard 17, B-1210 Brussels, Belgium**

Time	Topic
08:30 – 09:00	**Arrival and registration**
09:00 – 09.30	**Introduction to the CatRIS project**

	Ana Helman, Science Officer/CatRIS Coordinator (ESF)
09:30 – 10:00	**Introduction: Workshop objectives and context** *Alasdair Reid, Policy Director (EFIS)* **Initial typology of RIs' services: a summary of findings** *Vladimir Cvijanović, Senior Researcher (EFIS)*
10:00 – 11:00	**Discussion**
11:00 – 11:30	**Coffee break**
11:30 – 11:45	**Case in point: Building the catalogue of the general services of RIs participating in CORBEL** *Frauke Leitner, Scientific Project Manager & Technology Advisor CORBEL and Euro-BioImaging*
11:45 – 12:30	**Discussion**
12:30 – 13:30	**Towards typology of RI services**
13:30 – 13:45	**Conclusions and next steps**