ENHANCE
European Universities of Technology Alliance

GOOD PRACTICES IN RI MANAGEMENT

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REPORT ON GOOD PRACTICES IN RESEARCH INFRASTRUCTURE MANAGEMENT

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EXECUTIVE SUMMARY

In the report, the results of the activity of Enhanceria partners within WP6 Task 6.1 *Exchanging best practices and sharing experiences on managing RIs* are presented and analyzed. The report contains a general introduction to the issues of managing RIs, provides a short glossary of terms and definitions, a short overview of the research infrastructures of Enhanceria, followed by a description of the methodology and presentation of the results.

A variety of tools have been used to gather, compare and analyze the data – workshops on managing Enhanceria's RIs (including joint work on the MIRO table), a dedicated survey on approaches to managing the RI followed by interviews with selected partners, all of these complemented by internal discussions between leaders of WP6 tasks.

The analysis of the gathered data enabled not only the comparison of different approaches to managing RI within the Enhanceria consortium but also defining a broad set of **good practices to follow** and **recommendations on RI management**, summarized in the last paragraphs of the document. The authors believe that the current version of the report might serve as a good starting point for further analysis and recommendations on Enhancerias' RI management, which is not covered by this document. The report does not provide the ultimate solutions or receipts – that would be impossible considering a variety of approaches, the specificity of individual universities, research facilities, research groups, etc. Oppositely – it summarizes the approaches, compares these, and provides a solid foundation for efficient management of RI. The good practices and recommendations formulated in the report, as a result of the joint effort of RI managers, are of a general nature and, therefore, seem to be efficiently implementable in any research infrastructure, not only in the specific RIs owned by Enhanceria partners.

1. INTRODUCTION

In the continuously evolving landscape of scientific research, the effective management of research infrastructure (RI) plays a crucial role in driving innovation, stimulating collaboration, and exchanging knowledge. Research infrastructure encompasses diverse physical, digital, and human resources that support and enable scientific investigations. These resources may include state-of-the-art laboratories, specialized service facilities (like clean-room technological labs, particle accelerators, synchrotrons, additive manufacturing facilities, etc.), specialized equipment, computing systems, data repositories, and technical and research staff as well. All of these resources require a specific approach to managing, focused not only on keeping the infrastructure up and running but also taking into account the needs and demands of RI's current and future users.

The term ***"research infrastructure management"*** might be roughly defined as the sum of all processes and actions aimed at developing and keeping the research infrastructure up and running – this covers, in particular, the RI structure, funding scheme (considered as investment, operational, and maintenance costs), sharing (understood as access to RI for internal/external partners), RI development (investments policy, road-mapping), staff management, IPR management, etc.

In general, RI management covers a number of activities related to systemic support of scientific research. It is based on the pillars of the strategic planning, coordination, administration, and optimization of resources, facilities, and services supporting research activities within the individual organization (or its part) or a broader research community composed of various research infrastructures. RI management, in a natural way, is focused on the efficient and effective utilization of infrastructure, including physical assets, equipment, technology, data, and human resources, to enable and enhance research conducted with the use of RI. By effectively managing research infrastructure, institutions can maximize the impact of their research, enhance interdisciplinary collaborations, and provide a solid foundation for scientific breakthroughs.

The management of research infrastructure requires a comprehensive understanding of the needs and goals of researchers, as well as the technical, financial, and organizational challenges. This involves developing long-term strategies for infrastructure development, upgrading or acquiring new equipment, ensuring regulatory compliance, allocating appropriate resources, and providing trainings and dedicated support for researchers and technical staff.

Research infrastructure management also encompasses the aspect of data management and preservation. With the exponential growth of research data gathered and analyzed, it is essential to establish the appropriate data management practices to ensure their integrity, security, and accessibility. This includes in particular, data storage, sharing, and compliance with ethical and legal considerations.

Furthermore, effective research infrastructure management requires cooperation and partnerships at various levels. Institutions, funding agencies, industrial stakeholders, and research teams need to work together to jointly use the resources, share expertise, and build a sustainable ecosystem that would support scientific progress and implementation of the results to the economy.

To sum up, the management of research infrastructure is a complicated task, covering various aspects like:

planning and strategy, which involves developing a coherent vision and long-term strategy for managing research infrastructure aligned with the research goals of the institution and main stakeholders; this includes in particular identifying research priorities, assessing needs and demands, and defining the roadmap for infrastructure development.

resource allocation, which focuses on allocating resources effectively to ensure optimal utilization of RI and avoid not necessary duplication; this includes in particular, budgeting, securing funding, and making decisions regarding the investments, maintenance, and retirement of infrastructure resources.

facility management, which focuses on the physical infrastructure (laboratories, specialized equipment, others) everyday management; it includes in particular, planning and designing facilities, ensuring safety and compliance with regulations, coordinating maintenance and repairs, and providing necessary support services.

technology and data management, which involves advanced technologies and large-scale data management; it includes, in particular, implementing and maintaining computing systems, data storage and sharing solutions, implementing data security measures, as well as ensuring data integrity and accessibility.

collaboration and networking, which involves fostering collaboration and networking among researchers, institutions, and industry partners; this includes active searching and establishing partnerships, sharing resources and expertise, promoting interdisciplinary research, and facilitating knowledge exchange.

training and support, which involves providing trainings, technical support, and guidance to researchers and staff members to ensure appropriate utilization of infrastructure assets; this includes in particular, organizing workshops and conferences, offering specialized training programs, and providing technical assistance for equipment and technology.

evaluation and performance monitoring, which involves the evaluation and monitoring of research infrastructure to systematically assess its impact, efficiency, and alignment with research goals; this includes in particular, defining and checking key performance indicators (KPIs), gathering user feedback, conducting impact assessments, and using the gathered information to improve infrastructure management strategies.

In this document on best practices in RI management, we explore the key principles, challenges, and best practices associated with managing research infrastructure within the Enhanceria consortium.

2. DEFINITIONS

Discussion of the research infrastructure management requires a common language of communication. Therefore, in this chapter, definitions, and explanations of the selected terms related to research infrastructure management are provided. The terms are focused on technical aspects of research infrastructure, mainly covering the classification of RI elements, and might be considered as the first set of a glossary, which might be further developed to take into account also other aspects of RI management and efficient utilization.

Please note that the definitions provided here are for informational purposes and may vary depending on specific contexts and interpretations. This glossary aims to serve as a starting point for further exploration and understanding of research infrastructure management. Each term provided below is accompanied by a concise explanation to provide a clear understanding of its meaning, as it will appear in the following sections of the document.

Research Infrastructure

European Commission, in the documents on research and innovation strategy, defines the **research infrastructure** as "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. They include major scientific equipment or sets of instruments; collections, archives or scientific data; computing systems and communication networks; any other research and innovation infrastructure of a unique nature open to external users."[1]. In this document, the term "research infrastructure" will be understood according to this exhaustive definition.

Core facility

A core facility, also known as a shared resource facility or a research support facility, is a specialized research facility or service center that provides access to advanced equipment, technical expertise, and specialized services to support scientific research. Core facilities are typically established within academic institutions, or other scientific/research organizations.

The primary purpose of a core facility is to provide researchers with access to specialized resources and expertise that may not be readily available within their own research groups or departments. The core facility houses state-of-the-art equipment, technologies, and infrastructure that are typically expensive to procure and maintain. By centralizing these resources and services, core facilities enable researchers from different disciplines and departments to access and utilize them efficiently.

[1] https://research-and-innovation.ec.europa.eu/strategy/strategy-2020-2024/our-digital-future/european-research-infrastructures_en

Apart from providing access to equipment and technologies, core facilities typically offer trainings, consultations, experimental design assistance, and data analysis support, thus playing a crucial role in promoting collaboration and interdisciplinary research and enhancing the overall research capabilities of an institution or research ecosystem.

Research Centers

These are dedicated research units or organizations that focus on specific scientific disciplines, thematic areas, or interdisciplinary research. Research centers typically have their own specialized facilities, equipment, and expertise and may collaborate with researchers across institutions.

Technology Transfer Offices

These offices facilitate the transfer of technology and knowledge generated through research to industry, commercial entities, or other applications. They provide support in areas such as intellectual property protection, licensing, industry partnerships, and commercialization of research outcomes.

Data Centers

These facilities specialize in storing, managing, and analyzing large-scale scientific data. Good examples are the fields of genomics, bioinformatics, medicine, climate research, and astronomy. Data centers provide the necessary infrastructure, expertise, and tools for data processing, curation, and sharing among researchers.

Research Support Units

These units are specialized teams or departments within research institutions that provide various support services to researchers. Examples include statistical consulting, research ethics and compliance, research administration, project management, grant writing support, and scientific writing and editing services.

Research Libraries

These libraries offer comprehensive collections of scientific literature, journals, databases, and other reference materials to support research activities. They may also provide specialized services such as literature searching, document delivery, and data management support.

Instrumentation Facilities

These facilities focus on providing access to specific scientific instruments or equipment, such as electron microscopes, nuclear magnetic resonance (NMR) machines, X-ray diffraction systems, or specialized laboratory setups. Instrumentation facilities often offer technical training and support for utilizing the equipment effectively.

3. AIM AND SCOPE OF THE REPORT

This report is focused on comparing the approaches to managing Research Infrastructures among the members of the Enhaceria consortium. Members of the Enhaceria are from different parts of Europe and differ in organizational culture, approach to solving problems, relationships with the external community, etc. Therefore, comparing the approaches to managing RI might provide added value to the consortium, resulting from different experiences, environments, and policies.

In the following parts, the different approaches are analyzed and compared based on information gathered during the Enhaceria workshops, the survey on managing RI, and interviews with selected partners. As a result, the best practices in the management of research infrastructures are formulated and discussed in the context of future implementation in the consortium.

4. RESEARCH INFRASTRUCTURES OF ENHANCERIA

The most important research infrastructure of Enhanceria was identified within Task 2.5 of WP2, focused on mapping research infrastructures (RIs) at the Alliance level and comparing definitions and management systems for user access and research data. The results were presented in the report on deliverable *D2.5 Report on mapping activities and main findings on the RI portfolio within the alliance*. As a result, 50 research infrastructures were identified and described, enumerated below.

POLİTECNİCO Dİ MİLANO, POLIMI (10)

1. CFDHub@Polimi - Computational fluid dynamic laboratory
2. DriSMi - Driving Simulator Politecnico di Milano
3. CUSBO - Center for Ultrafast Science and Biomedical Optics
4. LaborA – Physical and Virtual Modelling Laboratory
5. LPM - Materials Testing Laboratory (Laboratorio Prove Materiali, Strutture e Costruzioni del Politecnico di Milano)
6. PoliFAB - Micro & Nanotechnology Center of Politecnico di Milano
7. SOLINANO-Σ LAB - Solid-Liquid Interface Nanomicroscopy and Spectroscopy Lab
8. GVPM – Wind Tunnel
9. CIRC EV - Circular Factory for the Electrified Vehicles of the Future
10. LaST – Transport Safety Lab: Passive safety + Active safety

NORWEGİAN UNİVERSİTY OF SCİENCE AND TECHNOLOGY NTNU (12)

1. Centre for Advanced Structural Analysis (CASA); Fluid Mechanics Laboratory and Wind Tunnel
2. NMR Laboratory (NNP node)
3. Norwegian Laboratory for Mineral and Materials Characterisation (MiMac)
4. Norwegian Manufacturing Research Laboratory (ManuLab)

5. Norwegian Micro- and Nanofabrication Facility (NorFab/NTNU NanoLab)
6. NTNU SeaLab
7. The Applied Underwater Robotics Laboratory (AURLab)
8. The European CCUS Research Infrastructure (ECCSEL)
9. The National Laboratory for Age Determination
10. The Norwegian Centre for Transmission Electron Microscopy (NORTEM)
11. The X-ray Physics Laboratory (NEXT node)
12. X-ray powder diffraction laboratory (RECX node)

CHALMERS UNİVERSİTY OF TECHNOLOGY (10)

1. Chalmers Materials Analysis Laboratory
2. Chemical Imaging Infrastructure
3. Chalmers Mass Spectrometry Infrastructure
4. Computational Systems Biology Infrastructure
5. Kollberg Laboratory
6. Chalmers Nanofabrication Laboratory
7. Onsala Space Observatory
8. REVERE Chalmers
9. Chalmers e-commons
10. Aldenhoven testing center

UNİVERSİTAT POLİTÈCNİCA DE VALÈNCİA, UPV (11)

1. Servicio de Microscopía Electrónica (Electron Microscopy Service)
2. Radiation Service (Servicio de Radiaciones)
3. UPVFab (UPV Clean Room)
4. Photonics Laboratory (iTEAM, UPV)
5. Calibration Service (UPV)
6. Bioinformatics & Genomics Service (COMAV, UPV)
7. Micro/Nano Fabrication Facilities of the Nanophotonics Technology Center (NF-CTN) of the UPV - (Micro and Nano-Fabrication Clean Rooms Network- MICRONANOFABS)
8. Engine Test Benches (CMT-UPV)
9. Institute Of Plant Molecular and Cellular Biology (IBMCP)
10. ESA-VSC High Power Radio Frequency Laboratory
11. ESA-VSC High Power Space Materials

RWTH AACHEN UNİVERSİTY (2)

1. Ernst Ruska-Centre for Microscopy and Spectroscopy with Electrons
2. Competence Center NGP² Biorefinery

TECHNICAL UNIVERSITY OF BERLIN, TUB (2)

1. Mineralogical & Geochemical Micro-Analytical Laboratory (MAGMA Lab)
2. Center for Electron Microscopy (ZELMI)

WARSAW UNİVERSİTY OF TECHNOLOGY, WUT (8)

1. Integrated Photonic Laboratory (Research Centre FOTEH of the Faculty of Electronics and Information Technologies)
2. Experimental semiconductor pilot line (Centre for Advanced Materials and Technologies CEZAMAT)
3. Laboratory of Medical Biotechnology (Centre for Advanced Materials and Technologies CEZAMAT)
4. Laboratory for the synthesis of polymers and chemical compounds on a semi-technical scale (@Faculty of Chemistry)
5. Laboratory of Electron Microscopy for Materials Structure Characterization (EMMS)
6. Nanoelectronics Laboratory (Faculty of Physics)
7. Antenna Laboratory (Research Centre FOTEH of the Faculty of Electronics and Information Technologies)
8. Integrated line for manufacturing and characterization of prototype printed electronics devices (Center for Advanced Materials and Technologies CEZAMAT)

The survey on managing the research infrastructure and best practices at different universities, the workshops, and interviews have been addressing the selected examples of the RI enumerated above, represented by their managers (understood as a person in charge, irrespective of the formal background, education, official name of the position, etc.)

5. METHODOLOGY

The purpose of the report is to present to a wide range of interested parties the best solutions implemented in the field of research infrastructure management by members of the ENHANCE Alliance. A decision was made to collect data using qualitative methods, i.e., the interpretative paradigm in the methodology of management sciences. Methodological inspirations were drawn from qualitative sociology, anthropology of organization, and grounded theory.

It should be borne in mind that the purpose of the study was not (and could not be due to limited possibilities) to describe the issues of research infrastructure management fully. The conclusions drawn from the collected information are not representative for the entire European science sector or even for all processes carried out at the universities forming the ENHANCE Alliance. The purpose of research conducted in the qualitative paradigm is not to establish numerical or statistical facts but to illustrate the diversity of approaches and create a typology of models implemented in a given area. The goal is, therefore, to describe different ways of operating, and the study can be considered completed when the tested sample is saturated, i.e., when subsequent examined cases no longer bring new information about the collected resource.

The methodology inspired by organizational anthropology typically uses the following data collection techniques: participatory observation, in-depth interviews, analysis of existing documents, and various forms of field research. Poly-methodical approaches are also characteristic for management sciences. Management sciences have yet to develop their methodological workshop but borrowed methods from other sciences at the present stage. Management sciences are multidisciplinary, and so must be its methods. For this reason, for the needs of the report, it was decided to use techniques characteristic of quantitative social sciences, such as surveys. However, it should be noted that the purpose of the survey was not to determine the statistically significant values of the examined variables but to make a preliminary diagnosis of the researched area.

In the study conducted for the purposes of this report, a number of data collection techniques were used, starting with introspection, through a specific type of field research conducted during Alliance meetings and workshops, a survey addressed to Alliance members, in-depth interviews, and following case studies. The method of using each subsequent technique was conditioned by the results obtained using the previous one. The previous experience of the people conducting the study is important for the result of the study. According to the interpretive paradigm's fundamental assumption, no objective scientific method would make the research result independent of the researcher's uniqueness. This approach forces the researcher to be self-aware and self-reflexive. In the conducted study, the experience of the authors of the report was used to prepare the first version of the survey, the purpose of which was to initially identify the ways of operating in various areas related to research infrastructure management.

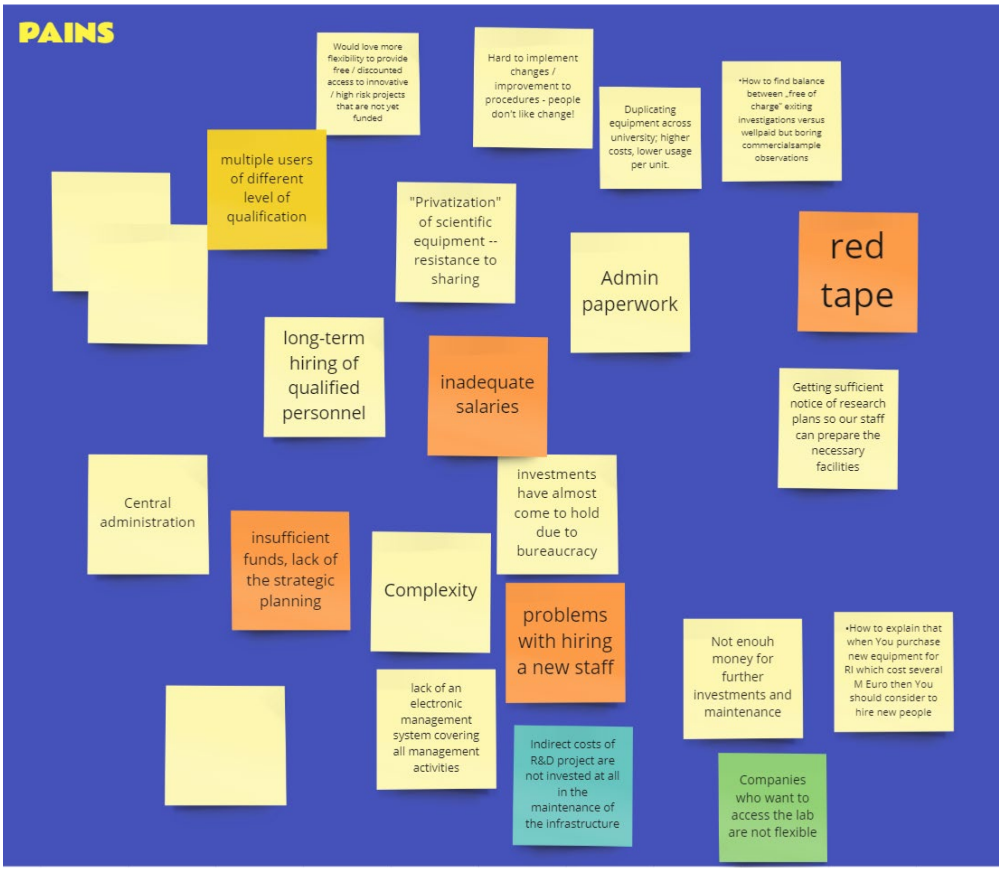
The survey was conducted from May 26 to June 12, 2023. The survey contained 33 questions in total, including eight open questions. The questions concerned the following areas: availability of research infrastructure to the external user, electronic management systems, professional managers, funding, development strategies, pricing, and recommendations. 13 respondents took part in the survey. The survey was conducted on-line using MS Forms. The average time to complete the questionnaire was about 70 minutes. As a result of the survey, approximately 18,000 signs of recommendations and comments were obtained. The survey was not anonymous, all respondents agreed to participate in an in-depth interview, the purpose of which was to deepen the particularly interesting threads that appeared in the answers to the survey questions.

Between 21 June and 13 July, in-depth interviews were conducted, the purpose of which was to deepen the answers obtained in the survey. The interviews lasted 30 to 45 minutes and were performed according to a script prepared separately before each interview. Particular attention was paid to deepening issues related to the commercial use of infrastructure, activities aimed at intensifying the commercial use of infrastructure, software supporting infrastructure management, and the nature and tasks of staff employed to manage infrastructure.

The results of the interviews are presented briefly in the "Case studies" section. The descriptions are not exhaustive case studies, but they indicate the most interesting or distinguishing aspects of the operation of the individual infrastructures.

WORKSHOPS

Within the reported period, two workshops on managing research infrastructure were organized. During the first workshop in Milan (21-22 March 2023), the general discussion on RI management issues took place based on the presented examples of RI of PoliMi, WUT, NTNU, and UPV (in total, 14 infrastructures have been presented). It enabled the first comparisons of the different approaches to the management of the scientific infrastructure and detailed discussion on the form of the survey planned to be launched between the workshops. The final version of the survey was launched on 8 May 2023, prior to the second workshop, which took place on 31 May 2023. The second workshop, apart from another five presentations of RI of Enhanceria (by WUT, PoliMi, and UPV), was focused more on the discussion of challenges related to managing the research infrastructure, both with respect to internal and external issues. The most important part was the joint exercise on pains and good practices in managing RI, organized using the MIRO board (available to participants during and after the workshop). The pictures below show the inputs provided by managers and other participants of the workshop, which have been then used as additional material for the analysis described in the next chapter and for final conclusions on best practices and recommendations.

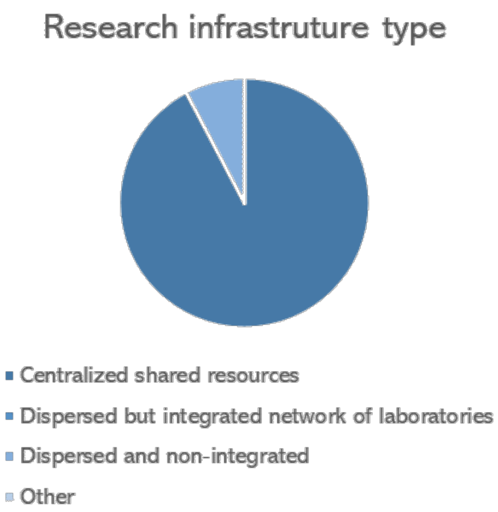

PAINS
Would love more flexibility to provide free / discounted access to innovative / high risk projects that are not yet funded
Hard to implement changes / improvement to procedures - people don't like change!
Duplicating equipment across university; higher costs, lower usage per unit.
•How to find balance between „free of charge" exiting investigations versus wellpaid but boring commercialsample observations
multiple users of different level of qualification
"Privatization" of scientific equipment -- resistance to sharing
Admin paperwork
red tape
long-term hiring of qualified personnel
inadequate salaries
Getting sufficient notice of research plans so our staff can prepare the necessary facilities
Central administration
investments have almost come to hold due to bureaucracy
insufficient funds, lack of the strategic planning
Complexity
problems with hiring a new staff
Not enouh money for further investments and maintenance
•How to explain that when You purchase new equipment for RI which cost several M Euro then You should consider to hire new people
lack of an electronic management system covering all management activities
Indirect costs of R&D project are not invested at all in the maintenance of the infrastructure
Companies who want to access the lab are not flexible


GOOD PRACTICES & DREAMS
evaluate and update the infrastructure's equipment, software, and systems
Look after good employees and make sure they are happy!
Developing a clear strategic plan for the research
Implement quality assurance processes
well defined roles and resposnibilities
Invest in training and professional development opportunities for staff members
You have to love Your job
Standardized pricing/cost calculation, ideally on national (even international) level
Developing good financial plan
Support and engage the community
Developing joint projects, knowledge exchange, and shared infrastructure initiatives
Guidelines for the R&D personnel
promote open access, data sharing, and long-term preservation
Reduce complexity of procedures for access. Clear guidelines are crucial.
Seek for feedback and colaborations
Find funding sources
Dedicated IT tools and resources
Experienced staff
automatic monitoring and evaluation of data for quality measures and scientific results
state-of-the-art or unique workstations
Cyclic events promoting the RI
Developed back-office
more support from administration (without complicating processes)
buy what you need (today's situation: even if there is money, it is spent according to bookkeeper's list not according to research/technological needs)
Create an environment that fosters innovation, creativity, and collaboration among researchers utilizing the infrastructure.
standardization and quality tests of running workstations
long term roadmap
Contract templates with slightly negotiable terms

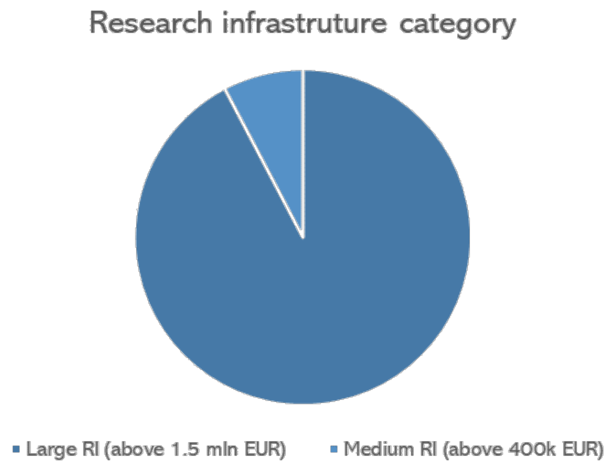
ANALYSIS OF THE SURVEY

General characteristics of the sample

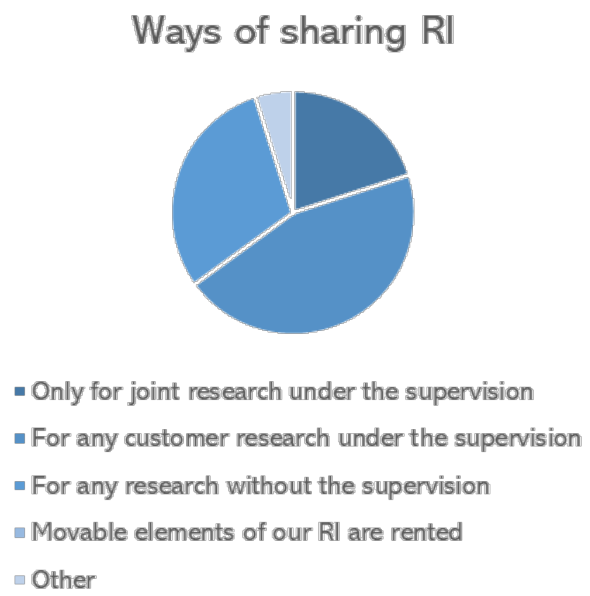
12 respondents representing 13 different facilities from 4 different institutions took part in the survey (an additional one was added in the interviews phase). The sample was not diversified in terms of the size and type of represented infrastructure. 12 out of 13 respondents described their research infrastructure as a centralized shared resource accessible to all research teams under internal agreements. Only one was described as dispersed and non-integrated (each element of RI is an exclusive property of individual research team/institute/faculty, with no general sharing rules). Other options available in the survey (dispersed but integrated network of laboratories – no common management system, but a full flow of information about resources and clear sharing rules; other) were not chosen by any respondent.



Infrastructures are also not differentiated in terms of the cost of their creation. 12 out of 13 are large infrastructures. The cost of their construction amounted to over EUR 1.5 million. One respondent described their infrastructure as a medium. Its cost was less than EUR 1.5 million but more than EUR 400,000. This is not the same infrastructure that was described as distributed in the first question.



All infrastructures make their services available to external users, but different forms of sharing have been identified. It was possible to indicate more than one answer to the question. Nine respondents answered that the infrastructure can be made available for any customer research under the supervision of RI's employees. In six cases, it is possible to use it for any research conducted by the customer without the participation of RI's employees. Four infrastructures can only be used for joint research under the supervision of RI's employees. No one of them rents movable elements of RI outside RI's premises.



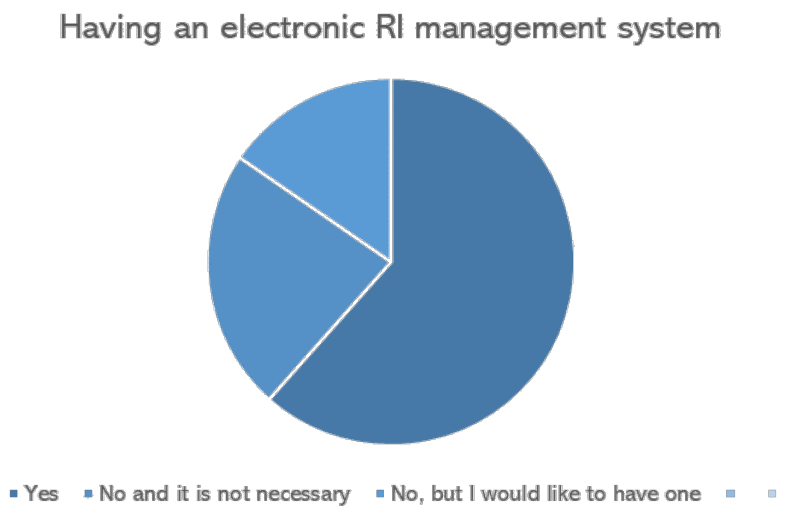
Recommendations on the development of ways of sharing infrastructures

The optimal way of making research infrastructure available to external users requires many conditions to be met. Among the recommendations formulated by the respondents, the following opinions appeared most often:

1. The condition for maximizing the use of research infrastructure by external users is the adoption of **clear rules** and guidelines for providing access to external users provided by the university authorities,
2. It is advisable to use **standardized contracts** (however negotiable), **standardized prices** of the lab access or rental of the equipment,
3. Employment and wise training of **staff** involved in providing access to the infrastructure
4. Organization by the authorities of institutions of cyclical (not one-off) **trainings** and **seminars** pinning the possibilities and rules of making infrastructure available
5. Developing **modern forms** of sharing, especially remote sharing
6. **Expanding services**, including expert information for potential users about the possibilities of obtaining funding for their research
7. Creating a **network of institutions** and disseminating information about the owned infrastructure.

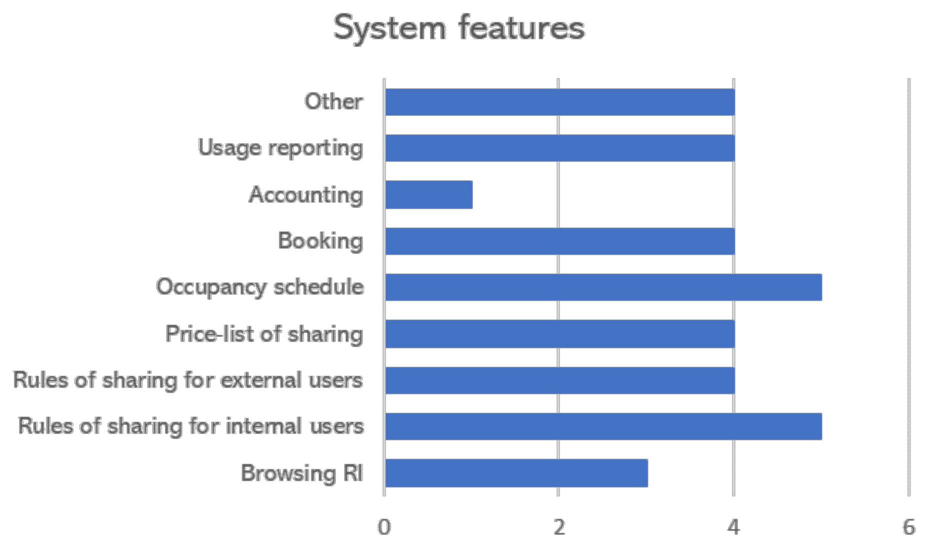
Electronic research infrastructure management systems

Eight respondents replied that their institution uses an electronic management system. Five respondents replied that their RI did not have such a system, but two of them would like to have one. Three respondents considered such a system unnecessary.



Five institutions developed their own system, three uses commercially available systems. These are:

1. **BookItLab** offered by Prog4biz Ltd., the system is widely used by universities and companies around the world, including Stanford University and Unilever (https://bookit-lab.com/),
2. **Myfab LIMS** offered by The Swedish Research Infrastructure for Micro and Nano Fabrication (http://www.myfablims.com/),
3. **ARIA** offered by Instruct-ERIC, developed in the framework of an EU project, the system provides cloud services (https://aria.services/).



The systems used offer various functionalities. Of the eight systems used, none has all the features asked for in the survey. Most often, the systems have the following characteristics: rules of sharing for internal users, rules of sharing for external users, pricelist of sharing, occupancy schedule, booking and usage reporting. Less often systems allow browsing RI and accounting (only one of eight).

The general opinion expressed by the respondents is unambiguous - it is not possible to manage a large research infrastructure without an electronic system with specific features. Implementation of an electronic system saves a lot of time previously spent on administrative tasks. Particularly valuable are the functionalities of automatic billing and invoicing (however only one system described by the respondents has this feature).

Among the features that the owned systems do not offer but which would be valuable, the following were most often mentioned:

1. up-to-date catalog of labs and equipment (both those combined in e.g., technology lines and complex measurement setups as well as stand-alone devices)
2. up-to-date catalog of the research groups operating in these labs on a daily basis
3. references to the scientific articles that are a "product" of the research conducted by the research groups active in the labs
4. repository of documents (contract templates, price list, rules, and terms of access/rental)
5. CRM system
6. repository of scientific data obtained in the labs
7. possibility to set restrictions on bookings as necessary (require user training, minimum/maximum reservation time)
8. automated invoicing.

The potential for the integration of an RI management system with systems such as a knowledge base on scientific achievements looks particularly interesting. Such solutions will become part of the process of deep digitalization of science and integration of many systems into one in the near future.

Research infrastructure management specialists

Seven of the twelve facilities employ specialists in infrastructure management. Everyone is satisfied with their work, and with that the institution allocates a budget for their salaries. Five infrastructures do not employ such specialists, of which two consider such a situation to be correct, and three would be happy to employ such a person.

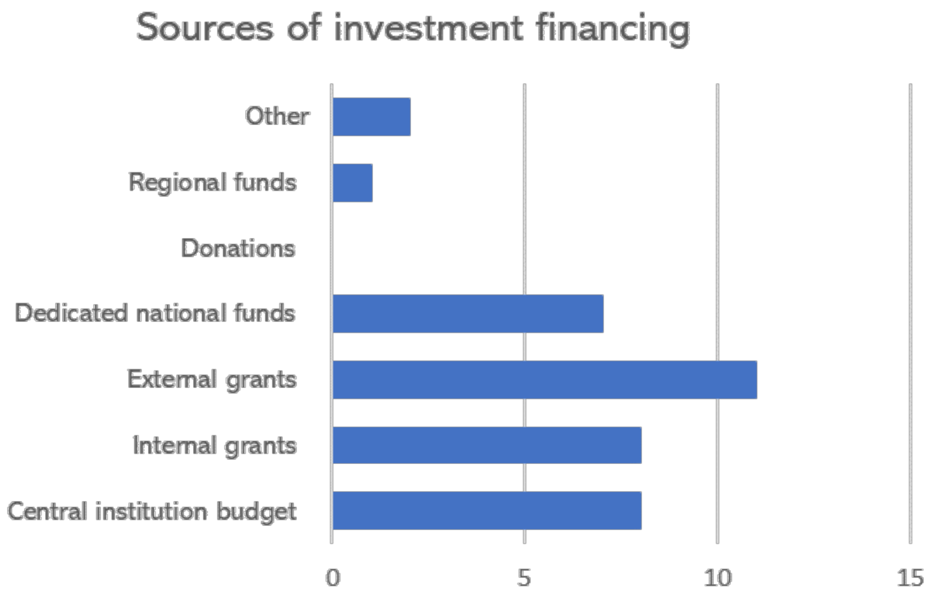
The most important skills of people employed as RI management specialists include:

1. technical and research skills
2. engineering background (MSc or PhD degree preferred)
3. long-term experience in the usage of laboratory facilities (as a junior engineer, a senior engineer, or a manager of a single lab)
4. broader (than purely technical) view on the topic of management (e.g., by successfully following a course/training/study on management, etc.)
5. open-minded and assertive approach
6. fluency in English
7. management skills related to leading, motivating, and communicating with people
8. commercial/financial awareness
9. forward planning and strategy
10. effective decision making
11. ability to compromise and find solutions when necessary but still be firm when the rules cannot be broken or bent.

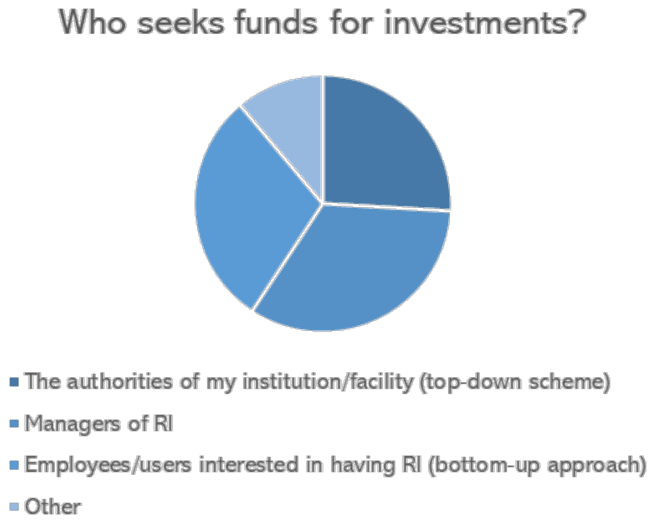
The overall conclusion is that having scientific experience is beneficial for those who perform RI manager tasks. Usually, such people are effectively recruited from a group of former researchers who complement their competencies in the area of management and soft skills.

Financial aspects of research infrastructure management

The surveyed institutions raise funds for investments from various sources. Among the most frequently mentioned are external grants (policies of European countries seem to be consistent in this area). The second source is the budgetary funds of the institution - the central budget and/or internal grants. None of the respondents indicated donations as a source of financing for investments.



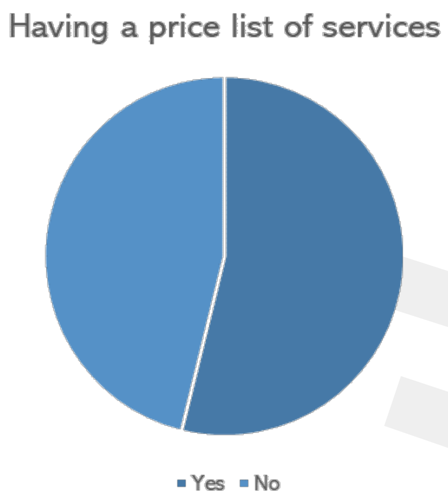
The answers to the question about persons responsible for seeking investment financing supplement the section devoted to professional managers. The management specialists were the most often indicated as the persons responsible for searching the sources of investment financing. In seven cases, the respondents indicate the authorities of their institutions as responsible for seeking investment financing. In eight cases, responsibility also lies on the researchers associated with the infrastructure or directly benefiting from RI’s potential.



One of the biggest problems faced by large infrastructures related to universities is the change in the operating model. In accordance with the modern approach, the use of infrastructure is paid not only for external but also for internal users. For many university employees, this is incomprehensible and requires detailed communication of the reasons.

An equally big problem is the commercial use limits set by the institutions financing the investments. Financing the maintenance of infrastructure in most cases is assessed as insufficient, and at the same time exceeding the limit of commercial use is against the regulations.

The answers provided in the survey show that the correct direction for transforming financial systems is their centralization combined with high transparency and stability. A key role in the stability of the facility's finances (and its attractiveness to commercial customers) has a stable and transparent price list. Seven out of 13 respondents answered that their RI has a price list. However, there is no doubt that they consider having a stable and transparent price list as fundamental for cooperation with external users.



At least two pricing methods have been found for the services offered. The most basic method is the cost-driven method, according to which the prices of services are set in relation to the value of the equipment owned and the costs of their operation. Alternatively, it is possible to use the market-driven method, which consists in setting prices for services provided by similar infrastructures. The market-driven method is not applicable to highly unique facilities. The cost-driven method fails in a situation where it is difficult to determine the value of equipment or to settle operating costs.

Challenges, pains, and areas to be developed

The investigated researched infrastructures are developed in different countries, under slightly different regulations, and therefore in different conditions. This is evidenced by the diversity of opinions on the biggest challenges for their managers. The main problems mentioned are summarized below. Please note that what is a problem for one facility may not be a problem for others. The following points are by no means a list of common problems.

1. **Public procurement**. Overly defensive approach compared with peers. Excessive formal requirements consume a lot of resources
2. **Employing non-scientific personnel**. Universities are the only employers for researchers, but support employees have much more competitive offers outside the research sector.
3. **Internal differences in approach to management**. It is useful to centralize the approach so that different infrastructures within the same institution work in the same way
4. With the growing number of external users paying market fees for the use of services, it requires increasing the **efficiency of support processes** – public procurement and settlement of services.
5. Searching for **financing to maintain and develop** the existing infrastructure poses major problems. One should start thinking about investing in people whose duty would be to look for new sources of financing.
6. The importance of **communication and the promotion of infrastructure** is growing. It is necessary to ensure that all potential users are aware of the offer that they can take advantage of.
7. The **pace of digitalization of RI management** is too slow. The use of computer resources and systems is fundamental to the efficiency of managing and providing infrastructures. Computerization needs to happen at a faster pace.

Recommendations and thoughts on best practices

Respondents made many recommendations based on their own experiences. Recommendations cover a variety of issues - from attempts to influence state policy to detailed technical solutions valuable to less experienced managers. Below, we present the collected recommendations in the form of short suggestions:

Run your facility like a company, not a research project! Don't forget that infrastructure management is not the same as research project management.

Be aware of your goals - scientific and commercial! The key to success is to consciously balance the various forms of using your infrastructure.

Standardize everything! Having clear rules, standardized templates of contracts, and fixed price lists is a key success factor. The implementation of the electronic management system could be very helpful.

Take care of internationalization! Collaborating with researchers from other countries is a chance to learn what approaches to resource management are being implemented by others.

Make your finances transparent! You need to know where funds are coming from and where exactly they are spent in order to keep them in sustainable balance.

Call your institution to ensure a high level of independence for RI management! This will allow you to be flexible enough in carrying out operations to ensure your success.

Encourage collaborations between all the laboratory users! It is a simple way to achieve synergy.

Debrief after test activities! This permits us to identify strategies to manage possible critical situations in tests both concerning the technical and the organizational point of view.

Keep an eye on the new technologies offered by the market! It will allow you to provide new set-ups to upgrade the quality of the tests performed.

Push your institution to coordinate a management approach! It is important in order to increase the potentiality of the RI in terms of funding, networking and shareability.

Talk to your users! Strong coordination with the research groups representing the typical users in order to adapt the services provided to the real needs is strongly advised.

6. CASE STUDIES

Following the survey and discussions during the two workshops, the selected RIs were subjected to individual interviews, deepening the subject and providing a broader picture of RI management problems and challenges.

CEZAMAT

POLITECHNIKA WARSZAWSKA

The Centre for Advanced Materials and Technology (CEZAMAT) is one of the largest R&D investment projects in high technology in Poland. The project, co-financed by the European Union, set up laboratories equipped with state-of-the-art facilities and the necessary infrastructure. The main objective of the CEZAMAT project was to create a platform that integrates the research community and enables the interdisciplinary development of research on modern materials and technologies. Thanks to the new research infrastructure and integrated research programs, it is possible to conduct joint scientific research and development at the highest level and to popularise and implement modern technologies.

A key objective of CEZAMAT is to transfer advanced technologies and commercialize the developed ideas. The Centre promotes cooperation between the Mazovian and national scientific and research centers and businesses and supports activities for the region’s development.

CEZAMAT is a centralized shared resource accessible to all research teams under internal agreements. It is a large RI and is available to external users but primarily exclusive for joint research under the supervision of the facility’s employees.

In the first period of operation of the facility, strictly regulated by the guidelines of the financing institution, commercial use amounted to approximately 15% in terms of the working time of the equipment. After the end of the period in which the limits resulting from the nature of the source of financing were in force, commercial use increased to approx. 25%. Another 50% is the use of infrastructure for implementing projects carried out by WUT teams in cooperation with business partners. The share of commercial activity will increase for two reasons. The stream of funding for R&D in the new EU financial perspective has been redirected to entrepreneurs, and on the other hand, CEZAMAT is completing the certification of laboratories in the field of pharmaceuticals and genetics, which will contribute to increasing interest from enterprises in this sector.

CEZAMAT employs two people who carry out sales activities. They are looking for potential customers, especially for the bio-tech-med sector. The price list of services is created using the cost method. Its use is possible thanks to extensive cost analysis.

CEZAMAT uses an in-house-developed electronic system – very specific and meeting the expectations and needs of the laboratory complex. CEZAMAT LIMS has many features of similar systems but has also been strongly integrated with the building automation management system. The system is not available to external users because CEZAMAT, as a rule, does not provide access to devices, but it offers comprehensive research and research and development services.

The biggest problems are high fixed costs, as well as the scale of development needs. The accumulated infrastructural base exceeds the needs of the university itself, which means that active state policy supporting the full use of its potential would be necessary for its development.

polifab POLITECNICO DI MILANO

Polifab is the micro- and nano-technology center of the Politecnico di Milano created to provide the highest technological standards for a wide range of applications and processes involving all the Key Enabling Technologies: photonics, micro and nanoelectronics, biotechnologies, advanced materials, and nanotechnology. The main mission of Polifab is to provide technology infrastructure, high-technology tools, and know-how supporting research from proof-of-concepts on materials science and devices to fast prototyping for industrial applications.

PoliFAB is a centralized shared resource accessible to all research teams under internal agreements. It is a large RI and is available to external users: for any customer research under supervision and for any research conducted by the customer without supervision.

About 50% of RI's working time is used by external institutions, including 23% by companies that conduct industrial research. Polifab has clear and permanent rules of access to the infrastructure, both for internal and external users. In the opinion of the facility management, the clarity and availability of the price list is fundamental for the success of the infrastructure. Prices for third parties are higher than for internal users, to whom the access is provided on a flat fee basis. Among enterprises, typical users of infrastructure are spin-off companies established at PoliMi and companies of the Regione Lombardia.

Polifab does not pursue an active sales policy but actively disseminates information about the service offer (also within PoliMi to keep all university employees aware of the opportunities that Polifab provides).

The prices of research services and shared infrastructure have been set in the market-driven model. The method of linking the prices of services with the cost of acquiring equipment could not be applied in the case of Polifab because a large part of the equipment was obtained by donation, not purchase. It was also possible to compare prices with other laboratories in Europe with similar characteristics.

Polifab has five persons of permanent staff, including one acting as infrastructure manager (a former researcher with a Ph.D. in material science and research experience, which is beneficial for the tasks he performs).

Polifab uses an electronic system developed at the university to manage the infrastructure. Its most important and appreciated function is booking. Having such a system is significant for the efficiency and effectiveness of infrastructure management. The system enables in-depth analysis of the use of devices and also allows the sharing of data obtained through the use of devices.

The fundamental problem that Polifab struggles with is the lack of physical space. The success of Polifab and its popularity means that the space allocated for it at the beginning (in 2015) is no longer sufficient today. The high maintenance costs of the equipment are also, to some extent, problematic.

Both interviewed managers pointed out that it is valuable for large infrastructures to have office space in close proximity to laboratories. It is worth remembering that working in a large infrastructure also requires room for work. Its proximity also allows users to contact other researchers, which is of additional value.

An important success factor for a large infrastructure, as mentioned by Polifab managers, is the ability to create a network of users (specifically important are internal users). Polifab successfully developed a network of research teams of Politecnico di Milano using its laboratories, which means that from the perspective of the academic community and university authorities, the investment in Polifab is clearly successful.

NTNU

NTNU SeaLab is a multidisciplinary facility for research requiring access to fresh- or seawater. The scientific focus areas include sustainable aquaculture, environmental and trophic interactions, and marine technology. SeaLab has a range of highly specialized scientific equipment, including custom-built rearing tanks for a fish fry with automated feeding, respiration chambers for physiological research on fish, and a number of flexible climate-controlled rooms. SeaLab also has a unique culture of the marine copepod Calanus finmarchicus that can be used for a wide range of experiments.

SeaLab is a centralized shared resource accessible to all research teams under internal agreements. It is a large RI and is available to external users: for any customer research under supervision and for any research conducted by the customer without supervision.

In accordance with the rules established in Norway, for infrastructure created with the use of public funds, SeaLab allocates no more than 20% of its capacity to commercial services (assuming the use of devices for 7 hours a day). All users use the infrastructure for a fee according to the price list. External users incur costs approximately 15% higher than internal users. SeaLab does not conduct specialized sales activities but actively promotes its services, among others, during the industry fairs held in Trondheim (SeaLab's location).

SeaLab employs one infrastructure management specialist who is the first point of contact for external users. The task of a person in this position is to recognize the needs of a potential customer. At a later stage of cooperation, customers already use the electronic system for booking and settling services provided by SeaLab. Automatic invoicing, which has significantly simplified the financial handling of services, is indicated as one of the most important advantages of the system. The system is used not only in SeaLab, but also in other infrastructures operating within NTNU. The advantage of centralizing IT support is common knowledge of how the booking system works across the university.

The biggest challenge for SeaLab was the implementation of a new model of operation, assuming paid use of the infrastructure also by internal users, which is sometimes difficult for employees to accept. It is also difficult to correctly communicate justifications for administrative procedures. For many employees, the procedures are a hindrance, but implementing them is necessary due to, among others, animal welfare, which SeaLab is obliged to provide.

UPVfAB

UPVfab is a clean-room facility for micro- and nano-fabrication, designed to support R&D works at TRLs up to TRL 5/6. It operates within Universitat Politècnica de València, a leading Spanish university with world-wide reputed groups in the fields of telecom and datacom, instrumentation, environmental sensing, chemistry, bio/life sciences, food & drug analysis, to enumerate the most important. The facility’s core is constituted by a 500 m2 class 100-10000 (ISO-5/7) 6'' MEMS pilot line clean-room originally established by Siliken company. Since 2018, the clean room is operated by UPV personnel as UPVfab.

According to the information gathered, UPVlab is a dispersed but integrated network of laboratories (no common management system, but a full flow of information about resources and clear sharing rules). As declared, it is a medium-scale RI (however, the replacement value would suggest large-scale, as the more appropriate classification) and is available for any customer research conducted under supervision and for external users bringing their own equipment to UPVlab as well.

UPVlab has its own fixed price list with three client categories differing in pricing levels. The lowest one is intended for internal users. The medium one is for spin-offs and small and medium enterprises (SMEs). The highest level is for external users and large companies. The price list is relatively complex, but generally, the lowest prices are half the medium, and the highest prices are twice the medium. All prices are negotiable.

UPVlab does not employ dedicated RI managers, all infrastructure is managed by researchers (however, there is a person in charge). UPVlab uses a MyFab LIMS system mainly for booking and as a first line of contact with users. It also uses several internal electronic systems to manage infrastructure maintenance and process operations. The main challenge indicated is to integrate all subsystems so that all functions can be found in one place.

The source success of UPVlab-like RIs is the precise knowledge and clear vision of their goals. Also – based on experience of UPVlab – it is very beneficial to develop clear and unambiguous templates of contracts with partners very quickly at the beginning of the business. This significantly improves the efficiency of bureaucratic procedures.

RWTH AACHEN UNIVERSITY

Since spring 2017, the six process engineering chairs at RWTH Aachen University share laboratories, offices, and conference rooms under the roof of the Center for Next Generation Processes and Products (NGP²), situated at the RWTH research campus Melaten. The multi-disciplinary environment at NGP² enhances academic exchange and creates a perfect platform for cooperation with partners from universities and industry.

The biorefinery is the heart of NGP²: a 680 m² large pilot plant area offers room for a modular set-up, which enables processes from 25 - 150 l batch volume. The biorefinery has got modular equipment for the technical conversion of biomass into chemicals: reactors for biomass conversion (50 l, batch and continuous, up to 25 bar/200 °C), fermenter (100 l, batch and continuous, up to 10 bar) and apparatus for filtration, membrane separation, extraction, crystallization, chromatography, and distillation.

The biorefinery is a centralized shared resource accessible to all research teams under internal agreements. It is a large RI and is available only for joint research under the supervision of its employees. It operates as a research partner rather than a service provider. Due to national regulations, the biorefinery does not provide external entities with services with IPRs fully transferred to the client. Due to the implementation of such a model of cooperation with external entities, the biorefinery does not have a fixed price list but has a cost monitoring system that can be used to calculate the full operating cost for individual equipment. This is the basis for the requested cost.

The most important success factor for large infrastructure indicated in the interview is to find a budget for high-class personnel, an indispensable asset of the RI, able to fully use the capabilities of the state-of-the-art equipment.

7. GOOD PRACTICES IN RESEARCH INFRASTRUCTURE MANAGEMENT

The analysis of the results of the workshops, surveys, and interviews enabled the definition of a basic set of good practices in managing research infrastructure that can contribute to its effective operation and support of research activities. Here are some key concepts on good practices extracted from the survey and workshop results, discussions, and interviews with Enhanceria partners representatives and RI managers:

Strategic Planning – developing a long-term strategic plan for the research infrastructure, aligned with the research goals and priorities of the organization, reflecting the vision, mission, and objectives of the infrastructure and defining its development and management principles.

Governance & Leadership – establishing an efficient governance structure with clearly defined roles and responsibilities for decision-making, oversight, and accountability; effective leadership and management of the infrastructure together with providing flexible formal conditions (freedom to operate).

Users Engagement – engagement of the user community that helps to understand their needs, obtain feedback, and involve them in decision-making processes.

Versatile Support – providing comprehensive user support services, including training, technical assistance, and access facilitation to help researchers effectively utilize the infrastructure.

Financial Sustainability – developing a sustainable funding model for the infrastructure, taking into account diversified resources (institutional support, external grants, user fees, and partnerships with industry or other stakeholders); regularly reviewing and updating the financial plan to ensure long-term sustainability.

Quality Assurance – implementing quality assurance processes to ensure the infrastructure operates at high standards, comply with relevant regulations and standards, and maintains data integrity and security; monitoring and assessing the performance of the infrastructure to identify areas for improvement.

Collaboration and Networking – fostering collaborations and partnerships with other research institutions, industry, and relevant stakeholders to leverage resources, expertise, and funding opportunities; seeking opportunities for joint projects, knowledge exchange, and shared infrastructure initiatives.

Data Management and Open Access – establishing data management policies and practices that promote open access, efficient and safe data sharing, and long-term preservation; ensuring proper data management and data-sharing platforms to maximize the usability of research data generated by the infrastructure.

Continuous Improvement and Evaluation – regularly assessing the performance, impact, and efficiency of the infrastructure through evaluations, impact studies, and user surveys; using the findings to identify areas for improvement, set performance targets, and implement changes to enhance the infrastructure's effectiveness.

Training and Professional Development – investing in training and professional development opportunities for staff members involved in managing and operating the infrastructure; keeping up-to-date with emerging technologies, best practices, and advancements in the field to ensure the infrastructure remains at the forefront of research capabilities.

All the abovementioned practices can help ensure efficient and effective management of research infrastructure, continuously enhance its value to the research community, and support high-quality scientific research. All these practices can be easily adapted to the specific needs and demands of individual research infrastructures and organizations.

RECOMMENDATIONS FOR EFFECTIVELY MANAGING RI

Below, there are summarized recommendations on the efficient management of research infrastructures, being a main result of the works, discussions, and analysis conducted in the framework of WP6 task 6.1 of the Enhanceria project.

1. **Develop a Comprehensive Management Plan** - create a detailed management plan that outlines the goals, objectives, and strategies for the research infrastructure; this plan should cover issues of governance, funding, operations, user support, sustainability, and future development.
2. **Engage Stakeholders** - involving stakeholders, including internal and external research groups, administrators, funding agencies, and user communities, requesting their input and feedback to ensure that the RI meets their needs and demands.
3. **Foster Collaboration and Partnership** – actively look for collaborations and partnerships with other institutions, industry, and relevant organizations to leverage resources, share expertise, and expand the impact of the infrastructure; collaborative efforts can enhance the capabilities and reach of the infrastructure.
4. **Establish Clear Governance and Management Structures** – clearly define roles, responsibilities, and decision-making processes to ensure effective coordination, accountability, and transparency in RI management.
5. **Develop a Sustainable Funding Model** – identify and secure diverse funding sources to support the infrastructure's ongoing operations, maintenance, and development; explore various options such as institutional funding, external grants, user fees, public-private partnerships, and philanthropic support as well.
6. **Prioritize User Support and Training** – provide comprehensive user support services, including training, technical assistance, and access facilitation; invest in training programs to enhance the skills and knowledge of users in effective and safe utilizing the infrastructure.

7. **Regularly Evaluate and Assess Performance** – implement mechanisms to regularly evaluate and assess the performance, impact, and user satisfaction; use this feedback to identify areas for improvement and make informed decisions about resource allocation and future directions.
8. **Monitor and Follow Technological Trends** – keep abreast with emerging technologies and trends related to the research infrastructure; continuously update the equipment, software, and support systems to ensure that RI remains at the forefront of scientific capabilities.
9. **Promote Open Science and Data Sharing** – encourage open science practices by promoting data sharing, open-access publications, and transparent methodologies; develop policies and procedures for effective data management, storage, and dissemination to maximize the impact and reusability of research outcomes.
10. **Implement a Culture of Innovation and Collaboration** – develop an environment that fosters innovation, creativity, and collaboration among researchers utilizing the infrastructure; encourage and stimulate interdisciplinary collaborations and knowledge exchange.

8. SUMMARY AND CONCLUSIONS

In the report, the results of the activity of Enhanceria partners within WP6 Task 6.1 Exchanging best practices and sharing experiences on managing RIs are presented and analyzed. A variety of tools have been used to gather, compare, and analyze the data – workshops on managing Enhanceria's RIs (including joint work using the MIRO table), a dedicated survey on approaches to managing the RI followed by interviews with selected partners, all of these complemented by internal discussions between leaders of WP6 tasks.

The analysis of the gathered data enabled not only the comparison of different approaches to managing RI within the Enhanceria consortium but also the definition of a broad set of good practices to follow and recommendations on RI management, summarized in the previous two paragraphs. The current version of the report might serve as a good starting point for further analysis and recommendations on Enhancerias' RI management, not covered by this document. By its nature, the report does not provide the ultimate solutions or receipts – that would be impossible considering a variety of approaches, the specificity of individual universities, research facilities, research groups, etc. Oppositely – it summarizes the approaches, compares these, and provides a foundation for efficient management of RI. The good practices and recommendations formulated in the report are intentionally generalized and, therefore, seem to be efficiently implementable in any research infrastructures, not only the specific RIs owned by Enhanceria partners.

This can be easily seen in numerous synergies between Enhaceria's actions and tasks and work packages defined in other SwafS (Science with and for Society) projects. A few examples are enumerated below.

In the **TRAIN4EU+** project Work Package 3 *Sharing research infrastructure and developing research support resources* aims at developing the strategy and models for sharing resources and infrastructure with research groups, business clients and students, providing an inventory of Ris, and identifying best practices for managing and potential barriers in sharing Ris.

Una.RESIN project focuses on development and implementation of the three research enhancing strategies, among these innovative formats of sharing research infrastructure and resources and actions on mapping Ris are directly enumerated.

Work Package 3 of the **EUGLOHRIA** project is entirely focused on the shared use of research infrastructure, with a specific task of developing a joint action plan for sharing RIs.

EPICUR assumes the development of an experimental open research format EPIClusters to inspire sharing of research infrastructures and resources as well as providing support in access to the state-of-the-art RIs available at EPICUR partner institutions.

It is clearly seen that the report, although representing the approach discussed within the Enhanceria consortium, addresses the far broader problem and might be considered as a complementary document, providing additional perspective to the other SwafS projects' outputs of other European University Alliances committed to developing a European strategy for managing and sharing Research Infrastructures.

It should be also emphasized that the conclusions and recommendations formulated in the report are in line with the objectives proposed by the five destinations of the Horizon Europe Research Infrastructures Programme (Work Programme 2023-2024), a part of the general European Union's funding program for research and innovation. The Research Infrastructures Programme specifically focuses on supporting the development, enhancement, and operation of research infrastructures across various scientific fields, therefore defining a natural formal context for the analysis conducted within this report.

In particular, the report addresses Destinations I, II, and V - *Developing, consolidating and optimizing the European research infrastructures landscape, maintaining global leadership **(INFRADEV)***, *Enabling an operational, open and FAIR EOSC ecosystem **(INFRAEOSC)*** and *Network connectivity in Research and Education – Enabling collaboration without boundaries **(INFRANET)***, which further confirms the importance of the topic and necessity of developing the strategies and standards for efficient utilization and sharing the research infrastructure and resources.