31-03-2023

Deliverable D4.2 Roadmap Towards an ESFRI Listing

Impact and Dissemination

Deliverable D4.2

Contractual Date:	31-03-2023
Actual Date:	31-03-2023
Grant Agreement No.:	951886
Work Package	WP4
Task Item:	Task 4.1
Nature of Milestone:	R (Report)
Dissemination Level:	PU
Lead Partner:	ISI
Document ID:	CLONETS-M30-007
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The research leading to these results has received funding from the European Union's Horizon 2020 research and innovation program under Grant Agreement No. 951886 (CLONETS-DS).

Abstract

This document presents a plan for consortium members to take the necessary steps to implement the ESFRI strategy. In preparing this plan, we used the approved outputs of all scientific (WP1), technical (WP2) and conceptual (WP3) tasks in the form of documentation, to create a proposed infrastructure design. This plan for the provision of a CLONETS Research Infrastructure includes measures at both national and pan-European level, and is based on a survey of the procedures for processing the ESFRI Roadmap 2021, as well as on many consultations of representatives of the CLONETS-DS consortium, who also represent ESFRI and other organizations at national and European levels.

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Executive Summary

This *D4.2 Roadmap Towards an ESFRI Listing* document presents a plan for consortium members to take the necessary steps to implement the ESFRI strategy. In preparing this plan, we used the approved outputs of all scientific (WP1), technical (WP2) and conceptual (WP3) tasks in the form of documentation, to create a proposed infrastructure design. This **plan for the provision of a CLONETS Research Infrastructure** includes measures at both national and pan-European level and is based on a survey of the procedures for processing the ESFRI Roadmap 2021, as well as on many consultations of representatives of the CLONETS-DS consortium, who also represent ESFRI and other organizations at national and European levels.

1 Introduction

This document summarizes the outputs of the CLONETS-DS project, which describe the design of the future CLONETS European Research Infrastructure for the transmission of accurate time and frequency signals over optical networks from the point of view of technical and legal arrangements. This document contains a summary of the knowledge and results of the surveys carried out by the partners of the CLONETS-DS project. It formulates guidelines for adopting the future CLONETS Research Infrastructure in line with the ESFRI European Roadmap for Research Infrastructures [ESFRI Roadmap]. Achieving this goal is an essential prerequisite for the subsequent implementation of this infrastructure within the European Research Area.

1.1 European Strategic Forum for Research Infrastructures

European research infrastructures (RIs) are essential for the European Union's ability to make scientific progress and support fundamental innovation. Due to broad political consensus on the need to quickly solve the social challenges facing Europe and the world, research and development also have a critical mission to lead and propose the necessary economic, social and environmental changes. The European Strategic Forum for Research Infrastructures (ESFRI) was established in 2002, to coordinate and plan effective development [ESFRI]. This work has fundamentally changed the availability of state-of-the-art facilities for researchers in Europe by facilitating joint investment at national, regional and European levels, and strengthening Europe's global leadership in this field. Europe has a rich spectrum of global research infrastructures covering all scientific areas. European research infrastructures are critical to Europe's ability to deliver scientific breakthroughs and foster innovation.

ESFRI does not directly finance the building of individual transnational research infrastructures in Europe but ensures the coordination of the necessary work at the governmental level between the individual participating countries.

1.2 Structure of the Document

The *D4.2 Roadmap Towards an ESFRI Listing* document is focused on four areas:

a) Describing ESFRI's strategy for adopting a new research infrastructure in line with the ESFRI Roadmap (Section 2).

b) Creating guidelines for CLONETS-DS project partners to take the necessary steps to implement the CLONETS Research Infrastructure into the ESFRI Roadmap (Section 3).

c) Carrying out a survey in individual member countries from the point of view of national users (Section 4).

d) CLONETS Research Infrastructure report for ESFRI Roadmap Landscape Analysis 2023 (Section 5).

The ESFRI Strategy Plan created includes measures at both the national and European Union level. Based on the guidelines, it will be possible to submit a Questionnaire to ESFRI for the next update of the ESFRI Roadmap, expected from 2024-2025.

2 ESFRI Strategy for the Adoption of a New RI

ESFRI is a strategic tool for strengthening Europe's integration in research and its international cooperation. ESFRI's mission is to support a coherent and strategic approach to policymaking regarding European research infrastructures and multi-lateral initiatives that will lead to better use and development of research infrastructures at European and international levels. ESFRI is a platform for delegates of EU member states and associated countries and, with the participation of representatives of the European Commission's Directorate General for Research and Innovation (DG RTD), facilitates its participants in conducting strategic debates on the most current policy-making issues of research infrastructures of European character, importance and impact. As an ERA-related group, ESFRI acts as the leading expert advisory body of the EU Council for Competitiveness, and provides expert advice on the preparation of political and conceptual documents adopted in the EU research infrastructures.

2.1 Structure of ESFRI

ESFRI is represented by a chairman elected at the ESFRI Forum from among the delegates to ESFRI. The central coordinating body of ESFRI activities is the Executive Committee. It consists of the President of ESFRI, a representative of the Directorate-General for Research and Innovation of the European Commission (DG RTD) and selected delegates to ESFRI, elected to the Executive Committee at the ESFRI Forum. Debates of ESFRI delegates take place in plenary sessions. To discuss the issues of European research infrastructures, constructed and operated in the scientific fields of physical sciences and engineering, energy, environmental sciences, health and food (biological and medical sciences), social and humanities (social and cultural innovation) and e-infrastructure (data, computer and digital research infrastructures) strategic working groups (SWGs) are established. The Implementation Group evaluates progress in the implementation of European research infrastructure projects, while the Monitoring Group deals with issues of the methodology of this monitoring. Beyond that, ESFRI has also established other working groups focusing on specific matters of European research infrastructures, such as their long-term sustainability and/or contribution to innovation. The European Commission's Directorate General for Research and Innovation (DG RTD) provides the ESFRI Secretariat.

2.2 ESFRI Roadmap Document

ESFRI periodically creates and publishes an action plan (ESFRI Roadmap) defining research infrastructures of pan-European importance and corresponding to the long-term needs of the

European research community. In the second half of the CLONETS-DS project the ESFRI Roadmap 2021 was compiled and published, which hasthree parts:

1) ESFRI Roadmap & Strategy Report on Research Infrastructures,

2) ESFRI Landscape Analysis,

3) ESFRI Projects and ESFRI Landmarks.

The third part of the ESFRI Roadmap includes European research infrastructures with the so-called "ESFRI Project" and "ESFRI Landmark" status:

1) European research infrastructures with the status of "ESFRI Project" are located on the ESFRI Roadmap thanks to their scientific excellence. These are in an advanced state of preparation, assuming the start of their implementation/construction phase within 10 years of inclusion on the ESFRI Roadmap.

2) European research infrastructures with the status of "ESFRI Landmark" have either completed their implementation/design phase and thus entered the operational/user phase or have advanced so much in their implementation/design phase that they have a clearly defined timetable for its completion and commissioning.

The latest update of the ESFRI Roadmap is from 2021. It brings together 63 European research infrastructures, of which 41 fall under the "ESFRI Landmark" category and 22 under the "ESFRI Project" category.

The CLONETS-DS Work Package 4 team presented the ESFRI Roadmap Landscape Analysis in detail in our CLONETS Research Infrastructure gap analysis described in *D4.1 Positioning Paper on Access Models*, which documented a clear need to build such a research infrastructure in the European Research Area.

2.3 Model of Lifecycle Approach of an RI

In this section, we present how ESFRI envisages the life cycle of the European Research Infrastructure (RI). We take the explanation from the ESFRI Roadmap 2021 – Public Guide. This is the model shown in Figure 1.

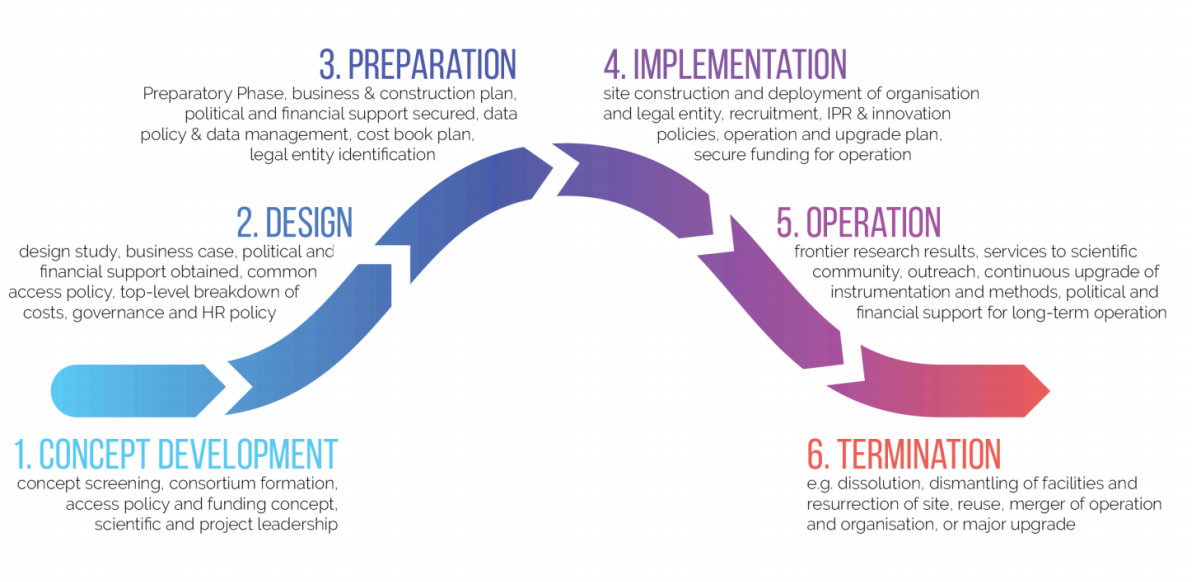

Figure 1. Lifecycle approach of a Research Infrastructure (source ESFRI Roadmap 2021 – Public Guide)

ESFRI distinguishes a total of 6 phases for a Research Infrastructure lifecycle approach:

1) Concept,
2) Design,
3) Preparation,
4) Implementation,
5) Operation,
6) Termination.

The **Concept** of a new RI typically emerges bottom-up from scientific communities clustering around established scientific needs and goals. Such a concept can originate from entirely novel approaches to answer scientific questions or to respond to the need for enhanced capacity at a pan-European level and from new insights in existing RIs resulting in a plan for a significant upgrade or merger.

The **Design** phase covers the proof of the scientific concept and technical feasibility of the RI, the analysis of the potential user community – both science and innovation-oriented, the outline of a business case and the rationale for the international consortium. Feasibility studies can be carried out with institutional, national or international support – e.g. Framework Program (FP) Design Study grants. The design also includes an initial analysis of its position in the RI landscape, e-Infrastructure requirements and (open)-data management and policy. Notably, the RI also foresees the financial and political support from governments and funding agencies necessary for the PREPARATION phase.

The **Preparation** phase, carried out at institutional, national, European or international level, is directed towards developing the RI as a fully-fledged organisation. Completion of preparation for the RIs in the Roadmap is often carried out through a **Preparation** phase contract under a FP, resulting in a business plan, a legal entity, and an agreed role for the RI also in the context of the landscape of existing RIs at European and global level, and secured funding safeguarding the financial sustainability for the Implementation Phase and also extending for the **Operation** Phase. Some projects face a gap

in financing between the end of their **Preparation** phase contract and the final decisions for implementation – legal, funding and construction – which can lead to the establishment of ad hoc interim legal entities and governance to ensure appropriate funding to complete the preparation and start building.

Implementation is different for single-sited and distributed RIs. In the first case, it corresponds to an intense investment period of several years for construction involving human and financial resources, with a significant impact on the market, including suppliers of goods and technologies. Longer-term benefits are generated to the hosting territory: employment, upgrade of services, internationalisation and up-skilling of the population, increased demand on high-level services – schools, communication, financial services for international employees – and joint development of novel technologies that remain as competitiveness legacy to the procuring firms. In the case of distributed RIs, the implementation implies intense negotiations as both the Central Hub and the national nodes require specific commitments. Developing a successful governance and management structure may be of higher complexity than for single-sited RIs. Nevertheless, distributed RIs have been quite efficient in several cases at establishing their legal entities and launching services to the user community.

During their **Operation**, RIs produce frontier research and deliver advanced services for excellent science satisfying the users' demand, boosting brain circulation of early career scientists and trainees, and improving the ranking of their academic and research institutions. RIs can create spin-offs and start-ups and attract corporate partners with high innovation potential. The operational costs of RIs range from 8 to 12% of the initial capital investment per year. A 20-year operation cycle may develop before major upgrades, requiring new substantial capital investment, are needed. The upgrade cycles in the case of e-Infrastructures are typically much shorter.

The **Termination** may encompass dissolution of the organisation, dismantling of facilities and related safety aspects and resurrection of the original site, but it does not apply in these identical terms in all research domains. The **Termination** phase could also result in new infrastructure development as part of the field's evolution. Re-orientation of RI sites has already occurred, e.g. in nuclear research or high-energy physics, where outdated RI have been transformed into analytical facilities with new scientific missions built upon the presence of technological infrastructure, logistics, human resources and organisation.

2.4 Submission of Proposal for a New ESFRI Project

The partners' goal of the CLONETS-DS project is to prepare guidelines for activities after the end of the project, which will then lead to the creation of CLONETS Research Infrastructures in the ESFRI Project category. First, however, we must state how the proposal for a new European research infrastructure is established on the ESFRI Roadmap. This is based on our experience preparing and implementing the ESFRI Roadmap 2021. The scheme for submitting the proposal for the new ESFRI Project is shown in Figure 2.

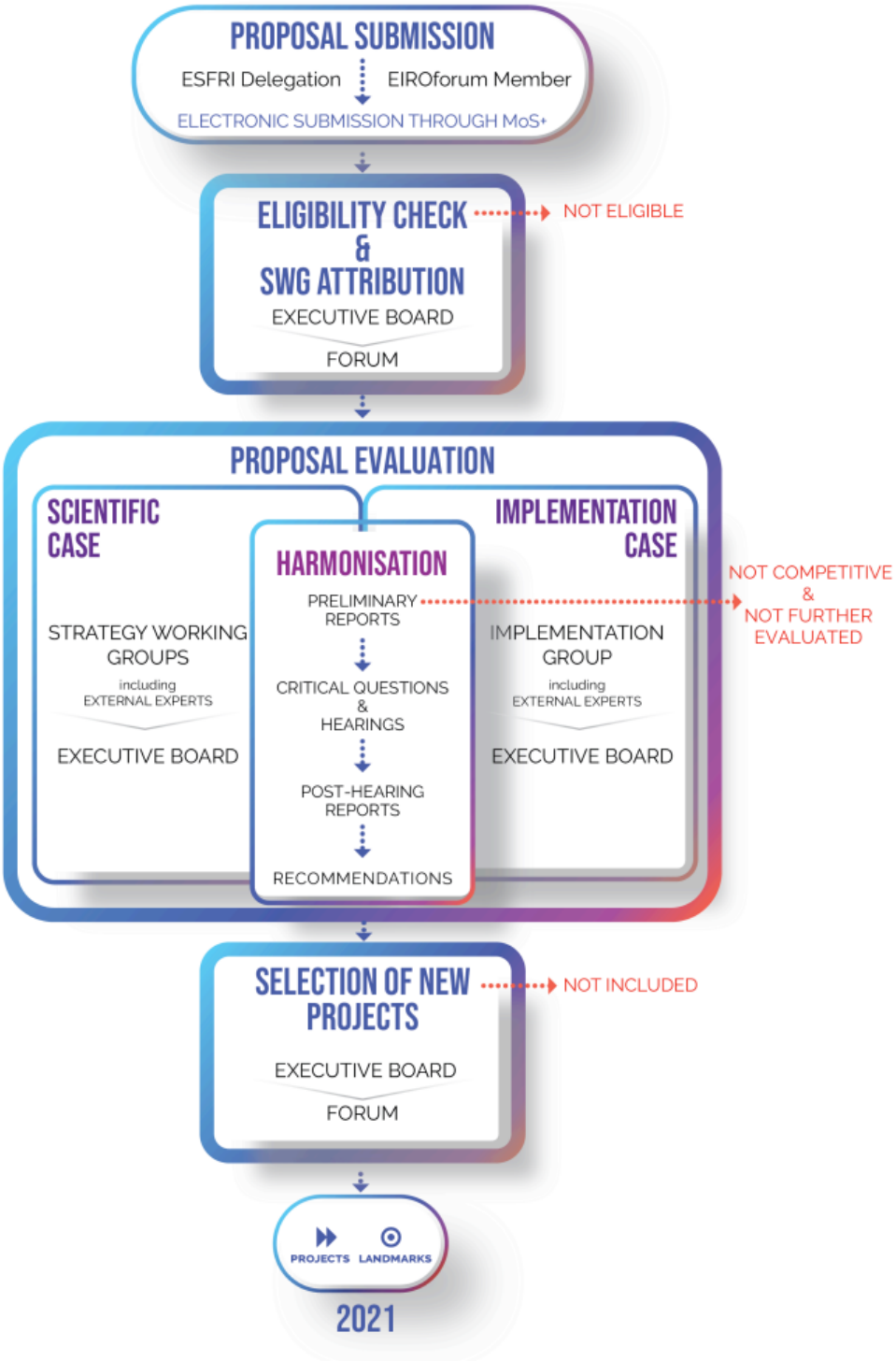

Figure 2. Schematic diagram of the submission and selection of new proposals (source: *ESFRI Roadmap 2021 – Public Guide*)

New Project RI Proposals of ESFRI are candidate projects for the ESFRI Roadmap update that underwent the selection procedure based on the evaluation of the Scientific Case and for the Implementation Case, according to a sound expectation that the proposal – if selected as ESFRI Project – will reach the **Implementation** phase within the ten-year term. Member States, Associated

Countries, and EIROforum Members can submit proposals for the ESFRI Roadmap. Since the Roadmap 2016, to identify a limited number of projects with a high degree of maturity to ensure the maximum likelihood of reaching the implementation within the ten-year deadline, ESFRI introduced the necessary eligibility conditions:

a) the **proof of political support** by the **lead** Member State or Associated Country or a resolution of the Council for EIROforum Member and **at least two** additional Member States or Associated Country or EIROforum Member,

b) the **expression of funding commitment** by the **lead** Member State or Associated Country or a resolution of the Council for EIROforum Member, and

c) the **inter-institutional and multi-lateral agreement** signed by the core partners formally involved in the consortium.

These requirements strengthened links with the governments as well as the research communities, encouraging a closer dialogue between them and support from the beginning of the RI project, resulting in the increased likelihood of successful implementation.

ESFRI differentiates between the following categories:

a) Lead country/entity: Member State, Associated Country or EIROforum Member, which leads the preparation of the RI,

b) Prospective member country/entity: Member State, Associated Country and a third country, which have submitted Expressions of political Support (EoS) signed by the national ministries responsible for the RI or other entity – such as EIROforum Member – whose mandated authorities have expressed interest to join the RI through a Council resolution,

c) Participants: Research institutions and other entities which are partners in the RI Consortium.

2.5 Guidelines and Evaluation of an RI Scientific Case

The appropriate strategic working group (SWG) evaluates the Scientific Case along five dimensions:

1) Scientific Excellence (Section 2.5.1),
2) Pan-European Relevance (Section 2.5.2),
3) Socio-Economic Impact (Section 2.5.3),
4) User Strategy and Access Policy (Section 2.5.4),
5) e-Needs (Section 2.5.5).

The goals of the evaluation of the Scientific Case of New Proposals for the Roadmap (ex-ante) are to evaluate which minimal key requirements along the five dimensions of the Scientific Case are met, assess future scientific plans, advise ESFRI on the strategic value of the proposals, projects and landmarks within the broader RI ecosystem, evaluate the potential of the proposals, projects and landmarks for further internationalisation and globalisation, identify links and complementarities

among RI and the prospect of integration, and recognise e-needs, including the integration of RI in open e-networks, the compliance with FAIR principles and the link to EOSC.

When evaluating the Scientific Case, the SWG takes the dimensions of the Implementation Case into account.

The following subsections contain the minimal key requirements for the **Design** and **Preparation** phases in the lifecycle of RI on the five dimensions of the Scientific Case, and assessment of outcomes of the CLONETS-DS project if these requirements are fulfilled.

2.5.1 Scientific Excellence Requirements

Design: long-term science program defined, scientific community well-established, scientific leadership described, cutting edge science and technology outlined.

Preparation: scientific vision and mission outlined, (multidisciplinary) scientific new frontier drafted, scientific leadership recruited, science concept tested and found feasible, services for the scientific community described, technical maturity and feasibility tested and achieved, cutting edge science and technology defined, availability of human scientific resources have proven.

CLONETS-DS Project Outcomes: Scientific Excellence can be demonstrated in all the above requirements and for all the phases of the CLONETS Research Infrastructure. Deliverables *D1.2 Requirements and Definition* document and *D4.1 Positioning Paper on Access Models* for scientific community requirements, *D2.1 Technical Design* report and *D2.2 Roadmap for Technical Implementation* of the T&F-Reference System for scientific leadership, services will serve as a source of information and cutting-edge science and technology.

2.5.2 Pan-European Relevance Requirements

Design: a pan-European approach for the scientific area is outlined, targeted user community is pan-European, national/international facilities with complementary or synergistic potential.

Preparation: positioning in the RI landscape defined, case for European added value defined, research capacity and current/potential geographical distribution defined, links to relevant RI and other large pan-European programs identified.

CLONETS-DS Project Outcomes: Pan-European Relevance can be well demonstrated in all the above requirements and for all the above phases of the CLONETS Research Infrastructure. *D1.2 Requirements and Definition* document and especially *D4.1 Positioning Paper on Access Models* mainly for positioning in the RI landscape, complementary or synergistic potential, and national/international facilities with complementary or synergistic potential will serve as a source of information.

2.5.3 Socio-Economic Impact Requirements

Design: relevance to societal challenges identified and potential economic impact predicted, including innovation aspects.

Preparation: the case for the impact made, supporting innovation, other types of benefits such as services for society, cultural aspects and attraction of business, industry and public services, etc.

CLONETS-DS Project Outcomes: Socio-Economic Impact can be well demonstrated in all the above requirements and for all the above phases of the CLONETS Research Infrastructure. D4.1 Positioning Paper on Access Models mainly for the impact made, supporting innovation, and other types of benefits such as services for society will serve as a source of information.

2.5.4 User Strategy & Access Policy Requirements

Design: vision about user community, access modes described.

Preparation: identified user categories, a survey executed demonstrating the expected user community and description of it in terms of origin and size, identified services based on a clear identification of user demands and needs, and the single-entry point for users outlined.

CLONETS-DS Project Outcomes: User Strategy & Access Policy can be well demonstrated in all the above requirements and for all the above phases of the CLONETS Research Infrastructure. *D4.1 Positioning Paper on Access Models* for access modes, *D2.1 Technical Design* report and *D2.2 Roadmap for Technical Implementation* of the T&F-reference system for identified services based on clearly identifying user demands and needs will serve as a source of information and single-entry point for users.

2.5.5 e-Needs Requirements

Design: vision on e-infrastructure requirements, including access policy and security measures ready, interfacing with communication networks or distributed calculation or HPC/HTC.

Preparation: conceptual design of e-infrastructure ready, contributions of e-infrastructure resources at all levels (institutional, regional, national, international) described, access policy and Data Management Plan (DMP) outlined, compliance with FAIR principles.

CLONETS-DS Project Outcomes: e-needs can be well demonstrated in all the above requirements and for all the above phases of the CLONETS Research Infrastructure. D4.1 Positioning Paper on Access Models for e-infrastructure requirements, including access policy and security measures and Data Management Plan (DMP), will serve as a source of information.

2.6 Guidelines and Evaluation of an RI Implementation Case

The Implementation Group (IG) evaluates the Implementation Case along five dimensions:

1) Stakeholder commitment (Section 2.6.1),
2) Preparatory work and planning (Section 2.6.2),
3) Governance, management & human resources (Section 2.6.3),

4) Finances (Section 2.6.4),

5) Risks (Section 2.6.5).

The goals of the evaluation of the Implementation Case of New Proposals for the Roadmap (ex-ante) are to assess which minimal key requirements along the five dimensions of the Implementation Case are met, consider future implementation plans, and enable specific and targeted follow-up by ESFRI and support to the projects to move towards full implementation within the ten-year rule.

When evaluating the Implementation Case, the IG considers the Scientific Case's dimensions.

The SWGs evaluate the Scientific Case, and the IG assesses the Implementation Case of new proposals. SWGs and IGs work independently with regular interactions; they deliver joint reports and contribute to harmonising the conclusions and recommendations with the Executive Board at various stages.

The following sections contain the minimal key requirements for the **Design** and **Preparation** phases in the lifecycle of RI on the five dimensions of the Implementation Case and assessment of outcomes of the CLONETS-DS project if these requirements are fulfilled.

2.6.1 Stakeholder Commitment Requirements

Design: institutional Letters of Intent (LoI) signed, formal agreement among partners for design study agreed upon (e.g. Consortium Agreement).

Preparation: political support provided by a satisfactory number of prospective members, acceptable inter-institutional and multi-lateral agreement, e.g. a Memorandum of Understanding (MoU) signed by all core partners - being research institutions - formally involved in the consortium, clear strategy about how to gather necessary commitments at institutional and governmental level.

CLONETS-DS project outcomes: Stakeholder Commitment will be the subject of further steps described in the guidelines for actions at the national and European level for all the phases mentioned above of the CLONETS Research Infrastructure. *D3.1 Governance and Sustainability* and *D4.1 Positioning Paper on Access Models* for getting political support will serve as a source of information.

2.6.2 Preparatory Work & Planning Requirements

Design: concept screening successfully completed and described in a conceptual design, overall project plan for design study with significant milestones and deliverables approved.

Preparation: design/feasibility study completed, clear business case developer, a clear strategy for tackling technological and construction issues, detailed plan for preparation and implementation agreed, including relevant investment decisions, and the overall plan for operation and decommission defined.

CLONETS-DS Project Outcomes: Preparatory Work & Planning will be the subject of further steps described in the instructions for actions at the national and European levels for all the phases mentioned above of the CLONETS Research Infrastructure. *D3.1 Governance and Sustainability* and *D2.1 Technical Design* report, and *D2.2 Roadmap for Technical Implementation* of the T&F-Reference System will serve as a source of information.

2.6.3 Governance, Management & Human Resources Requirements

Design: project organisation approved, scientific leadership, project manager and required staff identified.

Preparation: satisfactory project organisation and management for preparation and implementation with clearly defined skills and staffing plans, responsibilities and reporting lines approved, measurable and acceptable Key Performance Indicators identified, governance for operation with clearly defined responsibilities and reporting lines outlined, including Supervisory and other Advisory Boards, human resources policy for implementation and operation to gather necessary competencies, hiring, equal opportunities (including gender balance and diversity), secondments, education and training outlined.

CLONETS-DS Project Outcomes: Governance, Management & Human Resources will be the subject of further steps described in the guidelines for actions at the national and European level for all the phases mentioned above of the CLONETS Research Infrastructure. *D3.1 Governance Sustainability* measures and *D2.1 Technical Design*, and *D2.2 Roadmap for Technical Implementation* of the T&F-reference system will serve as a source of information.

2.6.4 Finance

Design: funding concept and potential partners (e.g. nature of the partnership, in-kind versus cash) contributions outlined, budget for design study approved.

Preparation: a financial commitment by the lead country or EIROforum Member and possibly other entities satisfactorily covering the preparation and implementation phases, top-level breakdown of cost elements with overall order of magnitude estimates (including for Central Hub, National Nodes and main upgrades), assessments and confidence levels available for each component, funding opportunities identified for the whole lifecycle, in-kind contribution policy outlined.

CLONETS-DS Project Outcomes: Finances will be the subject of further steps described in the instructions for actions at the national and European level for all the phases mentioned above of the CLONETS Research Infrastructure. *D3.1 Governance and Sustainability* measures and *D2.1 Technical Design* report, and D2.2 Roadmap for Technical Implementation of the T&F-reference system will serve as a source of information.

2.6.5 Risks

Design: conceptual ideas about scientific, technological, political and financial risks.

Preparation: clear identification of significant risks involved and appropriate mitigation strategies described.

CLONETS-DS Project Outcomes: Risks will be subject to further steps described in the instructions for actions at the national and European level for all the phases mentioned above of the CLONETS Research Infrastructure. *D3.1 Governance and Sustainability* and *D2.1 Technical Design* report, and *D2.2 Roadmap for Technical Implementation* of the T&F-reference system will serve as a source of information.

2.7 ESFRI Roadmap Questionnaires

ESFRI prepared two questionnaires for its 2021Roadmap:

1) Project Monitoring Questionnaire – for monitoring the progress of the implementation of an already existing ESFRI project

2) Proposal Submission Questionnaire - for submitting a new ESFRI Project proposal.

The questionnaires were submitted electronically through the ESFRI system MOS+ in both cases. From the point of view of submitting a proposal for a new ESFRI Project, questionnaire 2) Proposal Submission Questionnaire, which is filled in by ESFRI Delegations or EIROforum Members, is essential.

2.7.1 Proposal Submission Questionnaire Content

The online submission form consists of three parts to be fully completed, and allows for a limited number of necessary attachments:

PART A: GENERAL INFORMATION is used for the eligibility check by the Executive Board, for the overall evaluation of the organisation and support to the New Proposal and – if selected – for the public description of the project in the ESFRI Roadmap 2021.

PART B: SCIENTIFIC CASE is used by the SWG(s) to evaluate the SCIENTIFIC CASE of the New Proposal.

PART C: IMPLEMENTATION CASE is used by the Implementation Group to evaluate the IMPLEMENTATION CASE of the New Proposal.

2.7.2 Eligibility Check and Assignment to SWG

The Eligibility Check will check whether the proposals are complete, submitted within the deadline, written in English and compliant with the specific eligibility criteria, i.e. proof of political support, proof of financial commitment and proof of inter-institutional agreement. The Eligibility Check then proposes a list of eligible proposals and their assignment to the Plenary Forum to the lead SWG and any other relevant SWGs.

3 Survey and Guidelines for a CLONETS RI

In this chapter, we summarise the knowledge that the partners of the CLONETS-DS project gained during negotiations with ESFRI representatives, ESFRI delegates and important representatives of government institutions across EU countries, which are related to the ESFRI agenda, especially to the creation and update of the ESFRI Roadmap.

3.1 Findings from Survey at European Level

During the solution, the partners of the CLONETS-DS project conducted a series of conversations with representatives of ESFRI (Jan Hrušák, former chairman of ESFRI, Jean-Marie Flaud, Chairman of Environment SWG of ESFRI, and Christian Chardonnet, former chairman of the Implementation group of ESFRI). Participating ESFRI representatives were asked in particular:

What must we prepare before applying for an ESFRI Project?

The answers and instructions were then summarised in the following subsections.

3.2 Political Support and Financial Commitment for CLONETS Research Infrastructure

Based on experiences with other new ESFRI Project proposals: the three-country minimum defined in Section 2.4 is insufficient. The minimum number of states in a successful ESFRI Project proposal is six to seven, to provide more substance, which is also more suitable than ten states.

Recommendation: In addition to the core member countries of the CLONETS-DS project partners (Czech Republic, France, Italy, Germany, Poland, Spain), other EU countries such as the Netherlands, Austria, Finland and Sweden are considered, which would reach the recommended number of 10 countries expressing political support for the new ESFRI Project. In Figure 3 is a map of Europe showing the member states of the CLONETS-DS project.

Figure 3. List of member states and organisations participating in CLONETS-DS project

3.3 Memorandum of Understanding for ESFRI Project Proposal

A condition for submitting an ESFRI Project application is a comprehensive agreement between participating partners across member states of the future CLONETS Research Infrastructure.

Recommendation: By the decision of the CLONETS-DS partners, and also, as stated in *D3.1 Governance and Sustainability measures* of the document, a Memorandum of Understanding (MoU) for CLONETS Free Association will be established between partners who are interested in building the CLONETS Research Infrastructure. In applying for the ESFRI Project, it will be possible to use this concluded MoU and attach it as proof of fulfilment of part of the required criteria according to Section 2.7. It will be necessary to ensure that organisations from ten EU member states accede to the MoU, see Section 3.2.

4 Survey and Guidelines at National Levels for CLONETS RI

In this chapter, we present the results of consultations held by representatives of the partners of the CLONETS-DS project with representatives of ESFRI and other organizations, especially at the national levels of the member states of the CLONETS-DS project. When starting work on this task, the CLONETS-DS partners established the CLONETS-DS ESFRI Working Group (CLONETS-DS ESFRI WG), which includes one representative for each member state of the CLONETS-DS project. Guidelines for conducting follow-up consultations were drawn up for more straightforward opening talks with ESFRI and governmental representatives. These documents were:

a) the **information letter** for CLONETS ESFRI Working Group, which explains the position of European research infrastructures in the European Research Area, Conditions for applying ESFRI, which were defined in Chapter 2, and further essential points for outcomes of negotiations at the national level,

b) the **introductory letter** to arrange the meeting with an ESFRI representative, which represents the intention to build an international CLONETS Research Infrastructure,

c) a sample **presentation** of the CLONETS Research Infrastructure plan, in which individual members of the CLONETS-DS ESFRI Working Group then elaborated on national specifics in the member states of the CLONETS-DS project and presented to representatives of ESFRI and other organizations at the national level,

d) **guidelines** for a potential interview with the ESFRI delegate or government, which contain a number of questions aimed at obtaining information for the subsequent procedure in establishing the CLONETS Research Infrastructure on the ESFRI Roadmap.

e) an **ESFRI interview report** which each representative of CLONETS-DS ESFRI Working Group prepared as an outcome of the provided survey.

In the following chapters, we present the content of some selected documents and outcomes from the provided surveys.

4.1 Guidelines for Interview with ESFRI Delegate or Government Representatives

Instructions were drawn up to supplement and reinforce the presentation of the CLONETS Research Infrastructure, finalized by members of the CLONETS-DS ESFRI Working Group in each of their member states. These include: bring out institution of the CLONETS-DS ESFRI Working Group member, mention that time (frequency) is the most precisely defined physical unit in the present time, state role of this institution in time metrology (NMI, research institution, National Research and Education Network (NREN), company), indication why it is necessary to provide the time dissemination via long fibre (international way), relate the initiative we started years ago with CLONETS funded from H2020 INFRAINNOV-02-2016, informing about CLONETS-DS project parameters - number of partners, number of member states, budget, particular share of the budget for the member country, what have

been done during research activities so far, showing the map with Time/Frequency dissemination network, potential infrastructure indicative budget for to be set up and for operation per year in this member state, presentation of key applications provided by the future CLONETS Research Infrastructure, picking up that the consortium CLONETS-DS continues in the infrastructure preparation with the support of CLONETS-DS from H2020 INFRADEV – Design Study programme.

The following list of questions for delegate interviews was also prepared:

1) What is the way of funding infrastructures (ESFRI or nationals) in the member state? In particular, how does the national budget cover the establishment and operation of these infrastructures in the member state?

2) What are the criteria for the mentioned infrastructure to be supported by national delegate so that it can apply for inclusion on ESFRI roadmap?

3) Is there a national infrastructure (supporting) program in the member state?

4) If so, are there any periodic calls in the member state to apply for such a program? When will the next call be?

5) Can they give examples of infrastructures in the member state that are on the ESFRI roadmap and are currently funded?

6) Can they mention examples of not successful infrastructures (or applicants) in the member state? What kind of mistakes did they make?

7) What is crucial to emphasize in the application for inclusion on the ESFRI roadmap?

8) Do they have any recommendation for the short-term horizon in the member state?

9) Excluding the ESFRI delegate, who else can help (e.g. Help Centre) with EU projects in the member state?

10) What are other possibilities of the infrastructure funding (e.g. structural funds) in the member state?

Subsequently, a list of members of the CLONETS-DS ESFRI Working Group and representatives of ESFRI and government institutions in the individual member states was compiled. It is presented in Table 1.

Country	Partners	Representative	e-mail	Lead	GOV Person
Czech Republic	CESNET, ISI	Ondrej Cip	ocip@isibrno.cz	ISI	Lukas Levak, MEYS CR, Director of R&D and RI
France	CNRS, UP 13, RENATER, Muquans	Christian Chardonnet	chardonnet@univ-paris13.fr	LPL	Elena Hoffert, Elena.Hoffert@recherche.gouv.fr , Jean-Marie Flaud, jean-marie.flaud@recherche.gouv.fr
Germany	PTB, Menlo, TUM,	Dieter Meschede	meschede@uni-bonn.de	Uni-Bonn	Eckhart Lilienthal Eckart.Lilienthal@bmbf.bund.de, Peter

Country	Partners	Representative	e-mail	Lead	GOV Person
	University of Bonn				Wenzel-Constabel Peter.Wenzel-Constabel@bmbf.bund.de
Italy	INRIM	Davide Calonico	d.calonico@inrim.it	INRIM	Gelsomina Pappalardo, gelsomina.pappalardo@imaa.cnr.it , Caterina Petrillo, caterina.petrillo@unipg.it, Glauco Tocchini-Valentini, Consiglio Nazionale delle Ricerche-CNR, gtocchini@emma.cnr.it
Poland	PSNC, Piktime Systems, AGH	Bartosz Belter	bartosz.belter@man.poznan.pl	PSNC	Agnieszka Zalewska, ESFRI Executive Board Member, Institute of Nuclear Physics Polish Academy of Science, Agnieszka.Zalewska@ifj.edu.pl, Michal Rybinski, ESFRI Delegate, Head of Unit of Ministry of Education and Science of Poland, Michal.Rybinski@mnisw.gov.pl
Spain	University of Granada, Seven Solutions SL	Javier Díaz	javier@sevensols.com	UGR	Inmaculada Figueroa, ESFRI Vice Chair, Deputy Vice-Director General for Internationalisation of Science and Innovation, Ministry of Science, Innovation and Universities, inmaculada.figueroa@ciencia.gob.es , José Luis Martínez Peña, Working Group Chair, Director, ESS-Bilbao, jlmartinez@essbilbao.org
UK	University College London	Alwyn Seeds	a.seeds@ucl.ac.uk	UCL	Gabriela Maria Pastori, Working Group Chair, Associate Director International, UK Research and Innovation - BBSRC, gabriela.pastori@bbsrc.ukri.org , Andrew Harrison, Chief Executive Officer, Diamond Light Source Ltd, andrew.harrison@diamond.ac.uk

Table 1. List of CLONETS-DS, ESFRI, and national government representatives

4.2 Findings and Guidelines from Survey at National Levels

Each member of the CLONETS-DS ESFRI Working Group conducted an interview with the ESFRI representatives and was subsequently asked to fill in an exit questionnaire about the information they learned during the interview with the ESFRI and government delegates. These were the following questions:

1) Do you have/know any T&F dissemination infrastructure? If so, please write down the entire designation. Is it on your national roadmap of research infrastructures?

2) Do you plan to submit T&F dissemination infrastructure on your national roadmap of research infrastructures? If so, please describe the way how to do – next steps?

3) What is the way of funding research infrastructures (ESFRI or nationals) in your country? In particular, how does the national budget cover the establishment and operation of these infrastructures in your country?

4) Is there a national infrastructure (supporting) program in your country? If so, are there any periodic calls in your country to apply for such a program? When will the next Call be? Is this a call for funding and/or national recognition?

5) What are other possibilities for infrastructure funding (e.g. structural funds) in your country?

6) What steps do you plan to obtain a declaration of financial support from your country to apply for the scheduled CLONETS infrastructure on the ESFRI roadmap? Does obtaining such support seem realistic within 3-5 years?

7) What steps do you plan to obtain a declaration of political support from your country to apply for the planned CLONETS infrastructure on the ESFRI roadmap? Does obtaining such support seem realistic within 3-5 years?

Answers from France, Poland, Germany, the Czech Republic, Italy, and the United Kingdom were received, which is a sufficiently representative sample for drawing up guidelines for the partners of the CLONETS-DS project on how to proceed with drafting the ESFRI Project proposal for the establishment of the future CLONETS Research Infrastructure.

The responses were divided into sub-categories, as presented in Table 2. In the following section, we present an overview and, in particular, a comparison between individual member states in which they have organized the implementation of research infrastructures at the national level. Potential key political support and a financial commitment from the national level for building the future CLONETS Research Infrastructure is also included.

	Question	France	Poland	Germany	Czechia	Italy	United Kingdom
	Representative of CLONETS-DS	Christian Chardonnet	Wojbor Bogacki	Dieter Meschede	Ondrej Cip	Davide Calonico	Alwyn Seeds
	ESFRI and government delegates	Elena Hoffert, Jean-Marie Flaud	Michal Rybinski	Eckhart Lillienthal	Lukas Levak, Jan Hrusak, Petr Travnicek	Glauco Tocchini-Valentini	Gabriela Pastori
1.1	Is there existing national T&F dissemination infrastructure or Initiative?	YES, national RI	YES, national RI	NO	YES, initiative	NO, but	NO, but The National Dark Fibre Facility and NPLTime are established
1.2	If yes, what is the name?	REFIMEVE	PIONIER-LAB		CITAF	Italian Quantum Backbone	NDDF, NPL Time
1.3	Is the infrastructure on the country roadmap of research infrastructures?	YES, since 10/2021	YES, national RI	NO	NO	NO	NO
2.1	Is there a plan to submit T&F dissemination infrastructure on your national roadmap of research?	Already done	Already done	YES	YES	YES	YES
2.2	If YES, what steps are needed?	Already done	Already done	Presence of the future T/F infrastructure on National Roadmap, threshold 50MEUR/project	Incorporating CITAF into existing infrastructure "e-infra"	There is a discussion on the potential unification of QKD and the T/F infrastructure into one Nat. RI	Discussions with UKRI-EPSRC are ongoing with the objective of increasing the geographical reach of NDFF to UK-wide
2.3	If YES, when?	Submitted by 2020	Not specified	Likely summer 2023	Autumn 2023	Likely 2024-2025	Not known
3.1	What kind of funding of RI is provided in the country?	Government Programs and Institutional funding	National Roadmap of Research Infrastructures	Ministry of EDU and Research, Strategic Foresight Process for Research Infrastructures	Program of support of National RI	Italian National Plan for Research Infrastructures funded by Research Ministry	National Research Facilities are supported by the UKRI Research Councils-EPSRC
3.2	Which resources for building up of a RI?	ANR, program EQUIPEX	As above + research projects, science and institutional funding + users fee	Ministry of EDU and Research, Strategic Foresight Process for Research Infrastructures	Program of support of National RI + structural funds ESIF (OP VVV, OP JAK)	As above + research projects, science funding	From Infrastructure Fund of UKRI, UKRI is a non-departmental public body sponsored by DSIT
3.3	Which resources for operation of a RI?	ANR, CNRS, Universities, other institutions	As above + research projects, science and institutional funding + users fee	Ministry of EDU and Research, Strategic Foresight Process for Research Infrastructures	Program of support of National RI	As above + research projects, science funding	From Infrastructure Fund of UKRI, UKRI is a non-departmental public body sponsored by DSIT
4.1	Is there a national infrastructure (supporting) program in your country? What is the name?	YES, no funding, but for national recognition	YES, National Roadmap of Research Infrastructures	YES, Strategic Foresight Process for RI	YES, National Roadmap of RI of CR	YES, Italian National Research	YES, it is under Creating world-class research and innovation

	Question	France	Poland	Germany	Czechia	Italy	United Kingdom
			from Ministry of Science			Infrastructure Plan (PNIR)	infrastructure – UKRI
4.2	When was the last Call?	2020	2019	2023 - results from previous survey	2020	2020	2020
4.3	When will be the next Call?	not known, there is not fixed agenda for calls	not known, there is not fixed agenda for calls	not known, there is not fixed agenda for calls	2023	not known, there is not fixed agenda for calls	not known, there is not fixed agenda for calls
5.1	What are other possibilities for RI funding in the country?	from French Ministry of EDU, support is very rare	from the provision of paid end-user services	EU structural funds funding, support by institutions (Helmlholtz Society), synergy with EuroQCI and some technol. infrastructures	EU structural funds (source ESIF and programs OP VVV, OP JAK)	Different initiatives based on research institutes funding, the ministry of research and the ministry of industry	Not specified for while
6.1	Is possible to declare "financial support" for ESFRI application from your country?	YES	YES	Conditionally YES, after getting political support	YES	Conditionally YES, after getting political support	NO commitments can be made at this stage
6.2	Which steps are needed?	Support to the CLONETS RI through the REFIMEVE, as a trans-national access or a virtual access	Project is on the road map. The next step will be finding opportunities to get support to put infrastructure to ESFRI	Under discussion	CITAF will be associated with “e-infra” infrastructure and it has positive evaluation from the Call to update the National Roadmap of RIs of CR	The discussion on the platform of Italian Quantum Backbone is ongoing	In the next ESFRI Roadmap process, ESFRI UK process will be put in place to consider ESFRI applications including UK partners
6.3	Does support seem realistic within 3-5 years?	YES	YES, in 5 years	not known	YES, in 2025 approx.	not known	not known
7.1	Is possible to declare "political support" for ESFRI application from your country?	YES	YES	YES	YES, in 2025 approx.	Conditionally YES	NO commitments can be made at this stage
7.2	Which steps are needed?	Not relevant	The national application must include a draft project to be submitted to ESFRI	To obtain financial budget for a project of national T/F network from BMBF	CITAF will be associated with “e-infra” infrastructure it also has positive evaluation from the Call to update the National Roadmap of RIs of CR	The discussion on the platform of Italian Quantum Backbone is ongoing	In the next ESFRI Roadmap process, ESFRI UK process will be put in place to consider ESFRI applications

	Question	France	Poland	Germany	Czechia	Italy	United Kingdom
7.3	Does support seem realistic within 3-5 years?	YES	YES, in 3-5 years	YES, conditionally 2024	YES	not known	not known

Table 2. Summary of the results of the survey of conditions for obtaining political support and financial commitment from institutions at the national level

4.3 Conclusions and Guidelines from Survey Carried out at National Levels

The primary purpose of the next steps of the CLONETS-DS project partners and possibly other partners who will join the CLONETS Free Association MoU will be to obtain sufficient political support and, ideally, financial commitment from national representations of research infrastructures. However, this is not just a formal act but the result of fundamental harmonization processes, especially at the national level. As can be seen from Table 2, in all the surveyed countries (France, Poland, Germany, Czech Republic, Italy, and the United Kingdom), there is a strongly developed system of National Roadmaps for the design, construction and operation of national research infrastructures. For all of them, it can be stated that, similarly to how ESFRI carries out regular updates of the ESFRI Roadmap in the European Research Area, there is also a standard process in the individual states aimed to:

a) Assess the operation, efficiency and especially excellence of existing RIs,

b) Survey of the needs of the national research landscape, and

c) Assess applications to build brand new RIs.

As the CLONETS Research Infrastructure is intended to serve primarily to synchronize the National RIs for the transmission of precise time and frequency signals with each other, the upcoming CLONETS Research Infrastructure will be a distributed European RI. The creation or further development of National T/F research infrastructures is, therefore, a key step at the national levels of the member states. In some countries, the partners' activities of the CLONETS-DS project are already at a very advanced stage.

In France and Poland, these National infrastructures are already established according to the National Roadmap, and their further development is underway. The process in the Czech Republic and Italy looks very promising, where large sections of fibre infrastructure are already being implemented and in operation. But they need to be added to the National Roadmap for RIs. Some parts of the transmission network are also in implementation and operation in Germany and the United Kingdom. Still, the inclusion process in the National Roadmap is only at the beginning. The situation in Spain is still in the preparatory phase because it is an extensive area, so building the National RI for time and frequency (T/F) will be a big challenge.

Thanks to the WP2 (*D2.1 Technical Design Report*) survey of optical network segments on which routes for the transmission of time and frequency signals have been built thanks to broad research activities

in Europe, we know that the state of construction is also advanced in other countries. In Austria, a large national project is underway to build a common infrastructure for QKD and T/F signal transmission. The Netherlands, Sweden, Switzerland and Finland have several connections that can gradually be the seed of National RIs for T/F.

From the survey, we can further read that the renewal periods of National Roadmaps are different in individual countries, so it is up to the CLONETS-DS partners to continue contacting government institutions' representatives for the development of National RIs for T/F. So, the following steps will be necessary to:

1) continue the expansion of National RIs for T/F where they have already been established (France, Poland) and start negotiations on issuing political support and financial commitment,

2) establish already existing infrastructures for T/F, which, however, do not have the character approved by the National RI for T/F, on the National RI Roadmap (Czech Republic, Italy, Germany),

3) start negotiations on the establishment of physical infrastructure for T/F transmission where there are not yet directly dedicated fibre connections (Spain),

4) for non-EU member states, continue negotiations on the association of National RIs for T/F within the framework of ESFRI (United Kingdom, Switzerland),

5) members of the MoU CLONETS Free Association will offer participation in this MoU to partners from other countries that are not members of the CLONETS-DS project (e.g. Austria, Sweden, Finland, Croatia),

6) at the regular MoU meetings of the CLONETS Free Association, the progress in individual participating countries in terms of building National RIs for T/F will be carefully monitored, and efforts to obtain, especially political support, will be coordinated; here we remind that it will then be necessary to have approximately 10 supports for the European phase,

7) time schedule for obtaining these political supports can be estimated at 3 to 5 years according to the information obtained from the survey,

8) in parallel with the process of establishing other National RIs for T/F, it will be appropriate to address the financial side of the CLONETS Research Infrastructure, especially the amount of the contribution to the construction and operation of this future European infrastructure for individual member states; subsequently, the negotiation process for establishing the CLONETS-ERIC legal entity should take place (see *D3.1 Governance and Sustainability*).

As we have already mentioned, France and Poland are the closest to being the principal applicants for the ESFRI Project under Section 2.4 under the current situation, with a particular perspective that they could be joined by the Czech Republic, Italy and Germany in the next 2-3 years. As soon as these political approvals and financial commitments are available, further action will be taken according to the instructions in Section 2.7.

5 CLONETS RI Landscape Analysis Questionnaire for the ESFRI Roadmap

In 2022, information was submitted for an update of the ESFRI Roadmap, the Landscape Analysis section, was opened[1]. The partners of the CLONETS-DS project took advantage of this and compiled answers to the Questionnaire, which ESFRI published on its website. In this chapter, we attach the wording of this Questionnaire, which is called Report for ESFRI Landscape Analysis 2023: strategic considerations about the functioning of the current ecosystem of RIs and its future development. The Report has been submitted on behalf of Institute of Scientific Instruments of CAS (ISI), one of the partners of CLONETS-DS project.

5.1 Introduction to Questionnaire for ESFRI Roadmap Landscape Analysis 2023

Today, timing is more crucial than ever. Many European economies and societies depend on advanced technologies such as satellite navigation, smartphones and an energy grid that gives on-demand uninterrupted power. At their core, these and many other systems are possible through accurate timing and positioning services. From everyday uses such as telling the time on a mobile phone, positioning and location applications, to synchronisation of radio and sending data in telecommunications, accurate timing is essential.

Our institution (ISI) is focused on the field of atomic and molecular physics. We work on laser cooling of atomic ions, and we work with their quantum states. We perform high-precision laser spectroscopy with individual ions trapped in electrical traps. We also use cooled ions to realise the ultimate generation of clockworks – optical quantum clocks, which are currently among the world's most accurate sources of time and frequency signals.

The rest of this section details the response to the following questions:

- What are your priorities regarding the European RI ecosystem?
- What are the gaps and needs for RIs and their services in each domain and across domains?
- How, in your opinion, could RIs best contribute to Horizon EU Programme Missions, Green and digital transition, and transformation.

It also provides additional information on an RI for precise time and frequency dissemination along optical fibres.

What are your priorities regarding the European RI ecosystem?

An important issue of our work in the field of optical quantum clocks is to compare the stability of generated time and frequency signals between optical quantum clocks in our laboratory and laboratories across the European continent. Only by comparing remote clocks with each other can the achieved degree of accuracy and stability be identified.

[1] ESFRI Roadmap Landscape Analysis 2023, link.

Optical quantum clocks are usually large laboratory systems that cannot be easily transported from one laboratory to another that would be hundreds of kilometres away. Traditional methods for comparing the stabilities of time standards, such as Caesium atomic clocks, are done using satellite transmission systems. Transceivers transmit the atomic clock signal from the site of one atomic clock towards the satellite. The signal is then propagated back to the second atomic clock laboratory site. There, the signal is received and compared to this local atomic clock. However these systems, due to the physical properties of the atmosphere through which radio signals propagate, do not allow transmitting time and frequency signals with stability higher than approximately 15 decimal places. But leading-edge optical quantum clocks generate time and frequency signals with stability more than ten thousand times higher than this limit, i.e. stability of signals higher than 19 or 20 decimal places is achieved, and in the future, this requirement will grow.

Since the turn of the millennium, excellent research teams in Europe have been intensively researching methods of transmitting precise time and frequency signals over optical fibres. Such methods allow breaking the limits of stability limit up to 20 decimal places. Europe is at the top in this field, and the publications of excellent European teams in prestigious journals like Nature, Science, PRL, etc., are among the world's most cited in this field.

With the development of the Internet and especially extensive continental and transcontinental optical fibre networks for the transmission of data, there is an opportunity to build a specialised optical network that would implement the developed methods for the propagation of precise time and frequency signals from optical quantum clocks along installed optical fibres across the entire European continent.

What are the gaps and needs for RIs and their services in each domain and across domains?

Currently, there is no complex international infrastructure on the European continent, neither research nor commercial, which would allow the transmission of signals from optical quantum clocks over long distances, i.e. in the order of thousands of kilometres with the required stability higher than 19 decimal places.

This requirement is a huge complication for us as well as a priority. It concerns many other European research institutions, including National Metrological Institutes, research institutions, and universities with cutting-edge research focused on improving current and research on new optical quantum clocks or the next generation of clockworks – optical nuclear clocks. Thanks to rapid advances in atomic and optical quantum clocks, the unit of time 1 second is the most precisely defined unit of the SI metric system. Its determination, therefore, significantly impacts a whole range of fields. Transporting precise time and frequency signals through a complex research infrastructure to user locations would substantially impact progress in the individual monitored domains of ESFRI research areas. If such a potential RI were to be built, it would broadcast accurate time and frequency signals from National Metrology Institutes certified laboratories, research institutions and universities to individual stakeholders. In the opposite case, i.e. the non-existence of such a European RI, research and development in specific fields will lose effectiveness in the medium term (approx. 5-10 years).

Because, in cooperation with many other partners, we are dealing with the possibility of building such a RI along optical fibres, we would like to contribute to the current ESFRI Landscape Analysis with our findings and recommendations. These are impacts and gaps on the following monitored domains (we only list key cases):

- Data, Computing & Digital Research Infrastructures

  For HPC RI and mainly high-speed data transfer, both time and frequency from a single source with high accuracy and stability are critical. The instability of local clocks in different places of the communication network can limit the research of new methods for high-speed data transmission. In the same way, such synchronisation is necessary for networks that transfer encrypted keys (Quantum Key Distribution - QKD) for secure communications and. In the future, also it is for the " quantum internet". The lack of synchronisation of high-resolution communication networks may limit the future transmission speeds of high-speed data networks and further define the security of quantum key transfer (QKD) networks.

- Energy

  Energy and especially electricity transmission networks are the key critical infrastructure of Europe. With the massive deployment of renewable sources and the reduction of traditional fossil fuel sources, the need to optimise electricity flows across the continent is growing. Emphasis is therefore placed on research in systems such as Smart Grids, which depend on precise time synchronisation. Also, all energy sources must have their phase precisely synchronised with the network. Ideally, all sources should be capable of external synchronisation to signals from accurate time and frequency sources propagated through any infrastructure (or RI). In the case of insufficient or unavailable synchronisation, resources in the energy network are pushed against each other and energy losses increase.

- Environment

  Monitoring the level, especially very small changes in the concentration of carbon dioxide in the atmosphere, is done using very sensitive methods of laser molecular spectroscopy. Synchronisation of the optical frequency of the measuring spectroscopic lasers is necessary for the long-term reliability and repeatability of the data measured by these systems. To carry out geographical mapping of the distribution of carbon dioxide concentrations, such measuring systems are located in several locations throughout the continent. If they are not precisely synchronised with the optical frequency by distributing the time and frequency signals using the possible RI, a reliable evaluation of carbon footprint changes cannot be guaranteed, which will have implications for many research studies in the field of Environment.

- Health & Food

  Surgery requires precision in everything aspect, including timing. This accuracy allows staff in operation theatre to make split-second decisions during critical situations with total confidence in their timekeeping. Anaesthetists require similar precision when administering anaesthetics to patients and at the proper intervals. Failure to adhere to these exact timings can lead to complications and failures in patient care. The unavailability of accurate time information can cause the ineffectiveness of medical care.

- Physical Sciences & Engineering

  The synchronisation by time signal distributed via potential RI for precise time and frequency dissemination will benefit areas of astronomy that exploit observations from multiple sites and/or use various techniques. A prime example is VLBI infrastructures for astrometry, which

will allow improved data analysis with the potential for discoveries and improvements to the celestial reference frame. VLBI has stringent requirements for both short-term and long-term. Pulsar timing is another well-established area expected to benefit, while there is a potential for applications to other fast-growing topics such as multi-messenger astronomy. Potential RI for precisely time and frequency dissemination can provide the infrastructure for measuring gravitational potential of Earth differences between atomic quantum clocks located at as-needed locations and can therefore be used to measure height differences throughout Europe and establish a unification of Europe's height system and ultimately, satellite gravity mission validation and geodetic network consistency.

The lack of precise synchronisation using mentioned potential RI will not allow from a certain level to improve the quality of acquired images of space observed synchronously or to further improve the European height system and a geological survey by detecting very small changes in the Earth's gravity field.

- Social & Cultural Innovation

  The world of time synchronisation is evolving quickly as applications get faster and faster. Technological advancements around smart grids, 5G and 6G networks and IoT devices like autonomous vehicles underscore the importance of more precise, secure time synchronisation. Not only that—but to successfully operate modern computer networks, we must have clear information about the timing of events. As we move toward a need for ultra-precise synchronisation, BIG DATA environments face some time sync challenges. Still, the potential RI for time and frequency dissemination can provide highly secure timing signal delivery over low jitter interconnected networks to keep all your systems in sync.

  The new potential RI for precise time and frequency dissemination would fill the gap in the existing RI Landscape in Europe, in all the domains mentioned above and across these domains.

How, in your opinion, could RIs best contribute to?

Finding solutions to the crises: RIs support crisis management and their own increased resilience when faced with problems caused by natural hazards such as health, environment, and energy.

RIs could be more connected to a particular organisation. Thus, they could better target the services offered to stakeholders from the research sphere to specific groups. ESFRI, thanks to Roadmap and Landscape Analysis, monitors the complementarity of individual RIs, so actual databases of provided services can be introduced. The subsequent finding and use of the service for stakeholders from the research sphere would thus be much easier than it is now. It would also solve crisis situations of global threat because then the states' organisational units (security, health, defence, environment etc.), which can never be prepared for every type of danger, are under tremendous pressure. Since in the field of research infrastructures across the entire European continent, there is a great diversity of areas, with the existence of the overview mentioned above database of RIs services, the state’s organisational units could more easily find and subsequently effectively use the cumulative know-how and top infrastructure facilities in situations of an entirely new type of threat.

Horizon EU Programme Missions

As HEU (Horizon EU programme) is organised in three pillars: Excellent Science, Global Challenges & European Industrial Competitiveness, and Innovative Europe, existing RIs play the role of accelerator in all three pillars very well.

Green and digital transition, also through their transformation

Thanks to the periodic renewal of the facilities of individual RIs, new energy-saving technologies are being implemented, which are then less demanding on energy consumption. New technologies also have a higher level of maturity in terms of communication and interoperability. If this periodic renewal of the facilities of individual RIs is carried out consistently, the green and digital transition will be implemented effectively.

Additional information on potential RI for precise time and frequency dissemination along optical fibres

As we mentioned in question of Section -536268128.461.73751.0, we have long-term cooperation with our partners across the European continent to build a Pan-European Research Infrastructure for Time and Frequency Signal Dissemination along optical fibres. Our effort is focused on two areas. We define that mentioned Pan-European Infrastructure as a distributed research infrastructure formed by: (1) National Research Infrastructures for Time and Frequency Signal Dissemination on the national level in each participating country and (2) Research Infrastructure (European Core Network) for time and frequency dissemination and overall synchronisation of National Research Infrastructures for Time and Frequency Signal Dissemination over the whole continent.

At the national level, in many countries, we already have a pilot and, in some cases, very advanced national infrastructures that allow precise time and frequency signal dissemination from optical quantum clock to stakeholder's application. These National Research Infrastructures, which we can metaphorically call national in ESFRI terminology Landmarks, are, for example, France [T-REFIMEVE], Italy (Italian Quantum Backbone) [ITALIAN-QB], Germany links from National metrology institute PTB to Hannover, Garching and Paris, France), Poland [OPTIME] Czech Republic [CITAF]. In these cases, funding takes place mainly from national sources.

Since 2017, we have been working together at the European level on the proposal of Research Infrastructure for time and frequency dissemination, which would connect above mentioned national infrastructures being built using a transnational optical network, which we call the European Core Network. First, we were supported by the H2020-INFRAINNOV-2016-2017 call (Fostering the innovation potential of Research Infrastructures) and implemented by the CLONETS project (https://doi.org/10.3030/73110, www.clonets.eu), in which we evaluated the need for such an infrastructure for the European Research Area. Subsequently, we were supported by the call H2020-INFRADEV-2018-2020 (Development and long-term sustainability of new pan-European research infrastructures) and implemented by the CLONETS-DS project (https://doi.org/10.3030/951886, www.clonets-ds.eu), in which we proposed the specific technical arrangement of the European facility arrangement being built, as well as the legal framework for its implementation.

6 Conclusion

This document will serve as a detailed agenda for placing the CLONETS Research Infrastructure on ESFRI Roadmap. We surveyed and analysed the ESFRI strategy for adopting new infrastructure on the ESFRI Roadmap. Based on European and National Levels talks and discussions, we created guidelines for CLONETS-DS project partners to take the necessary steps to implement the CLONETS Research Infrastructure into the ESFRI Roadmap. We also defined required guidelines for the National RIs for Time and Frequency establishment on National roadmaps of RIs in many European countries. We also prepared a Report about future CLONETS Research Infrastructure and submitted it to the ESFRI Roadmap Landscape Analysis 2023 campaign.

References

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[EIROforum]	European Intergovernmental Research Organisation forum https://www.eiroforum.org/
[Italian QB]	Italian Quantum Backbone: https://www.inrim.it/en/research/scientific-sectors/time-and-frequency/italian-quantum-backbone
[OPTIME]	https://optime.org.pl/
[T-REFIMEVE]	https://www.refimeve.fr/index.php/en/

Glossary

AC	Associated Country to EU Framework Programme for Research and Innovation
CLONETS	CLOck NETwork Services
CoI	Conflict of Interest
DMP	Data Management Plan
EB	Executive Board
EC	European Commission
e-IRG	e-Infrastructure Reflection Group
EIROforum	European Intergovernmental Research Organisation forum
EoC	Expression of Commitment
EoS	Expression of (political) Support
EOSC	European Open Science Cloud
ERA	European Research Area
ERIC	European Research Infrastructure Consortium
ESFRI	European Strategy Forum on Research Infrastructures
ESIF	European Structural and Investment Funds
EU	European Union
FP	EU Framework Programme for Research and Innovation
GRI	Global Research Infrastructure
GSO	Group of Senior Officials
HPC	High-performance computing
IG	Implementation Group
KPI	Key Performance Indicator
LoI	Letter of Intent
MoU	Memorandum of Understanding
MS	Member State
NREN	National Research and Education Network
QKD	Quantum Key Distribution
RFO	Research Funding Organisation
RI	Research Infrastructure
RPO	Research Performing Organisation
SDG	Sustainable Development Goal
SWG	Strategy Working Group
T/F	Time and Frequency