Baltic Science Network

Connecting Through Science

Roadmap for Transnational Utilisation of Existing and Planned R&I Infrastructure

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VATP VENTSPILS AUGSTO TEHNOLOĢIJU PARKS
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Project in brief

Baltic Science Network (BSN) serves as a forum for higher education, science and research cooperation in the Baltic Sea Region (BSR).

BSN is a policy network gathering relevant transnational, national and regional policy factors from the BSR countries. The Network is a springboard for targeted multilateral activities in the frame of research and innovation excellence, the mobility of scientists and expanded participation. These joint activities are modelled with an overall aim to ensure that the BSR remains a hub of cutting-edge scientific solutions with the capacity to exploit the region´s full innovation and scientific potential. The activities are modelled as examples of best practice which form the basis of the policy recommendations drafted by the Network.

The platform is tailored to provide advice on how to enhance a macro-regional dimension in higher education, science and research cooperation. Recommendations jointly formulated by the Network members address the European, national and regional policy-making levels.

BSN is a flagship of the EU Strategy for the Baltic Sea Region under the Policy Area Education, Research and Employability, as well as one of two cornerstones of the Science, Research and Innovation Agenda of the Council of the Baltic Sea States.

Disclaimer: This working paper is based on input from stakeholders and BSN partners and does not necessarily reflect the views of all participating Member States and organisations.

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List of abbreviations

BBMRI-ERIC – Biobanking and Biomolecular Research Infrastructure

BSR – Baltic Sea Region

CBSS – Council of the Baltic Sea States

CERN – European Organization for Nuclear Research

CESSDA – Consortium of European Social Science Data Archives

EADH – European Association for Digital Humanities

EIT – Electronic and Information Technology

ERA – European Research Area

ERIC – European Research Infrastructure Consortium

ESFRI – European Strategy Forum for Research Infrastructures

ESS-ERIC – European Social Survey – European Research Infrastructure Consortium

EU – European Union

ESI Funds – European Structural and Investment Funds

EUR – Euro currency

GDP – Gross Domestic Product

H2020 – Horizon 2020 research and innovation program

HEI – Higher education institution

ICT – Information and Communication Technology

MoES – Ministry of Education and Science

OECD – The Organization for Economic Cooperation and Development

PRO – Public research organisation

RP – Research programme

R&D – Research and Development

R&D&I – Research and Development and Innovation

R&I – Research and Innovation

RCNI – Research centre of national importance

RFBR – The Russian Foundation for Basic Research

RI – Research Infrastructures

ROI – Return on investment

SHARE-ERIC – Survey of Health, Ageing, and Retirement in Europe

VAT – Value Added Tax

European XFEL GmbH – The European X-Ray Free-Electron Laser Facility GmbH

Summary

The research infrastructures have become a crucial pre-condition to conduct top-level research and drive innovation. While many countries of the Baltic Sea Region have identified their individual research development and innovation commitments, including research infrastructure development objectives, the research infrastructure in the Baltic Sea Region lacks sufficient and extensive interconnectivity and is not equally distributed between countries. Increasing the efficiency and intensity of the research infrastructure cooperation in the Baltic Sea Region is important because it facilitates time and cost efficiency, especially in the Eastern countries of the Baltic Sea Region. This roadmap has been created to provide practical suggestions on the efficiency of the research infrastructure utilisation and cooperation. It is focused merely on the research infrastructure that is already established or is in the phase of development, rather than suggesting the creation of new research infrastructure. In this roadmap, the best practices of the research infrastructure utilisation and cooperation in Europe are analysed, and the tool-box of best practices is created to understand the qualities of and processes in the research infrastructure that should facilitate successful utilisation and cooperation. Then, an evaluation of European research infrastructures of interest for the Baltic Sea Region is performed. As a result, a framework is provided to analyse the efficiency of the research infrastructure cooperation and utilisation. This framework can further be used on the research infrastructures of the Baltic Sea Region to assess and enhance their qualities. Finally, suggestions are provided for the science ministries or other relevant political institutions of the countries of the Baltic Sea Region, in order to indicate possible ways for them to facilitate and enhance the efficiency of the research infrastructure utilisation and cooperation.

1. Introduction

This roadmap aims to provide the support and useful tools for enhanced cooperation between scientific institutions in the Baltic Sea Region (BSR), in order to facilitate the macro-regions ability to become a leading player in science and innovation. The roadmap has three sub-goals, namely: to provide the responsible ministries with specific suggestions on how to facilitate the efficient utilisation of the research infrastructure (RI). The second sub-goal is to provide the responsible ministries with suggestions on how to increase the socio-economic return of these RI. The third sub-goal is to provide the scientific institutes with a toolbox that would allow assessing of the current state of RI utilisation and development of certain steps to enhance the utilisation of RI.

There are various RI across the BSR. However, the existing facilities are not equally distributed and interconnected.[1] Establishment and maintenance of the research infrastructure usually is a costly and complicated project. This determines the need for efficient utilisation of the RI in order to make it economically feasible. This, in turn, indicates that countries and regions where distances between them are not huge, and travel infrastructure is well-developed have more favourable conditions to develop more intensive cross-country cooperation to achieve higher efficiency goals. BSR has those pre-conditions. The challenge is, however, to find a way to utilise them.

Cooperation between the BSR countries and regions becomes especially relevant and beneficial. In particular, there are strong reasons for the South-eastern BSR countries to cooperate in order to build the critical mass of researchers so that investments in newly established RI have as high returns as possible. Overcoming the gap in the distribution of RI is bound to be a long process because the establishment of new RI not only bears considerable costs but also takes much time. Therefore, the emphasis of this activity should be put on ensuring better interconnection and mobility (e.g. university researchers from one country can more easily use research laboratories in another country).

[1] European Commission. (February 20, 2017). Commission Staff Working Document. European Union Strategy for the Baltic Sea Region. Action Plan. See Appendix 6 for source.

1.1. Structure of the roadmap

This roadmap is structured in the following way. Firstly, framework conditions concerning RI and the field of science in general in the BSR are provided for the reader to understand the present situation in the macro-region. Secondly, the best practices of RI cooperation and efficient utilisation thereof are identified. Those are further developed into four pillars crucial for the efficient utilisation of RI and RI cooperation. The pillars are: strategy; cooperation; personnel, researchers and scientists; and funding. Those four pillars are later developed and further elaborated by the participants of the working group seminars and interviews (primary sources). Thirdly, different RI across the BSR are assessed and evaluated using six factors necessary for efficient utilisation of RI in the BSR, namely, scale, uniqueness, and the four pillars[2]. The RI were chosen with the purpose to ensure sufficient representativeness as well as sufficient variety regarding size, scope etc. The aim was to select one half of RI with extensive cooperation with Latvia and another half with limited or no cooperation with Latvian RI. Also, the size of RI was taken into account. This was done with the aim to provide the suggested model with sufficient testing opportunities. In particular, the scale of the RI is evaluated based on the fact that larger facilities easier develop the necessary critical mass for effective cooperation and utilisation of the RI[3].

Further, the uniqueness of each particular RI is evaluated because it was identified as an essential factor for international cooperation in the life science, biomedicine research and drug development working group seminar[4]. The evaluation framework, which is available in Appendix 1, can be used further to assess the performance regarding cooperation and successful utilisation of RI of national importance and also to identify opportunities for improvement. Finally, suggestions are provided to the responsible ministries, based on the four pillars identified during the research, concerning national and international RI. The expected results are also described, in the case of successful implementation of the suggestion.

[2] Funding of the RI is not evaluated due to lack of information about it.

[3] Andersson A. E. and Persson O. (1993). Networking Scientists. *The Annals of Regional Science,* 27:11-21.

[4] Life science, biomedicine research, drug development working group seminar. April 26th, 2018. Latvian Institute of Organic Synthesis, Riga, Latvia.

2. Methodology

Based on the analysis and the existing body of research, the roadmap identifies opportunities for improvement in scientific development and research cooperation in the BSR; provides conclusions, solutions, and suggestions for further actions. At first, the desk research on BSN and other relevant materials was performed, and an in-depth case study analysis of six different RI was conducted (see Chapter 2.2), two for each of the fields of scientific excellence discussed in this paper. Based on the case studies, a RI's best practice framework containing nine factors for the overall success of RI was developed (see Chapter 3.2). Then, the working group discussions and semi-structured interviews with international experts were held (see Chapter 2.3). This also included discussion about factors derived from the case study analysis. In the working groups, four pillars for successful RI cooperation in the BSR were developed (see Chapter 3.3), which were complemented by the insights given by the interviewed international experts. These four pillars were used as the foundation to develop an RI evaluation framework (see Appendix 1), which was supplemented by two additional factors identified as crucial for the evaluation, based on additional remarks in the final working group seminar[5] and also input from the case studies.

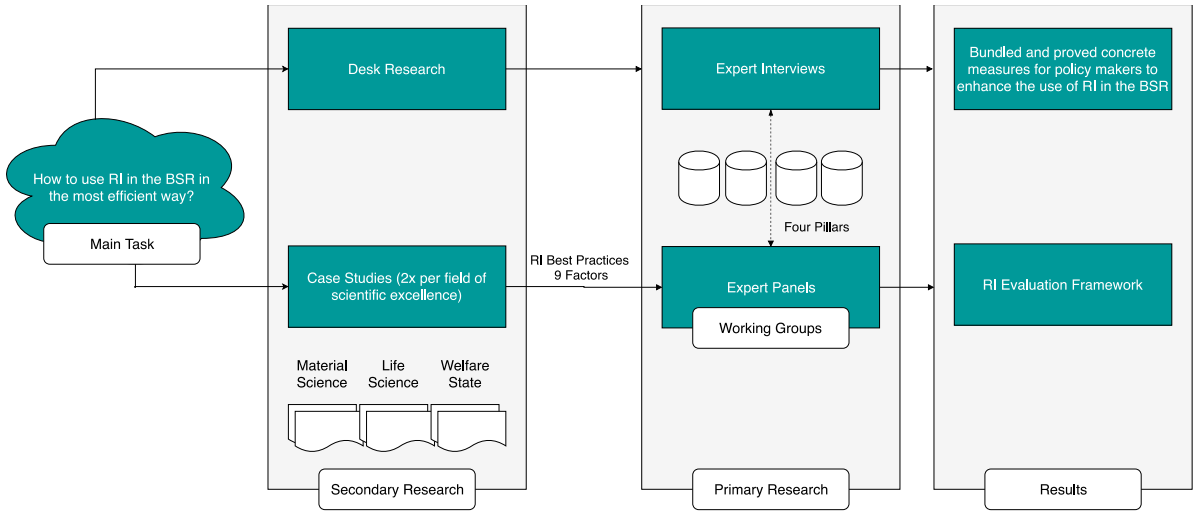

Figure 1. Visualisation of the overall research approach. Created by the authors.

Finally, considering all the findings in the case studies, the working group seminars, the interviews, suggestions in each of the fields of scientific excellence were devel-

[5] The final working group seminar. June 27th, 2018. Riga Technical University Conference Hall, Āzenes street 6, Riga, Latvia.

oped for the ministries of the BSR in order to enhance the macro-regional RI cooperation (see Chapters 4.2, 5.2, 6.2) followed by overall conclusions, suggestions for the ministries and RI in general (see Chapter 7). For the overview of the research approach used in this roadmap see Figure 1 on the previous page.

The Baltic Science Network (BSN) project partners, based on their national expertise and the BSN commissioned study[6] results, have agreed on key topical science areas where cooperation among the BSR countries could be appropriate and most useful. The analysis in this roadmap is based on the following areas of the research excellence:

- **Materials, photon, and neutron sciences**, which have a high potential to advance as an area of joint scientific excellence. Material science research institutes in the BSR are among the highest rated institutions in the world, while in some BSR countries materials science research institutions receive the highest evaluation results. Also, there is a high density of materials sciences RI in the BSR, which further increases the scientific field's potential to develop as an area of joint scientific excellence. Finally, innovations in the fields of materials, photon, and neutron sciences are of benefit to other scientific areas of high importance in the BSR, such as biotechnology and medicine.[7]
- **Life sciences** (including biomedical research, biomedicine, diagnostics, and drug development), which are currently of high priority in the countries of the BSR and have high potential to become an area of joint scientific excellence in the BSR. Compared to other scientific fields, biomedicine and chemistry research institutes in the BSR are rated the highest in the world rankings regarding citation impact and publications in the world's best scientific journals. Also, medicine has the highest number of H2020 projects where the countries of the BSR cooperate, while participation levels in other projects in the fields of biomedicine, biology, etc. are one of the highest compared to other scientific fields.[8]
- **The welfare state**, one of the greatest achievements of the European countries, might be the most important single factor that distinguishes Europe from any other continent. The welfare state is a topic relevant to every country in Europe while the Nordic countries are the forerunners not only in Europe but also in the world.

[6] Musiał K. and Schumacher T. (2018). Scientific Excellence: Joint Potentials in the Baltic Sea Region – an explorative study (Baltic Science Network Activity 3.2): 92 - 100

[7] Ibid.

[8] Ibid.

Organised solidarity between different socioeconomic groups is important in other BSR countries as well, hence, the welfare state is the third identified area prioritised for collaboration within the macro-region.[9]

2.1. Main Terms

In the following table, the terms used in the roadmap are defined and elaborated. This is done mostly for the reader to have a better understanding of these terms and to prevent any ambiguity that may arise from these terms. The description should be assessed more as authors' interpretation that will be used all through the report rather than precise definitions.

Term	Description
Research infrastructure	"Facilities, resources or services of a unique nature identified by European research communities to conduct top-level research activities in all fields"[10].
Distributed research infrastructure	"A Research Infrastructure with a common legal form and a single management board responsible for the whole Research Infrastructure, and with a governance structure including among others a Strategy and Development Plan and one access point for users although its research facilities have multiple sites" [11].
Single-sited research infrastructure	A research infrastructure which is located in a single place as a whole[12].
Virtual research infrastructure	A research infrastructure which is available for use electronically[13].
Research infrastructure of local importance	A research infrastructure which usually belongs to one scientific institution is under the governance thereof and is utilised on a local level.

[9] Musiał K. and Schumacher T. (2018). Scientific Excellence: Joint Potentials in the Baltic Sea Region – an explorative study (Baltic Science Network Activity 3.2): 92 - 100

[10] Strategy Report on Research Infrastructures. ESFRI Roadmap 2016.

[11] Strategy Report on Research Infrastructures. ESFRI Roadmap 2010.

[12] Research Infrastructures. European Commission website: https://ec.europa.eu/research/infrastructures/index.cfm?pg=about#

[13] Ibid.

Research infrastructure of national importance	A research infrastructure which may allow for and support research cooperation on a national level and which is often attributed to the scientific performance of the country. The capacity of this research infrastructure limits the ability of a single institution to establish and govern it.
Research infrastructure of international importance	Exceptional or rare national research infrastructure which is available for use to foreign scientists and researchers.
Landmark research infrastructure	A large-scale science facility which is attributable to the global scientific performance, as in but not limited to ESFRI landmark[14]. It serves large and varied user groups and involves national and international partners in funding and access procedures.
European Research Infrastructure Consortium	"A specific legal form to facilitate the establishment and operation of research infrastructures with European interest"[15].

*In this paper, the word international is used to describe the involvement of multiple states (including the EU and the BSR), unless otherwise stated.

2.2. Case Studies

During the current research, there were two case studies conducted in each of the fields of scientific excellence. The topics analysed in the case studies were:

- best practices and approaches that allow attracting scientific knowledge and competence;
- expansion of cooperation that would be beneficial for all involved partners;
- factors influencing the development of scientific research, e.g. focus on collaboration, solutions and achieving goals.

Firstly, the focus of the case study analysis was on international RI, which are attractive to scientists due to more substantial opportunities, access to advanced knowledge as well as possible knowledge spill-overs. Secondly, the cases were chosen based on different types of RI (e.g. single site RI and distributed RI), in order to

[14] Strategy Report on Research Infrastructures. ESFRI Roadmap 2018.

[15] European Research Infrastructure Consortium (ERIC). European Commission website: https://ec.europa.eu/research/infrastructures/index.cfm?pg=eric

assess the similarities and differences predetermined by the type of RI. Thirdly, the scope of the networks related to the leading institution of the RI was considered. This was because the networks are considered critical for cooperation. Finally, the cases were chosen based on the cooperation of the leading institute of the RI with institutes from other BSR countries. To sum up, the following RI were chosen for the case studies:

1. Materials science
    a. The European X-Ray Free-Electron Laser Facility GmbH (European XFEL GmbH)[16]
    b. SOLARIS National Synchrotron Radiation Centre[17]
2. Life science
    a. Biobanking and Biomolecular Research Infrastructure (BBMRI-ERIC)[18]
    b. European infrastructure for translational medicine (EATRIS)[19]
3. Welfare state
    a. Integrating Research Infrastructure for European expertise on Inclusive Growth from data to policy (InGRID)[20]
    b. Survey of Health, Ageing, and Retirement in Europe (SHARE-ERIC)[21].

2.3. Working Groups and Interviews

For each of the fields of scientific excellence, working groups consisting of international experts were created, in order to discuss a number of topics: e.g. financing and costs of RI[22], policies concerning the selected science domains and RI[23], the importance of retaining scientists[24,25], scientific cooperation, topics of joint interest for future multilateral research collaboration, support for scientists, promotion of RI usage, etc. During the final working group discussion[26], the members agreed to a set of issues that have to be addressed, namely, insufficient funding for

[16] The European XFEL GmbH website: https://www.xfel.eu/

[17] SOLARI National Synchrotron Radiation Centre website: http://www.synchrotron.uj.edu.pl/en_GB/

[18] BBMRI-ERIC website: http://www.bbmri-eric.eu/

[19] EATRI website: https://eatRIs.eu/

[20] InGRID website: http://www.inclusivegrowth.eu/

[21] SHARE-ERIC website: http://www.share-project.org/

[22] Working Group seminar on Photons, Neutrons and Structural Materials, April 16th, 2018. Institute of Solid State Physics, University of Latvia, Riga, Latvia.

[23] Ibid.

[24] Ibid.

[25] Working Group on the Welfare State. April 26th, 2018. University of Latvia, Faculty of Social Science, Lauvas street 4, Riga, Latvia. The final working group seminar. June 27th, 2018. Riga Technical University Conference Hall, Āzenes street 6, Riga, Latvia.

[26] The final working group seminar. June 27th, 2018. Riga Technical University Conference Hall, Āzenes street 6, Riga, Latvia.

RI, insufficient cooperation in certain science domains, the value of long-term strategies, and lack of qualified research personnel in certain science domains. Possible solutions to these issues have also been discussed. Also, it has been found that there might be certain commonalities of issues faced across the three selected science areas, with some exceptions that are outlined later in this roadmap. For the full list of working group seminars see Appendix 2.

After that, a total of six (two for each field of scientific excellence) international experts were selected to be interviewed. During the interviews, the importance of transparency and openness in RI access policies, the lack of funding for new and maintenance of existing RI, the importance of training of new scientists and RI personnel, and the cooperation development were discussed. The interviewed experts' insights mostly overlapped with the conclusions reached during the working group seminars, which adds additional validity that the identified issues are to be addressed. For the list of interviewed experts see Appendix 4.

3. Key Findings

3.1. The Baltic Sea Region Framework Conditions

The BSR (see Appendix 5 for a map of the BSR countries) is one of the most competitive regions in the world with top-level universities and research institutions. However, the research performance between the countries within the BSR is different. The existing RI is not equally distributed across the macro-region.[1] Countries in the BSR face similar problems and challenges in national higher education and research systems (globalisation, economic crisis, demography, technological progress, etc.). There are also challenges (e.g. climate change, welfare, health) that the whole society faces, which can only be dealt with on a macro-regional level as a result of transnational cooperation.[27] Therefore, the common challenges faced by the BSR countries should serve as a motivator for cooperation in cases when interests and areas of excellence are overlapping.[28] According to the Council of the Baltic Sea States (CBSS)[29], facilitating "continuous dialogue and collaboration in science, research, innovation and higher education" must be considered. The MoES's in the BSR should take advantage of mutual benefits from the RI in the BSR. The ministries should engage in collaborative value-adding projects to support the macro-regional framework for R&I. So, it can be concluded that in general there is a consensus about challenges and RI cooperation opportunities present at the BSR arena. This roadmap is designed to help the MoES's of the BSR to take advantage of these opportunities and enhance the macro-regional RI cooperation to reach the goals set out in the BSR.

Some of the goals on the BSR, EU and national levels are to increase the effectiveness of and the investments in R&D&I, improve the transparency, openness and accessibility of RI, and reduce the administrative burdens in RI utilisation, collaboration and research programmes (RPs). On the macro-regional and national levels, cross-border cooperation in R&I should be enhanced. It has been found that scientific publications that originate from collaborative projects in the BSR are of much higher scientific quality than those who do not[27], which provides further motives to facilitate the research cooperation in the macro-region.

[27] BSN Working Paper 5.2 "Drivers for participation in transnational research cooperation and recommendations for increasing participation of low performing countries/regions in transnational research activities"

[28] Ministry of Education and Research of Republic of Estonia, Research Policy Department. (2018). Drivers for Participation in Transnational Research Cooperation, Recommendations for Increasing Participation of Low Performing Countries and Regions in Transnational Research Activities. *Baltic Science Network.*

[29] CBSS Science Ministers' Conference Kraków. (June 15-16, 2016). Baltic Science: Renewing the Commitment to Science/Research Joint Actions in the Baltic Sea Region.

The importance of researcher mobility and networking in the BSR is emphasised by the BSN. Mobility stimulates research cooperation and provides sustainability for co-operation networks through the attraction of new young scientists. Therefore, the number of networking and mobility activities in the BSR should be increased. Furthermore, mobility should be promoted from outside the BSR, in order to increase the macro-region's scientific capacity by attracting scientists from outside the region.[27, 30] Also, the RI and research institutions of the BSR should be promoted outside the BSR, in order to make the RI of the BSR attractive for partners outside of the macro-region.[31] The targets set for the BSR by the EU Strategy for the Baltic Sea Region are amongst others an increase regarding attracted students and researchers from abroad by 10% by 2020, as well as the number of students who gain education-related experience abroad.

Each country in the BSR has developed strategic guidelines where scientific institutions have developed visions for science, R&D and RI. Together they constitute the strategic vision for efficient collaborative RI utilisation in the BSR which amongst others implies transparent, open and accessible RI, mobile personnel, researchers and scientists, equal capacity in terms of RI performance. However, a clear international strategy for the BSR has not been defined; the challenges faced by the society on a broader scope than purely national should be addressed by enhancing transnational cooperation in the utilisation of RI and R&I in general. RI are centres for the training and development of scientists and creating stronger ties between the nations in the BSR, thus, opening up a wide range of opportunities for collaboration with partner countries.[32] After assessing the strategic vision of the BSR, it is concluded that the countries of the BSR should combine their efforts to enhance macro-regional cooperation in the field of science, R&D and RI. BSR countries have to lay the foundations for closer, more connected collaboration to achieve this common goal.

[30] BSN news entry "High Time for Expanding the Talent Pool Housed by the Baltic Sea Region" offers more information on one of the earlier BSN presentations and calls to seek more possibilities to attract talent to the Baltic Sea Region http://www.baltic-science.org/index.php/news-and-press-releases/bsn-press-releases/85-high-time-for-expanding-the-talent-pool-housed-by-the-baltic-sea-region
For more information about the mobility tools in the Baltic Sea Region see S. Sepponen, S. Roschier,
M. Bröckl, J. Mikkola and M. Hjelt. Gaia Consulting Ltd. (March 2018). Researcher mobility tools for the Baltic Sea Region. *Baltic Science Network.*

[31] BSN Position paper. Tackling widening participation in R&I from the Baltic Sea Region perspective. *Baltic Science Network.*

[32] German Federal Ministry of Education and Research. Internationalisation of Education, Science and Research Strategy of the Federal Government.

All of the before mentioned aspects, for example, transparency and openness of RI, the mobility of researchers, and others are looked upon in this roadmap. Furthermore, suggestions on enhancing the cooperation in the BSR are provided for the MoES's of the macro-region based on the described policy framework conditions.

3.2. Best Practices

This chapter is focused on the analyses of the examined 6 cases of the EU housed RI. The analysis was conducted from the publicly available materials only. This includes thorough analysis and assessment of RI webpages, statutes, annual reports and developed strategies, etc. In some cases, the information was missing or was insufficient in some areas. This was considered a clear indication of flaws in collaboration strategy since extensive and sufficient information about all the aspects of cooperation is a necessary pre-condition for success. The analysis was conducted according to the insights provided in the methodology chapter. However, the analysis in accordance with the complete framework was not possible due to the lack of publicly available data and information.

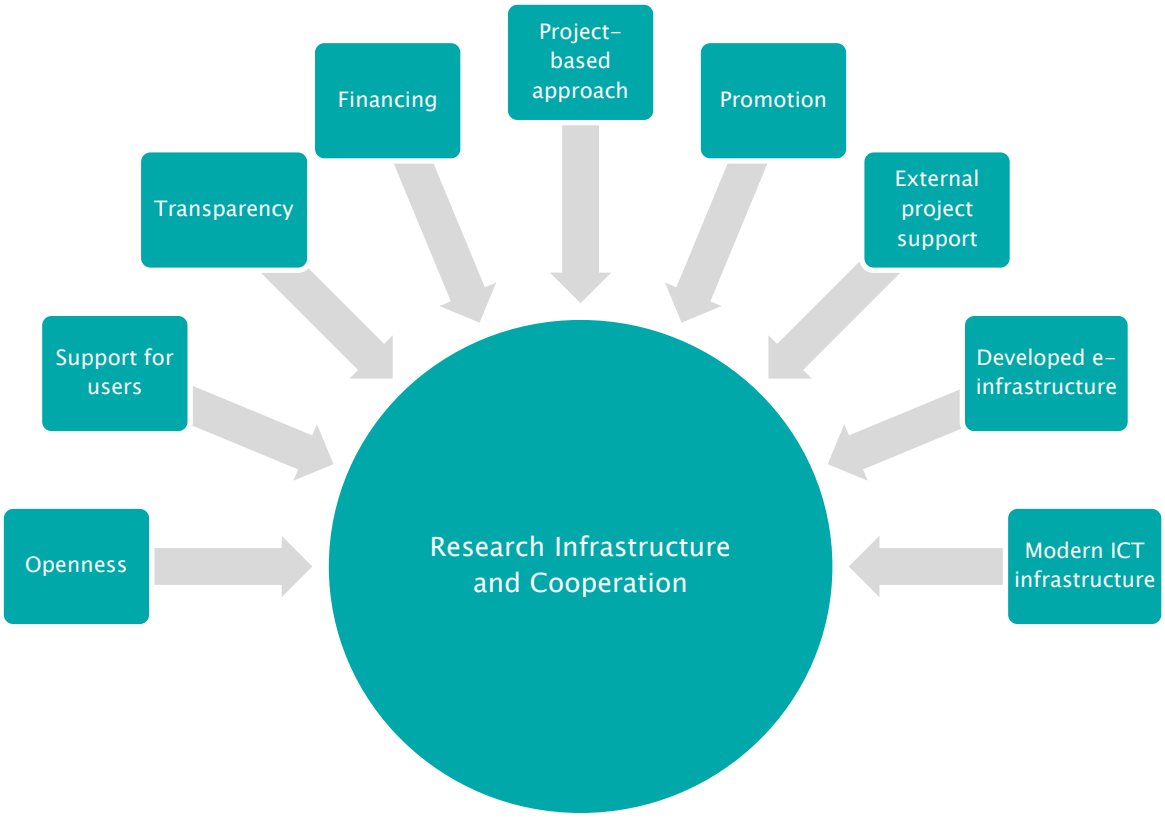

Figure 2. Best practices for research infrastructure and cooperation.

This is because some of the information can be acquired only through primary research, e.g. interviews with managers and administrators of the facility and because some information cannot be accessed at all due to the security regulations of the facility. Thus, it was decided to use a combined approach: integrating the insights from secondary sources with the in-depth case studies developed for the selected areas. The chosen areas of excellence are different in terms of the type of operation; however, the conducted analyses revealed that the cases are similar regarding factors and approaches used to facilitate the use of RI as well as local and international cooperation. In the following paragraphs, the most important factors (see diagram on the previous page) for enhanced collaboration are identified and described.

3.2.1. Openness

This is the first criteria observed in all the selected cases: e.g. the information about the projects and RI is available on the website in a number of languages, and English is the default language in all the analysed cases. However, the fact that the information is available does not necessarily mean that it is sufficient and appropriate to attract the interest and cooperation partners. It is important that the available information is structured and provided in a way that creates a clear and adequate perception of the expected rules for collaboration. It is equally important to ensure that the provided information is accurate, attractive, and describes all the opportunities offered for scientists, in order to create the interest in collaboration as well as adequate expectations for the possible cooperation partners.

Even though the selected cases can be considered as fairly open, the openness as such is not a sustainable facilitator of cooperation. It is important to develop a clear strategy for openness, and this is supported by both the theoretical findings and the case analysis. Such a strategy outlines both short and medium-term activities aimed at the promotion of research and RI collaboration. A vital component of an openness strategy is the focus on international collaboration both within and outside the EU.

If such a strategy is developed, it should be publicly available to ensure that potential cooperation partners can gain information about the current state and future development of principles.

3.2.2. Transparency

Transparency is important for the attraction of scientists and cooperation partners, and to ensure that the projects accepted for development are of high academic and scientific value. Clear and transparent criteria for selection of projects facilitate the inflow of applications from all over the world. Both the appropriateness and the quality of projects are prioritised, instead of the country of origin, e.g., the fact that researchers come from the EU does not give them additional benefits in the application procedure.

3.2.3. Support for Users

The support measures for applicants can be described as significant. This includes support during the application process (to work with the RI) as well as during the use of RI. Support measures include detailed guidelines for preparation and submission of applications. The use of infrastructure often is also provided with additional support measures, e.g., courses, training and other support that is necessary to work with the RI.

If the support system is developed, it should also be available for wide access through the website in order to give the scientists a clear and explicit picture of the support measures available and provided to enhance smooth integration of the external scientist in the existing research system.

3.2.4. Financing

RI are usually developed with extensive financial support from one or multiple governments and/or the EU. This includes financing for development and operation of the RI. The large cost of the development and operation create a notion that the use of RI will be expensive, and charges will be applied to all researchers who are using it. To some extent, it is true since membership fees are charged from participating universities and countries. However, the fees are usually not applied for individual scientists. Moreover, in some cases, financial support is provided for scientists in order to attract them and make their stay more comfortable.

3.2.5. Project-based Approach

During the study, it was identified that science is experiencing a shift in focus from general knowledge development to finding new solutions. Such a paradigm shift demands a change in the way the work is organised in a RI facility. Such a change also means that the project-based approach is used more extensively in all areas of operation. This implies the focus on goals of the project, the necessary resources, and planned timeline. Such an approach to the organisation of scientific work ensures stronger result and solution orientation as well as more predictable planning and allocation of resources. Also, from the perspective of a scientist, such an approach is more favourable since rules regarding the use of a facility and important milestones are clearly defined and can be used for the progress assessment any time.

3.2.6. Promotion

Promotion is an important tool for the facilitation of the more extensive use of RI. This includes, in the spirit of the earlier suggested "myth buster",[33] the spreading of information about the opportunities provided at the facility. Also, scientific publications play an important role in the promotional package of a facility. In the analysed cases, it can be observed that publications are being developed and promoted intensively in order to attract and arouse the interest among skilled and knowledgeable scientists.

3.2.7. External Project Support, e.g. Horizon2020

Currently, Horizon 2020 (H2020) funding is the main EU instrument to support science and research. All the analysed institutes have set high priority for H2020 applications. This is relevant both for the development of own H2020 applications and also support for other scientists in this respect. This implies that the toolbox suggested for other RI should include support for the development of H2020 projects. Then, this support can be further broken down into smaller details: help in the preparation of applications, support for understanding the essence of H2020, financial support for some parts of the development of an H2020 project, etc.

[33] Danish Agency for Science and Higher Education. (March 2017). Working Paper of Activity 3.1 "Challenges and barriers to research cooperation in the Baltic Sea Region". *Baltic Science Network*.

3.2.8. Developed E-infrastructure

To a large extent, the analysed cases offer remote use of the RI. This implies significant reduction of costs and increased use of the RI. The cost savings are achieved because there is less need to travel and less physical space necessary, while the intensity of use is achieved through shorter lead times and better opportunities for multi-use of the RI.

In general, there are two ways of using the e-infrastructure: direct remote access to the facility or access through the local node functioning as a gateway to the main infrastructure. In both cases, it is important to focus on the development of the interface and the compatibility of the remote facility with the equipment used by the scientists.

3.2.9. Modern ICT Infrastructure

This tool can be considered self-explanatory since ICT infrastructure is crucial in many areas of our lives and especially in science. Modern research cannot be operational and competitive without sufficient computing power, fast broadband, modern communication and video conferencing tools, etc. Thus, in order to facilitate cooperation and the use of RI, the facility holders need to update and upgrade ICT systems regularly to ensure that they are up to date and operational. This is relevant for specialised and general ICT infrastructure that is operational in the facility.

3.3. Four Pillars

Based on the discussions of international experts from the BSR and the best practices of RI (Figure 4), the four main pillars concerning the development of RI in the BSR, which are outlined in chapters 3.3.1 – 3.3.4, are identified:

Funding	Cooperation	Strategy	Personnel, Researchers and Scientists
Consistency Sustainability	Sufficiency Efficiency	Long-term planning Transparency Openness	Qualified personnel Sufficient number of researchers and scientists

The identified topics are similar in all fields of scientific excellence and, therefore, elaborated for the three fields together.

3.3.1. Funding

This section briefly outlines the existing funding practices and possible shortcomings, where apparent lack of comprehensive approach to the various financial components of establishing and running an RI known for its delivered science excellence, are identified. Funding for RI, e.g. institutional funding (base funding as competitive institutional funding), especially for the maintenance and service of RI, and for the training of scientists and RI personnel often is not sufficient. That is especially evident in the field of the welfare state as emphasised by experts in the final working group seminar[34]. In fact, the ESI Funds programmes do not cover the maintenance, repair or updating costs of RI. Therefore, buying new RI instead of maintaining the existing RI, which is more expensive and often ineffective, is implicitly promoted. Also, RI funding is inconsistent and unsustainable, i.e. a project may be started, but there might be lack of resources to finish it, or RI are being funded, yet the training of personnel who uses the RI is not. Also, if maintenance is funded by project funds and grants, it is not always appropriate or in favour of sustainable operation of the RI. Those issues concerning the long-term sustainability of RI are also recognised on the European level[35]. In addition, it is emphasised by international experts that dedicated funding for research collaboration is insufficient or even non-existing.

3.3.2. Cooperation

It was emphasised by international experts that due to important positive aspects that could potentially be achieved, as the promotion of innovation, visibility, and recognition, increasing of cooperation between researchers based in the BSR is important[36]. The importance of international visibility is further elaborated – in order to attract more RI users and collaboration projects, the effectiveness of RI should be advertised and maintained. One of the means for the advertisement and proving of the efficiency of an RI are publications with examples of successful projects. Also, it is noted that one of the limiting factors for cooperation is the oversubscription of certain RI (mostly physical RIs), meaning that researchers are often not able to use heavily demanded RI.

[34] The final working group seminar. June 27th, 2018. Riga Technical University Conference Hall, Āzenes street 6, Riga, Latvia.

[35] Long term sustainability of Research Infrastructures. Non-paper Stakeholders Workshop of 25th November 2016.

[36] While small population can neither be called a negative, nor a positive factor, it is, however, also cited as an aspect that provides the necessity for promotion and enhancement of RI cooperation in the BSR.

3.3.3. Strategy

Implementation of long-term operation and funding strategies is not promoted – there is a need for a long-term strategy that is coordinated within the RI development programme of the ESI Funds, and a need for monitoring and control of such strategy on the level of the BSR.

3.3.4. Personnel, Researchers and Scientists

Declining demographic trends in the BSR countries and insufficient funding for the training of personnel for specific RI, especially in the EU13 countries, is resulting in an overall shortage of qualified RI personnel, scientists and researchers. Unqualified and untrained personnel determine the inefficient utilisation of RI. Hence, the research potential of the macro-region is not fully developed if the personnel shortages are not addressed properly.

In the following chapters, ways of addressing the issues related to the four pillars of RI and RI cooperation development in the BSR are discussed. Suggestions are provided for the respective policy makers in the BSR countries in the three fields of scientific excellence as identified earlier.

4. Research Infrastructure Evaluation

In this chapter, the assessment of RI is performed based on the framework provided in Appendix 1 for each field of scientific excellence. Here it should be emphasised that the aim of the current research is to develop a roadmap and not extensively analyse different aspects related to the use of RI, but rather develop and test a tool that can be utilised to enhance the co-operation and improve utilisation of RI. Due to limited availability of information, the assessment is merely indicative and serves as an example for the aforementioned framework. It also shows how the tool can be used for self-assessment by different RI. An actual, more precise evaluation could be done given access to more information and data about these particular RI. Also, it has to be noted that the funding aspect of the RI is not evaluated at all due to lack of publicly available information about it. There were no specific criteria for the choice of RI, and they were selected randomly but still ensure some sufficient variety. In the second part of chapters 5.1, 5.2, and 5.3 suggestions concerning the four pillars mentioned in chapter 4.3 are provided for the policymakers in the BSR.

4.1. Materials, Photon, and Neutron Sciences

4.1.1. Research Infrastructure Overview

In the following paragraphs, RI in the field of materials, photon, and neutron sciences are described. The description is divided into six factors, namely, scale, uniqueness, strategy, cooperation, personnel, and funding. Further, the evaluation (example) of the RI is provided based on the available public information. The criteria of the evaluation and evaluation scale see in Appendix 1.

Nanoscience Foundries and Fine Analysis – Europe (NFFA-Europe)[37]

Provides RI specialised on growth, nano-lithography, nano-characterisation, theory and simulation and fine-analysis with Synchrotron, FEL and Neutron radiation sources. Users of the RI have access to analytical large-scale facilities, theory and simulation and high-performance computing facilities, which is coordinated through a single-entry point portal.

[37] NFFA-Europe website: https://www.nffa.eu/

Scale	Uniq.	Strat.	Co-op.	Pers.	Total
3	3	3	2	3	**14**

Scale. Distributed RI among 19 partners in 10 European countries.

Uniqueness. The first and only such RI in the macro-region.

Strategy. All applications are collected through a single-entry point. A dissemination programme is in place (part of TLNet) to provide access to research and industry communities which do not have sufficient access to other RI in the field of nanoscience. The RI is also creating a platform-wide data model in order to efficiently store and share the results of projects and to build a successful public access data policy. Access to the sites is provided free of charge for both the industry and academia. Moreover, the RI covers subsistence and travel costs. So, the strategy part seems rather developed even if far from excellent.

Cooperation. The RI has defined five Joint Research Activities (JRAs) in order to overcome certain bottlenecks of nanoscience research, which is done by the collaboration of multiple NFFA-Europe partners. This cannot be considered an extensive cooperation focus.

Personnel. User support and the exchange of technical information is provided by the Technical Liaison Network (TLNet), which operates across the nodes of NFFA-Europe. Training and mobility are provided by NFFA-Europe through the TLNet in the form of schools, training materials, and occasional short-term visits to NFFA-Europe facilities.

Funding. Funded by H2020. Here and further in text not analysed in detail.

The Integrated Initiative of European Laser Research Infrastructures (LASERLAB-EUROPE)[38]

Offers to researchers the access to facilities of 22 laboratories in Europe, in order to perform advanced laser-based inter-disciplinary research. The main objectives of LASERLAB-EUROPE are to promote the use of advanced lasers and laser-based technologies for research and innovation, to serve both the academia and the industry through transnational access to its facilities, to train new users in the field of lasers, and to improve human and technical resources through joint research activities and technology exchange and expertise sharing.

[38] LASERLAB-Europe website: https://www.laserlab-europe.eu/

Scale	Uniq.	Strat.	Co-op.	Pers.	To-tal
3	3	3	2	2	**13**

Scale. Distributed RI (consortium) among 33 institutions and members from 16 countries, while 22 of all laboratories offer public access.

Uniqueness. The only such RI in the macro-region.

Strategy. Access to the facilities is provided free of charge, also covering the travelling and accommodation fees (public access). The RI promotes industrial use thereof. Guidelines for the application process are provided on the RI website. So the strategy is rather well developed.

Cooperation. The RI is participating in four JRAs together with other RI, including ESFRI RI. The aim of these JRAs is to improve the RI of the consortium and its partners and services provided by these RI.

Personnel. Training is provided in the form of summer schools (both local and international) and short-term visits to other sites at the RI with an emphasis on new researchers and research groups who haven't used the particular RI yet and young researchers (doctoral studies, post-doc).

[39] SINE2020 website: https://www.sine2020.eu/

Funding. Funded by H2020.

Science and Innovation with Neutrons in Europe in 2020 (SINE2020)[39]

Provides user services in sample preparation, sample environment and data treatment in large-scale facilities; R&D technology through instrumentation and detectors; industry consultancy; and education and training through an e-learning platform and schools. The objectives of SINE2020 are the preparation for utilisation of opportunities provided by the proposed European Spallation Source (ESS)[40] and development of the innovation potential of neutron Large Scale Facilities (LSF's).

Scale	Uniq.	Strat.	Co-op.	Pers.	Total
3	3	4	2	1	**13**

Scale. Distributed RI (consortium) among 18 partner institutions in 12 countries.

Uniqueness. The only such RI in the macro-region.

Strategy. The application, as well as the evaluation processes, are clearly described on the website of the RI. The access to the RI is free of charge and it

[40] ESS website: https://europeanspallation-source.se/about

is required to make the results of the research public.

Cooperation. The RI is involved in various JRAs and networking activities inside the consortium. However, there are no indications of more extensive cooperation development plan.

Personnel. The RI provides training and education to both new and experienced scientists in the neutrons field in the form of e-learning materials and schools. So, this part can be considered rather limited.

Funding. Funded by H2020.

4.1.2. Suggestions

In the field of materials, photon, and neutron sciences, further opportunities for enhanced RI cooperation in the BSR are identified, for which cooperation should be promoted between the states of the BSR. Foreign scientists should be involved in national consortiums, and joint scientific projects on the level of BSR should be prepared. Also, information about the opportunities provided by ESFRI / ERIC should be disseminated, and the opportunity to participate in ESFRI Landmarks – evaluated. There is also a lack of RI personnel and scientific personnel and insufficient information about RI cooperation possibilities in the BSR. Therefore, marketing programmes should be developed to address well-established, experienced researchers and scientists. Also, the general public with a view towards long-term sustainability of RI cooperation should be targeted. The society has to be informed about the socio-economic returns of RI[41], schools and teachers involved in science and research should be addressed, pupils and students should be encouraged to choose a career in science and research while shaping the image of science in the BSR. In the following tables, suggestions are provided for the policymakers in of the BSR, addressing the issues concerning the RI and RI cooperation in the field of materials, photon, and neutron sciences. Also, the expected results, should these suggestions be implemented, are stated.

[41] For more information on socio-economic returns of RI see Francesco Giffoni, Silvia Vignetti, Henning Kroll, Andrea Zenker, Torben Schubert, Emily DeYoung Becker, Ildiko Ipolyi, Elina Griniece, Jelena Angelis. (April 19, 2018). Deliverable 3.1 Working note on RI typology. *RI Paths.*

Strategy				
Issues	Suggestions			Expected results
	General	In case RI of local and national importance	In case of RI of international importance	
Limited international cooperation capacity and insufficient agility of Research centres of national importance (RCNIs).	1.1. Support the operation of RCNIs. Create RCNIs as separate legal entities with a holding organisation.	Concentrate investments in RCNIs, which would then distribute the funding amongst the respective RI.	Evaluate the utility of RCNI's membership in ESFRI / ERIC.	The agility of RCNIs is improved, which facilitates international cooperation. There is an increase in the number of orders from the EU15 PROs, as well as the industry.
The potential of national competence is not utilised on the international level.	1.2. Participate in mega-infrastructures in the BSR, for example, the European Spallation Source.	Provide equipment, data, etc. for mega-infrastructure projects, for example, as member countries do in the European Spallation Source project.	Support RI in the area of national competence in a particular field of science.	Visibility of scientists is improved.
EU15 PROs will cooperate with EU13 PROs if the latter have established developed RI, as well as great competence. It	1.3. Utilise bilateral and trilateral opportunities for cooperation.	1) Increase the political will to engage in cooperation. 2) Provide additional funding for bilateral cooperation.	Identify the possible synergies for cooperation by identifying the complementing research activities and services.	The idleness of RI is reduced. New opportunities for international cooperation arise. Performance capacity of local

is hard to facilitate cooperation between RI in different states of development. Critical mass is lacking in centres of regional excellence.	1.4. Expand the capacity of science and research in the BSR.	1) Reduce the differences in performance capacities in the BSR. 2) Create support programmes for integration in the RI of the BSR by in-kind contributions.	The countries of the EU13 have insufficient funds to participate in the mega-infrastructure in the BSR.	and national RI is increased.
	1.5. Concentrate investments in specific equipment.	Therefore, continue to invest systematically and consistently.	Adjust and align the planned investments between the countries.	
The cooperation of the science sector and the industry is insufficient.	1.6. Support and promote the availability of RI for commercial use at the market price, while providing RI for PROs free of charge or at a low cost (partial cost covering) price.	Plan for the equipment for commercial operations.	Attract customers from the countries of EU15.	Additional funds for the maintenance of the RI are provided. The visibility of RI is internationally enhanced.
	1.7. Promote the export of large-scale RI services.	Attract foreign entrepreneurs who commission scientific research.	Support creation of attractive offers to the customers.	
Insufficient, inconsistent, and unsustainable funding for RI and RI personnel.	1.8. Provide integrated medium-term government funding for scientific institutions.	Provide joint funding for RI, research and wages of personnel.	Take over the EU15 practices in medium-term financing.	Sustainability of funding for research is increased while also providing funds to maintain RI and its personnel.

RI is mainly funded by EU structural funds, which increases the dependence of research on the EU.	1.9. Gradually move from financing from EU structural funds to governmental budget funding.	Develop the existing competencies and the created RI. Strengthen the RCNIs with specialisation and division of labour of PROs.	Take over the EU15 practices.	Reduced dependence on the EU funds and better utilisation of existing RI.
Unique RI in the Baltic states are not utilised to full extent.	1.10. Involve the RI of the Baltic states in cooperation with international RI projects in the BSR.	1) Carry out analysis on the suitability of RI for cooperation. 2) Define the criteria of selection for cooperation projects.	Develop a comprehensive mid- to long-term strategies for promotion and utilisation of the existing and planned RI.	More efficient international cooperation and utilisation of RI.

Cooperation				
Issues	Suggestions			Expected results
	General	In case of RI of local and national importance	In case of RI of international importance	
Lack of visibility of the scientists and researchers from the countries of the EU13. Lack of involvement in international RI cooperation projects.	2.1. Increase the participation of EU15 countries in international RI projects of the BSR.	1) Facilitate utilisation of small-scale and medium-scale RI of the EU15 countries in order to train the research personnel. 2) Facilitate remote access. 3) Involve the BSR countries of EU15 in operations with data.	Expand the promotion of cross-border cooperation opportunities.	Small-scale and medium-scale RI of national importance are utilised efficiently, i.e. the smallest possible idle time, with a view to international cooperation.
Insufficient cooperation on the national level due to the	2.2. Promote the creation and operation of	Utilise the opportunities of RCNIs.	Attract PROs of the BSR to par-	The critical mass is developed, and

individuality of RI and their holding organisations, which is a precondition for inefficient cooperation on the international level.	national consortiums.		ticipate in national consortiums.	the specialisation of partner institutions is facilitated, which results in cooperation while reducing internal duplication and competition.

Personnel, Researchers and Scientists				
Issues	Suggestions			Expected results
	General	In case of RI of local and national importance	In case of RI of international importance	
Lack of competence in RI utilisation.	3.1. Prioritise the development and growth of RI personnel, scientists and researchers.	1) Increase the number of doctorates in the field of natural sciences and engineering. 2) Organise summer schools, seminars, working groups for young scientists. 3) Conduct mobility programmes for students, scientists, engineers and technicians, administration and management. 4) Support engagement of students in RI	1) Support training and internship programmes on the international level in order to reduce the differences in capacities between the scientists of PROs in different countries. 2) Facilitate mobility programmes for internships in mega-infrastructure projects of the RI.	A new generation of researchers and scientists is established. Sufficient workload for RI is provided.

		utilisation training.		
Lack of support for competence in RI utilisation.	3.2. Provide doctoral study and post-doc financing specifically for scientific institutions.	Assign additional credit points to students for the utilisation of RI of national importance. Attract talented international students.	Disseminate information about admission competitions through international sites.	
Lack of competence in RI utilisation.	3.3. Provide grant programmes for scientists and researchers to use foreign RI. It should cover travelling and housing costs.	Provide grants for training, internship, and research programmes in similar but foreign RI.	Provide grants for training, internship, and RPs in ESFRI / ERIC RI.	

Funding				
Issues	Suggestions			Expected results
	General	In case of RI of local and national importance	In case of RI of international importance	
Cooperation between national RI is ineffective, which also limits the capacity of international cooperation.	4.1. Enhance mutual transactions inside RCNIs.	1) Do not charge VAT for mutual transactions inside RCNIs. 2) Do not classify these transactions as public procurement.	Provide VAT exemptions in specific cases as is done in certain ERICs.	The availability and public access to RI on the national level are enhanced while increasing the capacity of international cooperation.
Insufficient resources to maintain RI, pay wages for RI personnel and	4.2. Create a centralised target financing programme to ensure proper operation of RI.	The financing programme should include funding for RI maintenance;	The financing programme should cover the costs of technical service for the RI.	More efficient utilisation of RI, i.e., decreased the time of breakdowns

cooperate in the BSR.		wages of RI personnel; cooperation in the BSR.		and non-operational RI.
Limited information about the opportunities and possibilities of RI cooperation in the BSR.	4.3. Provide funding for marketing.	Disseminate information about the available RI on the national level.	Disseminate information about the available RI and cooperation opportunities on the international level.	Increased information availability would boost the motivation for scientists to utilise the RI existing in other countries.
Dependence on project funds (grants) in maintaining the RI.	4.4. Increase the base funding for RI.	Increase the share of H2020 (and other similar EU programmes) projects in PRO budgets. Integrate the plan for acquisition of funding from EU funds and local budgets. Ensure sufficient security of funding in order to provide sustainability of the projects.	Increase the share of H2020 (and other similar EU programmes) projects in PRO budgets. Integrate the plan for acquisition of funding from EU funds and local budgets. Ensure sufficient security of funding in order to provide sustainability of the projects.	Project funding can be used effectively for project needs, while RI is also maintained and operating.
Limited capabilities to utilise foreign RI opportunities.	4.5. Funding for the utilisation of foreign RI.	Provide public access by outstanding scientists in the EU13 countries.	Expand the support for the utilisation of foreign RI. Develop exchange programs where different research related services can be exchanged.	Opportunities provided by the RI of the BSR are utilised, and the visibility of scientists in the countries of EU13 is enhanced.

4.2. Life Science

4.2.1. Research Infrastructure Overview

In the following paragraphs, RI in the field of life sciences are described and assessed to exemplify the use of the suggested tool. The description is broken down into six factors, namely, scale, uniqueness, strategy, cooperation, personnel, and funding. Further, an evaluation of the RI is provided based on 5 of these factors excluding funding. The criteria of the evaluation and evaluation scale are available in Appendix 1.

European Virus Archive goes global (EVAg)[42]

Provides an online catalogue of viruses and other similar databases for relevant research. EVAg is a non-profit organisation that mobilises global network with expertise in virology to collect, amplify, characterise, standardise, authenticate, distribute, track viruses and derived products.

Scale	Uniq.	Strat.	Co-op.	Pers.	Total
4	4	4	3	3	**18**

Scale. E-infrastructure (online catalogue). 26 partner laboratories from 17 EU and 9 non-EU research centres.

Uniqueness. The only such RI worldwide.

Strategy. EVAg provides public access to its products and services after transparent evaluation of the application. Access is provided free-of-charge (product shipment charges apply) for eligible parties, and the publication of research results and findings is mandatory. Information about the application procedure, the products, etc., is easily accessible and available on the website of the RI.

Cooperation. EVAg is involved in JRAs, the aim of which is to exchange know-how information between its partners, develop the RI, and strengthen the services provided by the RI. The RI actively collaborates with other organisations and RI internationally and offers other RI to become the repository thereof.

Personnel. In addition to products, one can enrol for training, workshops, etc. through the EVAg portal. The same policies (open access, free-of-charge if eligible, etc.) apply to these services.

Funding. Funded by H2020.

[42] EVAg website: https://www.european-virus-archive.com/

Research Infrastructures for the control of insect vector-borne diseases (INFRAVEC2)[43]

Provides free of charge access to products and services for research of insect vectors of human and animal disease, including mosquitoes, sandflies and other flies.

Scale	Uniq.	Strat.	Co-op.	Pers.	Total
3	3	3	2	1	**12**

Scale. E-infrastructure (online catalogue). Consortium of 24 partners, mainly from the Central and Western Europe.

Uniqueness. The only such RI in the macro-region.

Strategy. Provides public free-of-charge access to products, services, and research facilities for research in the field of insect vectors of human and animal disease. Guidelines for the evaluation of applications (clear evaluation criteria) are provided. Clear guidelines are provided for the operation with the online catalogue of INFRAVEC2. However, the evaluation process is not fully transparent.

Cooperation. Cooperation is promoted through the establishment of a database containing information about the skills necessary for insect vector research, ongoing projects, etc.

Personnel. Courses are held for scientists (especially young scientists) to increase their research expertise in fields that deal within sectors. Yet, the access is limited, and therefore it can be concluded that the personnel attraction is not extensively developed.

Funding. Funded by H2020.

Infrastructure for NMR, EM and X-rays for Translational Research (iNEXT)[44]

Provides transnational access to RI for structural biology. It is a consortium that offers researchers access to a wide range of advanced structural biology technologies, including X-ray technologies, NMR spectroscopy, Electron Microscopy and Biophysics.

Scale	Uniq.	Strat.	Co-op.	Pers.	Total
3	4	3	2	2	**14**

Scale. Consortium of 23 partners from 14 different European countries.

Uniqueness. The first research infrastructure project worldwide that combines access to different structural biology technologies (SAXS, X-ray crystallography, NMR, EM, biophysical characterisation).

[43] INFRAVEC2 website: https://infravec2.eu/

[44] iNEXT website: http://www.inext-eu.org/

Strategy. Provides transnational free-of-charge access. Three access levels are provided for researchers who want to use the iNEXT RI: structural audit – for researchers with no previous experience in biology research, enhanced support for biologists not familiar with the field of structural biology. The results of conducted research should be published and available via open access

Cooperation. In iNEXT three Joint Research Activities are defined: developing structure-guided drug discovery workflows, enabling technologies for integral membrane protein systems, enabling integrative methodologies for cellular structural biology. These Joint Research Activities involve different iNEXT partners, and the goal of these activities is to enhance the quality of the iNEXT services provided to users.

Personnel. Training is provided for the users and potential users of iNEXT RI through workshops. The aim of the workshops is to train experts to use the RI, as well as to attract scientists, both young and already experienced, to the field of structural biology.

Funding. Funded by H2020

Biobanking and BioMolecular resources Research Infrastructure (BBMRI-ERIC)[14]

Provides access to biobanks of human biological samples. The network brings together main players in the field, namely researchers, biobankers etc. The aim of the network is to make new treatments possible.

Scale	Uniq.	Strat.	Co-op.	Pers.	Total
3	3	3	4	2	**15**

Scale. Distributed RI consisting of 19 member states (most of them are member states of the EU) and one international organisation.

Uniqueness. The only such RI in the macro-region.

Strategy. Operates on the non-economic basis (ERIC). Researchers who are looking for cooperation with BBMRI-ERIC or its nodes are provided with all the necessary information about the application conditions on the BBMRI-ERIC website.

Cooperation. Participation in several ongoing as well as already completed international RI projects. BBMRI-ERIC provides the BBMRI-ERIC DIRECTORY 4.0 which is storage of information about biobanks that are open for co-operation. The tool facilitates visibility and cooperation efficiency of biobanks and the researchers using them. Amongst other services providing similar benefits are the SAMPLE/DATA

LOCATOR and the SAMPLE/DATA NEGOTIATOR.

Personnel. BBMRI-ERIC provides training in international biobanking standards, general quality management systems, integrated management systems, interface management systems on the spot, online, through university courses, summer schools, etc.

Funding. Funded from the membership fees of participating countries and H2020.

INSTRUCT-ERIC[45]

Provides RI for structural biology with the aim to promote innovation in biomedical science. It is Pan-European distributed infrastructure developing high-end technologies and methods in structural biology and making them available for others.

Scale	Uniq.	Strat.	Co-op.	Pers.	Total
3	3	4	2	2	**14**

Scale. Distributed RI consisting of 11 member states.

Uniqueness. The only such RI in the macro-region.

Strategy. Operates on non-economic basis. The RI is open access, and the application procedure is quick (reviewed in 6 weeks), transparent, and efficient. The RI can be accessed free of charge (INSTRUCT-ERIC also covers travel fees and accommodation). The application conditions and requirements are clearly stated on the website of INSTRUCT-ERIC.

Cooperation. Promotes and facilitates cooperation with the industry. The RI is working jointly with its partners and members to enhance the RI and the opportunities provided by the RI.

Personnel. Each year a training programme is published by INSTRUCT-ERIC. It contains a handful of workshops on structural biology. The RI also funds internships.

Funding. Funded by the membership fees of participating countries and EU programmes (e.g. H2020).

European Research Infrastructure on Highly Pathogenic Agents (ERINHA)[46]

Provides access to RI for the study of high-consequence pathogens of risk Group 4. The infrastructure is bringing together European high containment and complementary research facilities and expertise required to perform cutting-edge research in shorter time frames.

Scale	Uniq.	Strat.	Co-op.	Pers.	Total
3	3	3	2	2	**13**

[45] INSTRUCT-ERIC website: https://instruct-eric.eu/

[46] ERINHA website: http://www.erinha.eu/

Scale. Distributed RI consisting of 12 partners in 11 countries.

Uniqueness. The only such RI in the macro-region.

Strategy. The RI has developed its scientific strategy, and it is available in the form of a research portfolio[47]. In the development of its scientific strategy, the RI will collaborate with other organisations and RI in the field of infectious diseases, keeping it up-to-date with the trends in the sector. Access to the RI is ensured by the central access unit.

Cooperation. The RI collaborates with other RI and organisations (e.g. development of new vaccines, additions of samples to biobanks).

Personnel. Support in the form of consulting is given to international organisations, states, and private and public institutions. Training for the potential users of the RI is provided.

Funding. Funded from contributions of its members. This funding does not cover the costs of scientific projects; rather it is spent on developing the organisation. However, projects are funded by national funding, European funding, and others.

European Clinical Research Infrastructure Network (ECRIN)[48]

Offers to researchers support in preparation and implementation of multinational clinical trials. The aim is to provide researchers with diverse trial support services and contribute to other capacity-building projects.

Scale	Uniq.	Strat.	Co-op.	Pers.	Total
3	3	4	3	2	**15**

Scale. Distributed RI among 8 member states and 2 observer states with a national scientific partner (a network of clinical trial units) in each state.

Uniqueness. The only such RI in the macro-region.

Strategy. Trial management services are provided for no cost to approved projects. ECRIN offers advice on topics concerned with the execution of multinational clinical trial free of charge, for example, advice on possible sources of funding, selection of research facilities. ECRIN also requires publishing the clinical trial results and patient data publicly.

Cooperation. ECRIN helps to overcome issues concerning the funding for international cooperation in the field of

[47] ERINHA Research Portfolio. Retrieved from http://www.erinha.eu/wp-content/uploads/2018/07/ERINHA_Resarch_Portfolio.pdf

[48] ECRIN website: http://www.ecrin.org/

clinical research through trial support services. ECRIN is also involved in international cooperation with other RI and organisations.

Personnel. Support for researchers is provided in the form of management of submissions to regulatory and ethics authorities, provision of insurance information, data management, etc.

Funding. Funding by the member and observer countries is mainly spent on the development of the RI and the services that the RI provides. Scientific projects are funded from the services provided to the industry and European funding bodies, for example, Innovative Medicines Initiative 2.

4.2.2. Suggestions

In the field of life science, there is a considerable lack of transparency in the strategy of RI, as identified in the life science, biomedicine research, drug development working group seminar[49]. Therefore, information about RI of all scales and RI cooperation possibilities should be provided through dissemination channels thereof and the dissemination channels of RCNIs, PROs, HEIs, therefore, contributing to the development of a clear, explicit, and transparent strategy. As a result, it is expected that more applications for projects in the particular RI will be prepared and accepted. In the following tables, suggestions are provided for the policy- makers in the BSR, addressing the issues concerning the RI and RI cooperation in the field of life science in the BSR. Also, the expected results, should these suggestions be implemented, are stated.

<table>
<tr><th colspan="5">Strategy</th></tr>
<tr><th rowspan="2">Issues</th><th colspan="3">Suggestions</th><th rowspan="2">Expected results</th></tr>
<tr><th>General</th><th>In case of RI of local and national importance</th><th>In case of RI of international importance</th></tr>
<tr><td>Insufficient base funding, especially for projects in the early stages of the development.</td><td>1.1. Increase the government budget funding for research and base funding for science.</td><td>Support for scientific ideas that are in the early stages of development is necessary.</td><td>Provide base funding according to the evaluation matrix described later in the text.</td><td>More scientific activity and efficient utilisation of the potential of curiosity research.</td></tr>
<tr><td rowspan="2">Insufficient funds do not allow paying to foreign representatives for maintenance of the RI. Therefore, the maintenance and repairing are often performed by local scientists themselves.</td><td>1.2. Proper mechanisms should be created and implemented to maintain RI.</td><td>Train local service personnel. Ensure international exchange of best practices and developments.</td><td>Involve in international cooperation and co-utilise and/or exchange the service personnel</td><td rowspan="2">The idleness of RI is reduced. RI is successfully and conveniently maintained.</td></tr>
<tr><td>1.3. Create a centralised RI technical (maintenance) service.</td><td>Base the service in RCNIs of particular fields of science.</td><td>Adopt the practices of ESFRI networks.</td></tr>
</table>

[49] Life science, biomedicine research, drug development working group seminar. April 26th, 2018. Latvian Institute of Organic Synthesis, Riga, Latvia.

Insufficient and inefficient international cooperation.	1.4. Define the strategic targets of cooperation in the BSR.	1) Shape the national science politics to motivate the BSR to cooperate. 2) Form cooperation between groups of the same scientific field. 3) Establish cooperation in education and doctoral studies through common courses, summer schools, etc.	1) Research the experience of European alliances of universities and disseminate it to local RI 2) Co-ordinate national science policy.	Cooperation opportunities in the BSR are successfully utilised in order to achieve the set targets.
Lack of a sustainable long-term strategy for RI cooperation and utilisation.	1.5. Utilise RI effectively considering sustainability.	1) Develop an action plan where financing is assigned in the long-term. 2) Train RI technical personnel. 3) Develop big data and ICT.	Define and agree (between countries) on common measures and indicators involved in the assessment of sustainability	More effective utilisation of the RI in the long-term.

Cooperation				
Issues	Suggestions			Expected results
	General	In case of RI of local and national importance	In case of RI of international importance	
Lack of RI cooperation on a national level as well as on an international level.	2.1. Expand national consortiums and RCNIs	Attract and include additional institutions.	1) Integrate into ESFRI / ERIC structures. 2) Attract CEE and Eastern European partners.	The capacity of RI cooperation, as well as the efficiency, is increased.
Insufficient government support for the	2.2. Government support for wider and	1) Provide support for the participation in	1) National RI has to meet a	Researchers and scientists are provided with

involvement in ESFRI / ERIC RI.	more active involvement in ESFRI / ERIC RI.	new ERIC projects. 2) Consider memberships in global RI projects, e.g., CERN.	certain quality level. 2) Establish the competence of excellence. 3) Ensure that data repositories are compliant with the EIT standard.	more RI opportunities and motivation for further RI development.
Insufficient RI opportunities provided for the PhD students.	2.3. Involve the RI of independent scientific institutions in the processes of higher education.	Funding for doctoral studies should be large enough to cover the cost price of the RI and reagent costs.	Attract guest lecturers and foreign interns to utilise the RI.	Improvement in higher education and more scientists are attracted to utilise the RI and its cooperation opportunities.
	2.4. Promote mobility and networking.	1) Provide seed money for networking. 2) Organise summer schools in RI. 3) Provide students with internship possibilities in the BSR in the field of research. 4) Provide short-term scholarships for PhD students. 5) Engage in international post-doctoral projects in the BSR.	Promote short-term mobility to visit RI in the BSR.	
Insufficient innovation and the utilisation thereof.	2.5. Promote the commonality of science and the industry.	1) Create fiscal instruments for the attraction of the industry to utilise the RI. 2) Provide industry grants	Support and ensure the development of cross-border cooperation within industries.	The industry is more capable of creating innovative products and utilises the

		for PhD students.	Conduct "direct sales" on targeted international markets.	available RI opportunities to their full extent.

Personnel, Researchers and Scientists				
Issues	Suggestions			Expected results
	General	In case of RI of local and national importance	In case of RI of international importance	
Wages of scientists are often financed from project funding which is inconsistent and unsustainable.	3.1. Provide funding to finance the wages of scientists.	Develop a long-term sustainable financing plan.	Develop a financing system that ensures cooperation and decreases brain drain.	Wages of scientists are consistent und sustainable as is their workplace, while the project funds are used efficiently for project needs.

Funding				
Issues	Suggestions			Expected results
	General	In case of RI of local and national importance	In case of RI of international importance	
Base funding is often insufficient.	4.1. Increase the base funding for science.	Ensure sustainable and predictable financing schemes	Ensure a long-term financing plan to develop critical mass able to attract scientists.	More efficient utilisation of existing RI.
Currently, procurement of new equipment is promoted while the existing RI is left to be idle because funding is not provided for maintenance	4.2. Provide EU structural funding for the support, modernisation, and maintenance of RI.	Promote a centralised government budget programme for the maintenance and support of RI.	Support involvement in international consortia and EU funded projects.	

and modernisation.				
Long-term research is not promoted.	4.3. Increase the funding for long-term research.	Provide financing for the period of 3 to 5 years.	Establish consistency and sustainability in a relationship with ERA.	Significant socio-economic returns.
Lack of funding for internal scientific projects.	4.4. Promote the funding of internal scientific projects, while allowing employment of people from other national consortiums or RCNIs.	Develop an internal system for "project applications" for funding.	Develop an internal system for "project applications" for funding. Those applications should be focused on international co-research.	Enhanced capacity to compete for cooperation projects on an international level.

4.3. Welfare State

4.3.1. Research Infrastructure Overview

In the following paragraphs, RI in the field of the welfare state are described. The description is broken down into 6 factors, namely, scale, uniqueness, strategy, cooperation, personnel, and funding. Further, an evaluation of the RI is provided based on 5 factors excluding funding. The criteria of the evaluation and evaluation scale are available in Appendix 1.

A consortium of European Social Science Data Archive (CESSDA-ERIC)[50]

Provides social science data archive services in order to promote the results of social science research and support national and international research cooperation.

Scale	Uniq.	Strat.	Co-op.	Pers.	Total
3	3	1	2	2	**11**

Scale. Distributed RI consisting of social science data archives from 16 member and one observer countries across Europe. Also, CESSDA has established partnerships outside of the consortium.

Uniqueness. The only such RI in the macro-region.

Strategy. The RI is not yet fully developed. However, the aim of the RI is to provide its services in an open access way and internationally.

Cooperation. The provision of and operations with data by the RI requires efficient cooperation between the partners, members, and other associated partners of the RI.

Personnel. CESSDA provides training on research data management, data curation, and other topics in the social sciences. It is involved in different projects, seminars, workshops, etc. on data management training for researchers.

Funding. Funding for CESSDA is provided by the member states' ministries of research or a delegated institution.

SHARE-ERIC[19]

Provides a multidisciplinary and cross-national panel database of micro data on health, socio-economic status and social and family networks free of charge.

Scale	Uniq.	Strat.	Co-op.	Pers.	Total
3	3	4	3	1	**14**

[50] CESSDA-ERIC website: https://www.cessda.eu/

Scale. Distributed e-RI (cross-national panel database) with research data from 27 European countries and Israel.

Uniqueness. The only such RI in the macro-region.

Strategy. Data access to commercial enterprises is not allowed, while the entire research community can openly access the data free of charge. Transparent application instructions and guidelines are available for access to a set or a certain service the RI provides. Any data obtained through the RI and later used in research projects, publications, etc. should be referenced.

Cooperation. The RI is involved in multiple cooperation projects, including the Research Infrastructures Training Programme (RItrain)[51], which will develop a training programme for the enhancement of RI. The provision of and operations with data by the RI requires efficient cooperation between the partners, members, and other associated partners of the RI.

Personnel. The RI provides a data set called easySHARE which is made primarily for educational and learning purposes. However, no explicit support is provided nor is the attraction mechanism developed.

Funding. SHARE has been funded by various EU initiatives, including the 7th Framework Programme and H2020. However, most support is provided by national funding from member states.

European Research Infrastructure for Language Resources and Technology (CLARIN)[52]

Provides online databases of digital language resources and tools for research in human and social sciences.

Scale	Uniq.	Strat.	Co-op.	Pers.	Total
3	3	3	1	3	**13**

Scale. Distributed e-RI among 20 service providing centres across the countries of Europe.

Uniqueness. The only such RI in the macro-region.

Strategy. Detailed and clear information about the services provided by the RI, how to use them, and information about all involved technologies is available on the RI website. The RI aims to provide scientific, social data with a single sign-on feature in Europe and internationally.

Cooperation. The provision of and operations with data by the RI requires substantial involvement and cooperation between the partners, members, and other associated partners of the RI.

Personnel. The RI provides a handful of training materials, case studies, video

[51] RItrain website: http://ritrain.eu/

[52] CLARIN website: https://www.clarin.eu/

materials, etc. aimed at researchers and students. Mobility grants are available, for which clear and transparent guidelines on the application process are provided.

Funding. Initially set up with the financial support of the European Commission. Now funded by the participating countries. The funding is spent on building, maintaining, etc. of the RI, while the research is neither funded nor conducted.

European Social Survey (ESS-ERIC)[53]

A cross-national survey which measures the attitudes, beliefs and behaviour patterns of diverse populations and collects and provides its data free of charge.

Scale	Uniq.	Strat.	Co-op.	Pers.	Total
3	3	3	1	2	**12**

Scale. Distributed e-RI among 23 member states and 1 observer.

Uniqueness. The only such RI in the macro-region.

Strategy. Guidelines on how to use the RI (the data provided by the RI) are provided. The data provided by the RI is of open access and available free of charge. References to datasets are required in publications, research projects, etc.

Cooperation. The provision of and operations with data by the RI requires extensive involvement and cooperation between the partners, members, and other associated partners of the RI.

Personnel. Training and courses are provided for researchers. Also, the EduNet (e-learning) resource is available for higher education purposes. The RI enables the users of the ESS to share resources amongst the ESS community.

Funding. Funded (consisting of the basic fee and an additional amount based on the country's GDP) by the participating countries. Also funded by H2020 to implement Sustainable tailored integrated care for older people in Europe (SUSTAIN)[54], a project concerned with the long-term sustainability of ESS.

[53] ESS-ERIC website: http://www.europeansocialsurvey.org/

[54] SUSTAIN website: http://www.sustain-eu.org/

4.3.2. Suggestions

The welfare state is often considered as not requiring substantial RI and funding. Therefore, awareness of the research needs in the area of the welfare state of politicians and decision-makers should be developed. In the field of the welfare state, there is a large need for data repositories, archives, etc., which are the main RI of the scientific field. It is expected that in the long-term, the scientific fields of the welfare state are provided with data repositories and other necessary RI to perform the research. In the following tables, suggestions are provided for the policymakers in the BSR, addressing the issues concerning the RI and RI cooperation in the field of the welfare state in the BSR. Also, expected results, should these suggestions be implemented, are stated.

Strategy				
Issues	Suggestions			Expected results
	General	In case of RI of local and national importance	In case of RI of international importance	
The restriction on outsourced services does not allow for full and qualitative completion of fieldwork (surveys).	1.1. Allow outsourced services within social research programs to comprise 25% of the total services.	Amend regulations of the Cabinet of Ministers.	Conduct a study on practices in other countries of the EU.	More effective utilisation of the potential provided by foreign PROs and other organisations.
Funding is often provided only for some of the steps of new RI establishment.[55]	1.2. When creating new RI, provide financing for the implementation of an entire business plan.	This financing should include funds for staff, programmers, engineers; their training; joining ESFRI entities; setting up national consortia; etc.	Long-term planning should be developed considering and aligning with other research institutes and projects.	Effective utilisation of RI after creation thereof.
Insufficient financing for social sciences.	1.3. Improve the governance	RCNI activity should be enhanced by	The necessity for internation-	As a result of improved gov-

[55] The issue has been identified also in previous mapping performed for the Baltic Science Network as captured by "Challenge #7" on p. 7 of the Baltic Science Network Working Paper of Activity 3.1 "Challenges and barriers to research cooperation in the Baltic Sea Region"

Often already allocated financing is used inefficiently.[56]	of social sciences.	means of division of labour and specialisation.	alisation strategy for research should be accepted, and the strategy development should be facilitated.	ernance, the assigned funding is used efficiently.

Cooperation				
Issues	Suggestions			Expected results
	General	In case of RI of local and national importance	In case of RI of international importance	
Insufficient involvement in international research projects	2.1. Actively participate in ESFRI and ERIC structures.	1) Create a national programme. 2) Support needed for the participation in new ERICs.	Support participation in ESS-ERIC, SHARE, and CESSDA.	Increased involvement in international research projects
Insufficient development and utilisation of cloud computing opportunities	2.2. Facilitate the creation of an open access infrastructure cloud.	Enhance the utilisation of cloud computing.	Facilitate the publicity of data created by means of public funds. Ensure data exchange and joint cloud development	Enhanced acceleration of research development based on cloud computing.

Personnel, Researchers and Scientists				
Issues	Suggestions			Expected results
	General	In case of RI of local and national importance	In case of RI of international importance	
Lack of local personnel[57]	3.1. Provide RI with trained operators.	Set up a centralised technical service.	Involve in international cooperation for	More efficient use of technical personnel.

[56] The issue has been identified also in previous mapping performed for the Baltic Science Network as captured by "Challenge #8" on p. 7 of the Baltic Science Network Working Paper of Activity 3.1 "Challenges and barriers to research cooperation in the Baltic Sea Region"

[57] The issue resonates in a more pronounced manner among the countries experiencing brain drain, where the challenge and suggested solutions under the section "Challenge 10" on p. 24 of the Baltic Science Network Working Paper of Activity 4.1 "Challenges to researchers´ mobility in the Baltic Sea Region"

			shared technical services.	
The insufficient attraction of visiting scientists[58]	3.2. Establish a policy for visiting scientists.	Provide funding for the use of RI by visiting scientists.	Involve in real and virtual co-operation projects. Enhance both formal and informal networks of scientists.	More intensive cooperation and visiting.
Insufficient experience exchange especially for young scientists[59]	3.3. Establish scholarships for traineeships abroad.	Monitor local and international funding options	Develop the scholarship exchange system between the institutes	The wider offer of mobility and internships programs for interested researchers.

Funding				
Issues	Suggestions			Expected results
	General	In case of RI of local and national importance	In case of RI of international importance	
Insufficient funds for the maintenance of existing RI.	4.1. Create a state budget financed target program for RI maintenance.	Integrate RI investment with investment in training of personnel.	Increase the efficiency and quality of maintenance.	More efficient utilisation of existing RI.
	4.2. Increase and improve the base funding for science.	Provide a long-term financing plan for welfare state research projects and facilities.	Develop an integrated and aligned long-term financing strategy and plan.	
Insufficient funding for memberships in international RI organisations.	4.3. Provide target financing for membership fees in ESFRI.	Continue to provide financing after the end of the support from the ESI Funds and	Continue to provide financing after the end of the support from the ESI Funds and	Greater visibility of national RI and scientists.

[58] The issue resonates in a more pronounced manner among the less advanced research centres, where the challenge and suggested solutions under the section "Challenge 8" on p. 24 and "Challenge 3" on p. 23 of the Baltic Science Network Working Paper of Activity 4.1 "Challenges to researchers´ mobility in the Baltic Sea Region"

[59] The section echoes earlier identified challenges and suggested solutions under the section of "Challenge 2" on p. 23 of the Baltic Science Network Working Paper of Activity 4.1 "Challenges to researchers´ mobility in the Baltic Sea Region"

		for new ESFRI / ERIC projects.	for new ESFRI / ERIC projects.	
The use of funding is administratively burdening.[60]	4.4. Reduce administrative burden and bureaucracy for fundraising.	Increase the target-oriented approach to funding efficiency evaluations.	Develop and agree on a common approach in administrative practices and routines that are transparent and easily accepted by all involved stakeholders.	More scientific research projects and applications thereof.

[60] The section echoes earlier issues and solutions identified in the framework of Baltic Science Network under the "Challenge #4" and "Challenge #5" of on p. 6 of the Baltic Science Network Working Paper of Activity 3.1 "Challenges and barriers to research cooperation in the Baltic Sea Region"

5. Suggestions

In this chapter, overall suggestions concerning more efficient utilisation of RI are provided mainly for the policymakers of the BSR countries, with several suggestions for RI and RI holder institutions. The suggestions are split into two subcategories: facilitating mechanisms, which include the necessary conditions for successful RI cooperation in the BSR, and motivational elements, which further provide ways to enhance RI cooperation in the BSR. The facilitating mechanisms are more related to structures, interaction tools and mechanisms whether the motivational elements are more personally related to researchers and ways to influence a decision about more active use of RI. Then, suggestions are developed based on the four pillars that were identified in the final working group discussions[61], the interviews, and the case studies.

5.1. Facilitating Mechanisms

Funding

Increased funding for RI should be provided with a focus on investment and maintenance needs. The funding schemes should be developed in a more integrated manner (e.g. EU funding and national financing) with the focus on sustainable development of RI as such as well as both scientific and technical human resources. Equally important is to create long-term financial plans which are coordinated on the national level across institutions and the international level across the BSR countries. Funding schemes in the future should be more oriented towards measurable goals and achievements or in other words solutions that are expected from scientific institutions. Financing mechanisms in the future should address the challenge of finding the balance between advantages provided by a larger concentration of scientific excellence (critical mass) and economies of scale on the one hand and brain drain, which is a topical issue especially in EU13 countries, caused by the gravity processes on the other.

Cooperation

The main preconditions for successful cooperation are openness and transparency; therefore, openness and transparency plans for each RI object should be developed and implemented by RI. These plans should include clear conditions, terms and rules for the use of RI, the costs of RI use, the collaboration process involving the RI etc.

[61] The final working group seminar. June 27th, Riga Technical University Conference Hall, Āzenes street 6 (11th floor), Riga, Latvia.

This would also include support for participation in different consortiums, projects and applications developed. The cooperation component should be included as an additional advantage for project applicants. The information relevant for cooperation enhancement should be developed in a clear and constructive manner. This information should be distributed through appropriate information channels, e.g. websites, databases, publications, conferences, seminars etc. The information channels also should include responsible ministries and other institutions. Ministries, in turn, should proactively communicate with RI representatives to identify the cooperation opportunities, develop optimal support measures and support credible and appropriate partnerships.

The possible forms of cooperation and cooperation promotion activities are as follows:

1) Creation of **national RI nodes** (e.g. part of ESFRI and ERIC), which would result in better visibility of the BSR research community in Europe and create opportunities for young and experienced scientists.
2) **RI consortiums**; three main strategic tasks can be identified: enduring and more active participation in RI consortiums, initiation of participation in RI consortiums, management of and leadership in RI consortiums.
3) Promotion of participation in **RI projects**; provide support with the lowest possible administrative burden for preparation and submission of applications. This would increase the absolute number of applications, and, therefore, improve overall competitiveness. Thus, the quality of applications would improve leading to more accepted applications.

Strategy

According to the best practices described in chapter 3.2., there should be a clear strategy for the development of openness, promotion of RI, and research collaboration. The strategy should be publicly available and easily accessible, in order to attract and retain the possible collaboration partners. As discovered in the case study analysis, working group discussions and interviews with experts, such a strategy might include the following activities and concepts:

1) Assessment of opportunities to enrol in international research consortiums, ERIC in particular, which provides benefits (e.g., new and larger networks of

scientists, prestige, more funding possibilities etc.) for local institutions and researchers.

2) A clear definition of national level RI and provision of target funding for the maintenance and development of a strategy for the national level RI.
3) Provision of funding for medium-scale RI (while small-scale RI can still be financed internally by higher education institutions).

It is important that strategies are created in accordance with the strategies of other RI on a general level and on a level of fields of scientific excellence, i.e., strategies should be harmonised, not conflicting. If more coordination is achieved more synergies are expected to appear. In fact, in the long-term, strategies and business models for RI should be harmonised between countries as well. The urgency of this RI aspect should be pointed out, since, for example, in the Swedish context it has been recognised that the funding aspect has grown in importance over the last years due to the steady rise of infrastructure costs which are expected to increase further in the future.[62]

While the suggestions above are mostly addressed to the policymakers in the BSR, the following suggestions are provided for RI in particular:

1) Creation of sustainable long-term and personnel development plans with risk analysis and prevention strategies. It is important that personnel development plans are integrated together with infrastructure development plans. Such a strategy also will facilitate more efficient use of RI.
2) Creation of business-oriented financial plans for inclusion in long-term strategies.
3) The attraction of additional financial resources for RI from a wider variety of public and private sources supplementing the already provided funding.
4) Monitoring of the RI: costs of RI and costs associated with the use of RI, depreciation of RI, the track of RI usage, etc.

[62] Baltic TRAM. (October, 2017). Swedish Innovation and Smart Specialisation Governance in the Baltic Sea Region´s Context: Towards an Enhanced Macro-Regional Science-Business Cooperation.

Personnel, Researchers and Scientists

To solve the RI personnel and researcher shortages, it is suggested for RI in particular to:

1) Create mechanisms to support the development and retention of new scientists and researchers;
2) Prepare the RI personnel, researchers and scientists for international cooperation providing the opportunity for them to become the coordinators of RI utilisation;
3) Create unified and aligned plans for the development of RI and RI personnel, researchers and scientists;
4) Require the RI personnel, researchers and scientists to take part in at least a minimum amount of mobility events, which should be included in long-term RI development strategies.
5) Create RI engagement programmes and organise summer schools, workshops, courses for students.
6) Develop financial incentives for scientists to return to the home institution after mobility actions and international exchange.
7) Develop incentives for each scientific institution to accumulate a sufficient amount of competence and excellence to trigger gravity- namely attraction of other scientists.

It is also suggested to introduce some verification mechanism for companies servicing RI, e.g. responsible ministries of the BSR could create centralised technical support teams for RI, thus eliminating the unavoidable RI service contracting firms, which often provide low-quality service.

5.2. Motivational Elements

Funding

In order to reduce the portion of idle RI, investment in RI should come together with investment in the development and retention of personnel, researchers and scientists. Also, a financial support programme has to be created for RI personnel, scientists and researchers to visit foreign RI. Also, dedicated financing should be provided for the support (e.g., courses, summer schools, workshops, seminars, and training) of personnel and scientists in order to increase the motivation to participate in more cooperation and research projects.

Cooperation

RI objects should be well documented, i.e. all the necessary information concerning technical attributes of the RI as well as user manuals should be provided in a clear, accessible, and structured way. In addition, high-quality publications, portals, databases with data about RI possibilities, webinars, and conferences are also regarded as good means for the development of research cooperation, which together with plans for openness and transparency would form the core for the attraction of collaboration partners. Promising preconditions for ensuring the overall availability of data and research delivered by RI housed by the BSR are testified by several of RI captured in a list of institutions endorsing the EOSC Declaration[63], such as ESS-ERIC and the European XFEL GmbH, being also among the first signatories of the European Open Science Cloud Declaration.[64] Also, the OpenAIRE's National Open Access Desks could play a role in establishing open access repositories and their integration in the existing European structures.[65] All the above-mentioned aspects are identified as important and even crucial to enhance motivation to participate in more cross-border cooperation.

Strategy

To attract and retain researchers and scientists, and increase the number of collaboration projects, the following strategic activities and conceptions are suggested:

1) Creation of databases containing data about research collaboration possibilities, research projects, available RI, application guidelines, etc. This should be accompanied by motivational instruments for submission of data and information to this database.
2) Provision of digitalisation and availability of data and ICT support for RI.
3) Availability of RI for external users at the preferential price (free of charge when possible) on condition that the results of the research will be publicly available (open access).
4) Creation of clear, transparent, and structured guidelines for preparation of project applications and submission of conditions and requirements.

[63] European Commission. (November 24, 2017). List of institutions endorsing the EOSC Declaration.

[64] European Open Science Cloud (EOSC). European Commission website: https://ec.europa.eu/research/openscience/index.cfm?pg=open-science-cloud

[65] National Open Access Desks. OpenAIRE website: https://www.openaire.eu/72-noads

5) Creation of dedicated centralised data centres for storage of open access data. In terms of data centres and databases, bigger emphasis should be put on the field of the welfare state where data is the most crucial part of RI.
6) Creation of databases containing raw research data (measurements, discoveries/findings, etc.) in the field of life science and materials science.
7) Provision of support for users of RI during the application process and afterwards, i.e., courses, training, workshops, in order to provide the necessary knowledge and competencies for work with a particular RI.
8) Promotion of RI through publications, in order to attract skilled and knowledgeable scientists.
9) Provision of clear information about the costs associated with the use of RI.
10) Creation of a clear pricing strategy that conforms to the general strategy, which is differentiated amongst two types of clients, namely, commercial clients (a fixed fee) and non-commercial clients (free of charge).

6. Conclusions

The development of the roadmap for enhanced cooperation in the BSR included extensive research on both primary and secondary sources. In this process, a number of significant discoveries were made, and suggestions developed. Regarding the general BSR strategic vision for the future a number of aspects were identified:

- Increased cross-border cooperation and co-utilisation of research facilities will be facilitated and promoted and is expected to become a more usual way of working.
- More extensive and coordinated development of country strategies will contribute to more efficient use of resources and increased competitiveness of the macro-region.
- Cooperation with industries between countries will be on the agenda for all BSR countries.
- The attraction of global talents outside the macro-region was[66] and will be on the agenda for all BSR countries to sustain the development of competitiveness and innovations.
- In the future, more aligned and coherent financing mechanisms will be developed in the region in order to facilitate the development of jointly financed projects.

The roadmap developed within this research project includes the assessment tool that can be utilised by RI as well policy makers to evaluate the current preconditions for cooperation and identify the possible actions in order to enhance the opportunities for cooperation in the future. This toolbox is considered as a more internal instrument for self-assessment and work on a strategic improvement. It allows the RI to identify and assess the preconditions for international cooperation and actions needed to improve the attractiveness for cooperation. Those, in turn, can be further developed in different forms of cross-border cooperation and co-utilisation of RI. During the development of this research several possible options for cooperation forms were identified:

- Support the development of local nodes for international RI.
- Increase participation in different consortia.

[66] For a more nuanced elaboration on earlier European remarks on the subject matter and proven potential of certain CBSS Member States to attract talent in certain sectors consult p. 22 of the Working Paper of the Welfare State Expert Group "Fostering Sustainable and Inclusive Labour Markets in the Baltic Sea Region: A Life Course Perspective" (2018) prepared for the Baltic Science Network.

- Support leading of the projects and applications with extensive participation of partners from BSR.
- Formal cooperation should be supported by the informal one, e.g. more direct contact between scientists will have a positive impact on cross-border cooperation between the institutes.

The most important factors for the cooperation development are the scale or size of the RI, uniqueness, existing strategy for development, cooperation facilitation mechanisms, personnel-related issues for support development and attraction of the talent. All those factors should be assessed and addressed in an integrated manner since no-one of them alone is sufficient to provide a significant impact.

7. Appendices

Appendix 1. The Evaluation Framework for RI.

	Scale		Uniqueness	
1	RI of local importance		Similar or better RIs are available in the macro-region	
2	RI of national importance with the focus on local collaboration		Some similar RIs are available in the macro-region	
3	Large RI of international importance with the focus on cross-border collaboration		The only such RI in the macro-region	
4	Very large RI of global importance with the focus on global impact on innovation.		The only such RI worldwide, with unique capacities and also competencies.	
	Strategy	**Co-operation**	**Personnel**	**Funding**
+1	Available free-of-charge for public research	International collaboration opportunities provided by the RI are promoted	Support for users of the RI during the application process is provided	Development of the RI is being funded consistently
+1	Clear (openness - accessible, well-structured, and complete information) and [time] efficient project application procedure	Well-structured and complete information is provided about the RI co-operation opportunities	Support for users of the RI during RI utilization is provided	Maintenance of the RI is being funded consistently
+1	Clear (openness - accessible, well-structured, and complete information) project application evaluation procedure	RI is involved in research collaboration on multiple levels (bi-lateral, tri-lateral, multi-lateral) with other RIs and organisations internationally	Guidelines for application preparation and submission are provided	The access to the RI is funded
+1	Research transparency is promoted via publication of research results which are available for the research community (open access)	Co-operation with the industry is promoted	Courses, workshops, summer schools, etc. are organised	Travel expenses and accommodation are covered

Appendix 2. List of the Working Group Seminars.

Working group seminar	Date	Location
Working Group seminar on Photons, Neutrons and Structural Materials.	April 16th, 2018.	Institute of Solid State Physics, University of Latvia, Riga, Latvia.
Life science, biomedicine research, drug development working group seminar.	April 26th, 2018.	Latvian Institute of Organic Synthesis, Riga, Latvia.
Working Group on the welfare state.	April 26th, 2018.	University of Latvia, Faculty of Social Science, Lauvas street 4, Riga, Latvia.
The final working group seminar.	June 27th, 2018.	Riga Technical University Conference Hall, Āzenes street 6 (11th floor), Riga, Latvia.
The first meeting of Baltic Science Network Expert group on photon and neutron science, structural research.	April 19th, 2018.	DESY Research Centre, Hamburg, Germany.
First Life Science Group meeting.	May 7th, 2018.	Helsinki, Finland.
Second Life Science Group meeting.	June 6th, 2018.	Stockholm, Arlanda, Sweden.

Appendix 3. Interview Questions.

1. How would you describe the research infrastructure in the Baltic Sea Region in general? Is it sufficient to promote the achievement of science excellence goals?
2. What in your opinion are the key factors contributing to the development of cooperation with a view to more efficient use of research infrastructure objects in general and in specific areas of science?
3. What factors interfere with this cooperation in general and in specific areas of science?
4. Do you think that science institutions and research infrastructure holders in the BSR region need a special strategy for the promotion of cooperation and use of infrastructure? If so, what would be the objectives/tasks of this strategy? Can you name any examples of successful strategies?
5. What are the main benefits of creating national connection nodes in each country to link the infrastructures more closely?
6. Do you see research consortiums as a good tool to enhance cooperation and utilisation of the research infrastructure? Why?
7. Do you think that additional training is needed for scientists before they can use the infrastructure? Why?
8. To what extent should institutes/infrastructures pay attention to openness and transparency factors when developing a cooperation strategy? Is there a need for a separate and detailed strategy of openness and transparency?
9. What channels in your opinion should be used to disseminate or receive information about the possibilities of cooperation between research infrastructures in different countries? What is the most important information that should be provided through those channels?
10. Would you agree that large research projects facilitate cooperation and utilisation of the research infrastructure? Why?
11. Is it possible to develop cooperation and utilisation of the research infrastructure outside the specific cooperation projects? If so, what factors could influence and promote it?
12. What in your opinion would be the most appropriate financing model for co-utilisation of research infrastructure? Which stakeholders should be involved in cost covering?

13. Can the lack of personal contact be considered a significant barrier for more efficient utilisation of the research infrastructure? What measures could prevent the negative impact of the lack of personal contacts?
14. To what extent the open and widely available information about the possibilities offered by the infrastructure should be disseminated to promote the mobility of scientists?
15. Finally, are there any additional aspects that we should consider that were not covered during the interview?

Appendix 4. List of the Interviewed Experts.

Expert	Occupation	Country
Ana Proykova	Professor for Atomic and Molecular Physics (Strategy Working Group on Data, Computing and Digital Research Infrastructures) at the University of Sofia.	Bulgaria
Innar Liv	Associate Professor of Data Science at Tallinn University of Technology Data mining (association & sequential rules, clustering), segmentation and prediction models.	Estonia
Kristo Karjust	Professor of mechanical and industrial engineering, manufacturing optimisation, monitoring and prediction; rapid product and processes realisation.	Estonia
Mari Leino	Planning Officer, Project Coordinator, Research Development, University of Turku.	Finland
Mari Riipinen	Head of Unit, Research Development Unit from the University of Turku.	Finland
Bahne Stechmann	Scientific Manager of the EU-OPENSCREEN consortium at the Leibniz-Institut für Molekulare Pharmakologie (FMP).	Germany

Appendix 5. The Baltic Sea Region and its countries. Source: Interreg Baltic Sea Region (interreg-baltic.eu).

Appendix 6. Sources used in footnote references.

Foot-note No.	Source
1	https://www.balticsea-region-strategy.eu/action-plan?task=document.viewdoc&id=17
5	http://www.baltic-science.org/index.php/downloads/public/bsn-publications/207-scientific-excellence-joint-potentials-in-the-baltic-sea-region-an-explorative-study
9	http://www.esfri.eu/sites/default/files/20160308_ROADMAP_single_page_LIGHT.pdf
10	https://ec.europa.eu/research/infrastructures/pdf/esfri-strategy_report_and_roadmap.pdf
13	http://roadmap2018.esfri.eu/media/1066/esfri-roadmap-2018.pdf
27	http://www.baltic-science.org/index.php/downloads/public/bsn-publications/219-drivers-for-participation-in-transnational-research
28	http://www.cbss.org/wp-content/uploads/2016/07/FINAL-CBSS-Science-Ministers-Meeting-Chairs-Conclusions.pdf
29	http://www.baltic-science.org/index.php/downloads/public/bsn-publications/227-researcher-mobility-tools-for-the-baltic-sea-region
30	http://www.baltic-science.org/index.php/component/phocadownload/category/8-bsn-publications?download=60:tackling-widening-participation-in-r-i-from-the-baltic-sea-region-perspective
31	https://www.bmbf.de/pub/Internationalization_Strategy.pdf
32	http://www.baltic-science.org/index.php/downloads/public/press-releases/press-release-12/118-bsn-o3-1-working-paper
34	https://ec.europa.eu/research/infrastructures/pdf/non_paper_for_lts_stakeholdersworkshop.pdf
39	https://RI-paths.eu/wp-content/uploads/2018/05/D3-1_Working-note-on-RI-typology_SUBMITTED.pdf
55	http://www.baltic-science.org/index.php/downloads/public/bsn-publications/178-challenges-to-researchers-mobility-in-the-baltic-sea-region
60	https://www.baltic-tram.eu/sites/sites_custom/site_baltic-tram/content/e24058/e24059/e60781/e60877/SwedishInnovationandSmartSpecialisationGovernanceinthe-BalticSeaRegionsContext_eng.pdf
61	https://ec.europa.eu/research/openscience/pdf/list_of_institutions_endorsing_the_eosc_declaration.pdf#view=fit&pagemode=none