REPUBLIC OF SLOVENIA
MINISTRY OF EDUCATION, SCIENCE AND SPORT

Research Infrastructure Roadmap 2030 (NRRI 2030)

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List of abbreviations

+1MG	One Plus Million Genome
BBMRI	Biobanking and Biomolecular Resources Research Infrastructure
Belle 2	Belle 2 Detector
CERIC	Central-European Research Infrastructures Consortium
CERN	European Organisation for Nuclear Research
CESSDA	Consortium of European Social Science Data Archives
CLARIN	Common Language Resources and Technology Infrastructure
CTA	Cherenkov Telescope Array
DARIAH	Digital Research Infrastructure for the Arts and Humanities
EATRIS	European Advanced Translational Research Infrastructure in Medicine
ELIXIR	The European Life-Science Infrastructure for Biological Information
eLTER	European Long-Term Ecosystem Research
EMBRC	European Marine Biological Resource Centre
EOSC	European Open Science Cloud
EPOS	European Plate Observing System
ERA	European Research Area
E-RIHS	European Research Infrastructure for Heritage Science
ESFRI	European Strategy Forum on Research Infrastructure
ESRR	European Regional Development Fund
ESS	European Social Survey

EuroBioImaging /EuBI	European Research Infrastructure for Imaging Technologies in Biological and Biomedical Sciences
European XFEL / EuroFEL	X-ray Free Electron Laser European Free Electron Lasers
FAIR	Facility for Antiproton and Ion Research in Europe
GUIDE	Growing Up in Digital Europe: EuroCohort
ILL	Institute Laue Langevin
Instruct	Integrated Structural Biology Infrastructure
ISBE	Infrastructure for Systems Biology Europe
LifeWatch	e-Science and Technology European Infrastructure for Biodiversity and Ecosystem
METROFOOD	Infrastructure for Promoting Metrology in Food in Nutrition
NRRI	Načrt razvoja raziskovalnih infrastruktur
OPERAS	Open scholarly communication in the european research area for social sciences and humanities
PRACE	Partnership for Advanced Computing in Europe
RESILIENCE	Religious Studies Infrastructure - Building a European Response to the Challenges of Religious Diversity
ReZrIS30	Resolucija o znanstvenoraziskovalni in inovacijski strategiji Slovenije 2030
RISS	Raziskovalna in inovacijska strategija Slovenije
S4 /S5	Strategija pametne specializacije
SHARE	Survey of Health, Ageing and Retirement in Europe
ZZrID	Zakon o znanstvenoraziskovalni in inovacijski dejavnosti

1. Introduction

The Research Infrastructure Roadmap for the strategic period until 2030 (hereinafter referred to as NRRI 2030) is being prepared due to the expiry of the Research Infrastructure Roadmap 2011–2020 (No. 63000-2/2014/4, dated 28 April 2011) and the 2016 Revision (Government Decision No. 63000-2/2016/3, dated 14 December 2016) (hereinafter referred to as NRRI 2016 Revision) as an implementing document of the Resolution on the Slovenian Research and Innovation Strategy 2011–2020 (Official Gazette of the Republic of Slovenia No. 43/11; hereinafter referred to as RISS). The NRRI 2030 is prepared on the basis of Article 33 of the Scientific Research and Innovation Activity Act (Official Gazette of the Republic of Slovenia, No. 186/21; hereinafter referred to as ZZrID) and the Resolution on the Slovenian Research and Innovation Strategy 2030 (Official Gazette of the Republic of Slovenia, No. 49/22; hereinafter referred to as ReZrIS30).

The NRRI 2030 is aligned in terms of content with the latest revision of the priority list of international projects of the European Strategic Forum on Research Infrastructures (hereafter referred to as ESFRI Roadmap 2021). A revision is planned for the period until 2030, which is expected to take place by 2026 and will be timed to coincide with the next revision of the ESFRI Roadmap in 2025.

Definition of Research Infrastructure (RI)

Research infrastructures (RIs) are facilities, resources or services of a specific nature that support cutting-edge research activities in their fields and include:

- major scientific equipment, knowledge-based resources (collections, archives and scientific data);
- e-Infrastructures (data and computing systems and networks); and
- other tools essential for excellence in research and innovation.

Research infrastructures can be concentrated in one place, distributed or virtual (electronically enabled services). They often need a structured information system to manage data and enable information and communication.[1]

1 Povzeto po http://roadmap2018.esfri.eu/media/1066/esfri-roadmap-2018.pdf, str. 11, in https://roadmap2021.esfri.eu/media/1295/esfri-roadmap-2021.pdf, str. 12.

Examples of research infrastructures are large research installations, collections, libraries, databases, biological archives and collections, high-performance or broadband communication networks, research vessels, telescopes, satellite and airborne observation facilities, HPC networks, clean rooms, coastal observatories, synchrotrons and accelerators, etc.

Purpose and objectives of the NRRI 2030

The NRRI 2030 is consistent with the purpose and objectives of ReZrIS30, which identifies a modern, competitive and accessible research infrastructure as one of the key tools for excellent science and career development. Without research infrastructures, there is no quality research and important discoveries, nor the desired development of science in Slovenia, and thus no achievement and maintenance of an adequate level of science in the country at a European or world comparable level.

Research infrastructure is therefore one of the foundations for the development of Slovenia into a knowledge and innovation society. An internationally competitive research infrastructure is expected to strengthen cooperation between research institutes, universities and business in Slovenia and abroad, with a particular focus on EU countries. Research infrastructure could thus attract more excellent researchers from abroad and reduce the brain drain. Slovenia needs to make up for the backlog in the development of basic research infrastructure, large research equipment and the construction of new facilities.

Research infrastructures play a key role in our ability to generate new knowledge and innovations that help us understand and tackle the environmental, social and economic challenges we face. Research infrastructures are a powerful resource for industry and a prerequisite for collaboration between industry and the academic sphere. They provide unique training opportunities and play an important role in educating and training new generations of scientists, engineers and data professionals. Research infrastructures are strongly rooted in regions and have a critical impact on regional development.

The NRRI 2030 sets out the priorities of the Republic of Slovenia in the field of research infrastructures and serves as a guide for implementation in this area. Access of Slovenian researchers to large research infrastructures is crucial for the country to achieve and maintain a level of science at a comparable European or global level. Due to the complementarity and rationalisation costs, it is reasonable to include larger national research infrastructures in the European network of research infrastructures.

A key objective of the NRRI 2030 is to update the existing priority list of international projects and national priority areas, assuming the identification of new projects or areas, the analysis of the progress of each project or area to date, its financial inputs and impact assessment, and the setting of objectives for the next strategic period, including implementation planning and the establishment of appropriate bases for their upgrading and for their sustainable operation and funding.

Analysis of the NRRI 2011–2020 implementation

The preparation of the NRRI 2030 has taken into account the results of the past decade, as well as new international and national circumstances in the field of research infrastructure or science and research. In the preparation of the Roadmap, it has become clear that in the field of research infrastructures, it is not necessary to repeat the entire process started ten years ago, but rather to take into account, update and build on the foundations already in place. The NRRI 2030 revises all segments (not just individual sections, as was the case for example in the 2016 Revision), i.e. both the international priority projects and the national priority areas within research infrastructures.

The implementation of the priority international projects to date can be assessed as very successful, as Slovenia has successfully engaged in most of the priority international projects of the NRRI 2011–2020 and its 2016 Revision, despite a worsening financial situation in at least a few years of the past decade, and has established itself as a credible and stable partner in them. In several cases, in particular for projects requiring major investments in upgrading research infrastructures in national hubs, this would not be possible with integral funds alone, but only with significant funding from the European Cohesion Policy (ERDF). In the context of international networking, we are also pursuing the Smart Specialisation priority areas, reinforcing in particular national priority areas. Slovenia is involved in 18 international RI projects (in alphabetical order): BBMRI, CERIC, CESSDA, CLARIN, CTA, DARIAH, EATRIS, ELIXIR, EPOS, ESS, Euro-Biomaging, ILL, LifeWatch, PRACE and SHARE; it participates in the construction of BELLE II in Tsukuba, Japan, and in the construction of the FAIR Centre in Darmstadt, Germany; and it became an associate member of CERN in 2017. According to the NRRI 2011–2020, it was planned for Slovenia to join EuropeanXFEL or EUROFEL by the end of 2020 (i.e. within 10 years) and BBMRI, E-RIHS, eLTER, ISBE and METROFOOD by 2026, according to the revision of the NRRI 2016 Revision.

The development of national research infrastructures has been regularly co-funded through the Slovenian Research Agency (hereinafter: ARRS).

Slovenia has pursued and achieved its national objectives in the field of research infrastructure mainly through the use of European Cohesion Policy funds, in some cases directly, and in several cases indirectly through co-financing of the upgrading of national hubs in the framework of international projects, which are in fact also investments in priority areas of national infrastructure. Between 2010 and 2013, the European Cohesion Policy funded eight Centres of Excellence in the amount of EUR 43.8 million. Under the 2014–2020 Operational Programme (at the level of Priority Axis 1, where investment in research infrastructure is an action aimed at strengthening research, innovation and excellence infrastructures and capacities in this field), the HPC RIVR project has co-financed the upgrade of the computational capacity of the existing HPC research infrastructure available for research and development and educational activities, accessible under the Open Research Infrastructure principle, in an amount of EUR 20 million. The EUR 16 million project Development of Research Infrastructure for the International Competitiveness of the Slovenian RDI Area (RI-SI project) co-founded the upgrade of research infrastructure needed for participation in seven international projects: CERIC, CLARIN, DARIAH, EATRIS, ELIXIR, EPOS and LifeWatch. The EUR 29 million RIUM project co-funded the upgrade of the University of Maribor research infrastructure. The Ministry of Education, Science and Sport (hereinafter referred to as MIZŠ) assumed the obligation to co-finance the project for the establishment of a state-of-the-art laboratory "Centre of Excellence for Research and Innovation in Renewable Materials and Healthy Living Environment – InnoRenew CoE" in a total amount of EUR 30 million, which was awarded under the EU Teaming project.

Unfortunately, this is not sufficient to achieve all the strategic objectives in the field of national research infrastructures. The European Commission Country Report – Slovenia 2020 states that Slovenian investment in research and development is below the EU average. In order to increase the productivity and competitiveness of its economy, Slovenia should strive to be closer to the best performing EU Member States in the field of research and development. This would require increasing public and private investment, establishing an adequate research infrastructure and research capacity and ensuring that potential is fully exploited. The Development Report of the Institute of Macroeconomic Analysis and Development of the Republic of Slovenia (IMAD, 2021) also shows that research and development (R&D) expenditure has been increasing since 2018, while Slovenia is lagging far behind comparatively. In 2019, R&D investment was the highest ever in nominal terms, but in relative terms, at 2.05 per cent of GDP, it still lagged behind the 2012–2013 peak by half a percentage point and the EU average by 0.2 of a percentage point of GDP since 2016. Compared to the top five countries within the measurement

of the European Innovation Index, the gap, which was only half a percentage point in 2013, has again exceeded a percentage point of GDP.[2]

In order to achieve and maintain a level of science in the country comparable to the European or global levels, it will be necessary to increase investment in the remaining scientific and research equipment in the PROs, as it is ageing rapidly and no longer meets modern standards. The depreciation rate of equipment and other tangible fixed assets of public research institutions has been increasing since 2011, according to data from the annual reports of the Pubic Research Institutes; it was already 81 per cent in 2011, 84.8 per cent in 2017 and 86.2 per cent in 2018 . At the same time, direct investment should also continue to be provided in research infrastructure in the remaining national priority areas. In order to address the issue of research infrastructures in a comprehensive manner, the provision of adequate personnel to operate and maintain the equipment (facilitators and user educators, technical maintenance personnel, custodians), as well as the premises in which the equipment is installed, including the maintenance of buildings or their construction, if necessary, should be ensured alongside the provision of equipment.

2 https://www.eu-skladi.si/sl/dokumenti/po-2020/2019_porocilo-o-drzavi-2019.pdf.

3 Vir: Bilance stanja JRZ, letna poročila JRZ od leta 2012 do 2018.

Analysis of the progress of existing international projects

When preparing the NRRI 2030, the MIZŠ invited the coordinators or lead institutions of the existing priority international projects (Letter No 511-17/2020/1, dated 17 February 2020), both in preparation for membership and already implemented international projects (the so-called landmarks), to submit a progress report on their project. In addition, it invited the holders of potential new projects to submit an expression of interest in new projects for inclusion in the revised list of priority international projects in the NRRI 2030.

Reports of 21 emerging projects, priority projects and landmarks were provided, which were the basis for assessing and updating information on individual projects in the NRRI 2030. There was no report only for European XFEL or EuroFEL, and for BBMRI the report was submitted indirectly as part of the Expression of Interest for new international projects. A report was also submitted for the ISBE project, which failed to develop as a stand-alone international project in the international context and has found its place in most partner countries (including Slovenia) under the ELIXIR project in terms of content and organisation.

In line with the progress shown since the last revision in 2016, the criteria for the so-called landmarks have been achieved by BBMRI, CTA, EPOS, Euro-BioImaging and ILL. E-RISH remains on the updated priority list of projects, and eLTER and METROFOOD are new emerging projects. For the reasons mentioned above, ISBE and European XFEL or EuroFEL projects are no longer on the list.

Analysis of applications for new international projects

The call for expressions of interest for new projects to be included in the revised list of priority international projects in the NRRI 2021–2030 received 13 proposals up to and including the extended deadline for responses of 17 April 2020 (in accordance with letter No 511-17/2020/34, dated 9.4.2020).

An analysis of the submissions was implemented, including through an external advisory panel involving Slovenian colleagues in ESFRI Strategic Work Groups as well as international experts in specific subject areas.

The analysis was concluded with interviews with the applicants or coordinators of the individual proposals (invited by letter No 511-17/2020/68, dated 16 November 2020), which provided additional and more detailed exchanges of views on the achievement of the key criteria for inclusion in the priority list of international projects for the NRRI 2030.

For inclusion in the NRRI 2030 Priority List, the key criteria were appropriate placement in the national context and potential to achieve critical mass at the national level, projected impacts in the fields of science, education and the economy, organisational maturity and cost rationality, and, as a prerequisite, the maturity and status of the project at the international level (according to ESFRI criteria).

The following projects have been identified as having the potential of an international project after the analysis was completed: EMBRC ERIC, FNH-RI-SI, GUIDE, Instruct-ERIC-SI, Operas and RESILIENCE. In the case of EMBRC ERIC and Instruct-ERIC-SI, these were already established projects at the international level from the ESFRI Roadmap (ESFRI Landmarks), while the remaining four cases of FNH-RI-SI, GUIDE, Operas and RESILIENCE were candidates for the update of the ESFRI Priority List in 2021 (ESFRI Roadmap 2021). In these last cases, inclusion in the ESFRI Roadmap 2021 was a key criterion for demonstrating the relevance of the project's content and organisational maturity at the European level, in which GUIDE, Operas and RESILIENCE succeeded, but FNH-RI-SI did not. EMBRC, GUIDE, Instruct, Operas and RESILIENCE met the criteria for inclusion in the priority list of international RI projects.

Analysis of initiatives for national priority areas

In preparation for the NRRI 2030, it was also necessary to update or prioritise research infrastructure at the national level. In the NRRI 2011–2020, indicative priority areas where research infrastructure should be developed as a priority in terms of achieving critical mass and scientific excellence in Slovenia, with the aim of achieving a critical mass of medium or large research infrastructure, were identified on the basis of various studies and other national strategic documents mentioned and described in the RISS 2011–2020.

The MIZŠ invited the heads of the national Public Research Organisations (letter No 511-17/2020/44, dated 29 May 2020) to submit their reactions to the implementation of the existing national priority areas and proposals for possible new areas.

By the deadline, 18 Public Research Organisations had provided their responses with 36 proposals for renewed or new national priority areas. After analysing the responses with the recommendations of the external advisory panel, a proposal for an extended list of national priority areas was prepared.

The updated list includes 12 areas which do not substantially deviate from the NRRI 2011–2020 list. All previous areas remained relevant, sufficiently broad and inclusive, while some have been expanded or restructured into several stand-alone areas.

Table 1: NRRI 2030 projects

	PROJECTS	LANDMARKS
Social and Cultural Innovation	E-RISH OPERAS GUIDE RESILIENCE	CESSDA CLARIN DARIAH ESS SHARE
Energy		
Natural sciences and engineering	BELLE 2 CERIC CERN CTA FAIR ILL	
Environment	eLTER	LifeWatch EPOS
Data, computing and digital RI		PRACE
Health and food	EMBRC INSTRUCT METROFOOD	BBMRI EATRIS ELIXIR EuroBioImaging

2. International projects

The largest part of the NRRI 2030 is the renewed list of priority international projects and projects already implemented. In this context, an overview of the implementation progress of each international project on the current list is provided, as well as a projection for the continuation.

Old and also unimplemented projects that have shown adequate progress at the international and national levels may be reinstated or remain on the list, but a given unimplemented project may remain on the priority list for a maximum of ten years. In addition to scientific relevance, the key substantive criteria for including a new international project on the priority list include the potential to upgrade existing research infrastructure and achieve critical mass at the national level, the impact of the research infrastructure on regional cooperation, comparability at the European and global levels, and its positioning in the ERA.

An implemented project (which, according to the ESFRI Roadmap, is called a landmark) is one in which Slovenia has formally joined as a member and thus accepted international and national obligations for its construction and/or operation. These projects that follow the example of the ESFRI continue to be properly monitored, periodically evaluated and provided with the basic conditions for their continued operation, development and long-term sustainability. Landmark projects are those which as such demonstrate a clear reference of scientific excellence, national relevance and competitiveness in their subject area.

2.1 Updated list of priority projects

2.1.1 Social & Cultural Innovation

2.1.1.1 E-RIHS

E-RIHS
EUROPEAN RESEARCH INFRASTRUCTURE FOR HERITAGE SCIENCE

European Research Infrastructure for Heritage Science

www.e-rihs.eu

Status

The project was placed on the priority list of the ESFRI Roadmap 2016 and the national priority list of international projects with the NRRI 2016 revision. In 2017, Slovenia formally joined the preparation of the project with the aim of becoming a founding member of the E-RIHS ERIC. The preparation of the legal, technical and financial framework for the establishment of the E-RIHS ERIC is being finalised and is expected in 2022. In 2018, the national consortium E-RIHS.SI was established, in which the Institute for the Protection of Cultural Heritage of Slovenia (ZVKDS) as coordinator and the University of Ljubljana (UL) are participating as the basis for the establishment of a national hub within the E-RIHS ERIC. Further expansion of E-RIHS.SI is planned with other providers of scientific research in the field, such as the Slovenian National Building and Civil Engineering Institute, the National Institute of Chemistry, the Jožef Stefan Institute, the University of Maribor, the InnoRenew CoE and the National and University Library.

Infrastructure description

The E-RIHS is a distributed research infrastructure project for the interpretation, preservation and management of cultural heritage. The project establishes a central international E-RIHS hub and national E-RIHS hubs with a related fixed and mobile national infrastructure of recognisable excellence, and accessible material collections, archives and virtual data pertaining to heritage. The E-RIHS supports research on heritage material characterisation (material science), the impact of the environment on heritage (environmental

science) and digital sciences. Knowledge and protection of heritage will be enhanced globally by the highest quality tools and interdisciplinary research services. The project will support collaborative research work, access to analytical equipment, methodologies, data and tools, highly trained personnel and storage, processing, interpretation and the optimum utilisation of large amounts of data based on FAIR principles. Strategic planning will prevent duplication of equipment and research work and increase the competitiveness of European science dealing with cultural heritage.

The core of the E-RIHS project consists of the central international and national E-RIHS hubs with associated fixed (FIXLAB platform), digital (DIGILAB) and mobile (MOLAB) infrastructure, collections and archives (ARCHLAB). Strategic planning will prevent duplication of equipment and research work and increase the competitiveness of European science dealing with cultural heritage. The E-RIHS project will join the efforts of many already connected infrastructure groups.

Expected benefits of membership

The strategic objectives of joining the E-RIHS ERIC are: (1) preservation of cultural heritage and national identity; (2) identification and understanding of culture and heritage; (3) promoting innovation in heritage science; (4) resilience of heritage to climate change; (4) sustainable tourism. The E-RIHS. SI Laboratory for Macromolecules in Cultural Heritage is already recognised as a laboratory of outstanding excellence offering international access, and from the aspect of scientific excellence, membership will also allow international integration for other laboratories into the E-RIHS.SI consortium.

In terms of research, Slovenian involvement will contribute in particular to the scientific excellence of Slovenian researchers through cutting-edge scientific publications, the development of new research methods and procedures for the protection of cultural heritage, the meta-analysis of large databases and the protection of intellectual property. Increased international activities and mobility will increase the recognition and visibility of Slovenian researchers and users from the heritage sector as well as from institutes, institutions, universities and companies. By standardising research procedures and avoiding duplication of research infrastructure and work, we will increase the efficiency and effectiveness of research. The E-RIHS project will also strengthen interdisciplinarity, as heritage science encompasses the natural sciences, social sciences and humanities, and promote science by integrating these subjects for educational purposes.

In terms of education, Slovenian involvement will encourage greater mobility and enhanced infrastructural offerings for external institutions and users, the integration of RI in the delivery of educational programmes, both postgraduate and lifelong, and will stimulate the recruitment of researchers over the next three to five years.

The economic benefits of the integration relate in particular to the transfer of knowledge and services to industry and to innovation and the development of new market products in collaboration with enterprises. Heritage science has a direct or indirect impact on the economy (e.g. improved measurement and diagnostic techniques), and makes an essential contribution to better heritage management and enables quality cultural tourism. The work of the E-RIHS is in line with the Smart Specialisation Strategy (S4).

Financial aspect

The co-financing of national activities within the E-RIHS project (in particular the costs of coordination, international networking and the constitution of the national hub) started in 2019 within the Infrastructure Programme of the UL FKKT at the ARRS. The investments in the national infrastructure to date amount to EUR 165,000, with the latest annual value being EUR 65,000. The annual membership fee of the E-RIHS ERIC is estimated at around EUR 40,000 for Slovenia (after 2022). As soon as possible, the co-financing of the national hub will be reinforced with Structural Funds.

The total estimate of the potential investment for the establishment of a national RI as an integral part of a dispersed international E-RIHS ERIC infrastructure is approximately EUR 20 million, of which approximately EUR 4 million is for MOLAB, EUR 2 million for DIGILAB, EUR 0.5 million for ARCHLAB and EUR 13.5 million for FIXLAB (of which EUR 5.5 million is for the upgrade of the Laboratory for Macromolecules in Cultural Heritage). The estimate of investment in basic research and development work is from an initial 5 to a final 10 FTE/year, and from 2 to 15 FTE/year for access implementation. E-RIHS.SI will require around EUR 120,000 per year to operate and maintain the national hub. Part of the funds for the operation will be obtained by participation in international projects and the inclusion of commercial partners. The project is already funded through ARRS, and the Ministry of Culture (MK) is expected to increase its support to the core activity.

2.1.1.2 GUIDE

Growing Up
In Digital Europe

EuroCohort

Growing Up in Digital Europe: EuroCohort

www.eurocohort.eu

Status

The project was placed on the priority list of the ESFRI Roadmap 2021 and the national priority list of international projects in the new NRRI 2030. At the national level, it is coordinated by the Koper Science and Research Centre (ZRS Koper), which also includes the Institute for Social Studies (IZDŠ ZRS Koper) and the Centre for Public Opinion Research (CRJM ZRS Koper), which has all the necessary infrastructure for the implementation of GUIDE. A national consortium is not foreseen. The preparatory phase of GUIDE (2021–2024) has started in the framework of the O2020 project "Coordinate" (COhort cOmmunity Research and Development Infrastructure Network for Access Throughout Europe) and includes the establishment of implementation field teams, the design of a measurement instrument, the pilot testing of instruments and the extension of the existing consortium. The project itself is planned to be implemented between 2024 and 2029 and is expected to last 25 years. The Coordinate project already involves the IZDŠ ZRS Koper.

Infrastructure description

GUIDE is the first European longitudinal comparative study on children, their psycho-physical development, welfare and well-being. Methodologically and in terms of implementation, this project is similar to the SHARE study, which focuses on the older population. As such, in addition to its academic contribution, it will be a key source of systematically collected data on children that will be relevant for future policy makers in the fields of health, education and social welfare. GUIDE, like related social science research infrastructures, is organised as an international network of national partners, coordinated and led by a responsible international coordinator. In the development of this RI, they are collaborating with established European research infrastructures,

such as SHARE, ESS and CESSDA in particular, and a new project in the ESFRI Roadmap 2021, the Generations and Gender Programme (GGP), and the UNICEF Florence Innocenti Research Centre as a leading institution in the field of child well-being research.

The main objective of the GUIDE Research Infrastructure is to study different aspects of children's well-being in a holistic way, identifying key indicators of well-being derived from their immediate family and community environment and analysing them in a complex way. It studies children's psycho-physical health, educational achievement, indicators of well-being, as well as their family, living and immediate social environment, etc. The measurement instrument – a questionnaire to be completed by children and parents – will evolve and adapt over the course of a child's development to reflect the changing life of children, in particular their transition through the different phases of the education system and growing up. GUIDE is designed as an "accelerated cohort study", which will include a sample of new-borns and a sample of school children. By including two parallel age cohorts, it will be possible to implement specific analyses and comparisons right from the start of the study, which will provide useful data for different stakeholders at the policy and academic levels relatively quickly. It involves regular data collection, storage and dissemination, in compliance with the standards and plan of the international consortium. The pilot study of the school children cohort is expected to start in 2022 and the new-born cohort in 2024. The sample size of children included in the study will be tailored to each national context, and in Slovenia will be between 1,500 and 2,000.

Expected benefits of membership

GUIDE data will be used here, first and foremost, at the scientific and educational level, and as such will be a direct source and basis for new knowledge and publications. GUIDE will also contribute to the further development of research and methodological capacities and skills relevant for the implementation of longitudinal research and data analysis.

In addition to the academic sphere, the knowledge generated by GUIDE will also be integrated in Slovenia in cooperation with government policy makers, NGOs, and the professional and wider public. Particular attention will be paid to promoting and creating synergies between researchers and policy makers to ensure the transfer of knowledge into practice, as this type of longitudinal research can have a significant impact on rationalising national financial expenditure on health, education and social services and increasing

the efficiency of the resources invested. The results of GUIDE will be useful for the design of targeted social policies, thus contributing to a better quality of life for children or future adults in the short and especially in the long term, and to the better use, efficiency and economy of public expenditure.

The long-term ambition of the GUIDE project is to generate data and knowledge that are of practical use in various fields, such as research, education, health, social welfare, but also specifically family policy, scholarships, housing policy, statistics, economics, law and legislation, etc., both in our country and internationally. This will also provide the necessary knowledge to better understand and respond thoughtfully to contemporary social change and its impact on the upbringing and well-being of children and young people as the future upholders of society. The potential of the GUIDE longitudinal research is to show the current and future needs and to enable the design of public policies that emerge directly from the field, while also allowing for the evaluation of the effectiveness of interventions as they will manifest themselves during the course of the GUIDE research. GUIDE data and knowledge will thus enable the development of policies to improve the well-being of children and young people, their welfare and, consequently, their school and business performance in later life. Strategic investment in children's well-being follows the EU and OECD guidelines and is driven by the desire to increase their capacity to best adapt to modern challenges. This also increases a country's performance and competitiveness; therefore, ensuring optimal development opportunities, access to education, health and general well-being for all children must be a key priority of modern social and economic policies to ensure that the resultant healthy, educated and skilled adults are adequately prepared to face the social, health, economic, ecological and other political challenges of the country and society.

Financial aspect

The cost aspect for Slovenia has not yet been finalised. We assume that the costs will be comparable to the SHARE or ESS projects, in which the key costs are related to the coordination and implementation of the field survey, data storage and dissemination and communication of the data. Initial estimates for the implementation of GUIDE at the national level assume 3 FTE per year and associated material costs. No specific investment in the national infrastructure is required. The details for international financial commitments have not yet been defined.

2.1.1.3 OPERAS

OPERAS

open scholarly communication in the european research area for social sciences and humanities

Open scholarly communication in the european research area for social sciences and humanities

www.operas-eu.org

Status

The project was placed on the priority list of the ESFRI Roadmap 2021 and the national priority list of international projects with the NRRI 2030. It is coordinated at the national level by the Science and Research Centre of the Slovenian Academy of Sciences and Arts (ZRC SAZU), which has been a member of the OPERAS Operational Group since 2019.

Infrastructure description

The overall objective of the OPERAS project is to organise and produce technologically advanced information and communication systems for the dissemination of research results, with a particular focus on the social sciences and humanities (SSH). It focuses on the principles of open science and free access to research results, especially in the form of publications (journals and monographs), and on systemic solutions for their presentation and integration. OPERAS also aims to transfer to the Slovenian environment the standards and principles adopted by the international community in the field of scientific publishing in SSH. Publishing in this field is in many ways different from publishing in other scientific disciplines and is often closer to education and/or general publishing. As the main user of the scientific results of both disciplines is a narrow professional public, this activity remains essentially non-profit-making, and dependent on subsidies and other sources of funding. Another important feature of SSH scientific publications is that they are more closely linked to the local and national environment than to the international one. SSH scientific publications are primarily domicile-oriented and represent an important segment of the national cultural heritage, describing the national space and nurturing the identity of the nation. The

strength of the multinational association OPERAS is that it has, as one of its basic principles, multilingualism or the importance of national languages and autonomous national diversity.

Expected benefits of membership

The OPERAS project builds on the activities of some NRRI projects such as DARIAH, E-RISH and CLARIN in the humanities and CESSDA in the social sciences. Its objectives are also partly addressed by existing investments in e-infrastructure and the horizontal preparation of strategic and practical aspects of open access in all areas of data work. At the national level, one of the most important benefits of OPERAS membership will be the participation of all key actors of SSH publishing in Slovenia: public research institutions, universities, societies and other public entities involved in SSH scientific publishing. The consortium's main goal will be to develop a publishing model for open science, which will be at least partly suitable for other scientific fields in addition to SSH through systematic promotion of standards and education regarding scientific publishing. This is the only way to put domestic scientific publishing more firmly on the European map and for it to become more recognised. In particular, free access to research results also contributes to socio-economic impacts and indirectly influences the economic development of society in the case of humanities-oriented research, especially in the field of tourism and the green economy.

Financial aspect

Current cost estimates show low financial needs at the national level (around EUR 45,000 per year). They also include the cost of associate members' labour (around 0.5 FTE in total). As such, they do not yet take into account the costs of involving potential other partners. The details for international financial commitments have not yet been defined.

2.1.1.4 RESILIENCE

RESILIENCE

Religious Studies Infrastructure - Building a European Response to the Challenges of Religious Diversity

www.resilience-ri.eu

Status

The project was placed on the priority list of the ESFRI Roadmap 2021 and the national priority list of international projects with the NRRI 2030. It is coordinated at the national level by the Faculty of Theology of the University of Ljubljana (UL TEOF) and a consortium of partners is foreseen.

Infrastructure description

The RESILIENCE project plans to establish a research infrastructure in the field of theology and religious studies, with the aim of building a high-performance, accessible platform. It will provide data, tools and expertise on religions and religious experience. It responds to the need for a broader and more structured collaboration of top researchers in this field who generate new knowledge, apply interdisciplinary approaches and make a visible contribution to innovation in the scientific field of theology and religious studies. At the same time, the project responds to the important challenges and needs of contemporary society, such as interreligious dialogue and the coexistence of religions, globalisation, multiculturalism and global environmental, health and technological threats, which are essentially related to ways of being and making sense of being. This will be possible on the basis of the recognition that the religious, philosophical and non-religious identities of individuals and communities are essential to the resilience of society, genuine democracy and community cohesion. The project therefore brings together tools, resources and knowledge to provide public function holders and institutions with effective means to understand the complexity and implications of religious situations, their long-term historical roots and their deep connection to cultural and political contexts. It seeks to establish easy access to digital and other data on religions, and to advanced tools

for knowing and understanding this data, in order to facilitate, animate and disseminate quality research on religions across Europe and beyond. Religious diversity has been and continues to be a constant challenge to European society and identity, calling for mutual understanding, and the Resilience project will play a key role in this. The project's fundamental objective is to become the leading European research infrastructure for all religions present in the European area, responding to contemporary multidisciplinary research needs and strengthening international cooperation in this field.

The Resilience International Network is based on the Horizon 2020 project, which involved twelve prominent academic institutions from ten European countries, and is coordinated by FSCIRE (Fondazione per le Scienze Religiose Giovanni XXIII) from Italy. As an international infrastructure network, it is already linked to key initiatives in this field, such as Europeana, Time Machine, CESSDA, SSHOC (Social Sciences & Humanities Open Cloud) and GEANT. The national parts of the infrastructure network (the hub) will gain access to databases, international knowledge, experience and existing links.

Expected benefits of membership

In particular, membership in the RESILIENCE project, in conjunction with other existing research infrastructures in the humanities and social sciences, will strengthen research and scientific excellence in the field of religious studies. Interdisciplinary perspectives and new technologies will contribute to this, in particular in the context of dialogue between the different disciplines in the humanities and social sciences that religious studies encompass: history, law, theology, philosophy, philology, political science, sociology, anthropology, intellectual history. The project will create a framework that will allow quantitative and qualitative research on the same sources from different perspectives. It will increase the possibilities for international exchange of data, knowledge, information, human resources and research funds between stakeholders, as well as strengthen and shape the research and wider social community at the international level: researchers, students, librarians, archivists, publishers, educational institutions, policy and opinion makers. This will also open up new perspectives, encourage the dissemination of results and the formation of new researchers. The field of religious studies, in particular through interdisciplinarity, internationalisation and digitalisation, is significantly changing its previous research approaches and research paradigm.

Benefits of membership are also expected in the field of education. The infrastructure project will be based on qualified collaborators, knowledge transfer and access programmes. The integration will strengthen the national research system, its efficiency, competitiveness and innovation, international cooperation and the fluidity of researchers, as well as the interest of young people in research in this field. The Slovenian membership of this European research infrastructure will aim, in particular, to promote networking without cultural, ideological, world-view or religious constraints, through a single entry point where research resources (books, periodicals, archives, databases, maps, documents, digitisation tools, expertise, etc.), research content, working conditions (libraries, archives, study rooms, etc.) and skills and competences (interdisciplinary approaches, language skills, appropriate methodologies) will be pooled.

The broader societal impact will be particularly a contribution to an inclusive and less conflictual society of the future. The infrastructure project will foster the development of interreligious dialogue and guide policy and law makers in the search for and implementation of practices of social cohesion and inclusive societies, especially in religion-related aspects.

Financial aspect

For the period until 2030, the total cost is estimated at around EUR 1.8 million, of which 25 FTE for R&D and the rest for equipment modernisation and technical support. The role of potential other consortium partners in the financing scheme is not yet clear. The details for international financial commitments have not yet been defined.

2.1.2 Environment

2.1.2.1 eLTER

European Long-Term Ecosystem Research

www.lter-europe.net

Status

The project was placed on the priority list of the ESFRI Roadmap 2018 and the national priority list of emerging international projects in the NRRI revision 2016. The Slovenian national network, which was founded in 2003 and currently comprises eight umbrella organisations under the coordination of the ZRC SAZ, is also included in the eLTER project. A considerable level of interest and the potential for the inclusion of the national network in the European eLTER exist. The project is being developed in Slovenia in close cooperation with the LifeWatch project (see section 2.2.3.1), with the same national coordinator ZRC SAZU and several other common actors, which will also be key for the formation of the national consortium. In 2017, Slovenia was one of 17 countries to sign a Letter of Political Support, while 161 research institutions from 27 countries supported the scientific aspect of the project (MoU signature). At the international level, the 2015–2019 planning phase and the 2019–2021 preparatory phase have been completed. The implementation and construction phase of this RI is currently underway, managed by the eLTER Interim Council (eLTER IC), in which Slovenia is also participating, with the aim of establishing the eLTER ERIC in 2026.

Infrastructure description

Connections in the field of ecosystems research have been organised in a network of various institutions in the form of the LTER network since 2003. Within the latter and in cooperation with the LifeWatch project, the initiative to transform the LTER network into an infrastructure project was provided. The infrastructures complement each other as the LTER network includes high-tech equipped places where in situ ecosystem and biodiversity research and

their monitoring is performed, while the LifeWatch supports such research on the level of the protection, management and sustainable use of biodiversity. The group that has given the initiative for the creation of the infrastructure project eLTER has obtained the funding for the preparatory phase 2015-2019 with the aim to develop national networks and socio-ecological platforms from the European LTER network towards the creation of a multi-purpose distributed research infrastructure (eLTER RI).

The eLTER RI develops a thorough system approach to observing and analysing the environmental system, integrating biological, geological, hydrological and socio-ecological perspectives. While several existing thematic environmental research infrastructures focus on the impacts of climate change and/or other elements of environmental change, eLTER RI is the only research infrastructure that holistically integrates the integrated impacts of stressors on a wide variety of European ecosystems and critical zones. eLTER RI includes terrestrial, freshwater and transitional water research sites. The eLTER RI provides in situ ecosystem and biodiversity research and monitoring, enables the simultaneous, localised acquisition and collection of environmental variables, both biophysical and biodiversity, and socio-ecological data.

Expected benefits of membership

The emerging eLTER research infrastructure is complementary to the existing LifeWatch research infrastructure in which Slovenia is already involved; therefore, benefits are expected in several areas. The eLTER RI information and data centre is being set up at the Karst Research Institute, ZRC SAZU, as part of the LifeWatch project. At the level of eLTER RI and the national network of partners, there has been an increase in R&D activities (involvement in various projects, participation and organisation of events in the field of environmental sciences promoting open science, networking with the European scientific sphere in the framework of various EU projects and participating in joint scientific publications already). For the research, it is vital that the eLTER RI includes high-tech equipped sites for data capture, which is the basis for research work in the field of ecosystems, especially in the study of biodiversity. Databases that will be established and processed in accordance with the common methodology within the emerging research infrastructure enable complex ecosystem and biodiversity research. By becoming a member of eLTER, Slovenia accepts the obligation to provide data in the field of speleobiology, karst and other terrestrial, freshwater and marine ecosystems, thus further strengthening its important role in this field and opening the door for involvement in new international research on biodiversity and ecosystems.

In the educational context, it is expected that the research infrastructure will contribute to the dissemination of knowledge within the research community and the educational process. Members of the Slovenian LTER network institutions are already active lecturers and mentors at the University of Ljubljana, the University of Nova Gorica, the University of Maribor and the University of Primorska, integrating the knowledge and innovations from the eLTER project into their lectures.

From the economic aspect, the environment and its protection present an important area of new business opportunities. The research infrastructure to be set up under the eLTER will allow open access to important data which are the basis for innovation and new technological solutions in the field of environment protection. The free access and the possibility of data dissemination are of special importance in terms of entrepreneurial activity. In the field of environmental sciences, in situ collection of data in terrestrial, freshwater and coastal ecosystems is a challenge, essential for understanding past and present biogeographic conditions and the consequences for biodiversity. Based on the biodiversity and environmental data generated, we will develop protocols that can be used to provide expert support to representatives for monitoring and studying global climate change and its consequences. By adapting to new conditions, we will reduce the vulnerability of ecosystems and the damage we suffer each year from climate change (floods, droughts, fires). The monitoring of aquatic ecosystems implemented under the eLTER project will help to understand the level of pollution of the aquatic environment caused by industry or the economy and will help to raise awareness for sustainable development in improving processes and activities in economy and industry. Monitoring of environmental factors, biodiversity and microclimatic parameters in tourist caves is important for sustainable tourism, sustainable use of tourist caves and green tourism.

Financial aspect

Co-funding of national activities within the eLTER project (in particular coordination, international networking and project set-up costs) started in 2018 under the ZRC SAZU Infrastructure Programme (together with the LifeWatch project, detailed in section 2.2.3.1). Funding was also obtained from EU projects. In the coming years, the co-financing of the national hub will be enhanced by the resources from the Structural Funds as soon as possible.

For the period until 2030, the costs of activities and maintenance and upgrading of the eLTER equipment are estimated at approximately EUR 0.5 million per year. However, the R&D work of the eight active partners of the national network (the future eLTER-SI consortium) will require financial support for around 4 FTE per year.

2.1.3 Health & Food

2.1.3.1 EMBRC

EMBRC
EUROPEAN
MARINE
BIOLOGICAL
RESOURCE
CENTRE

European Marine Biological Resource Centre-European Research Infrastructure

www.embrc.eu

Status

The project was placed on the priority list of the ESFRI Roadmap 2008 and the national priority list of international projects with the NRRI 2030. It is coordinated at the national level by the Marine Biological Station Piran of the National Institute of Biology (MBP NIB), and a consortium of partners is foreseen. At the international level, it was established as EMBRC-ERIC in 2018, with headquarters in France.

Infrastructure description

The EMBRC project connects research centres to develop marine sciences from basic to applied research. It was created in response to pressing questions about the state of European seas and coastal areas and the high economic value of ecosystem services. Marine research takes place in areas where there is a lower concentration of knowledge and economic centres, which is true for the EU as a whole and also for Slovenia, and research is fragmented in smaller research centres. Access to the EMBRC research infrastructure (e.g. access to extreme ecosystems, technology platforms, marine organism collections, expertise, research vessels and sampling) is organised through central web access, which allows users to have visibility of the platforms and at the same time connects the small research entities into a coherent whole. Most marine stations, even in modern times, face high operating costs due to expensive equipment and the complexity of working at sea, and the link to the EMBRC allows equipment and services to be made accessible to external users

(researchers, industry, students) and optimally exploited through a centrally organised hub. The EMBRC has developed flexible protocols for cooperation with industry and protocols for the protection of intellectual property and does not disclose cooperation when it is in the interest of industry.

The EMBRC brings together distributed research infrastructures in nine current Member States, with its official headquarters in France. The implementation of the EMBRC-ERIC objectives is carried out through national nodes. The number of national partners varies among the Member States, depending on the organisation of the national network and also on the size of the coast and sea (e.g. Italy has ten entities involved). EMBRC-ERIC involves marine biological stations or institutions within which marine biological stations operate. Slovenia has a long tradition of marine research, which has been carried out for more than 50 years by the Marine Biological Station Piran (MBP), which operates within the NIB and, based on its experience and roles to date, could take over the coordination at the national level, while the national network (consortium) would involve interested institutions based on complementary services, equipment and expertise related to the marine environment (e.g. marine organism collections, marine databases, chemical and other analyses of the marine environment, specialised knowledge in marine research displayed on a common national portal and accessible to users from both the academic sphere and industry).

Expected benefits of membership

Biological, ecological and related marine research in Slovenia is mainly limited to MBP-NIB, FAMNIT, some sections of the Jožef Stefan Institute (environmental research, research on new antifouling materials in the marine environment), some departments of the University of Ljubljana, the University of Maribor, the University of Nova Gorica, the Institute of Chemistry, while other areas of research are in the field of maritime and other sciences and applications. All these institutions represent centres that can be partners of the Slovenian consortium and users of the services offered by EMBRC-ERIC. Slovenia participates in LifeWatch and Elixir, which are complementary research infrastructures and with which EMBRC is also intensively involved. The expected benefits of joining EMBRC are mainly facilitated access for Slovenian users to marine ecosystems in Europe and in Arctic areas (sampling of organisms, sediment, seawater, etc.), use of vessels and equipment at sea, access to collections of marine organisms and various databases, regulated rules on access to and exploitation of natural resources (ABS, Nagoya Protocol) and access to specialised laboratory equipment and expertise offered by the EMBRC centres. In Slovenia, there is a great need for

the services offered by EMBRC, which are essential in the research of marine environments and in various scientific disciplines ranging from biological, biotechnological (food, pharmaceutical industry), environmental sciences to the research of new materials and their applicability in the marine environment (antifouling), in climate change research in the field of biological and physical oceanography, for the development of aquaculture and parasite protection; as there is a lack of specific equipment, ecosystems and expertise in Slovenia that can contribute to the development of aquaculture and climate change impacts, the discovery and use of new bioactive compounds, the development of new model cell lines from marine organisms, biodiversity research at genomic level, etc.

There is also strong interest from others in access to the marine ecosystem of the northern Adriatic, a unique marginal habitat with high biodiversity, and in the technological platforms and specialised expertise that the MBP can offer to users. The list of competing services will grow with the inclusion of other institutions in the Slovenian network. This means that the facilities will be able to be used optimally and will allow for greater exchange of researchers and greater collaboration between domestic researchers and those from abroad, as well as with industry. This will lead to more competitive research (basic and applied), a greater number of high-quality scientific publications and the emergence of interdisciplinary biotechnology companies on the Slovenian coast. The inclusion in EMBRC will contribute to a more coherent network with high ethical standards for the exploitation of natural resources and sustainable development.

EMBRC also includes a portal with services for marine science education and the International Master of Science in Marine Biological Resources (IMBRSea) study, a joint programme of ten leading European universities in the field. It focuses on the development of the marine bioeconomy and the sustainable use of marine biological resources and offers rich opportunities for cooperation and exchange of students and teaching personnel, which is important given that Slovenia does not yet have such a specialised marine science degree. EMBRC-ERIC is a partner in a number of projects under different schemes, which provides further opportunities for development and cooperation for the members of the network.

Financial aspect

The cost aspect is not yet defined in detail, but current estimates suggest a need for around EUR 0.5 million over the next five years. The role of potential other consortium partners in the financing scheme is not yet clear. The details for international financial commitments have not yet been finalised.

2.1.3.2 Instruct

Integrated Structural Biology Infrastructure

www.instruct-eric.eu

Status

The project was placed on the priority list of the ESFRI Roadmap 2006 and the national priority list of international projects with the NRRI 2030. It is coordinated at the national level by the Institute of Chemistry (KI), and the basis for establishing a consortium of partners is already in place. It became operational in 2012 under the name Instruct, and was established as Instruct-ERIC in 2017, based in the UK.

Infrastructure description

Instruct is a pan-European research infrastructure for structural biology and biophysics, making state-of-the-art technologies accessible to all European researchers, both academic and industrial. Structural biology is a key scientific field within the life sciences, enabling the interpretation of molecular mechanisms at high resolution, down to the atomic scale, through complementary high-technology approaches. This allows understanding the mechanism of action and the role of biological molecules, either in isolated form or in the context of living cells and organisms, and these approaches are therefore also extremely important in medicine, pharmaceuticals and biotechnology. Methodological approaches in structural biology are constantly evolving and complementing, in protein preparation, (cryo-)electron microscopy, nuclear magnetic resonance, X-ray crystallography, lasers, mass spectrometry, various light microscopies, opto- and electrophysiology and molecular biophysics, as well as computational approaches.

All these approaches are integrated within the Instruct-ERIC research infrastructure. The relevant equipment is located at institutes, universities, synchrotrons, etc. within the Member States that have chosen to offer their equipment for sharing. Access to this equipment is free for Instruct-ERIC

members, thus rationalising investment in research equipment, sharing of experience, knowledge and training of new personnel. No Member State is obliged to offer its infrastructure, the decision is voluntary, it can only be a user of the infrastructure in other Member States, which is the key to rationalisation and also to the international networking of researchers. The costs of using the infrastructure are covered by Instruct-ERIC, as are the costs of visits by interested academic users from the Member States. Users can also be industrial partners, in which case the cost of use is not reimbursed. In Slovenia, in addition to the need for access to the state-of-the-art Instruct-ERIC equipment, there are also a few pieces of larger research equipment or a potential that could be offered for use within Instruct-ERIC, which would allow more frequent exchange of personnel and would strengthen international networking and the role of Slovenian science at both the European and global levels. Instruct-ERIC not only offers infrastructure, but also organises regular scientific conferences, training courses and workshops, grants scholarships for visits and longer training courses (three to six months) and co-funding of pilot projects. Instruct-ERIC also participates in other (EU) projects such as i-NEXT Discovery, EOSC-Life, Open Sesame, Transvac, etc.

Expected benefits of membership

In Slovenia, we have several research groups with expertise in structural biology, organised in a research network with broad support and regional coverage: in addition to KI, these include IJS, CIPKeBiP, NIB, and individual faculties of the University of Ljubljana and the University of Maribor. These groups already have informal contacts with Instruct-ERIC, including successful experience with this infrastructure, and have now been brought together in a draft consortium. Research equipment for structural biology is relatively expensive and, as a consequence, there is a shortage of younger personnel in this field, despite the research potential. Membership of Instruct-ERIC will allow easier and regular access for our researchers and other interested public to the most advanced infrastructure and training, personnel exchange, organisation of professional meetings in Slovenia, increased visibility and competitiveness of Slovenian science and greater success in obtaining international projects. International involvement in the field of the project will bring new opportunities for researchers, raise the level of education and, given the nature of the field, promise the exploitation of results or impacts for the economy. Instruct-ERIC is a unique organisation complementary to other infrastructure projects such as ELIXIR (including ISBE), EuBI, CERIC and EATRIS, of which Slovenia is already a member.

The main purpose of Instruct-ERIC is to give all European researchers access to the best research facilities in the field of structural biology. Through membership, Slovenian users will be able to achieve quality results faster and more easily with direct access to high-technology infrastructure and maintain international competitiveness, which is also crucial for winning projects in international calls for proposals. This will contribute to the development of science and also to the application of scientific achievements and the resulting socio-economic impact. The involvement of Slovenian researchers within the pan-European Instruct-ERIC structure would further develop and consolidate the existing international cooperation. The Slovenian (pharmaceutical, biomedical) industry is also showing an increasing need to apply methodological approaches of structural biology in the development and analysis of its products. In addition to sharing infrastructure within the Instruct-ERIC centres, Slovenian laboratories will also develop or invest in their own technological and methodological infrastructure in order to become an active part of this pan-European network. This would also enable the circulation of international knowledge in our country. Slovenian active membership of Instruct-ERIC would also mean greater opportunities in the context of decision-making policies at the European level.

In addition to a higher quality and international reputation of Slovenian science, membership in Instruct-ERIC would also open up opportunities for additional educational programmes (through Instruct-ERIC scholarships for shorter or longer courses abroad), the organisation of expert workshops and international scientific conferences or workshops in Slovenia. This would contribute to raising the overall level of knowledge of students, young and junior researchers as well as more experienced researchers, both academic and industrial, and to increasing the competitiveness of Slovenian research teams. Structural biology knowledge will be more easily and rapidly accessible, which will have a positive impact on integration with other natural sciences more widely in Slovenia. The quality and knowledge in this field will in turn have other socio-economic impacts, including industrial products.

Financial aspect

For the period until 2030, different cost options are possible, ranging from just paying a membership fee of around EUR 55,000 per year, which would enable the achievement of the fundamental or main objective, i.e. the access to the Instruct-ERIC programme offerings for Slovenian researchers, to the ambition of developing a national Instruct-ERIC Hub as a service provider within this RI for other partners, which would require a total investment in the national infrastructure of at least EUR 30 million in the medium term (over five years).

2.1.3.3 METROFOOD

Infrastructure for Promoting Metrology in Food in Nutrition

www.metrofood.eu

Status

The project was placed on the priority list of the ESFRI Roadmap 2018 and the national priority list of emerging international projects in the NRRI revision 2016. In Slovenia, a cooperation agreement was concluded in 2016, coordinated by the IJS, between interested stakeholders. METROFOOD-SI involves seven partners: three of which are metrology institutes. Slovenia was one of the ten countries to sign a Letter of Political Support in 2017. At the international level, the preparatory phase 2018–2022 is currently underway, with the aim of establishing METROFOOD ERIC in 2023.

Infrastructure description

The METROFOOD project is intended to provide metrological traceability in the field of nutrition, which will upgrade the existing infrastructure in partner states. For this purpose, a network of laboratories, research plantations, experimental fields and farms will be established. The project includes both the physical and e-infrastructure. Within the project, the existing capacities of the participating research centres will be particularly exploited. It will enhance scientific excellence in the field of food quality and safety, thus enabling an increase in opportunities for market analyses to be carried out by laboratories. The market value is also reflected in the development of new products and innovative approaches. One of the priorities of the research work is the orientation towards the various sources of financing of the research and development work by marketing new knowledge and products.

The project is innovative in particular because of its interdisciplinary approach and its dimensions, intervening in the field of food metrology and the

integration and harmonisation of currently scattered and incomplete data. It also links food and health, as food is not only a source of energy but also helps to prevent the onset of various diseases. The project will thus develop and integrate a range of metrological principles to ensure the quality, safety and traceability of food, including the development of new sensor technologies that will increase the measurement capacity pertaining to food. In the field of metrology, the analysis of inorganic, organic contaminants and nanoparticles in food samples is a particular challenge. These represent very complex matrices and often require complicated and time-consuming procedures to isolate the subject. The procedures themselves are mostly not standardised, nor are appropriate certified reference materials available. New approaches for the determination of GMOs (digital PCR, next generation sequencing, isothermal PCR methods) require new metrological definitions of traceability, criteria for the adequacy of validation parameters and measurement uncertainty. Ensuring comparable results and quality validation also influences the development of new technologies such as the development of new packaging materials, encapsulation, promoting the production of new functional foods from raw material residues and the return of food for re-use (link to the circular economy). Measurement and testing are also key to optimising primary production, food processing, storage and distribution, as well as waste management or by-product valorisation. Last but not least, it is important to develop internationally interconnected databases and knowledge bases and to upgrade them with appropriate tools and services for data management and exploitation for research and decision-making purposes.

Expected benefits of membership

For research activity, the inclusion in the METROFOOD project will primarily be of great scientific importance; in addition to scientific events and publications, patent applications are also being prepared. Important aspects of this project include strengthening the interdisciplinarity of research by integrating disciplines (chemistry, biology, microbiology, agriculture, tourism and economics), promoting science through dissemination activities, raising awareness of the general public and networking with the international professional community and leading institutions in Europe dealing with metrology and reference materials, as well as public agencies and authorities concerned with health and food safety, quality control and fraud detection. METROFOOD-SI will reinforce scientific excellence and establish an appropriate infrastructure in the field of food quality and safety by promoting metrology in this area and will facilitate scientific collaboration at the European and global levels. It will promote scientific collaboration and

cooperation between different stakeholders and the creation of common databases and knowledge bases. For this purpose, networks of laboratories, research plantations and pilot systems (fields and farms) will be set up within a physical-research infrastructure. For the electronic research infrastructure, a new information platform will be made freely available to share and integrate information and data on the availability of appropriate food analysis infrastructure and to integrate existing food databases with relevant nutritional content and contaminant content of foods produced in different geographical regions and using various advanced technologies. Field trials on olives and Mediterranean crops with a focus on agrotechnical measures should also be mentioned in the context of the activity. In addition, the presence of pests and the effects of climate change on agricultural crops are monitored in the Slovenian Istria region. Experimental fields and laboratory equipment provide support to research institutions, as well as to agricultural public service providers and local producers.

In terms of education, the use of state-of-the-art equipment will enable better working conditions, promote interest in the study of natural science and technology and thus contribute to the higher education of the Slovenian population and a greater link with the economy, while also attracting talents to our country. Education is oriented towards integration in the knowledge triangle: university education – research – economy. It is being implemented at various levels and is already included in various professional study programmes, especially at UL BF, UL VF and IJS, in professional training programmes in the field of agriculture and food processing, in the management of sustainable development, in the training of entrepreneurs, in the training of inspection services, official veterinarians, in international workshops for demonstration and learning of technologies and in awareness-raising for the general public. In parallel, training of industry personnel is already underway, which will be carried out by the participating actors at the companies' headquarters in the form of courses, demonstrations and interpretation of technological solutions. It is also worth mentioning the active cooperation within the Competence Centres, such as the Food Competence Centre and the Factories of the Future Competence Centre, which are designed to educate industrial partners at different levels and stages.

From the economic aspect, the inclusion will supplement the research and development capabilities of industrial partners which themselves do not have the critical amount of necessary knowledge and experience, e.g. cost viable and cheaper production of plant and animal raw materials in the manufacture of new products Domestic producers will be able to assert Slovenian origin and the quality of produce and food products. The systems

for tracking the food from producer to consumer, monitoring of environmental conditions, the system for determining the geographical origin of food and the identification of biological species will provide a comprehensive system that will consider buyer's wishes and needs. The project plans targeted research leading to the development of methods and products and further to implementation in enterprises. Slovenia is developing a wave of small, high-technology companies that are already globally marketed and combine IT with food production for new high added value products. Furthermore, METROFOOD-SI will also be an effective support to national and reference laboratories for food safety, to responsible management authorities and to consumers. The Slovenian METROFOOD-SI partners are already actively involved in the implementation of research and innovation strategies within the national Smart Specialisation Strategy (S4) in programme and project applications with industrial partners, thus strengthening collaboration with industry: "Functional Foods of the Future" (F4F) "Plasma seed treatment", "Fractionation and upgrading of whey proteins and use of the residue for the formulation of new functional foods and food supplements". They are also actively involved in the SRIP Action Plans: Circular Economy, Food, Smart Cities and Factories of the Future, which will allow them to be involved in new S4 projects at the national level, thus contributing to the development of new products, technological solutions and innovations. They are also part of the European EIT Food network. Within METROFOOD-SI there are also accredited laboratories, some of them official laboratories and national reference laboratories, which support the development of a monitoring system for food products and the development of methods for food control. The development of new sensor techniques will reduce the costs of monitoring and thus increase the possibilities for product quality control. The link created will allow closer cooperation with various stakeholders, including industry and food producers, and will enable the leap from classical food production and processing to the modern, industry-based era at the national and international levels. All this leads to greater consumer awareness and protection and ultimately to a strengthening of the competitive capacity of the Slovenian food industry.

Financial aspect

The co-financing of national activities within the METROFOOD project (in particular the costs of coordination and international networking) started in 2020 within the Infrastructure Programme of the IJS at the ARRS. The investments in the national infrastructure to date amount to EUR 75,000, with the latest annual value being EUR 35,000. In the coming years, the

co-financing of the national hub will be enhanced by resources from the Structural Funds as soon as possible.

For the period until 2030, the cost is estimated at around EUR 1 million per year, half of which will be spent on the purchase of equipment and other tangible fixed assets, and the other half on salaries, with 12 FTEs for researchers, including 4 FTEs for technical and professional personnel, for the whole project. METROFOOD-SI will first use the existing capacities of the consortium partners for its activities. After the necessary upgrading, these capacities will be networked and integrated into a system of high excellence that will be available to the wider scientific community and other stakeholders. In addition to direct funding, the consortium has its own resources, relying on national research programmes and projects on the one hand, and on funding from international institutions on the other. These represent not only a financial resource, but also a major potential for mobilising and transferring knowledge, experts, data and tools.

2.2 Implemented projects – landmarks

2.2.1 Social & Cultural Innovation

2.2.1.1 CESSDA

cessda
Consortium of European
Social Sciences Data Archives

Consortium of European Social Science Data Archives

www.cessda.eu

Status

The project was placed on the priority list of the ESFRI Roadmap 2006 and the national priority list of international projects in the NRRI 2011. By signing the Memorandum of Consent as of 19th January 2011, Slovenia has from the very beginning participated in the drafting of founding documents and the strategic direction of the operation and financing of the CESSDA. It became a founding and full member of the CESSDA AS by signing the Memorandum of Cooperation on 13th June 2013. CESSDA AS was transformed into the legal form CESSDA ERIC in June 2017. Slovenia is represented in CESSDA activities by the Social Science Data Archive (ADP), which operates within the UL FDV.

Infrastructure description

The CESSDA project presents an organisational and professional upgrade of the existing data infrastructure in the field of social sciences. At the European level, the work of the national service providers (in our case ADP), which have territorial responsibility for data, is integrated in development projects and in the implementation of standardised solutions at a harmonised level of quality of service provision. This results in less costly joint action of data service providers, simplified working and collaboration procedures, and more freely available data for users.

CESSDA is based on mutual professional and organisational support and aims to make it as easy as possible for researchers and other users to

access data services regardless of location, taking into account advanced international standards, recommendations and tools. European data archives and their services are interconnected and sustainable. CESSDA has identified four strategic orientations and areas of action: technology, tools and services, training and trust. Through participation in working groups, national service providers are preparing the ground for the implementation of these orientations and making commitments to implement them in a national environment.

The key functions ADP fulfils as a service provider within CESSDA are: (1) acquisition of research data from a wide range of social science disciplines; (2) evaluation of research data and selection for acquisition; (3) acquisition and processing of data together with documentation and creation of metadata for the preparation of a package for long-term digital preservation (AIP) and preparation of a package of data for access (DIP) and further use; (4) long-term digital preservation; (5) providing access to research data; (6) training researchers in the design, handling and preparation of data for open access delivery; and (7) actively promoting other data uses among users.

Planned membership benefits and achievements

For Slovenia, the CESSDA is important because it ensures the establishment of a modern and quality service of data access for social sciences with minimum investment, as the member states will lean on jointly established solutions instead of developing such solutions themselves. The solid inner organisational structure and rules of the CESSDA will ensure member states the usage of common services that will be based on uniform rules of operation, both in substance regarding the usage of protocols (metadata, controlled vocabularies, etc.), and by method upon assuring high quality and effectiveness of operation (e.g. enforcement of the FAIR and Core Trust Seal principles).

ADP is a national data centre for the social sciences that has been operating for more than twenty years. Since 2011, it has also been implementing tasks related to the international infrastructure unit CESSDA. ADP is a long-term depository of research data of interest for social science analysis, with a focus on issues related to Slovenian society or otherwise relevant to Slovenian society and social science, regardless of geographical boundaries. In addition to publications in the form of articles, the research data has an independent value as one of the results of scientific projects. The searchability of data publications by Slovenian researchers is ensured through the CESSDA Data Catalogue, thus increasing the international visibility and recognition of Slovenian science. The existing social

science data, alone or in combination with other data, is a source for a wide variety of social science and interdisciplinary research, the results of which are of unique value for science and for solving societal problems. Membership of CESSDA represents an investment in increasing the internal efficiency of ADP, which is achieved through transparent internal organisation through documentation and controlled workflow management, as well as through the professional support and training of colleagues within CESSDA. The ADP is fully involved in the operation of the CESSDA by contributions to the work programme and joint solutions and by training. Through the partnership in CESSDA, ADP is also actively involved in applying for joint European projects, thus strengthening its international visibility (e.g. the already implemented projects DwB, SERSCIDA, SEEDS, CESSDA SAW and current cooperation in projects such as SSHOC, EOSC Future).

ADP also acts as a consultancy centre in the field of data management. At the national level, it provides advice and support in the preparation of Research Data Management Plans (RDMPs), thereby contributing to the improved quality and usability of research data. It provides support to researchers and institutions in meeting the open data requirements of science funders and scientific journals. It advises various stakeholders (journals, ministries, funders, publishers) on the development of open data policies. ADP colleagues contribute to the transfer of knowledge to the Slovenian research community by contributing to various national conferences and workshops.

The primary task of digital repositories is to preserve research data and other digital content and to make it available for other uses. In order to be able to use the data for the widest possible purposes, the so-called FAIR principles must be followed, and there is widespread support for the CoreTrustSeal trusted services certification, which is ADP's way of demonstrating that those services are trustworthy and long-term oriented. Sustainable digital repositories are key building blocks of the evolving ecosystem of data infrastructures such as EOSC. ADP meets the requirements of CESSDA by using the DDI standard in the preparation of metadata, incorporating the ELSST (European Language Social Science Thesaurus) vocabulary and agreed classifications, and thus integrating itself into the CESSDA catalogue. The ADP's contribution has been the preparation of an internationally harmonised translation of the ELSST glossary into Slovenian, its continuous maintenance and updating, its inclusion in metadata descriptions searchable in various related catalogues based on the DDI metadata, and the introduction of permanent digital identifiers for the purpose of referencing the data used. ADP is also involved in the development of various social science data archiving services and, following the reference model of the OAIS archival standard, is implementing a sustainable approach

to the provision and promotion of targeted user-oriented services for the acquisition, preservation and access to high quality and multi-purpose research data. It ensures the sustainability and longevity of data access in accordance with the requirements of the CoreTrustSeal certification. The certificate has to be renewed every few years, which entails documentation and upgrading of protocols and equipment for working with the data.

ADP also provides training at the international and domestic levels. Regular activities include collaboration in the study process, ensuring that students from different faculties make use of the data for their education and thesis writing, and that professors from different faculties make use of the data for their teaching. This area also includes projects for the production of teaching materials aimed at promoting the use of microdata from official statistics provided by the Statistical Office. ADP acts as a facilitator in the production of files adapted for research and study purposes and runs workshops. In this context, it also disseminates knowledge on the RDMP, in particular to doctoral students in the social sciences and humanities and at international summer schools. At the international level, ADP leads the CESSDA Training and Education Coordination Group, in which partners within CESSDA work together to develop training content and deliver training to various users.

ADP also ensures that data is openly available to researchers and other interested public. Thus, ADP contributes to improving the quality, accessibility and visibility of the scientific results of social scientists in the national and international arena. ADP supports the development and integration of modern data infrastructures, services and professionally trained personnel. The key to the cost-effectiveness of the ADP infrastructure activities is that ADP researchers can obtain the same or better data for a given project and in a shorter time than if they had to create it from scratch. ADP data is also often used as a starting point and for comparison in research projects that are otherwise collecting data from scratch themselves. At the national level, the ADP links with other national sectoral infrastructures working on the topic of research data management and are also involved in international organisations. ADP mainly collaborates with representatives of the ESS, DARIAH and CLARIN. This is an exchange of experience, good practices, cross-disciplinary data sharing and the possibility to develop related infrastructure services at the national level.

Financial aspect

Slovenia started to co-finance the planned development of the national infrastructure and the implementation of national activities within the CESSDA in 2011. Approximately EUR 1.1 million has so far been invested in the national research infrastructure. The latest annual cost of Slovenia's participation in

CESSDA is EUR 130,000 and the membership fee for CESSDA ERIC is around EUR 2,000 per year.

For the period until 2030, it is planned to continue the current activities and to keep the indicative costs at the level of recent years, covering also the depreciation of the basic equipment and the costs of the research and development work.

2.2.1.2 CLARIN

CLARIN

Common Language Resources and Technology Infrastructure

www.clarin.eu

Status

The project was included in the priority list of the ESFRI Roadmap 2006 and on the national priority list of international projects in the NRRI 2011. Slovenia participated in the preparatory phase of the CLARIN ERIC, which lasted until the decision of the European Commission on the establishment of the CLARIN ERIC as of 29th February 2012, as an observer but it was planned to be included as a full member as soon as possible after its establishment. Slovenia sent the letter of accession on 29 April 2015 and became a full member of CLARIN ERIC in May 2015. The consortium CLARIN.SI the seat at the Jožef Stefan Institute (IJS) was established in June 2014 to implement national commitments pertaining to the CLARIN.

Infrastructure description

CLARIN is an international research infrastructure intended for the extensive and easily accessible storage of language sources and technologies, encompassing languages of the member states and languages taught in the member states or those which are important for reasons resulting from migration flows. The use of language resources and tools in CLARIN is unified, thus contributing

to the preservation and promotion of Europe's multilingual heritage. The online open infrastructure of language services creates a new paradigm of collective collaboration in the development of resources and tools, ensuring above all reusability while adapting to individual needs. The basic purpose of the CLARIN project is to make the existing tools and solutions available in the unified European infrastructure, to enable counselling and teaching activities on how to adapt the tools and sources to specific research needs and to contribute to the standardisation of sources and tools. The CLARIN is the second international research infrastructure in the ESFRI Roadmap, which was established by a procedure in accordance with the Council Regulation (EC) for the European Research Infrastructure Consortium (ERIC).

Planned membership benefits and achievements

Due to the increasingly rapid development of the internet and other e-technologies, technological support to individual languages is extremely important, particularly for languages with a smaller number of speakers, such as Slovenian. In the field of language technologies, several companies and research organisations operate at the national level. These joined the national consortium CLARIN.SI in accordance with the requirements of the CLARIN project. Thus, the consortium connects all major public institutions and companies and associations in Slovenia dealing with linguistics and language technologies; currently, it has 11 members. The vision of CLARIN.SI is to provide Slovenian researchers in the humanities and social sciences, as well as in other sciences and activities dealing with language or needing access to and the possibility of analysing linguistic data, with easy access to a rich set of linguistic resources and technologies, mainly for the Slovenian language but also for other South Slavic languages.

CLARIN.SI has two main target groups of users: researchers in the humanities and partly in the social sciences, and researchers in computational linguistics. In both cases, it offers support for the Slovenian language in the form of linguistic resources, web services and assistance with research data management. Through CLARIN.SI, researchers in the humanities and social sciences can obtain a wide variety of data on Slovenian language use, especially through the CLARIN.SI concordance, which can form the basis for empirically supported research. The two concordances currently offer access to over 100 corpora of Slovenian and other languages and record almost 700,000 queries. Researchers in the field of computational linguistics have the opportunity to acquire a wide variety of datasets from the CLARIN.SI repository, which enable in-depth research on Slovenian and other languages, including in an international context. The

CLARIN.SI repository of linguistic resources and tools has been certified by the Digital Seal of Approval (DSA) as well as by CLARIN ERIC (CLARIN B-Centre), and in 2020 it was certified by the Core Trust Seal, the successor to the DSA. The repository currently offers access to 240 entries (500 GB) from 380 authors and records around 150 acquisitions per week. Researchers can use the CLARIN.SI WebAnno platform (over 30 projects) for manual corpus tagging, the ReLDIanno tools for automatic text tagging, the CLARIN.SI GitLab repository for collaborative software development and manually tagged language resources, and the CLARIN.SI virtual organisation on GitHub. They can also permanently and securely deposit resources and tools they have developed themselves in the CLARIN.SI repository, which also improves the visibility and citation of scientific results. In 2019, CLARIN.SI, together with CLARIN Bulgaria, established the CLASSLA Knowledge Centre for Computational Processing of South Slavic Languages, certified by CLARIN ERIC. By offering a wide range of resources, tools and documentation on computer processing of the languages of the former Yugoslavia, CLARIN.SI has become the main point of contact for computer processing of these languages, significantly increasing its reach and visibility in the region. Last but not least, with Slovenian membership of CLARIN ERIC, all Slovenian researchers have authenticated access to the repositories and web services of all 20 CLARIN ERIC members, in addition to the services of CLARIN.SI.

Since 2015, CLARIN.SI has been funding individuals to transform their existing language resources to make them suitable for deposit in the CLARIN.SI repository. Since 2018, CLARIN.SI has been additionally running an annual call for projects that create or upgrade language resources or services, for a total of EUR 30,000 between CLARIN.SI consortium partners, to contribute to the CLARIN Infrastructure guidelines. In the period 2018–2020, 15 projects were successfully completed. In the resources deposited in its repository, CLARIN.SI requires data to be encoded in accordance with the open and internationally accepted standards or recommendations, thus promoting the interoperability, interchangeability and long-term use of the deposited data. CLARIN.SI has established cooperation at the national level with its sister research infrastructures DARIAH and CESSDA (ADP). With DARIAH-SI, CLARIN.SI has collaborated in the establishment of common standards for the recording of textual data, and subsequently in projects supported by CLARIN ERIC. It has a long-standing collaboration with ADP to address the issue of the functioning of subject repositories.

CLARIN.SI is a co-organiser of the regular international conferences “Language Technologies and Digital Humanities” and has supported a number of field conferences in Slovenia, including the “22nd International Conference on Text Speech and Dialogue” in Ljubljana in 2019. The CLARIN.SI colleagues have presented the work of the infrastructure at a number of events and as invited

speakers at several universities, such as the University of Ljubljana (FDV, FRI), the University of Klagenfurt, the University of Rijeka, the University of Zagreb and the University of Belgrade.

Although CLARIN.SI is primarily aimed at supporting research activities, it also has other socio-economic impacts. For example, CLARIN.SI corpora are used by researchers to produce terminology dictionaries, which are then used in business. In particular, the bilingual corpora under the concordances are directly useful for translators and translation agencies, as they can identify bilingual terms that are then used in translations. CLARIN.SI is also potentially useful for supporting language teaching and language use for people with disabilities. IT companies use the resources, which also allow commercial use, to develop their own solutions for Slovenian text processing. They can also directly use the software available on the CLARIN virtual organisation on the GitHub platform.

Financial aspect

The co-financing of CLARIN.SI started in 2013. The latest value of the annual sum is EUR 100,000 and the membership fee for the CLARIN ERIC is approximately EUR 14,000 per year. CLARIN also obtained funding from the European Cohesion Policy within the RI-SI-CLARIN in the amount of EUR 466,000 million. Approximately EUR 1.1 million has so far been invested in the national research infrastructure.

For the period until 2030, an amount of up to EUR 250,000 per year is estimated for the long-term sustainability of CLARIN.SI operations and R&D work.

2.2.1.3 DARIAH

DARIAH-EU
Digital Research Infrastructure for the Arts and Humanities

Digital Research Infrastructure for the Arts and Humanities

www.dariah.eu

Status

The project was placed on the priority list of the ESFRI Roadmap 2006 and the national priority list of international projects in the NRRI 2011. Slovenia

has been involved in the DARIAH project from the very beginning of its preparation (2008), including in the preparation of the founding documents and the strategic orientations for the operation and financing of DARIAH ERIC. It signed the Memorandum of Consent on 28 February 2011 and sent the letter of accession to DARIAH ERIC on 4 October 2013. Since the establishment of the DARIAH-ERIC on 6 August 2014, it participates in this research infrastructure as a founding and full member. On 3 September 2018, it renewed its membership for a further five-year period 2019 2024. Slovenia participates in the activities of the DARIAH through the Research Centre of the Slovenian Academy of Sciences and Arts (ZRC SAZU) and the Institute of Contemporary History (INZ), which also coordinates the operation of the DARIAH in Slovenia.

Infrastructure description

The DARIAH is the first digital research infrastructure in the field of humanities and arts in Europe to enable and encourage comparative international and interdisciplinary digital research and free access to research data, tools and results. DARIAH integrates and develops state-of-the-art digital humanities knowledge and methods, analytical and interpretative tools for working with digital research collections (e.g. manuscripts, printed texts, oral and pictorial materials) of individual members, and upgrades their results in line with pan-European needs. DARIAH maintains the good practices already in place and establishes new methodological and technical approaches to cultural heritage research. Digital humanities is not only about creating digitised collections of research data, but also about enabling new links between them through advanced ways of structuring and organising knowledge, thereby transforming analytical contexts and research methodologies.

Planned membership benefits and achievements

Participation in the DARIAH enables the unification of the national digital research infrastructure for the humanities and arts (DARIAH-SI), the transfer of European standards and guidelines in the national space and cooperation in the coordination and implementation of standards, and free access in the field of digital humanities at the national and European levels. It also enables the integration and upgrading of services that open up the work of researchers, improves research methods and encourages the use of new technologies. DARIAH-SI develops, maintains and manages the infrastructure that constitutes the basic support for research practices based on digital technologies. In collaboration with the existing science research communities and good practices,

DARIAH connects individual activities in the digital humanities across Europe. These collaborations produce new scientific results, which the national DARIAH-SI activities preserve, make freely accessible, disseminate and re-use. Particular emphasis is placed on the introduction of international established practices and, above all, methodological and technical standards into the national environment. At the national level, it is also important to establish links with the CLARIN ERIC and CESSDA ERIC consortia, which promise to jointly implement standards for the recording of research data and to provide sustainable and stable access to them.

The target user group of DARIAH-SI is researchers and other professionals working in the humanities, arts and social sciences. DARIAH-SI offers support to them and to IT companies in the form of a wide range of research data, web services and tools suitable for use in research and wider environments, as well as literacy for the digital humanities. It does this through open licensing, making resources and tools available on the GitHub and GitLab platforms, and developing learning materials. Research in the arts and humanities must be integrated with state-of-the-art technologies, placing them at the heart of a technologically evolving knowledge society. DARIAH-SI maintains the History of Slovenia portal – SIstory, which includes a digital library and repository of digital objects (currently over 50,000), mostly in the field of cultural and scientific heritage, as well as various databases and a tool for transcribing historical demographic data. The SI-DIH repository has been set up to meet the increasingly specific needs of researchers and research groups in the digital humanities for digital editions that are as tailored as possible to their research needs. At the same time, it maintains a virtual museum, the ARZENAL repository of collections and materials. By co-funding the Linguistic Advisory Service and the Fran portal, it makes dictionary information accessible to as wide a range of users as possible. It uses the open-source Archivematica application for the long-term and secure preservation of digitised cultural heritage and research data. It helps scientific publishers to establish open access to scientific journals by providing electronic publishing architecture (Open Journal Systems, Open Monograph Press) (19 journals and more than 700 scientific monographs in 2020). DARIAH-SI co-finances the collection, processing, tagging, linking and visualisation of various research data collections (e.g. Archaeological Cadastre of Slovenia, Electronic Scientific Critical Editions of Slovenian Literature, Encyclopaedia of Natural and Cultural Heritage of Slovenia, Historical Census of Slovenia, Slovenian Historical Topography, Slovenian Parliamentary Corpus, Victims of World War I and II).

Participation in DARIAH ERIC enables regular presentations of achievements at international conferences, workshops and other events organised in the framework of DARIAH and other related European infrastructures (CLARIN, OPERAS) and projects (SSHOC). At the national level, it supports: (i) academic activities:

learning about copyright and legal aspects in the digital era, technological solutions for scientific communication and publishing, open access to research data, promotion of open science; and (ii) educational and pedagogical activities: organising summer schools for students and new generations of researchers in the humanities, collaborating with professors and students on various projects (e.g. the processing of the corpus of the minutes of the sessions of the National Assembly of the Republic of Slovenia (1990–1992), the establishment of a project for the digitisation of the Slovenian legal tradition, the implementation of a work practice in basic literacy in the field of digital humanities).

DARIAH-SI is also involved in broader civil society activities, such as providing free infrastructure support to government departments and NGO initiatives, through the permanent preservation and production of digitised and digital archival material. By digitisation, character recognition, analysis and publication of a corpus of stenographic minutes, DARIAH-SI has made available the material of the National Assembly of the Republic of Slovenia, which is part of public information. In general, its tools and data resources also help economic activity, particularly in the fields of journalism, translation and tourism, and in policy-making, for example in the field of waste management and the promotion of eco-driving.

Financial aspect

The co-financing of DARIAH-SI started in 2011. The last annual national co-financing amounted to EUR 185,000 and the annual membership fee for DARIAH ERIC is around EUR 3,000 in money, representing 10% of the total membership fee. The remainder is settled in in-kind contributions, as evidenced by ongoing activities within the research infrastructure. DARIAH-SI has obtained European Cohesion Policy funding under RI-SI-DARIAH for the purchase of equipment amounting to EUR 98,000. Investments in the national research infrastructure to date total around EUR 2.3 million, of which the consortium partner, ZRC SAZU, has received around 30%, the national coordinator, the Institute of Contemporary History, 50% for SIstory: the history of Slovenia and 20% for SI-DIH (the Slovenian digital humanities portal).

For the period until 2030, the costs for the long-term sustainability of DARIAH-SI operations and infrastructure-development work are estimated at around EUR 350,000 per year, including infrastructure management, technical and content support, development of new methods and technologies, and dissemination and educational activities. This also presupposes the necessary extension of activities into new research areas and the involvement of new partners.

2.2.1.4 ESS

European Social Survey

www.europeansocialsurvey.org

Status

The project was placed on the priority list of the ESFRI Roadmap 2006 and the national priority list of international projects in the NRRI 2011. By signing the memorandum of understanding on 23 February 2011, Slovenia has participated in the drafting of the founding documents and strategic guidelines of the ESS ERIC operations and financing from the very beginning. It sent the letter of accession for the ESS ERIC on 26 April 2013, and since its establishment, on 22 November 2013, it has participated in this research infrastructure as a founding and full member. The ESS project itself has been implemented since 2001. Slovenia has been included in it through the Public Opinion and Mass Communication Research Centre at the Faculty of Social Sciences of the University of Ljubljana since the beginning, and since 2004 this Slovenian institution has been a member of the managing consortium and is thus one of the seven leading project partners. In this context, employees of the Faculty of Social Sciences carry out relevant research and management activities that are assigned to them as part of the project (participation in the management of the consortium, planning communication strategies, bibliographic monitoring, coordination, planning of activities and support for various national teams).

Infrastructure description

The ESS is the youngest among the large comparative social surveys of the general type and is intended for analyses of social trends and the guidance of social systems. Its most recognisable characteristics are high standards regarding the quality of all the aspects of preparation and implementation of the research procedure. By means of repeated measurements, it creates a time series of internationally comparable social indicators, with the content of ESS surveys being general and at the same time diverse in terms of disciplines.

Its scientific and managerial users come from the fields of sociology, political science, economics, psychology, demography, public healthcare, criminology, environmental studies, etc. The programme continuously provides data sources in various fields for the scientific assessment of the dynamics of the social climate, attitudes and values in a comparative perspective of more than 30 European countries. There is a consensus that the ESS research methodology has reached the highest level of standardisation in comparative social research of the general type, which was one of the key visions in the design of the project, whose strategic objectives are: 1. collecting reliable data to measure trends in the attitudes and values of Europe's population, 2. overcoming rooted barriers in the comparability of international research, 3. providing reliable indicators of positions, 4. training of social scientists for comparative research at the highest level. Slovenia is one of the most successful countries in attaining the demanding methodological goals in the implementation of the survey.

Planned membership benefits and achievements

Globally speaking, the ESS project has so far been the source of quality comparative data for more than 170,000 users worldwide and more than 4,700 in Slovenia, with Slovenia even ranking first in terms of the number of database users per capita. Through the partnership of the Faculty of Social Sciences in the international managing consortium, which consists of six countries, it also has a recognisable role both in project coordination and in the development of new methodological practices (international online surveys, mixed mode, etc.). In the scientific sense, the most important aspect is certainly the analytical one, because ESS files enable researchers, lecturers and students in Slovenia to gain access to comparative social indicators that enable the testing of scientific hypotheses in many fields in the international and intertemporal framework. In addition to the substantive benefits, the importance of the ESS survey in Slovenia is also in accelerating the flow of methodological knowledge in the pedagogical sphere, as the level of management of more complex methods of statistical data processing in Slovenian social sciences is not yet optimal. Knowledge transfer takes place through a regular study programme, methodological seminars, scientific and professional meetings, online workshops, individual exchanges and numerous scientific publications, as the ESS ERIC has established a broad network of methodological experts to transfer knowledge to a broader research area. Researchers of the Faculty of Social Sciences, as partners in the ESS ERIC, organised 19 methodological workshops through the related EU projects ESSi, DACE and SERISS, with a total of 730 participants from all over the world.

The key scientific contribution of the ESS ERIC project is, on the one hand, a qualitative leap in the development of comparative social science methodology and, on the other, open, timely and user-friendly access to internationally comparable indicators of the social dynamics of European companies, both the survey microdata of the ESS itself and the repository of comparable macro indicators of the participating countries for multilevel modelling of social processes. As mentioned, the academic profile of users is very diverse; in Slovenia, the ESS data is indirectly or directly used by a large number of research programmes and projects in various social sciences and interdisciplinary fields and sub-fields. What indicates that the ESS survey is broadly accepted by academic users is also the number of scientific publications, as the international bibliography of the ESS comprises over 6,000 units, with Slovenia being comparatively present in the vast majority (70%) of scientific publications, which is exceptionally important from the aspect of analysis and positioning of our country in the broader European space. Certain characteristic areas of analysis and development of theories are immigration, politics and democracy, welfare system, work–family conflict, subjective well-being, labour market, social inequalities, public health, climate change, etc.

The Slovenian partner in the ESS ERIC is also involved in a number of international projects: ESS SUSTAIN (collection and analysis of information on the number and type of users) and SERISS – CRONOS (finding solutions to develop cost-effective and methodologically appropriate online survey methods to support the European Commission and Member States). What should be mentioned in the context of broader integration is also the international research infrastructure CESSDA, EVS (WVS) and ISSP, which in the case of Slovenia are particularly linked to the ESS ERIC project. A number of pilot studies and methodological experiments are also under way under the auspices of the ESS, enabling new approaches and establishing new research tools that over time are being adopted and introduced by other research infrastructures (many other national studies benefit from this).

As mentioned, the use of ESS data and online pedagogical tools in the field of education is exceptionally widespread in Slovenia. These are, in particular, various study programmes dealing with the dynamics of attitudes, values and behavioural practices within modern European societies on the one hand and learning about modern research tools and methods on the other. Specific use shows in the implementation of several subjects of undergraduate and postgraduate studies, mostly based on ESS data, as well as in numerous research projects, diploma papers and master's and doctoral theses. This is an important substantive contribution to the stock of knowledge of the new generation of social scientists, with higher standards of data processing

being established, which new generations of analysts will transfer to their fields of work.

When it comes to broader public benefits, the content of ESS research allows monitoring the social trends of many important social subsystems, such as prosperity, health, education, economy, inequalities, environment, values, democracy, and minorities, thus providing quality support to decision makers with internationally comparable data. In the analysis of ESS-related publications, the field of departmental policies is being increasingly mentioned as one that bases its measures and activities on the results of social research. What can be considered as the broader social effects of the project are the possibilities of better leadership and management, as the important expected users of the results include holders of various sectoral policies aimed at ensuring an appropriate development strategy and the competitiveness of Slovenia. The ESS time series indicators are also an important empirical basis for tracking the dynamics of quality and life satisfaction, also in the context of comparisons with other European companies.

In addition to public institutions, the ESS knowledge and databases are also relevant for researchers from the private sector, as analyses of individual subgroups provide opportunities for the Slovenian economy, especially for specialised companies whose activities cover specific needs of the population (e.g. the elderly, families with children, special professional groups). Data and methodological knowledge are also useful in the areas of market analysis, advertising, analysis of human resources potential and analysis of behavioural habits for the needs of analytical departments in various industries. Owing to this type of infrastructure, all users can freely access high-quality international databases, for which they would spend enormous resources on their own.

Financial aspect

The co-financing of ESS research activities started in 2011. The latest value of the annual sum is EUR 165,000 and the annual membership fee for the ESS ERIC is approximately EUR 23,000. Approximately EUR 1.5 million has so far been invested in the national research infrastructure.

For the period until 2030, the annual cost for the national activities of the ESS is estimated at approximately EUR 180,000, which is mostly the cost of field work as part of the research, where 3.8 FTE per year would be needed for professional research work. The state of technical equipment is satisfactory, and most of the equipment has been upgraded in the last two years, which means that no additional funds for technical upgrades are needed in the medium term.

2.2.1.5 SHARE

Survey of Health, Ageing and Retirement in Europe

www.share-project.org

Status

The project was placed on the priority list of the ESFRI Roadmap 2006 and the national priority list of international projects in the NRRI 2011. SHARE-ERIC is an upgrade of the SHARE project and is the first international research infrastructure in the ESFRI Roadmap, which was established on 17 March 2011 in accordance with the Council Regulation (EC) No 723/2009 on the Community legal framework for a European Research Infrastructure Consortium (ERIC). Slovenia sent the letter of accession on 29 May 2013 and became a full member of SHARE-ERIC in September 2013, while it has been actively involved in SHARE activities through the Institute for Economic Research (IER) in Ljubljana since 2008. The IER as the main scientific partner institution also manages the activities in the SHARE-ERIC. Slovenia joined in the fourth wave of surveys (periodic two-year thematic preparations and implementation of field research). An extraordinary SHARE telephone survey, called SHARE COVID-19 or CATI (second wave), is currently under way, covering the same areas as the regular SHARE questionnaire, while being shorter and focusing on the direct effects of the Covid-19 epidemic on the lives of respondents, especially how older people cope with the health and socio-economic consequences of Covid-19.

Infrastructure description

SHARE is an international multidisciplinary longitudinal survey that establishes the economic, health and social situation of the population over 50 years of age. As a unique research infrastructure on a global scale, it is based on prior coordination of the questionnaire between countries, which allows comparison of the effects of different welfare systems (such as pension and healthcare system) on welfare, health, economic status, retirement and social inclusion of older people. Seven waves of data collection have been conducted so far as

part of this research in the following years: 2004, 2006, 2010, 2013, 2015, 2017 and 2019, and one wave of a retrospective survey on people's life histories in 2008 and in 2017, for countries that joined the survey after 2008. The data collected is available free of charge to the international scientific community and covers more than 140,000 individuals (approximately 480,000 interviews were conducted) from 27 European countries and Israel. At the beginning of 2021, the SHARE infrastructure was used by more than 12,000 scientists and other users from all over the world, of whom 169 were Slovenian. With the data collected in this manner it is possible to determine the causality or analyse the effects of reforms in many areas that are actually taking place in the EU countries and represent a kind of natural laboratory for studying the effects of individual measures on the behaviour and well-being of the population.

Strictly defined guidelines and procedures for conducting the survey ensure internationally comparable results. SHARE is harmonised with the American Health and Retirement Survey (HRS) and the English Longitudinal Study of Ageing (ELSA) and is an example for the development of many surveys on ageing around the world, such as CHARLS in China, KLoSA in South Korea, LASI in India, JSTAR in Japan, ELSI in Brazil and MHAS in Mexico. The key scientific advantage of the SHARE survey is its panel approach, which can capture the dynamics of the ageing process, and interdisciplinarity. By building a microdata infrastructure, it provides a scientific basis for empirical research of the ageing process in many sciences: demography, economics, medicine, gerontology and sociology. At the same time, it enables public policy planners to plan data-supported relevant policies and reforms in a number of areas affected by the ageing process: pension system, healthcare and long-term care system, labour market, social welfare and social policy, and housing.

Planned membership benefits and achievements

Slovenia is a country that is exposed to an ageing population and its various consequences, including the lack of sustainability of the public finance system. We are facing urgent key structural reforms of the pension system, healthcare, long-term care, social transfers, education and the labour market. To implement them, we need high-quality analytically supported strategies and measures based on mutually harmonised data. Such data is provided by the SHARE infrastructure project database. The participation in the SHARE, on one hand, enables Slovenia to obtain knowledge and experience from an international pool of experienced researchers from the previous operation of the project, while on the other hand, it helps to identify new business opportunities for the Slovenian economy. Benefits for Slovenia are related to

issues that accompany the ageing of the population, which is recognised as one of the greatest challenges of the 21st century in Europe. The participation is a bridge to many excellent scientists and scientific institutions in Europe. It enables researchers to have free access to all data of the survey. The research group at the IER has developed technical support for all those who have started to use the SHARE data. The organised data is available to the interested public. The inclusion in the SHARE was followed by new international scientific publications and the efforts of the research group at the IER to promote the use of the SHARE data. By continuing to participate in the survey, Slovenia will ensure the possibility of establishing a panel that will monitor the ageing of individuals and responses to the changing social and economic conditions. It will provide data for quality analytical support to public policy planners.

In the 2011-2020 period, several goals of the national part of the project were achieved: all waves of the survey were successfully carried out, the Slovenian sample was increased from the initial 3,000 to more than 5,000 individuals, thus enabling the domestic and international research community to include Slovenia in individual analyses and comparison with all other participating countries, cooperation with many excellent scientists and scientific institutions in Europe and beyond was ensured, the number of SHARE data users in Slovenia is gradually increasing and, with 81 users per million population, puts Slovenia in the 2nd place among the SHARE countries, just behind Luxembourg (for comparison: Austria 43, Germany 25, Czech Republic 22, Italy 11), SHARE data is used in Slovenia by researchers from all universities in the country and 19 other organisations, SHARE data is used both for scientific purposes and for preparing analytical and professional bases for strategic documents in the field of social security systems.

The basic areas that concern the research and development work in the project are health, long-term care, the labour market and pensions, and innovative methodological solutions. Slovenia's orientation is to address open issues and provide options for further research by using the existing methodological approaches or developing our own. This has served as the basis for cooperation with leading domestic researchers in these fields and several top-level scientific publications, several presentations at leading domestic and international conferences and seminars, and the publication of articles in top-level scientific journals. SHARE data has been used in several diploma papers and master's and doctoral theses and in teaching work at faculties, while international cooperation has been improved.

The Slovenian partners in the SHARE survey are very active in the field of dissemination of knowledge and education. At the initiative of the Slovenian

SHARE team, the international SHARE blog has become an important tool in informing the public about the results of the survey. Statistical data and descriptive statistics for the general public are also generated on the basis of SHARE data: on the ageing Slovenian population, on basic health indicators, use of healthcare services, expenditure of the elderly on healthcare, disability, long-term care, social exclusion, labour market for the elderly, pensions, etc. SHARE data is also used directly in teaching, for example by the Faculty of Medicine of the University of Ljubljana (easySHARE).

In Slovenia, the SHARE infrastructure is also intensively used in the preparation of analytical bases and several strategic documents that are the basis for developing relevant measures in the field of social security systems: among other things, in the preparation of expert bases for reforming long-term care and healthcare, the drafting of the White Paper on pensions as an expert basis for reforming the pension system, the expert document Older People and Labour Market in Slovenia and the relevant action plan, in the report Demographic Changes and Their Economic and Social Consequences, in the 2020 Development Report, in the Strategy on Long-Lived Society, etc.

Financial aspect

The co-financing of SHARE-ERIC research activities started in 2011. The total cost of the last two-year wave of the SHARE survey, which covers a sample of around 5,000 respondents, is EUR 654,000, of which EUR 444,000 for the survey on the ground, with the rest, EUR 105,000, being the cost of IER coordination. The cost of the annual membership fee is approximately EUR 20,000. Approximately EUR 3.6 million has so far been invested in the national research infrastructure.

For the period until 2030, additional five two-year waves are planned to be carried out as part of SHARE, the cost of which will be similar to the costs of implementation in the latest period. An upgrade of computer equipment is also planned, which is expected to cost approximately EUR 15,000.

2.2.2 Physical Sciences & Engineering

2.2.2.1 Belle 2

www.bell2.org

Status

The project was placed on the national priority list of international projects in the NRRI 2011 and is not an ESFRI project. A Slovenian research team based at the Jožef Stefan Institute (JSI) has been one of the operators of key activities in the Belle II project.

Infrastructure description

The Belle detector at the KEKB electron and positron collider in Tsukuba, Japan, one of the most successful projects of all time in particle physics (a decisive contribution to the 2008 Nobel Prize, more than 500 articles in top-level journals with more than 20,000 citations) stopped capturing data in 2010. This phase was followed by the preparation of an upgraded version, Belle II, which started making measurements in the spring of 2018. The upgraded research infrastructure of Belle II will considerably improve the precision of measurements enabled by the improved detection capabilities and by a substantial increase in the size of the recorded pattern. With the upgraded accelerator, the number of reactions will increase by a factor of 40. In ten years of operation, it is expected that the sample of detected B mesons will increase by a factor of 50, which will enable the study of very rare processes with hitherto unattainable accuracy. The main purpose of the measurements is to identify hitherto unknown particles and processes, which are popularly called “new physics”.

As the accelerator was upgraded, the Belle II detector also had to be thoroughly improved to enable efficient capture of data at the increased frequency of reactions and in an environment with a significantly increased background

level. In the upgrading of the Belle II research infrastructure in the total value of approximately EUR 400 million (including approximately EUR 300 million for the upgrade of the accelerator funded exclusively by the host country Japan), crucial contributions were made by research institutions from a total of 25 participating countries (including Japan, the US, Canada, Germany, Italy, France, Russia, Australia, Austria, the Czech Republic, Poland, China, South Korea and Slovenia, with a total of almost a thousand researchers). A central role in this part of the project was also played by Slovenian researchers who are responsible for the design and preparation of two detector sets for the identification of charged particles (TOP and ARICH detectors), for analysing data collected with these detectors and for developing new methods for studying rare decays of mesons B and D and for the coordination of the preparation of the entire detector (the Slovenian coordinator has been a member of the executive committee since 2013, and the technical coordinator for the construction of the detector since July 2015). They played a key role in the preparation of the Belle II project both in managing the research team (project manager in 2008-2013, coordinator of the preparation of the detector since 2015, coordinator of the physics programme in 2009-2013, head of one of the detector subsystems of the Belle II spectrometer since 2009) and in developing new detection methods and methods for analysis of collected data.

Planned membership benefits and achievements

By combining experimental approaches at the limit of achievable energies (CERN and LHC) and at the limit of achievable precision (the KEK and Belle II), it will be possible to discover and identify new types of particles and corresponding theories that will change our understanding of the very roots of the basic forces in nature. The discovery of possible new processes in basic particle physics would have a revolutionary impact on the development of science. Regarding the key role of Slovene researchers in the project, this would, in addition to being an exceptional scientific achievement, also have a significant influence on the worldwide position and reputation of Slovenia. With the expertise and achievements of the Belle and Belle II projects, Slovenian researchers have established themselves as the world's leading experts in individual fields of heavy quark physics and in the field of high-tech detectors of Cherenkov radiation.

The work on the project in the 2011-2018 period was mainly focused on the preparation and construction of the Belle II detector, as a Slovenian contribution in kind. An analysis of experimental data collected with the previous version of the detector was conducted along with the participation in the preparation of

the new accelerator and detector. In the last ten years, Slovenian researchers participated in 270 articles on the results of this research, which have been cited 11,000 times. The most important results include accurate confirmations of the Kobayashi-Maskawa matrix, which describes the asymmetry between particles and antiparticles, discovery of a new type of hadron composed of four quarks, and a series of measurements showing possible discrepancies between the Standard Model theory and the measurement results. Worth mentioning among the latter is the possibility of lepton-universality violation. In 2018, one of the key intermediate goals of the project, which is to complete the Aerogel Ring Imaging Cherenkov (ARICH) detector, was achieved. In the same year, the preparation of the TOP detector for the identification of charged particles in the barrel-shaped part of the spectrometer was continued and it was successfully used in the first measurements of decays of B mesons. In 2019, both sets were successfully connected to the rest of the spectrometer. The development and testing of new detectors has been extensively covered by the professional public; 37 articles have been published in the main journals for instrumentation in particle physics during this time. Also indicative of the importance of this research is the awarding of the European Research Council advanced grant this year to a group of Slovenian researchers for research with the Belle II detector.

The researchers on the project are also involved in work with students as lecturers, assistants and mentors at the University of Ljubljana and the University of Maribor, and in the preparation of courses at international postgraduate schools. The direct result of the research on this research infrastructure is eight high-profile doctorates. They have participated in numerous international seminars and summer schools and in doctoral commissions at foreign educational institutions.

The prestigious role of Slovenian researchers in the project has also helped in promoting the Slovenian high-tech industry in the search for technological solutions and preparation of components for the experimental apparatus (KENS d.o.o., Prebold), and in equipping the SuperKEKB accelerator (Cosylab d.d., Ljubljana, and Instrumentation Technologies, d.d., Solkan). The associated reading electronics was developed, tested and prepared for production in cooperation with the company Kens, d.o.o. of Prebold, which also produced all five hundred printed circuit boards that were installed in the detector. Another important contribution is the education of staff who, after completing doctoral or master studies, gain employment in Slovenian industry and administration. An example of knowledge transfer in basic particle physics is the development of new methods for healthcare, particularly, improvements related to imaging in medical diagnostics (positrontomography – PET). Important contributions in the field of knowledge transfer in grid technologies in computer science are also important.

Financial aspect

Co-financing for activities as part of the Belle II project started as part of the IJS infrastructure programme at the Slovenian Research Agency (ARRS) in 2011. The latest annual amount is EUR 100,000, while approximately EUR 1.58 million has so far been invested as part of the project. In 2011-2020, these funds were intended primarily to cover the costs of the Slovenian contribution to the construction of the Belle II detector.

For the period until 2030, the costs of this project are expected to continue to stand at approximately EUR 100,000 per year. The annual contribution for the operation of the accelerator and detector has not changed, while the costs of the accelerator in the amount of EUR 80 million will continue to be fully covered by the host country Japan, and Slovenia will continue to contribute to the operation and planned modernisation of the detectors. The plan for the period until 2030 includes the following stages: calibration of the ARICH and TOP detectors by using captured data, measurements with the Belle II spectrometer, maintenance of the ARICH and TOP detectors, maintenance of sufficient computing capacity, and upgrading of the ARICH and TOP detectors.

2.2.2.2 CERIC

CERIC

Central-European Research Infrastrucutres Consortium

www.ceric-eric.eu

Status

The project was placed on the national priority list of international projects in the NRRI 2011 and is not an ESFRI project. Slovenia has participated in the drafting of the founding documents and strategic guidelines of the CERIC-ERIC operations and financing from the very beginning (signing of the memorandum of understanding on 26 June 2011 in Bregenz, Austria). It sent the letter of accession on 29 November 2012, and since its establishment, on 24 June 2014, it has participated in this research infrastructure as a founding and full member. Slovenia is represented in CERIC-ERIC by the NMR Centre

at the National Institute of Chemistry, which was selected on the basis of a public call for applications and by a decision of the relevant ministry of 9 May 2012. The NMR Centre supports the scientific, technical and strategic work of CERIC-ERIC, including by ensuring access to its capabilities (as a contribution in kind), while also acting as the national coordinator of activities.

Infrastructure description

CERIC-ERIC is designed as a link between the existing regional facilities in Central Europe to facilitate more comprehensive research and infrastructure services in the fields of matter and materials and in life sciences. Initially, no construction of new or major joint upgrades of existing facilities was planned. Investments in the national infrastructure, including its upgrading, represents in-kind contributions from the partner countries in the form of services or the provision of existing research facilities, in principle already funded from other sources. The initiative for cooperation was provided by Italy (Elettra Synchrotron Trieste) with the intention of integrating the capabilities in the region and beyond. In addition to Slovenia and the host country, Italy, also participating in the project are Austria, Croatia, Hungary, Serbia, Czech Republic, Romania and Poland. The project optimises the use of existing facilities. The international cooperation increases the knowledge base in the partner institutions and their recognisability and reduces the price of use. Every country has decided at its own discretion which equipment to include in CERIC-ERIC, while the assessment of scientific excellence is within the competence of the International Scientific Committee as part of CERIC-ERIC. An important element in the selection and inclusion of individual research equipment and facilities is the complementarity of equipment. Slovenia has committed itself to developing, and enabling the development, of NMR spectroscopy for the needs of the entire region and all partner countries. The CERIC ERIC partner countries expect this development and relevant investment to be at an internationally comparable and competitive level.

CERIC-ERIC carries out two calls per year for access to equipment at partner facilities. Projects are evaluated internationally, and the best ones are given access to equipment and also to expertise, which is crucial in the use of the equipment and interpretation of the results. In addition to the above, access to the equipment of the partner facilities is also provided outside of regular calls for applications by means of fast-track access in cases of emergency. CERIC-ERIC has top-level knowledge of materials at its disposal, while it also possesses quality knowledge in the field of life sciences. However, in order to face the new challenges of biology and medicine, the existing infrastructures must be further renovated, expanded and better integrated, which would further integrate the facilities of the individual partners and strengthen the

competitiveness of the CERIC-ERIC infrastructures in the field of life sciences (the internal project INTEGRA has been created for this purpose). CERIC-ERIC organises scientific symposiums to promote the vision and objectives of the operation and the facilities of the research infrastructure and international expertise in individual partner facilities. In addition to presenting the facilities to the interested professional public, the symposiums also aim to promote interaction between individual partner facilities or their researchers, identify topics for joint research in various fields and find synergies in competing for calls for applications for projects.

Planned membership benefits and achievements

Inclusion in the CERIC-ERIC opens up possibilities for integration at several levels. The research infrastructure of the NMR Centre at the National Institute of Chemistry is used as a platform for cooperation between research institutes, universities and industrial partners in Slovenia and Europe, and as such ensures dissemination of knowledge about the possibilities of NMR spectroscopy use. It contributes to the Central European Consortium the access to NMR spectroscopy as complementary equipment to the facilities of other partners that provides unique and complementary data in the fields of life sciences and materials. Through the NMR Centre, Slovenian researchers have access to a wide range of techniques important for analysis and material characterisation and in the field of life sciences, and as part of CERIC-ERIC they are enabled access to modern research equipment such as the synchrotron in Trieste, neuron reactor in Budapest, SAXS methods in Graz, material characterisation methods in Prague, various microscopic methods in Bucharest, etc.

The inclusion in CERIC-ERIC has already produced concrete results. A new 600 MHz spectrometer (Aska) worth EUR 1 million (own funds) was acquired in 2019 as part of the NMR Centre exclusively for the CERIC-ERIC activities. In 2020, with the help of the European Cohesion Policy, the existing 800 (David) and 600 (Lara) MHz NMR spectrometers were renovated and new 600 (Oro) and 400 (Nika) MHz NMR spectrometers were installed in the total value of EUR 3.3 million. Since the end of 2020, six NMR spectrometers have been operating at the NMR Centre of the National Institute of Chemistry, the quality of which is of crucial importance for the implementation of the most demanding research. The 800 MHz and the two 600 MHz NMR instruments are equipped with cold probes that, with their high resolution and sensitivity, enable the studying of the spatial structure and dynamics of complex systems with high molecular weight, such as proteins and nucleic acids in solution. The third 600 MHz NMR instrument is used to study various solid samples, from (new) active ingredients to various materials that are useful, for example, in

energy storage and thus in the development of battery systems. The new 400 MHz and 600 MHz NMR spectrometers will be equipped with a set of various probes that will enable studies of samples in a solution, in solid and so-called semi-liquid samples (e.g. tissue or food samples). All new and refurbished NMR spectrometers will be or already are equipped with an automatic sample changer, which is particularly welcome in metabolomics studies. The modern research equipment and highly qualified staff, in cooperation with academic institutions, also enables numerous publications in top-level scientific journals.

An important aspect of the operation of the NMR Centre is its educational role. The NMR Centre educates researchers in the performance of NMR experiments and solves and interprets NMR spectra in specific structural problems as part of diploma papers and master's and doctoral theses. A large number of students at all levels of education use the equipment and services of the NMR Centre at the National Institute of Chemistry. The organisation of symposiums and workshops that feature internationally renowned foreign scientists indicates the future of development, modernisation and prudent investment in research equipment, which means that the potential of NMR spectroscopy is brought closer to the broader (professional) public as future users, and that knowledge about the existing and new research equipment is spread among the existing senior and junior associates. In addition to being enabled to conduct the desired experiments there, all users who come to the NMR Centre as part of CERIC-ERIC projects are also provided with interpretation of data and taught about the options for NMR spectroscopy use. Exchange of visits by secondary school and university students at individual facilities also take place as part of various CERIC-ERIC activities and projects. Guided visits for primary and secondary school students are organised several times a year at the NMR Centre (in 2019, it was visited by approximately 300 Slovenian children), who are introduced to NMR spectroscopy and its potential.

These activities and international involvement also have socio-economic effects. The equipment and internationally comparable expertise of the Slovenian NMR Centre contributes to the development of the ERA and regional integration, which enables the Central European countries in particular to gain a considerable amount by connecting the existing facilities: experience and knowledge for the general benefit of the economy and other segments of social activities and social challenges specific to this part of Europe. The integration of capacities in terms of equipment and knowledge helps strengthen technological and economic advantages. With Slovenia's membership in CERIC-ERIC, Slovenian researchers have gained the opportunity to access state-of-the-art equipment that it is not feasible to develop or invest in locally. From an economic point of view, it is very important that there is no requirement to purchase or maintain equipment needed for work, especially if it is expensive and large.

Financial aspect

The AARS started co-financing the activities of the NMR Centre as part of CERIC-ERIC within the infrastructure programme of the National Institute of Chemistry in 2015. The latest annual amount totalled EUR 170,000. No membership fee for CERIC-ERIC has been planned so far, while a proposal for its introduction in the coming years is being prepared (details are not yet determined). CERIC also obtained funding from the European Cohesion Policy within the RI-SI-CERIC in the amount of EUR 3.1 million. Approximately EUR 4 million has so far been invested in the national research infrastructure. The upgrade of the national research infrastructure is an in-kind contribution to CERIC-ERIC. In the coming years, the co-financing will be further enhanced with funding from the Structural Funds if possible.

In accordance with the CERIC-ERIC development strategy to maintain the required competitiveness, there is a need to expand the capacity of equipment, especially for the 1 GHz NMR spectrometer for measurements in solution and the 800 MHz NMR spectrometer with a wide aperture for measurements in solid state, which means investment in the total amount of approximately EUR 15 million. In addition, the plan includes the purchase of equipment for dynamic nuclear polarisation (DNP) to improve the sensitivity of the use of an 800 MHz NMR spectrometer with a wide aperture in the amount of EUR 2 million and the purchase of a cold probe for measurements in solid state (biological macromolecules) in the amount of EUR 0.5 million. To provide technical support to users, the existing human capacity should be increased from 3 FTE to at least 5 FTE.

2.2.2.3 CERN

European Organisation for Nuclear Research

www.home.web.cern.ch

Status

The first initiatives for the membership of the Republic of Slovenia in CERN date back to the year 1992; Slovenia sent the preliminary letter of intent as

the first formal step towards CERN in May 2009. In 2011, the conditions for the inclusion of the Republic of Slovenia in CERN were agreed. The stalled process was reactivated in the second half of 2015. The agreement between the Government of the Republic of Slovenia and CERN granting the status of an associate member as a preliminary phase to membership in CERN was ratified on 4 July 2017, specifically for the 2017-2022 period (five years), and at the request of Slovenia, the previous phase was extended for another two years until 4 July 2024.

Infrastructure description

CERN was established in 1954 in Geneva and represents the central world laboratory for particle physics. Its purpose is to provide the research infrastructure - accelerators of protons, antiprotons, heavy ions, electrons and positrons. CERN is among the most elite institutions in the world because the use of its facilities often enables the development of new technologies. As the world's leading laboratory for particle physics, its mission is to build and operate particle accelerators at the highest energy levels available to humankind or with special properties. They are designed to explore the microworld, the interaction of particles in high-energy collisions. These lead to the smallest of dimensions and highest of temperatures that prevailed in early space, a fraction of a second after the Big Bang. The core project of CERN for the past 30 years has been the Large Hadron Collider (LHC), which was launched in 2009. In July 2012, the experiments ATLAS, in which a Slovenian team of scientists works, and CMS announced that they had measured the existence of the Higgs boson, the last missing part of the Standard Model. Based on this experimental discovery, the Nobel Prize in Physics was awarded the following year to the theorists F. Englert and P.W. Higgs for their theoretical prediction of this particle nearly 50 years ago. An analysis of the captured data, together with the limited number of collisions of heavy, mainly lead ions, provided a set of precise tests of the properties of the Standard Model in all sectors. The search for phenomena in physics that are not described by the Standard Model continues, and the limitations on the existence of new particles predicted by the models of the new physics put many predictions of theoretical models to a difficult test. The results of the first two periods of operation of the LHC are documented in the ATLAS experiment alone in about 1,000 scientific articles, which received immense interest from the international scientific community. The articles have been cited almost 50,000 times, and their Hirsch index is approaching 100. The article on the discovery of the Higgs boson alone garnered over 5,000 citations. In 2021, the LHC began its third four-year cycle of operation. At the same time, preparations are under way to upgrade the LHC to high

luminosity – HL-LHC, which is also a project in the ESFRI Roadmap, which will operate in 2027-36 with approximately 10 times higher capacity than the LHC. This data will make it possible to accurately measure Higgs boson phenomena, including self-assembly, and to look for new physics phenomena either directly through the formation of new particles or through deviations from the predictions of the Standard Model. Detectors for HL-LHC will need to be renovated, while the tracker for ATLAS and CMS will be fully replaced and other detector assemblies will be renovated.

Planned membership benefits and achievements

Associate and, consequently, full membership in CERN will bring numerous additional benefits for Slovenia in the fields of science, education and economics.

1. Science: The membership shall bring Slovenian scientists full access to all programmes and projects running in CERN or the research infrastructure and technological projects of CERN, which take place in the presence of top experts from around the world, unlimited access to the programmes of CERN for the education of young engineers, training postgraduate and post-doctoral associates in competition and collaboration with colleagues from the most developed countries, access to and opportunities to work with devices of the highest level of technology, employment of scientists in CERN and participation in training programmes. This means widening and deepening the cooperation of Slovenian researchers in the CERN projects, the creation of a network of top Slovenian knowledge in the field of particle physics and opportunities to participate in educational programmes, which leads to new discoveries, new publications and, of course, to the improvement of the quality and competitiveness of scientific work. A group of Slovenian experimental physicists has worked at CERN since the 1970s, and they are organisationally connected as part of the Department of Experimental Particle Physics of the Jožef Stefan Institute, headed by Marko Mikuž, with about a third of them being employed as academic staff at the University of Ljubljana, University of Maribor and University of Nova Gorica. They participated in numerous experiments (OMICRON, CPLEAR, DELPHI), and since 1996 they have been full members of the ATLAS experiment on the Large Hadron Collider (LHC). They participated in the planning and development, construction and launch of the experiment, and in the preparation of a number of software tools for analysis. They are currently involved in the operation of the detector and several data analyses, and at the same time are one of the most active groups in preparing the upgrade of the detector for the operation of HL-LHC. Following the associated membership, a small group of chemists from the National Institute of Chemistry also joined the activities at the ISOLDE

isotope separator. From the research conducted in CERN, Slovenian scientists have published about 1,300 scientific papers in reputable international journals, which have brought about 20,000 citations to Slovenian science. A total of 25 bachelor's, 12 master's and 23 doctoral theses were written in connection with the work at CERN. The apparatus for positron tomography with a detector based on multi-wire proportional chambers was produced. Prototypes of the portable detector of radiation in the environment on the basis of proportional chamber and the detector of strontium in the environment on the basis of the Cherenkov detector were also made. A new type of detector for medical imaging based on silicon position sensitive sensors and the apparatus for the PET investigation operating in a strong magnetic field and therefore compatible with magnetic resonance imaging (MRI) are being developed. The computer grid technology has been transferred to Slovenia. Its first implementation was a cluster dedicated to computations for ATLAS; the extensions are available to the entire scientific sphere in cooperation with ARNES.

2. Education: Many initiatives, events and programmes aimed at educating and raising awareness of all activities that take place at CERN have been organised as part of CERN. The Member States have the opportunity to attend and participate in events and programmes aimed at all levels of education, from secondary to post-doctoral levels. Thus, CERN offers a wide range of possibilities for education and training programmes at all levels, second-cycle programmes for students and teachers, doctoral and post-doctoral study programmes, which are mainly carried out at the headquarters of the organisation while some are also carried out in member states. As part of the International Masterclass programme, more than 13,000 secondary school students in 60 countries come to one of the nearby universities or research institutes each year to learn the secrets of particle physics. Slovenia has also been actively involved in this programme for five years. Every year, CERN offers various in-service training programmes to secondary school teachers so that they can keep up to date with the latest findings in particle physics and related fields and experience a dynamic international research environment. Such a programme was organised for Slovenian teachers for the first time in 2019. The CERN Open Data project is a result of CERN's open access and open data policy. The portal allows data from experiments conducted on the LHC accelerator to be shared, on the one hand, with the scientific community, including researchers and scientists outside CERN-related experimental groups and, on the other hand, for training and education purposes. The first contributions based on data from the CERN Open Data project have been published. CERN also devotes considerable resources and effort to educating staff by means of various programmes, with Slovenians already having access to some of them: Doctoral Student Programme, Fellowship Programme, Associates Programme and some other positions for a definite

period of time. The CERN Directorate has set up the CERN against COVID-19 task force to coordinate community ideas and initiatives to support the collective global fight against the Covid-19 virus in collaboration with the World Health Organisation (WHO). The Slovenian computing infrastructure WLCG SiGNET Tier-2 has also recently been used in the fight against Covid-19. It contributes the computing capacity as part of the Folding@ home infrastructure in the project of calculating the three-dimensional structure of virus proteins.

3. Industry: There is also an important technological and economic motive for membership in CERN since this will allow the full and first-class access of Slovenian industry to orders from CERN and, thus, the related breakthrough to demanding markets with products that have a high degree of embedded knowledge and added value. Thus, it opens up to Slovenian partners, especially high-tech companies, the possibility of accelerated development and access to new global markets or other positive multiplier effects for their long-term growth and development. In order to facilitate familiarity with, and deepen the cooperation of, the Slovenian economy with CERN, several events were organised, such as the one on 7 November 2017 at the Chamber of Commerce and Industry in Ljubljana and especially the Slovenian Industry Day on 9 and 10 October 2019 at the CERN headquarters in Geneva, in which 24 companies from the construction, civil engineering and technical services, electrical engineering and magnets, electronics and radio frequencies, information technology, vacuum and low temperatures, mechanical engineering and raw materials, health, safety and the environment sectors took part. An important role in this is played by the Industry Liaison Officer (ILO), whose basic task is to identify needs and opportunities at CERN and transfer this information to interested Slovenian companies. Organisation for this kind of work at the national level is also important. A concept of organisational structure at the national level is being prepared for more efficient work in deepening the cooperation of the Slovenian economy with CERN and other research infrastructures. A positive trend in the cooperation of the Slovenian economy with CERN has been detected in recent years.

Financial aspect

A gradual pace of the payment of the obligation has been agreed for the period of the transitional membership phase in 2017-2021, with the initial commitment being 25% of the full membership fee due in 2017. The membership fee for full membership will amount to CHF 2,956,550. The new member states are also required to pay a one-off accession amount of 1.25% of the membership fee, i.e. CHF 3,695,700. The payments made to CERN so far in the 2017-2021 period amount to a total of CHF 4,975,650 (approximately EUR 4.48 million).

2.2.2.4 CTA

Cherenkov Telescope Array

www.cta-observatory.org

Status

The project was placed on the priority list of the ESFRI Roadmap 2008 and the national priority list of international projects with a revision of the NRRI 2016. The preparatory phase of the project as part of the non-profit organisation CTAO gGmbH is nearing completion, and the project is expected to be fully operational in 2026. Slovenia has been involved in the preparation of the CTA project since 2013 through a group of researchers from the Centre for Astrophysics and Cosmology (until 10 May 2017 the Laboratory for Particle Astrophysics) and the Department for Experimental Particle Physics of the Jožef Stefan Institute (IJS). Slovenia joined CTAO gGmbH when it was established in 2017 (letter dated 9 October 2017) and became one of the 13 full members of CTAO gGmbH, and at this stage was represented as partner by the University of Nova Gorica (UNG). Currently, the project is transitioning to the construction phase, while at the same time CTAO ERIC is being established as a new legal form for continuation of the project.

Infrastructure description

The CTA infrastructure will enable space exploration at wavelengths of Very-High Energy (VHE) cosmic gamma (photon) radiation with energies between 20 GeV and 300 TeV. These are an exceptionally important source of information about the most energetic processes in the universe, regarding which our understanding of natural laws is still very limited. VHE gamma radiation is believed to be formed as a secondary product of the acceleration of extreme-energy cosmic particles and their inelastic interactions with matter during the expansion of the universe. In contrast to charged cosmic particles, galactic and intergalactic magnetic fields do not affect gamma rays, which allows their tracing to the place of origin. The CTA has great research potential for the discovery of new physics, i.e. processes that are

not included in the standard model of particle physics or in cosmological models. The vision of the CTA project is to use VHE gamma radiation for research into hitherto unknown or poorly known phenomena and processes in space. Detailed and systematic research into non-thermal space with the CTA observatory will significantly contribute to the understanding of the mechanisms of formation of VHE gamma radiation, extreme-energy cosmic particles and physical processes in the proximity of neutron stars and black holes. Due to its exceptionally high sensitivity, the CTA will also be used as a tool to search for dark matter or other hitherto unknown forms of matter, assess possible violations of Lorentz invariance, and perform new tests of fundamental physical laws.

The strategic goal of the CTA project is to build northern and southern observatories, one in each hemisphere (Chile, South America and La Palma, Canary Islands, Spain) with greater sensitivity and better angular and energy resolution than all previous experiments, which will enable measurements of VHE gamma radiation all over the sky. It is estimated that the cost of development and construction of the CTA in the expected range of two observatories with more than 100 telescopes each will exceed EUR 330 million (in 2021 prices). Each observatory will consist of a network of tens of Cherenkov Telescopes, which will detect incident photons through atmospheric avalanches of charged particles. Computer grid technology developed to support experiments at CERN and based on the optimal exploitation of computer facilities distributed among a larger number of institutions in different physical locations to achieve common computing goals is used for the successful operation of the CTA observatories. The research infrastructure of the CTA observatories with all the associated instruments is at the top of the world's technological capabilities, and the plan is to include Slovenia in it with supercomputer capacities. In 2021, the CTA international consortium connects more than 1,500 researchers from 25 countries in Europe, Asia, Africa and the Americas.

Planned membership benefits and achievements

Slovenia's participation in the construction of the CTA observatory is of key importance for Slovenian astrophysics researchers, as they will be directly involved in top research into the most energetic processes in space at the very limit of technological capabilities. The Slovenian group, which includes researchers from the UNG and JSI, has already actively contributed to the planning of observatories and studies and simulations of possible research in the initial phase, while individual Slovenian scientists occupy important posts as part of the CTA.

In the national part of the project, Slovenian scientists have so far contributed both to the scientific framework related to research with the CTA observatory, and to direct preparations for its construction. In the first part, they focused on one of the most interesting areas of research in astrophysics – dark matter research and new physics, as part of which they made an important contribution to the preparation of observational strategies for searching for sources of extreme-energy cosmic gamma radiation and finding candidates for dark matter, thus helping create the CTA research strategy. Activities that involved extensive computer simulations in the grid system and the use of measurements from other experiments in particle astrophysics and high- and extreme-energy gamma radiation (Pierre Auger, IceCube, Fermi LAT and other observatories) are of key importance for the optimal operation of the CTA observatory after construction. In the second part, Slovenian scientists in cooperation with Spanish and Italian partners made an important contribution to the research and development and construction of a prototype of the Raman lidar for the characterisation and monitoring of the atmosphere above the observatory at La Palma. Atmospheric calibration of VHE gamma radiation energy measurements is crucial for achieving the planned CTA capabilities and thus for its successful operation. As part of CTAO gGmbH, the prototype of the Raman lidar became the official pathfinder and thus the first candidate for installation at the completed observatory. In this case, Slovenia's contribution to the construction of the Raman lidar will be considered an in-kind contribution to the construction of the CTA observatory. The lidar was installed at the La Palma observatory in February 2021, and the measurements, in which Slovenian researchers also participate, lasted until the end of 2021. The website of the CTA Pathfinder Raman lidar, prepared by the Slovenian part of the team, is available at https://ctan-lidar-pathfinder.ung.si/.

In the field of dissemination of knowledge and education as part of the project, the Centre for Astrophysics and Cosmology (CAC) of the University of Nova Gorica has so far played a key role by organising scientific seminars (approximately ten a year), several scientific meetings, workshops and events for the general public (Night of Researchers, Znanstival). They organised internships for Slovenian secondary school students on CTA-related topics, and they also help popularise science and disseminate knowledge about astrophysics by regularly appearing in the media. Also important is the role of the CTA in the field of education for doctoral students of physics who are involved in the work of research collaborations or as early-stage researchers.

Slovenia's involvement in the activities of the CTA observatory is also important for the economy, especially for companies in the fields of

information technology, electrical and electronics and high-tech companies in the field of optics and remote sensing of atmospheric properties that will be able to participate in its construction. At the "CTA, astrophysics and Slovenian companies" workshop in November 2019, organised by the UNG and the Chamber of Commerce and Industry, it transpired that there is a strong link between the knowledge and technologies required to build the CTA and the expertise of Slovenian small and medium-sized high-tech companies. Representatives of CTAO gGmbH who attended the workshop also expressed interest in the high-tech contributions of Slovenian companies to the construction of the CTA observatory during the building phase. In addition to the direct benefits for the economy, participation by Slovenian companies would also mean the acquisition of knowledge and references for participation in similar business opportunities in the future.

Financial aspect

The co-financing of participation in the CTA started in 2017 as part of the Infrastructure Programme of the UNG at the ARRS. The latest annual amount totalled EUR 100,000. The investments in this project (2017-2021) made so far amount to EUR 450,000, which covered Slovenia's obligations regarding the current costs of the observatory in 2018-2021 in the amount of EUR 209,000, while EUR 241,000 was intended for an upgrade of Slovenia's research infrastructure in this area.

For the period until 2030, an estimated EUR 150,000 per year will be needed in order to achieve all the project objectives of the CTA project, as activities are being intensified. During this period, the CTA observatory enters the final phase of construction and, consequently, the operational phase. After construction (2027–2030), the costs for Slovenia for the maintenance and operation of the observatory are estimated at EUR 70,000 per year. There is a possibility of additional investments in the form of participation by the Slovenian economy in the development and production of high-tech detector assemblies. These aspects and activities fall within the competence of the Ministry of Economic Development and Technology (MGRT).

2.2.2.5 FAIR

Facility for Antiproton and Ion Research in Europe

www.fair-center.de

Status

The project was included on the priority list of the ESFRI Roadmap 2006 and on the national priority list of international projects in the NRRI 2011. On 24 May 2011, Slovenia ratified the international Convention concerning the Construction and Operation of a Facility for Antiproton and Ion Research in Europe (FAIR Convention), and on this basis became one of the founders and consequently on 3 September 2012 also a partner of FAIR GmbH, in a share of approx. 1.18 per cent in its nominal capital. On 14 November 2014, a tripartite agreement was signed between the partner (Republic of Slovenia), a consortium of companies (Tehnodrom, d.o.o.) and FAIR for in-kind contribution to the construction of the FAIR Centre (FAIR IKC contract), which is the basis for the FAIR Convention, i.e. by developing and supplying high-tech research equipment in accordance with the specifications of the FAIR Centre. In 2015, a group of researchers from the Jožef Stefan Institute (JSI) joined the NUSTAR collaboration.

Description of infrastructure

The Facility for Antiproton and Ion Research in Europe (FAIR Centre) is one of the first and financially largest projects in the ESFRI Roadmap, which, when completed (expected in 2027), will study the basic building blocks of matter and space development. In addition to Slovenia and the host Germany, Finland, France, India, Poland, Romania, Russia, Spain, Sweden and Great Britain are involved in the project to build this large international research infrastructure, which will be located in Darmstadt, Germany. The total value of the project currently exceeds EUR 2.5 billion. More than half of this will be contributed by Germany as the host of the infrastructure. In accordance with the commitments from the international convention, Slovenia's contribution is at least 1 per cent of the estimated construction costs of the FAIR Centre and amounted to EUR 12,005,700.00 (at 2005 prices and excluding VAT

and project increases). The FAIR Centre is currently under construction. Preparations for the construction work began in 2012, followed by the construction of the foundations for the main building with the accelerator and other ancillary facilities. According to the latest information, the construction is expected to be completed in 2027. In parallel, the construction of basic research equipment, which is practically fully covered by in-kind contributions from partner countries (accelerators, magnetic systems) and the preparation of experiments: APPA, CBM, NUSTAR and PANDA are underway.

Slovenia is fulfilling its obligation under the said convention by making an in-kind contribution to the FAIR Centre, i.e. by developing and supplying high-tech research equipment in accordance with the specifications of the FAIR Centre. For this purpose, a tripartite agreement was concluded on 14 November 2014 between the partner (Republic of Slovenia), a consortium of companies (Tehnodrom, d.o.o.) and FAIR (FAIR IKC contract), which is the basis for the realisation of all obligations under the Convention. The Republic of Slovenia is thus involved in the development and construction of research equipment (components of the beam diagnostic system and the control system in the accelerator). Due to delays in the construction of the FAIR Centre, which were not the fault of the partner and the contractor, and due to the objective increase in material and labour costs, all milestones from the tripartite agreement had not been fully reached within the contractual deadlines by 2018. The final execution of the FAIR IKC obligations was regulated in 2020 with the conclusion of Amendment no.1, which increased the contract value to the final EUR 23,904,959.91 (including VAT) and extended the period for the implementation of the remaining milestones to 2024. In addition to the originally envisaged financial obligations under the FAIR IKC contract, additional obligations arose on the basis of objective circumstances, particularly due to delays and higher prices of construction works. These are justified and urgent requirements at the level of the FAIR project, which, in accordance with the signing of the FAIR Convention, bring additional financial obligations to the partners. In 2015, a deficit in construction works in the total amount of EUR 248 million was confirmed, with the share of the Republic of Slovenia being 1.18 per cent or EUR 2.9 million (both in 2005 prices). In 2019, as part of the repeated and comprehensive revision of the project, the last official total estimate of all additional costs, including construction works, spare parts for the accelerator, additional staff and contingency, was confirmed in the total amount of EUR 1,136 million, which is an additional EUR 13.4 million (both in 2019 prices) for the Republic of Slovenia.

Planned membership benefits and achievements

The goals of Slovenia's long-term participation in the FAIR Centre are: (1) benefits for the development of Slovenian science by participating in experiments using the research infrastructure provided by FAIR; (2) realising direct benefits for the economy in terms of orders for high-tech equipment for the FAIR Centre; and (3) wider societal benefits from scientific findings and technological breakthroughs in research activities in the fields of particle physics, biochemistry, biomedicine and related fields.

In parallel with the construction of the FAIR Centre, the so-called Phase 0 of the research program at the existing GSI acceleration capacities, in which the Slovenian scientific community is also involved, is being implemented. Phase 0 is intended for the immediate scientific application of new detector systems for the future FAIR. This will also ensure their operability from the first day of regular operation of the completed FAIR Centre. The Slovenian scientific group is focused mainly on the NUSTAR experiment (physical programme), i.e. the study of the nuclear structure and reactions of exotic atomic nuclei, which are crucial in the formation of matter in space. They are more strongly involved in three groups or sub-collaborations: HiSpec/DeSpec (HIgh-resolution in-flight SPECtroscopy / DEcay SPECtroscopy), R3B (Reactions with Relativistic Radioactive Beams) and SuperFRS (Super FRagment Separator). As part of the first group, the Slovenian team took over the optimisation of the BC-BGO detector to reduce the impact of the background. In the context of R3B, the group is intensively engaged in the construction and testing of the CALIFA scintillation calorimeter, for which 60 detector elements of their own production were contributed in kind. In preparation for the replacement of the existing magnetic ion fragment separator (FRS) with a more powerful superconducting one (SFRS) as the central instrument within the NUSTAR collaboration, a stabilisation monitor for electrostatic lenses was developed and added to the FRS in 2020. A few days after that, the 1:1,000,000 resolution was achieved for the first time, which, at the time, was the world record in the mass resolution of such ionic spectrometers. The access of Slovenian scientists to state-of-the-art and high-performance equipment at the FAIR Centre will reduce the need for additional investment in state-of-the-art equipment at the national level.

Slovenian researchers in the FAIR project are also holders of the educational process at the Faculty of Mathematics and Physics, University of Ljubljana (FMF UL), and some of them at the Jožef Stefan International Postgraduate School (IPS), transferring experience from research and development work

and structural engineering in the construction of FAIR systems to students at all levels. They were also provided with places in the relatively busy summer schools and workshops held at GSI in preparation for future researchers at FAIR. In a more popular form, the aforementioned concepts are also introduced within the framework of participation in summer research camps organised by science and technology-oriented secondary schools. Such academic beginnings of research careers have built such a good reputation in recent decades that they not only stop the brain drain from Slovenia, but even encourage the opposite trend, i.e. the interest of excellent students from the Western Balkans to work with the Slovenian FAIR team in finding master's and doctoral theses, which in practice is also an opportunity for a permanent influx of educated people to Slovenia.

During the years of construction of the FAIR Centre, participation in the project brings direct benefits to the participating Slovenian companies (consortium of 14 high-tech companies Tehnodrom, d. o. o.) in terms of orders for the development and production of high-tech equipment for beam diagnostic system components (led by I-Tech) and the control system of the accelerator (led by Cosylab). Participation in the construction of the FAIR Centre means, in addition to the revenue itself, an important competence reference and multiplier effects for entering the global market, access to state-of-the-art technologies and significantly greater opportunities to participate in other similar international projects.

In addition, it already encourages cooperation between Slovenian research and development institutions and the economy in terms of transferring theoretical knowledge to the economy and transferring market requirements and needs back to the scientific sphere, which will be further strengthened in the operational phase. With its numerous parallel physical, chemical, biological and technological programmes, the FAIR Research Centre will provide exceptional research opportunities for Slovenian scientists and thus extremely ambitious opportunities for cooperation with the Slovenian economy with the aim of developing new technologies and other high value-added products. The most typical example of such a development is the numerous contractual collaborations of the Slovenian scientific FAIR team and joint participation in international projects with well-known Slovenian companies in the acceleration, information, analysis and environmental sectors. Young scientists who are formed and trained in similar environments as FAIR are highly sought-after staff for economically attractive positions in the Slovenian economy, as in these processes they acquire not only high level scientific and technological references but also communication and effective organisation skills.

Financial aspect

Investments in the construction of the FAIR Centre, which commenced in 2011, so far amount to around EUR 25.7 million. The last estimated value of all Slovenia's envisaged construction costs is around EUR 42.6 million. The realisation of the remaining obligations from FAIR IKC is planned by 2024. The realisation of additional obligations from 2015 is planned for 2021 and 2022, and the treatment of additional costs from 2019 in the next phase after 2022. This does not take into account the operating costs that Slovenia, as a partner, will be obliged to provide after the launch of the research infrastructure (expected after 2027). An unofficial estimate is EUR 1.6 to 2 million per year.

The work of the Slovenian research team within the NUSTAR collaboration has been funded since 2018 within the JSI infrastructure program at the ARRS in the amount of EUR 150,000 per year, which amounts to a total of EUR 600,000 so far. By 2030, funding for the FAIR research is expected to gradually increase to EUR 375,000 per year, which would also allow for the appropriate development and strengthening of the research team between 2022 and 2025 for at least two additional FTEs for young researchers, which would be the basis for two FTEs for the new generation of doctoral students and an additional two FTEs for postdoctoral fellows in the 2026–2030 period.

2.2.2.6 ILL

NEUTRONS FOR SOCIETY

Institute Laue Langevin

www.ill.eu

Status

The project was included on the priority list of the ESFRI Roadmap 2006 and on the national priority list of international projects in the NRRI 2011. Years ago, Slovenian researchers expressed great interest in using ILL facilities. At

the initiative of the National Institute of Chemistry, they began to study the possibility of direct full membership or membership in a consortium of Central European countries: Austria, the Czech Republic, Hungary and Slovakia (CENI). The second option proved to be a model that is administratively and politically very difficult to implement and would not bring significant financial benefits for Slovenia's direct inclusion in the ILL, i.e. the appointment of the National Institute of Chemistry (NIC) as Slovenia's partner for scientific membership in the ILL. A scientific cooperation agreement between the NIC and the ILL was concluded on 24 August 2020 for a period of four years (2020–2023) with the option of renewal. For the NIC, this means the assumption of scientific and administrative obligations in the ILL and the coordination of the Slovenian scientific community in this context.

Description of infrastructure

The Institut Laue-Langevin (ILL) in Grenoble in France is the leading international research centre for neutron scattering. It features a high flux neutron nuclear reactor that provides the most intense continuous neutron beams and powers 50 state-of-the-art research instruments. The instruments cover all possible neutron scattering techniques and are constantly being developed and upgraded. As a supporting research institute, the ILL makes its research facilities, including all professional and technical assistance, available to visiting scientists. About 1,400 researchers from more than 40 countries visit the ILL each year and carry out 640 experiments pre-selected by a review scientific committee. The ILL has been operating since 1973 and is owned in equal shares by the founding countries of France, Germany and the United Kingdom. Eleven countries, i.e. Austria, Belgium, Switzerland, the Czech Republic, Denmark, Spain, Italy, Poland, Sweden, Slovakia and, from 2020, Slovenia, also cooperate with it. The institute boasts a large number of scientific publications in high-impact journals among all related global neutron scattering institutions.

Due to their specific properties, neutron scattering methods allow the solving of a wide range of complex scientific problems, particularly in studying the structure and dynamics of matter on different spatial and temporal scales, through neutron diffraction, spectroscopy, reflectometry and imaging. Therefore, neutron research is an indispensable complementary approach to other experimental methods, such as X-ray diffraction, vibration and NMR spectroscopy, electron microscopy, etc. They often play a key role in modern research of (nano)materials, and in life and environmental sciences. Each individual ILL instrument is designed to provide a state-of-the-art measurement approach in the selected field and is subject to continuous

(even major) upgrades to provide a global reference role. The ILL staff have relevant expertise and experience in neutron production (reactor physics, reactor design and operation, cold and hot neutron source), neutron beam guidance (neutron conductors, super mirrors), neutron optics (collimators, monochromators, speed selectors and neutron cutters), neutron detection, measurement techniques and data processing. Visiting researchers are provided with all the support to carry out experiments and access to a number of technological platforms to prepare experiments (laboratory for deuteration, structural biology, computational modelling, etc.).

Based on research conducted at the ILL, over 600 publications are produced annually, usually in leading scientific journals, in the following scientific fields: soft condensed matter (14 per cent), physics, including magnetism and nanomaterials (36 per cent), chemistry (12 per cent), materials science (20 per cent), structural biology (9 per cent), nuclear and particle physics (5 per cent) and others (4 per cent). In Lund, Sweden, a much more expensive and larger neutron scattering centre, the European Spallation Source (ESS), is under construction, which is expected to be in limited operation around 2025. The ESF is expected to gradually take the leading position in this field, but is not expected to take over all the activities carried out by the ILL.

Planned membership benefits and achievements

In accordance with the agreement on scientific membership, immediate fully fledged scientific cooperation was envisaged for the 2020–2023 period. The share of participation of Slovenian scientists is proportional to the projected amount of the contribution, i.e. the Slovenian partner will be entitled to 0.15 per cent beamtime in the first three years (2020–2022), when the accession contribution in the total amount of EUR 285,126.00 will also be paid in three instalments, and (with the planned renewal of membership after 2023) will reach the target value of 0.24 per cent of beamtime in 2023. The contribution for beamtime includes travel expenses for scientists from Slovenian universities and research institutes who will perform their experiments at the ILL. The introduction of neutron scattering research opens up a wide range of state-of-the-art analytical methods to Slovenian researchers in the fields of chemistry and physics of materials and nanomaterials, structural biology and nuclear physics. The use of neutron scattering methods complements other scattering methods (X-rays). Therefore, such methods are an indispensable tool of modern materials science and life sciences, and Slovenian researchers will gain unique opportunities to be included in top international scientific trends. Researchers from Slovenia will be able to apply for vacancies,

scholarships for doctoral or postdoctoral studies, and for staff exchanges.

In the framework of cooperation with the ILL, there are also many opportunities for the training of and research by young professionals at the ILL. The neutron scattering research training of all participating researchers is part of established practice at the ILL and is conducted by employees on beamlines. Slovenian doctoral students could also be trained to work on beam lines, gaining important knowledge and skills for Slovenia.

As neutron research also enables the study of industrial materials (e.g. cracks in alloys) and the study of crystals of active pharmaceutical ingredients, which are a major challenge in the pharmaceutical industry, the interest of Slovenian industry can also be expected. Within the ILL, industry needs are covered by a special Industry Liaison Unit that provides a single and specialised contact point for potential industry and service sector users and provides industry clients with a choice of different access modes, from fast proprietary research access to a combination with academic access. Installations at the ILL are already used by more than 50 European companies for their R&D activities. The implementation of continuous upgrade programmes of the ILL instrumentation will strengthen the potential implementation of R&D tools, promoting the competitiveness of companies specialising in precision mechanics, vacuum and engineering, neutron conductors and neutron cutters. Technologies developed by the ILL and partner companies are widely used in national and international facilities and laboratories.

Financial aspect

The financing of the ILL membership commenced in 2020 within the framework of the NIC infrastructure programme at the ARRS in the amount of EUR 250,000 per year. The current payments under this project amount to EUR 0.5 million. An annual cost of EUR 250,000 is still foreseen for the period of the first phase of scientific cooperation 2020–2023 and subsequently for the planned renewal of the agreement.

2.2.3 Okolje

2.2.3.1 EPOS

European Plate Observing System

www.epos-eu.org

Status

The project was included on the priority list of the ESFRI Roadmap 2008 and on the national priority list of international projects in the NRRI 2016. Slovenia was actively involved in the preparation of the project on the basis of a letter of support of 3 November 2011. In the preparatory phase, the key task, in addition to participating in international activities within the project, was to properly connect relevant Slovenian institutions in this field, which established the EPOS-SI consortium with the coordinator ZRC SAZU on 11 May 2016. Slovenia sent the accession letter for membership in EPOS ERIC on 11 January 2018 and became a full and founding member on 7 November 2018 upon its establishment.

Description of infrastructure

EPOS is an international research infrastructure for monitoring and observing geophysical and seismic phenomena based in Rome, Italy. Processes in the fields of seismology, volcanology, geology, geochemistry, geodesy, geomagnetism and other analytical and experimental laboratory research in the field of Earth sciences will be monitored through observatories and the development of infrastructure points. These are the processes that shape the Earth's surface (physical, geochemical and anthropogenic). The main purpose of the project is to monitor and collect data pertaining to the solid Earth from the perspective of physical, chemical and geological systems through field measurements and the development of infrastructure points, while developing common methodological platforms for data collection, processing, modelling and presentation. The EPOS research infrastructure provides innovative approaches to a better understanding of the physical processes that cause and affect earthquakes, volcanic eruptions, tsunamis,

landslides and other natural disasters, as well as those that affect tectonic shifts and land surface dynamics. Understanding the complex system of the Earth requires the integration of research and observation strategies and the infrastructure for multidisciplinary monitoring of geographically dispersed units. In this context, EPOS also fills the gap in the Earth research infrastructure, which consists of Earth observation satellite infrastructures and initiatives (GMES, GEOSS) and the ocean observation infrastructure (EMSO, ESONET).

The project creates a unified and sustainable infrastructure that includes field geophysical monitoring networks, local observations (permanent field and volcanic observatories) and experimental laboratories in Europe. It provides users with current, reliable and comparable data, which is available through the single portal for public administration, research purposes, for the purposes of prevention and rescue in cases of natural disasters, for education, etc. Over the past 50 years, scientific and technological equipment in this field has collected a vast amount of geological and geophysical data at national levels, which is used to design and improve models to describe the processes that cause earthquakes, volcanic eruptions, landslides and tsunamis. The exchange of data, information, and modelling and monitoring tools requires the integration of these national research infrastructures into a single infrastructure that will enable scientists across Europe to integrate, model and interpret multidisciplinary data sets. Above all, EPOS will take care of the integration of a very heterogeneous geographical pattern of observational and experimental data, and at the same time e-infrastructures will have to be developed to support and facilitate its construction. EPOS also plans to establish a scholarship programme for young researchers, which will enable a new generation of researchers in this field to acquire knowledge and skills to fully exploit the potential of the new research infrastructure.

Planned membership benefits and achievements

For Slovenia, which also lies on tectonically active terrain at the junction between the smaller Adriatic tectonic plate and the Eurasian plate, EPOS will be a good basis for preparing appropriate research infrastructure and improving earthquake safety in the region. Collecting data on seismic activities, tectonic shifts and volcanic activity requires interstate connections. To understand the causes of possible earthquakes, it is very important to monitor the movement dynamics of individual active fault zones, which can only be provided by a well-organised network of various precision field and laboratory instruments, and long-term measurement and analysis of data. Slovenia has a well-developed

research infrastructure in the field of seismology and geodesy. However, the latest trends in science see the development of new research equipment and tools that Slovenia also needs. The first underground seismic observatory in Slovenia operates in Postojna Cave. The collection and processing of data will have to be standardised within the framework of standards developed within EPOS. The existing national infrastructure is being upgraded in accordance with the requirements and standards within the EPOS project, further connecting key Slovenian actors in this field. The expected benefits of Slovenia's involvement in EPOS are reflected in the field of research, education and the economy.

By participating in the project, Slovenian researchers have the opportunity to access data collected and processed in a quality manner, join various working groups, and participate in drafting rules for collecting and processing relevant data for processing at the European level on the one hand and many opportunities for the development of international relations on the other. This also opens the possibility of involvement in major international and European projects. Membership in EPOS also includes participation in various international and domestic meetings, workshops and international summer schools in the field of karstology and other environmental sciences, as well as data management and involvement in applications and activities of EU projects. International cooperation is being strengthened, which is already reflected in involvement in international organisations and associations such as ORFEUS, EMSC, etc. At the same time, Slovenian organisations are active partners in EU projects. Together with the Geological Survey of Denmark, France, the Netherlands, the Czech Republic and Spain, and under the auspices of EuroGeoSurveys, the GeoZS has established the European Geological Data Infrastructure (EGDI), which is a pillar of EPOS TCS Geological Information and Modelling.

EPOS also provides an important source of data, analyses and methodological elements required in educational processes. In the field of education, members of the Slovenian consortium EPOS-SI are active lecturers at the University of Ljubljana, the University of Nova Gorica and the University of Primorska, where they include acquired knowledge and innovations from the EPOS project in their lectures.

The EPOS project has direct effects on the economy, as the primary activity of the project is the collection and processing of data that draw attention to various types of changes in the environment, showing possible developments that may harm the economic activity. Data affecting the field of construction and infrastructure construction may be particularly important. Understanding the size and direction of movements at regionally important faults in Slovenia is important for the planning of constructions and interventions and for measures to assess the threat to settlements in Slovenia in the event of catastrophic

earthquakes. An information and data centre is being set up in Postojna at the Karst Research Institute (IZRK ZRC SAZU), where data obtained from EPOS will be collected and edited, and which can be used for state administration, research purposes, assistance in prevention and rescue in cases of natural disasters for education, etc. The GeoZS is establishing a national geological hub, following the principles of accessibility of spatial information and services in one spot, i.e. combining spatial data from various field measurements, local observations, and research and projects, and the option of sharing this data with multiple users and applications. This ensures greater efficiency, coherence, quality and easier access to data and interpretations by means of information and communications technology. In the field of seismology (seismic observatories) and geodesy (GNSS stations), obtaining data within EPOS is important for understanding active tectonic shifts in Slovenia, which can help reduce and warn of seismic hazards as well as improve the construction of facilities. Water analyses carried out within the framework of EPOS help the understanding of the level of environmental pollution due to industry or the economy and raise awareness of sustainable development in improving processes and activities in the economy and industry. Based on the data obtained in EPOS, we can develop nature conservation guidelines for the development of sustainable tourism in Slovenian karst caves and also on natural heritage sites. Quality geological data, which are in line with the accepted standards for spatial data, provide reliable information to end users, spatial planners, economists, builders and conservationists or scientists who need and use spatial data in their work, which is important for the development of preventive management in the field of geological hazards and consequently the protection of lives and property, as well as for the awareness of inappropriate interventions in the environment.

Financial aspect

We commenced co-financing the implementation of national activities and the planned development of national infrastructure within the infrastructure programme of the ZRC SAZU at the ARRS in 2015. The latest value of the annual amount is EUR 85,000. The annual membership fee for EPOS ERIC is EUR 50,000. EPOS also obtained European Cohesion Policy funding under RI-SI-EPOS in the amount of around EUR 1.8 million. So far, investments in the national infrastructure of the project amount to around EUR 2.1 million. If possible, co-financing will be further strengthened in the coming years by the Structural Funds.

By 2030, the total annual costs are estimated at EUR 0.5 million, of which two to three FTE.

2.2.3.2 LifeWatch

e-Science and Techology European Infrastructure for Biodiversity and Ecosystem

www.lifewatch.eu

Status

The project was included on the priority list of the ESFRI Roadmap 2006 and on the national priority list of international projects in the NRRI 2011. Slovenia sent an accession letter on 4 May 2016 and became a full and founding member of LifeWatch ERIC when it was established on 17 March 2017. Slovenia did not formally participate in the preparatory phase of LifeWatch but was in constant contact through ZRC SAZU. The project is being developed in Slovenia in close cooperation with the eLTER project (see point 2.1.2.1). The coordinator is also the same, i.e. ZRC SAZU, and there are several other common actors from the national consortium LifeWatch.SI, which was established on 19 November 2015.

Description of infrastructure

LifeWatch is a distributed international research infrastructure based in Seville (Spain), which combines a system of marine, terrestrial and freshwater observatories, shared access to a large amount of related data from different databases and observatories, and computing capacity in user-centric virtual laboratories. The content is complemented by the eLTER project with the aim to become the world's leading e-infrastructure for research into the protection, management and sustainable use of biodiversity and ecosystems. Data from biological observation and collection networks are processed and integrated with analytical and modelling tools, making them accessible to all interested parties. LifeWatch supports access to integrated databases in an innovative way, highlighting gaps in the knowledge and understanding of life on Earth. At a European and multidisciplinary level, it facilitates the analysis and modelling of data to identify and learn about patterns and mechanisms at different stages of biodiversity. In addition to basic scientific research,

the infrastructure also has an equally represented application component with users, the public and private sectors involved. With its research goals, LifeWatch is integrated with EU biodiversity policy and is an essential part of the GEOSS (Global Earth Observation System of Systems) project.

The research infrastructure consists of resources and assets, e-infrastructure, an analytical centre and users. Sources include databases of measurements and observations, statistical operating programs, computing power, devices, and other assets for analysis and modelling. The e-infrastructure supports mechanisms for the dissemination of specific resources through an identification system, data reception and processing, a single security and access protocol, and a single semantic style. The analytical centre performs tasks with systems for uniform transfer of integrated data, which detect and securely store information and send it to a computer network. The last element of this infrastructure includes the main portal with a work-management tool that allows users to create specific domains and portals to support specific research (e.g. karst biodiversity). This creates a specific scientific environment for the control and monitoring of tasks and tools which contribute to tackling major global environmental challenges.

Planned membership benefits and achievements

Participation in LifeWatch enables Slovenia to develop in the long-term and use the most advanced research methods, and access to the experience and solutions of other national networks. Through LifeWatch, the participation of national partners in the complementary eLTER project is also strengthened. Slovenia is involved in the LifeWatch activity with many Slovenian institutions gathered within the LifeWatch-SI consortium. Since 2008, the ZRC SAZU has been involved in the LifeWatch activity as a partner in the preparatory project. An information and data centre for the national part of the project is being established at the ZRC SAZU, at the Karst Research Institute in Postojna. The University of Primorska and the Science and Research Centre Koper have important research infrastructure and services in the field of applying molecular biology to the study of biodiversity in Slovenia and South-East Europe. The study of biodiversity in the selected ecosystems using technology that captures data remotely and has the least impact on space will further strengthen the position of Slovenia as one of the world's leading contributors to the field of speleobiology and karstology. With almost half of the Karst territory within its national boundaries, Slovenia is amongst the global frontrunners in terms of the richness of subterranean biodiversity. Data on the rich karst fauna, karst flora and vegetation and socio-economic

aspects typical of the selected karst areas will be generated in a common database and processed accordingly. Our current knowledge of the karst, its biodiversity and the need to protect the fragile balance will gain higher added value and connect research, education, knowledge mobility and society in general. Membership in LifeWatch also includes the organisation of various international and domestic meetings, workshops and international summer schools in the field of environmental sciences and data management, as well as involvement in EU project applications and activities. Scientific articles and monographs have also been published with the LifeWatch affiliation.

In the field of education, members of the Slovenian consortium LifeWatch-SI are active lecturers and mentors at the University of Ljubljana, the University of Nova Gorica, the University of Maribor and the University of Primorska, where they include acquired knowledge and innovations from the LifeWatch project in their lectures. However, this research infrastructure can also be used directly or indirectly by schoolteachers and their students, and by the lay interested public. As it enables the establishment of an open meta database, it will not only serve the exchange of data in the scientific sphere, but also the dissemination of previously acquired knowledge and new knowledge within the educational process and to the interested public.

The LifeWatch research infrastructure is also extremely important for the wider society, as it enables the protection and sustainable management of biodiversity, which is one of the key values of human society. It can be expected to be used primarily by conservationists, managers of national parks and other biodiversity-important sites, life science experts for scientific purposes, and municipal and state services in summarising guidelines and action plans for the protection of biodiversity and ecosystems. The technological network for the integration of ecological and biodiversity data in Slovenia already brings together researchers and experts from various multidisciplinary scientific disciplines, who will be involved in long-term biodiversity research. Based on the collected and processed data, information on the endangerment of individual organisms, groups of organisms and habitats will be obtained. The protocol, including a spatial plan and criteria for the protection of biodiversity, will facilitate the protection of cities that have a high level of biodiversity. In this way, the research infrastructure will contribute to the preservation, protection and sustainable management of the karst natural and cultural heritage in Slovenia. Protocols will be developed to provide expert support to representatives in monitoring and studying global climate change and its consequences. The monitoring of aquatic ecosystems carried out as part of the LifeWatch project helps in acquiring an understanding of the level of environmental pollution caused by industry or the economy. Based on

the obtained data, nature conservation guidelines for the development of sustainable tourism in Slovenian karst caves and also at UNESCO natural heritage sites (e.g. Škocjan Caves) are developed. Adapting to new conditions reduces the vulnerability of ecosystems and the damage we suffer every year due to climate change (floods, droughts, fires).

Financial aspect

We commenced co-financing the implementation of national activities and the planned development of national infrastructure within the infrastructure programme of the ZRC SAZU at the ARRS in 2013. The latest value of the annual amount is (since 2018 together with eLTER) EUR 125,000. The annual membership fee for LifeWatch ERIC is EUR 75,000 (which is 20 per cent of the total membership fee, the rest is covered in kind). LifeWatch also obtained European Cohesion Policy funding under RI-SI-LifeWatch in the amount of around EUR 3.2 million. So far, investments in the national infrastructure of the project (together with eLTER) amount to around EUR 3.9 million. If possible, co-financing will be further strengthened in the coming years by the Structural Funds.

By 2030, the annual costs are estimated at EUR 0.5 million, of which two to three FTEs.

2.2.4 Podatkovna, računalniška in digitalna RI

2.2.4.1 PRACE

Partnership for Advanced Computing in Europe

www.prace-ri.eu

Status

The project was included on the priority list of the ESFRI Roadmap 2006 and on the national priority list of international projects in the NRRI 2011. On

24 January 2012, the Faculty of Mechanical Engineering of the University of Ljubljana first joined the project, and the public institute Arnes was appointed as the Slovenian representative in PRACE at the transition to the next phase of PRACE 2.0 (2015–2020). Arnes represents Slovenian supercomputing infrastructure holders as the coordinator of the national consortium within the Slovenian national supercomputing network (SLING).

Description of infrastructure

PRACE is a fundamental pan-European high-performance computing infrastructure for enabling greater research and application excellence in all scientific fields. With the high-performance computer infrastructure, it has significantly increased the research potential of the European Research Area and the competitiveness of the European Union, which has important positive social impacts. PRACE was established as an international non-profit organisation (AISBL) based in Brussels and includes 26 EU Member States, which participate in the development of supercomputing through their authorised organisations. The PRACE Statute stipulates that members may be governmental organisations or legal entities representing the government. Only one organisation per Member State of the European Union or an associated country can be a member of PRACE RI, as described in Article 217 of the Treaty on European Union. In addition, the legal entity (at national level) must be responsible for providing HPC resources and related services. PRACE is organised in three levels. At the highest level 0, there will be three to five PRACE high-performance computing (HPC) European centres. At level 1, there are national centres interconnected with grid network technologies or similar technologies, while at level 2, local centres are foreseen.

The PRACE project is one of Europe's responses to the need for increasing computing power in science and industry, which can no longer be optimally provided by buying more powerful computers. PRACE ensures that individual high-performance computing centres are integrated into a single European supercomputing infrastructure also linked to national, regional and local centres, creating a world-class scientific computer network. A particularly important role of PRACE is the development of knowledge and skills for computing on supercomputing infrastructures with the participation of all research disciplines. Therefore, PRACE aims to link European e-infrastructure with the ambition to make the EU a leader in supercomputing. In addition to cooperating in connecting high-performance computing, PRACE includes cooperation in the field of virtual computer networks and data warehouses with information resources distributed across Europe and connected to high-speed communication networks. PRACE works closely with similar initiatives such as the European Grid Infrastructure

(EGI). Particularly important is the cooperation of PRACE with EuroHPC JU, which has become the EU's flagship initiative for the development of supercomputing. The role of PRACE in the development and operation of EuroHPC is the transfer of knowledge and good practices in the development and management of a supercomputing infrastructure.

Planned membership benefits and achievements

The national SLING consortium has been established in Slovenia, with the participation of stakeholders in the field of computing, data and cloud infrastructures. In terms of content, it covers areas covered by PRACE, EGI, EUDAT, CECAM and the pan-European supercomputing company EuroHPC JU. The central vision of PRACE is to bring together key stakeholders, i.e. equipment owners and development and user groups, and to establish interdisciplinary and national cooperation. This model worked well and achieved a unified approach and cooperation in the establishment of the national infrastructure of the HPC RIVR in Slovenia and in joint applications for projects such as the EuroHPC Vega and EuroHPC Competence Centres. By investing in new systems and increasing cooperation, Slovenia has made a breakthrough from the circle of smaller members into middle-level members; by joining the EuroHPC Leonardo consortium, Slovenia will become a co-manager of one of the three largest EuroHPC systems, which will form the new pre-exascale Tier-0 of European supercomputing within PRACE.

PRACE will provide the existing high-performance computing infrastructure in Slovenia organised within the Slovenian national supercomputing network (SLING) with access to the latest knowledge and good practices in the field of supercomputing in the EU. Such integration supports the development and management of dispersed computing infrastructures in Slovenia for the needs of the Slovenian research and educational space. In this way, better information support for Slovenian cooperation in individual ESFRI infrastructures, such as CLARIN and DARIAH, and in other top research and infrastructure projects such as CERN, is enabled. Slovenia's participation in PRACE acts primarily as an additional opportunity to connect and means support for a horizontal supercomputing infrastructure applicable to all sciences. It complements the existing infrastructure for e-science and, in particular, natural or life sciences, which require high-performance computer and communication systems for data processing and transmission, and provides them with access to Europe's most powerful computer systems. Membership in PRACE accelerates and optimises the development and use of software tools for solving computationally demanding tasks in parallel and distributed autonomous networks. This involves not only the development of supercomputers, but the development of all mathematical knowledge for in-depth numerical simulation in the fields of biotechnology,

medicine, molecular structure, particle physics, fusion, hydromechanics, aerodynamics, environmental protection, economics, etc., which will contribute to the development of these and other sciences and various information technologies.

Within the PRACE development programmes and national activities, SLING members intensively conducted training that took place within the PRACE programmes, the organised international summit European HPC Week in Ljubljana (FME UL and SLING) and a series of SLING workshops and training. Members also participated in the organisation, implementation and infrastructural support of education within academic programmes in undergraduate, master's and doctoral studies and in postdoctoral training, and joined the education and knowledge transfer programme for researchers, technicians and systems engineers within the HPC RIVR project. Slovenian young researchers also participate in training and exchanges within the PRACE programmes. Some high-profile events were also organised as part of the CECAM activities.

Slovenian cooperation has progressed from project work focusing on the organisation of education and training to more strategic levels, such as participation in the PRACE Scientific Steering Committee, the co-creation of a joint action program with EuroHPC for managing tenders and organising competence centres, and involvement in strategic bodies and authorities of PRACE and EuroHPC. Due to Slovenia's strong initiative to build a common European infrastructure in EuroHPC, Slovenia received support for its own development investment in supercomputing systems. Thus, coordination between development work and strategic investments in Slovenia has taken the country and its researchers to the very top of the European strategy and enables Slovenia to invest in the EuroHPC Vega system to establish one of the most advanced systems used as an experimental model of new HPC technologies towards exaFLOP/s capacity.

Financial aspect

The cost of Slovenia's membership in PRACE 2.0 is approximately EUR 110,000 per year, including a membership fee of around EUR 55,000, financed through the Arnes annual programme. The need for investments in the appropriate connections and upgrades of the national infrastructure in this field: EuroHPC Vega, other centres with the HPC component at NIC, JSI, FIS, UM, etc., and investments in other equipment, research and development work and maintenance in this field are significantly higher, which goes beyond mere membership of this project and is presented in the chapter on national priority areas.

2.2.5 Zdravje in hrana

2.2.5.1 BBMRI

BBMRI-ERIC®
Biobanking and
BioMolecular resources
Research Infrastructure

Biobanking and Biomolecular Resources Research Infrastructure

www.bbmri-eric.eu

Status

The project was included on the priority list of the ESFRI Roadmap 2006 and on the national priority list of international projects in the NRRI 2016. It was established as BBMRI-ERIC on 3 December 2013. Slovenia did not participate in the preparatory phase of this project. It sent an accession letter on 9 July 2021 and became a full member of BBMRI-ERIC on 19 November 2021. To implement the national obligations of BBMRI, a national consortium was established in December 2020 in coordination with the University of Maribor, the Faculty of Chemistry and Chemical Engineering (UM FKKT), which includes a wider circle of Slovenian research institutions in this field.

Description of infrastructure

BBMRI brings together the main European players in the field of biobanking – researchers, biobankers, industry and patients, and is one of the largest research infrastructures in the field of health research in Europe. It provides access to biobanks and biomolecular resources through national hubs. The aim of BBMRI is to improve the availability and interoperability of the existing comprehensive collections of biological samples from different (sub) populations of Europe or rare diseases. These databases include related data on factors such as health status, diet, lifestyle, and environmental exposure of subjects. It also aims to reduce the fragmentation of the biomedical research landscape by harmonising procedures, implementing common standards, and promoting high-level cooperation.

BBMRI-ERIC provides support, services, tools and expertise, as well as the exchange of knowledge and experience on ethical, legal and social issues

(ELSI), information technology (IT) and quality management (QM) for biobanks and biomolecular resource research. BBMRI-ERIC thus provides one-stop access to the collections of the European biobanking community and facilitates the exchange of samples (tissues, blood plasma, etc.). It also provides expertise and services to promote access for other clients, including the private sector. On this basis, Europe is creating the conditions to improve socio-economic competitiveness and increase opportunities for fairer and more efficient healthcare, such as new medical applications, new therapies, new prevention, new diagnostics, personalised or stratified medicines and new biomedical industries. BBMRI-ERIC users can thus be from various fields of science and industry. BBMRI-ERIC promotes the development of personal medicine and disease prevention and covers certain needs of both basic research and the biotechnology and pharmaceutical industries. It allows for improvements in healthcare and the overcoming of some bottlenecks in drug discovery and development. BBMRI provides support for basic research and the rapid transfer of findings to applied research by biotech and pharmaceutical companies, enabling improvements in public healthcare. Potential users of RI are research groups, educational institutions and, in particular, smaller companies which need high-quality and diverse biological samples for their research to determine the causes and course of disease. Providing a large number of samples is also essential for biotechnology and pharmaceutical companies involved in the development of diagnostic tests. BBMRI brings together and complements other biomedical cluster projects at both European and national levels, in particular ELIXIR, EATRIS and EuBI.

Planned membership benefits and achievements

In the long term, Slovenia's inclusion in BBMRI-ERIC will contribute to internationally compliant technical standardisation and methodological harmonisation of biological resources, which are currently poorly connected and dispersed throughout the country, without a central register and under the auspices of individual research groups and organisations. At the same time, it will provide access to other samples and data within the wider (pan) European connection of this research infrastructure. The main goal of the project is to build a common national infrastructure for biobanks and data management in a single digital ecosystem and to transfer innovation to the biobanking community. The long-term achievements of the project will be the establishment of a biobank community in Slovenia, the integration of Slovenian biobank samples and data into a common digital data platform in accordance with international standards, the acquisition of new knowledge and its use for innovation activities in biomarker research. The establishment of a compatible and sustainable biobanking system

and a single digital platform in Slovenia will support the most modern ways of using biobanks in medicine and research. The specific new aspect here is in combining the complementary expertise available in the programme area, which will lead to an increase in research in the field of biomarkers and stimulate innovations in biomedical studies. The development of various bioinformation solutions and tools will increase the intensity of research and development work by facilitating new discoveries within existing data. The integration of biobanking resources will also accelerate international cooperation with leading foreign research and medical groups, as it will facilitate larger and more complex research studies.

The biobanking consortium includes members from all three Slovenian public universities, which will incorporate biobanking content into the curricula of their study programmes. This will develop e-learning materials and tools used to teach future scientists, professionals, entrepreneurs and clinicians. All bioinformation tools (data integration platform, e-learning tools, new research tools and methods) developed within the national consortium will be used freely (open license) in the biobanking, medical and research community in Slovenia. BBMRI.SI will also pay attention to the publication of popular science articles, the organisation of round tables and online content with which it will address patient associations and the interested public. For doctoral students, medical specialists, and for other levels and fields, education will be an unlimited source of human biological samples and health data, which will facilitate the preparation of research and raise its quality.

One of the project's long-term goals is to make greater use of the innovation potential of biobanks. Thanks to membership in BBMRI-ERIC, the competitiveness of existing companies in biotechnology, pharmacy, ICT and healthcare will gradually increase. The pharmaceutical industry is also the flagship of the Slovenian economy and has a highly qualified workforce and high added value. BBMRI is also important for the development of small and micro-biotechnology companies in the fields of medical technology and pharmacy, whose main problem is often mere access to biological and frequently inaccessible samples and biomolecular resources scattered throughout the country. Biobanks (samples and data) are crucial for the development of new medicines, and diagnostics and patient care in the field of personalised medicine.

Financial aspect

The co-financing of the implementation of national activities is expected to commence in 2022. The membership fee is around EUR 26,000 per year. The full membership of BBMRI presupposes an appropriate investment in the

upgrade of the national infrastructure, which is comparable to other projects in the field of biomedicine.

By 2030, the total estimated value for this purpose is around EUR 10 million, half of which will be used during the period of upgrading the national centre (hub). In addition, up to 13 FTE research jobs per year are planned. The co-financing of the national hub will be strengthened in the coming years as soon as possible through the Structural Funds.

2.2.5.2 EATRIS

eatris

European Advanced Translational Research Infrastructure in Medicine

www.staging.eatris.eu

Status

The project was placed on the priority list of the ESFRI Roadmap 2006 and the national priority list of international projects in NRRI 2011. It was established as EATRIS ERIC on 7 November 2013. Slovenia was not formally involved in the preparatory phase of this project, but it maintained contact with the international coordinators of the project through the Faculty of Pharmacy of the University of Ljubljana (FFA UL). The letter of intent of 16 May 2013 further strengthened the ties between Slovenia or its research community in this field and the EATRIS, and at the same time expressed the intention of Slovenia to become an observer or member state in the future. Slovenia sent the letter of accession on 2 March 2016 and became a full member of EATRIS ERIC in May 2016.

Infrastructure description

The objective of the EATRIS is to establish a state-of-the-art international infrastructure for translational research in biomedicine and pharmacy, which promotes innovation and a vision of seeking new entrepreneurial possibilities relating to biomedical research, medicinal product development and optimisation of efficiency of medicinal products usage and facilitates better and more effective integration of individual researchers and relevant

research centres around Europe. EATRIS is the answer to the global problem of a decreasing number of new medicinal products despite the constantly increasing investment in development. The main reasons for this, according to the pharmaceutical and medical experts, lies in the excessive fragmentation of research to individual smaller projects at the level of individual institutions as well as nationally and globally. Another reason is the challenging infrastructure, which includes expensive highly specialised equipment and access to suitable preclinical in vitro and in vivo models and the complexity of the feasibility of clinical studies. A concept of translational research has been developed in response to the deficiencies in research and development. The term "translational medicine" may be interpreted as translational research in pharmacy (medicinal product) or medicine as a medical profession performing medical services on a patient or for a patient. Both activities are of strategic significance for the development of the field and both infrastructures must be developed in a complementary and synergistic fashion. The EATRIS research equipment serves the development of state-of-the-art diagnostic methods and therapeutic approaches, including genomic, cellular and imaging technologies for biomedical research. The aim of translational research is to ensure that new findings and therapeutic and diagnostic options actually reach patients or the intended population as soon as possible and are used correctly. By connecting partners from different spheres (academic, research, medical and business), consistent introduction of the principles of translational research into practice can be achieved and thus facilitate the better and faster transfer and exchange of knowledge, new developments and expressed needs between individual partners: from basic research laboratories to a clinic or industrial environment and the transfer of complex clinical and developmental problems to laboratories for basic research.

The EATRIS preparatory project combined partners from several EU countries that attain a high level of infrastructure in translational research in biomedicine and pharmacy. They were integrated in the network of infrastructural centres and committed to cooperation and coordination in regulatory, scientific and expert fields. In addition to researchers and healthcare providers, the EATRIS interactive approach also includes subjects or patients undergoing individualised treatment, which is why the infrastructure is organised in a network of highly specialised partnership centres. Their significance also lies in the standardisation of procedures, harmonisation of regulations and the introduction of high safety standards in the field of clinical research. The EATRIS concept is thus multicentric and incorporates all phases of research and development of medicinal products from pathogenesis research, production of diagnostic biomarkers to synthesis of new molecules and the first phase of clinical testing either of new active substances or diagnostic biomarkers.

Planned membership benefits and achievements

In 2007 and 2008, the Faculty of Pharmacy of the University of Ljubljana (FFA UL) sent an expression of its interest in participating in the EATRIS activities to the EATRIS coordinators. For this purpose, the National centre (node) EATRIS-TRI.si has been established at the FFA UL, which has the status of the Slovenian EATRIS node and offers support to Slovenian research institutions in this field. As a coordinator of the national node, the FFA UL formed a network of partner organisations in Slovenia, which are involved in translational research of personalised therapy and medicine. Three institutions actively involved in the EATRIS ERIC platforms have formed a consortium, i.e. the FFA UL with competence in identifying and validating specific targets for selected diseases and developing biomarkers, planning, synthesis and development of new compounds, prototyping drugs, physicochemical and biopharmaceutical evaluation and analysis of medicinal products, the Faculty of Medicine of the University of Maribor (MF UM) with competence in planning and developing biomarkers in diagnostics and disease research, and the National Institute of Chemistry (KI) with competence in planning, synthesis and development of new compounds and physicochemical evaluation of active substances. In addition to these three, several other research institutions, public institutes and agencies participate in the consortium. By establishing the national node, strategic integration between partners and access to all relevant information and infrastructure was enabled, which contributed to a balanced development of cohesion regions. It is possible to implement research in personalised medicine and translational research in pharmacy, while the consortium also attains synergies for joint participation in international programmes and ensures efficient knowledge transfer and exchange.

The inclusion in the EATRIS ERIC results in integration and exchange of experts from various institutions, the EATRIS members and consultants, it provides opportunities for active participation in the bodies and activities of the EATRIS and the organisation and expansion of educational activities. The accomplishments include top scientific publications and patent applications by colleagues from the partner institutions of the consortium. Additional possibilities for offering services in the market and applications for joint international projects are opening within the EATRIS, for example in the H2020 EATRIS-PLUS project, which is intended to enhance capacities and ensure innovative scientific tools for attaining sustainability in personalised medicine. Access to modern infrastructure in the sense of physical equipment and the introduction of standards and harmonisation of procedures enables researchers an equal position when applying for large application projects (clinical studies) and attaining top results in pharmaceutical

science, clinical biomedicine, medicine and biotechnology. By establishing a modern multidisciplinary and multicentric research and innovation system, international cooperation is also enhancing through the integration in large infrastructure connections. Such integration enables public research organisations to have more autonomy and responsibility, greater mobility of researchers, students and professors, better knowledge transfer into the economy and the public healthcare system and to the expert and lay public, and an efficient system of intellectual property protection. All consortium partners are complementary and connected on the axis of translational research with regard to the development of biomarkers and medicinal products. The EATRIS-TRI.si research equipment is used for the development of state-of-the-art diagnostic methods and therapeutic approaches, while including genomic and cellular technologies. A joint application of the Teaming AdPharma project is planned within the EATRIS ERIC partnership, which will be intended for the upgrade of research infrastructure in the fields of advanced therapies, pre-clinical development of medicinal products and translational research, and the enhancement of the innovation capacities and competitiveness of the Slovenian research space.

The educational role of the EATRIS operations also presents an important aspect. Modern infrastructure and international integration contribute to better education of young people and motivate them to continue their research careers in the field of translational research. EATRIS is incorporated in undergraduate study programmes through diploma and master's theses, and particularly in doctoral and lifelong study programmes. The Slovenian centre participates in the education of doctoral students and post-doctoral researchers and in the implementation of basic and applied research projects, which has a significant impact on the HR development and prevention of brain drain. The dissemination activities between Slovenian researchers and pharmaceutical professionals are also important with regard to dissemination of knowledge and education, especially the organisation of promotional events and educational workshops for participation in the EATRIS activities, and the questions about intellectual property protection in medical innovations. The participation in numerous EATRIS educational programmes is also enabled. Such an example is the ADVANCE project (https://eatris.eu/projects/advance/) intended for the education of new generations of researchers of advanced immune, genetic and cellular therapies.

The upgrade of the current research potentials in applied biomedical research and the introduction of EATRIS translational research concepts also enable a faster adaptation to new global trends and contribute to the competitiveness of the Slovenian pharmaceutical industry. They contribute to

the establishment of legal and professional standards in applied biomedicine, such as for example the establishment of spin-off companies and support for medium-sized companies, economic centres, and competence centres in the relevant technological support fields. They enable standardisation of preclinical studies procedures, research in the first phase of clinical trials and faster implementation of diagnostic methods. In addition to the enhancement of the innovation potential and increased competitiveness, the participation in EATRIS also results in other significant social and economic effects and general benefits for Slovenian society, including support for preventive and personalised medicine, contribution to better diagnostic and therapeutic approaches, and efficient and economic treatment.

Financial aspect

The co-financing of the implementation of national activities and the planned development of the EATRIS national infrastructure began within the FFA UL infrastructure programme at the Slovenian Research Agency (ARRS) in 2013. The recent value of the annual amount is EUR 120,000. The annual membership fee for EARIS ERIC amounts to EUR 65,000. The EATRIS also obtained funding from the European Cohesion Policy within the RI-SI-EATRIS project in the amount of approximately EUR 2 million. Current investments in the project's national infrastructure total about EUR 2.9 million. In future, the co-financing will be further enhanced with resources from the Structural Funds if possible.

In the period up to 2030, joint costs are estimated at about EUR 14 million, whereby the planned investment growth in research and development work has been included with the aim of obtaining 6 FTE at the annual level; in addition to the maintenance and further updating of the equipment, the price also includes a significant investment in the premises. As part of the activities to contain COVID-19, active involvement of the Slovenian EATRIS in the development of new medicinal products and vaccines to manage the disease is also planned, whereby the anticipated activities amount to between 3 and 5 FTE over a period of three years.

2.2.5.3 ELIXIR

The European Life-Science Infrastructure for Biological Information

www.elixir-europe.org

Status

The project was placed on the priority list of ESFRI Roadmap 2006 and the national priority list of international projects in NRRI 2011. After signing the memorandum of understanding on 19 October 2011, Slovenia participated in the drafting of founding documents and strategic guidelines of the ELIXIR operations and financing from the very beginning. On 13 February 2016, Slovenia ratified the ELIXIR Consortium Agreement (ECA) and the ELIXIR Council confirmed its full membership on 23 February 2016. At the invitation of the ELIXIR International Consortium to express an interest in the construction of nodes as national ELIXIR platforms, the Centre for Functional Genomics and Bio-Chips at the Institute of Biochemistry of the Faculty of Medicine of the University of Ljubljana (CFGBC) applied, which brought together a consortium of 16 members from the academic field, representatives of research institutes, clinical institutes and the pharmaceutical industry. Following the formalisation of membership in the project, the ELIXIR National Consortium and the ELIXIR-SI national node were formed in 2018 with headquarters at the Faculty of Medicine of the University of Ljubljana (UL MF), which is also the leading partner or the ELIXIR-SI coordinator.

Due to the cancellation of the ISBE (Infrastructure for Systems Biology Europe) project at the international level, the transfer and incorporation of the activities of the ISBE.SI Consortium in the ELIXIR-SI node are planned, as in certain other partner countries and in the form of expanding the activities of the ELIXIR-SI node in the fields of systems biology and systems medicine (ELIXIR-SI-SB community). The activities of systems biology within the ELIXIR-SI-SB community will be managed by the National Institute of Biology (NIB; as well as the coordinator of the ISBE.SI National Consortium established in 2017), while the systems medicine will be developed by UL MF in particular.

Infrastructure description

ELIXIR is a distributed international research infrastructure for biological information in Europe intended to support research into life sciences and their transfer in medicine, the environment, bioindustry and society in general. The ELIXIR was established as a special project of the European Molecular Biology Laboratory (EMBL) with the conclusion of the ELIXIR Consortium Agreement (ECA) which entered into force on 13 January 2014. ELIXIR has currently 22 members and one observer state and combines nodes in 21 countries and EMBL-EBI. The harmonisation of ELIXIR's mission and activities and the inclusion of its nodes is implemented and managed by the hub, which forms an integral part of the EMBL structure and is located at EMBL-EBI in Hinxton (UK). In addition to its coordination role, the ELIXIR Hub is also the source of fundamental data and the home of the European data centre. ELIXIR is organised as a transnational network of information sources, services and tools regarding life sciences that is coordinated at the European level and is complementary to the activities and priorities of individual countries. Within the network's framework, basic and specialised biological data is acquired, and certain tools and services for integration of data from various sources are already accessible, and training and education for users are also enabled. ELIXIR combines (bio)informational capacities in order to increase the total capacities of archiving, integration, analysis and exploitation of extensive high-density and heterogeneous data produced by modern research in the field of life sciences. The mission of ELIXIR is primarily data science, which deals with long-term data management, data sources, standards with examples of good practice, tools, services, infrastructure of information and communication technologies (ICT), and promotion, training and education of personnel. To manage information, it was necessary in the first phase to provide an adequate infrastructure that generates data, such as the most powerful devices for next generation sequencing. In Europe, ELIXIR will continue to contribute to the improvement of healthcare in the sense of better understanding and disease management, early diagnosis and prognosis, the sustainable production of high-quality food in sufficient quantities with the help of in-depth information on plant genomes, competitive pharmaceutical and biotechnological industry, and environmental protection.

With the termination of the ISBE project, the establishment of a community for systems biology and systems medicine is being planned within the ELIXIR framework at the European level. Systems biology is an interdisciplinary branch of life sciences, which leads to a more comprehensive understanding of the functioning of living beings. It involves the integration of data and

quantitative calculation models, which together enable understanding and resolving of more complex biological problems. Systems medicine is an interdisciplinary study field that discusses human body systems as part of an integrated whole, which includes biochemical, physiological and environmental interactions. Systems medicine is based on systems science and systems biology and deals with complex interactions in the human body as per a patient's genomics, behaviour and environment. An important topic in systems biology and systems medicine is the development of calculation models, which describe disease progression and the effect of therapeutic interventions. The calculation models can predict the behaviour of a biological system at the level of molecules, cells and tissues through space and time. Such a level of research may have a significant impact on the development of treatment methodologies (e.g. for complex diseases such as metabolic or cancerous diseases), the establishment of safe food production and industrial biotechnology and will launch various fields of bioeconomy. The use of the infrastructure will increase basic knowledge ranging from the level of molecules and cells to entire organisms and will lead to new applications in biomedicine, agriculture and the environment. It will positively affect future healthcare and technological development related to life sciences, which will be felt in European society, industry and the economy.

Planned membership benefits and achievements

The planned benefit of Slovenia's inclusion in ELIXIR lies mainly in the fact that Slovenia has as yet no adequate national infrastructure in the field of life sciences. To this end, it was prudent to combine the activities in the construction of data management infrastructure (data node) and the data acquisition infrastructure (particularly infrastructure for next generation sequencing). The data node will allow simple and standard data exchange and the sharing of tools and services in Slovenia and the ELIXIR nodes in other partner countries. Services to assist life sciences researchers, particularly in the fields of bio(medical) informatics, bioinformatics analysis, data mining and biostatistics, are also planned. By means of a start-up infrastructure for next-generation sequencing and the ELIXIR-SI data node, Slovenia will ensure suitable "omics" data relating to biodiversity, particularly plant, animal and microbial. The established infrastructure will also contribute to the establishment of better quality and personalised healthcare and dietary supply, care for environmental conservation and environment-friendly and renewable economy in all fields connected to the biosphere. The application of the ELIXIR research infrastructure is also important for enhancing cooperation with smaller companies involved in biomedicine and

biotechnological sciences. So far, ELIXIR-SI has been particularly focusing internationally on the aspects of training and data management. In this context, the ELIXIR-SI operations are linked substantively with other NRRI projects in medicine, especially EATRIS, EuBI, BBMRI and ISBE until recently, including related European and international infrastructural initiatives (e.g. B1MG, Health-RI, 1+MG, GoE, GA4GH, GOBLET) and e-infrastructures (e.g. SLING, EOSC, EuroHPC JU).

The vision of ELIXIR-SI is the construction of a national research infrastructure in the field of life sciences in three parts, i.e.: (1) central national data node for data from various life sciences; (2) start-up national infrastructure also enabling the acquisition of high-density data, and (3) centre for education in the field of bioinformatics tools and services. With its equipment and personnel, the ELIXIR-SI national research infrastructure will help users in research, especially in the following fields: (1) research on data and work with data (dry lab); (2) omics technologies in biomedicine disease research in model systems and research of various micro-organisms and plants (start-up experimental lab); (3) remote promotions, training and education as an upgrade of the educational centre.

The research on data and work with data (dry lab) will form a foundation for the ELIXIR-SI data node. The objective is long-term data management, including the preparation of management plans, standards and examples of good practice. (Bio)informatics analysis and data interpretation are also included, whereby ICT infrastructure, tools and bioinformatics services will be used. With the help of high-speed connections, the infrastructure will be connected to individual ELIXIR-SI partners and with the national supercomputing (HPC) infrastructure and other international ELIXIR nodes through the national e-infrastructure. The strategy includes the upgrade of infrastructural equipment and education of suitable personnel/equipment administrators as the key elements of infrastructure. The equipment and trained personnel must, if possible, form integral units of core facilities for individual activities to facilitate work for individual researchers. The promotion and ordering of ELIXIR-SI services (information services, databases and tools) for domestic and foreign researchers will take place through the joint entry point of the ELIXIR-SI site (https://elixir-slovenia.org). If necessary, education is organised for all fields in cooperation with partners from the ELIXIR European network.

The medium-term plan for the data node is to establish a national node of the European Genome-phenome Archive (EGA), the so-called federated EGA (FEGA). An additional activity of the ELIXIR-SI node in the field of systems biology (which was so far managed by NIB within ISBE) is also planned. This

is compliant with the guidelines of the project at the umbrella level where the ELIXIR-SI partners actively participate in the establishment of systems biology and systems medicine within the ELIXIR International Consortium.

An important mission of ELIXIR-SI is to disseminate knowledge to the various interested public and to train different users. This is being implemented within the project through various courses and schools linked with data and bioinformatics tools and services, organisation of events, and as assistance in networking with the representatives of other national nodes. In the 2015–2019 period, the ELIXIR-SI colleagues actively attended more than 160 events, of which they organised more than 50 schools and courses. Since 2015, the ELIXIR-SI eLearning Platform (EeLP) has been developed in the ELIXIR register of tools and services to manage (open) learning material for remote learning and courses. The courses and materials are being developed together with other ELIXIR nodes in accordance with the Trainground principles.

By establishing a permanent distributed ELIXIR-SI national infrastructure, higher quality healthcare and dietary supply will be enabled in Slovenia. A large part of this is also raising the awareness of clinicians and the broader population, which the ELIXIR Consortium ensures by organising scientific events and symposiums intended for a broad array of participants and to provide information for the wider public. With ensured infrastructure and new research methods, new methods are being implemented through various education courses into clinical diagnostics to facilitate forecasting and prevention of various diagnosed diseases. The project will make it easier to trace the genetic diversity of viruses and other microbes. ELIXIR-SI is also striving to connect the academic sphere with the business sector and industry. The objective of such cooperation is the standardisation of events, education courses, materials and personnel to ensure faster and more efficient transfer of information in the business sector.

Financial aspect

The co-financing of the implementation of national activities and the planned development of the ELIXIR national infrastructure began within the UL MF infrastructure programme at the Slovenian Research Agency (ARRS) in 2013. The latest value of the annual sum totalled EUR 145,000. The annual membership fee for ELIXIR amounts to about EUR 18,000. The ELIXIR-SI also obtained funding from the European Cohesion Policy within the RI-SI-ELIXIR operation in the amount of approximately EUR 5.2 million. Current investments in the project's national infrastructure total about EUR 6.15

million. Separate co-financing of the activity for the needs of preparing the ISBE project began within the NIB infrastructural programme at ARRS in 2018; the latest value was EUR 65,000, and total investment in ISBE so far amounts to about EUR 200,000. In the future, the co-financing of the national node, including the requirements for upgrading the capacities of systems biology (ELIXIR-SI-SB community), will be further enhanced with resources from the Structural Funds.

For the period up to 2030, the total ELIXIR costs with included expanded activity in the fields of systems biology and systems medicine are estimated at about EUR 0.8 million annually, of which up to 18 FTE would be needed for the fully operational ELIXIR-SI node at the annual level, which particularly includes equipment administrators and a smaller amount of funds for managing ELIXIR-SI. At least EUR 1 million of additional funds would be required for systems biology (ELIXIR-SI-SB community) in the form of new equipment and highly qualified personnel. Total costs of operations of the ELIXIR.SI node with merging of the former ISBE.SI Consortium will be lower than the sum of separate costs for ELIXIR-SI and ISBE.SI.

2.2.5.4 Euro-BioImaging

European Research Infrastructure for Imaging Technologies in Biological and Biomedical Sciences

www.eurobioimaging.eu

Status

The project was placed on the priority list of the ESFRI Roadmap 2008 and the national priority list of international projects with the NRRI revision 2016. It was established as Euro-BioImaging ERIC on 6 November 2019. Slovenia did not formally participate in the preparatory phase, but the research community led by the Faculty of Medicine of the University of Ljubljana (MF UL) maintained direct contact with project coordinators, particularly in the last phase, in order to include Slovenia in this research infrastructure as a full

member. The application for full membership was submitted on 8 April 2020 and Slovenia became a fully-fledged member of Euro-BioImaging ERIC in May 2020. A national consortium coordinated by MF UL was established in June 2018 to implement the national obligations of Euro-BioImaging, which includes a broader circle of Slovenian research institutions in this field.

Infrastructure description

Euro-BioImaging (EuBI) is an international research infrastructure connecting technologies in the field of biological, biomolecular and medical imaging. The Euro-BioImaging project ensures an extensive and open access for physical users in life sciences to the most state-of-the-art imaging technologies. It offers imaging data support, training for infrastructure users and providers and an ongoing evaluation and inclusion of new imaging technology to ensure the sustainability of top services. Euro-BioImaging is composed of complementary and mutually closely connected and geographically arranged nodes (specialised imaging capabilities) in all partner countries. The infrastructure is managed by the Euro-BioImaging Hub as a support and coordination unit with headquarters in Finland. The hub guarantees a virtual entry point through which the users are directed towards their desired technology, as offered by the Euro-BioImaging nodes. Advanced and innovative imaging technologies are becoming increasingly more important for the analysis of molecular dynamics in cells and organisms and as such enable more advanced approaches than standard biochemical and cytochemical methods. Nevertheless, European researchers in life sciences frequently lack access to pioneering imaging technologies. Euro-BioImaging reduces this gap with harmonisation and a distributed offer of an open-access imaging infrastructure for external users from other European research institutions. Such an open-access model has numerous benefits for the scientific community: it reduces the lack of expert personnel and high costs of individual institutions for establishing innovative imaging technologies, increases international cooperation and promotes knowledge transfer between European researchers.

Euro-BioImaging will enable scientists in life sciences, either those working in the academic sphere, healthcare or industry, to have access to a broader selection of much-needed advanced imaging technologies and knowledge and to create a bridge between basic biological, medical and clinical research. Firstly, Euro-BioImaging will in practice offer physical access to top imaging technologies at nodes, including advanced probing, expert knowledge and training, methods, software and analysis tools. Secondly, it will enable virtual

access to common imaging data services offered by the hub, such as software tools for image processing, a common repository for shared image data reference sets, reuse and cloud storage, and academically owned computing services. Significantly improved conditions will not only enable Europe to ensure it has a leading position in imaging technologies in the world and open new fields of research but will also contribute to fundamental progress in the understanding of health and disease at the molecular level. This will enable new and swift development of medicinal products, which will lead to better diagnostics, treatment and disease prevention, including improved quality of life for patients. Furthermore, Euro-BioImaging will ensure a fundamental imaging infrastructure for European scientists, so they will be able to develop innovative solutions for other major global challenges, such as food safety, the bioeconomy, and an inclusive and innovative society. By enabling access to the entire range of state-of-the-art technologies and simultaneously by coordinating and sharing the costs of implementation, Euro-BioImaging will enable its members to receive a better return on their investment in imaging platforms for biological and medical purposes.

Planned membership benefits and achievements

In the activities of Euro-BioImaging, Slovenia is cooperating with a broad range of Slovenian research institutions in this field, gathered within the SiMBION Consortium. This combines several research organisations in order to accelerate research activities, which combine technologies in biological, biomolecular, biochemical and medical imaging and related technologies in cooperation with other infrastructures (e.g. data management), i.e. with the fundamental purpose of improving access for researchers and industrial partners to dedicated equipment, tools and services in the relevant field. The consortium represents a critical mass of Slovenian players in this field and remains open to other possible participants. Due to the special composition of the Slovenian SiMBION Consortium, which is made up equally of units involved in microscopy and units working with imaging chemical analyses of materials, cooperation with the business sector will be facilitated, particularly with the pharmaceutical and food industry, and the inclusion in clinical research work in Slovenia and abroad will also improve. The inclusion of Slovenia in Euro-BioImaging particularly enables better application of domestic data and facilitated access for researchers to foreign imaging and databases and archives. Coordinated cooperation with other related RI in Europe in the field of data management (permanent and secure storage, access security, high-speed network connections, use of computer clusters, e-learning) will increase research efficiency and performance and make an important contribution to scientific excellence.

The better-quality equipment and access to foreign sources will significantly improve the possibilities for the practical training of postgraduate students in the domestic infrastructure. Current equipment is available to students and end or clinical users, and it is also used for the work of young researchers and implementation of several study programmes.

The knowledge transfer from more developed European centres to us will also be more successful, resulting in the greater effectiveness of the research and development industry, which is based on knowledge and experience. Complementary activities in the field of modern imaging technologies increase the opportunities for establishing new contacts and business transactions for business entities; for example, they will enable the establishment of spin-off companies, etc. In Slovenia, this is important for connecting the pharmaceutical industry with high-quality and specialised centres in the field of microscopy and imaging analysis, which enables a more rational purchase of equipment and better quality of services, e.g. cooperation of the Institute of Cell Biology within MF UL with the company, Sandoz Lek, d.o.o., NIB with numerous companies involved in transmission electron microscopy, etc.

Financial aspect

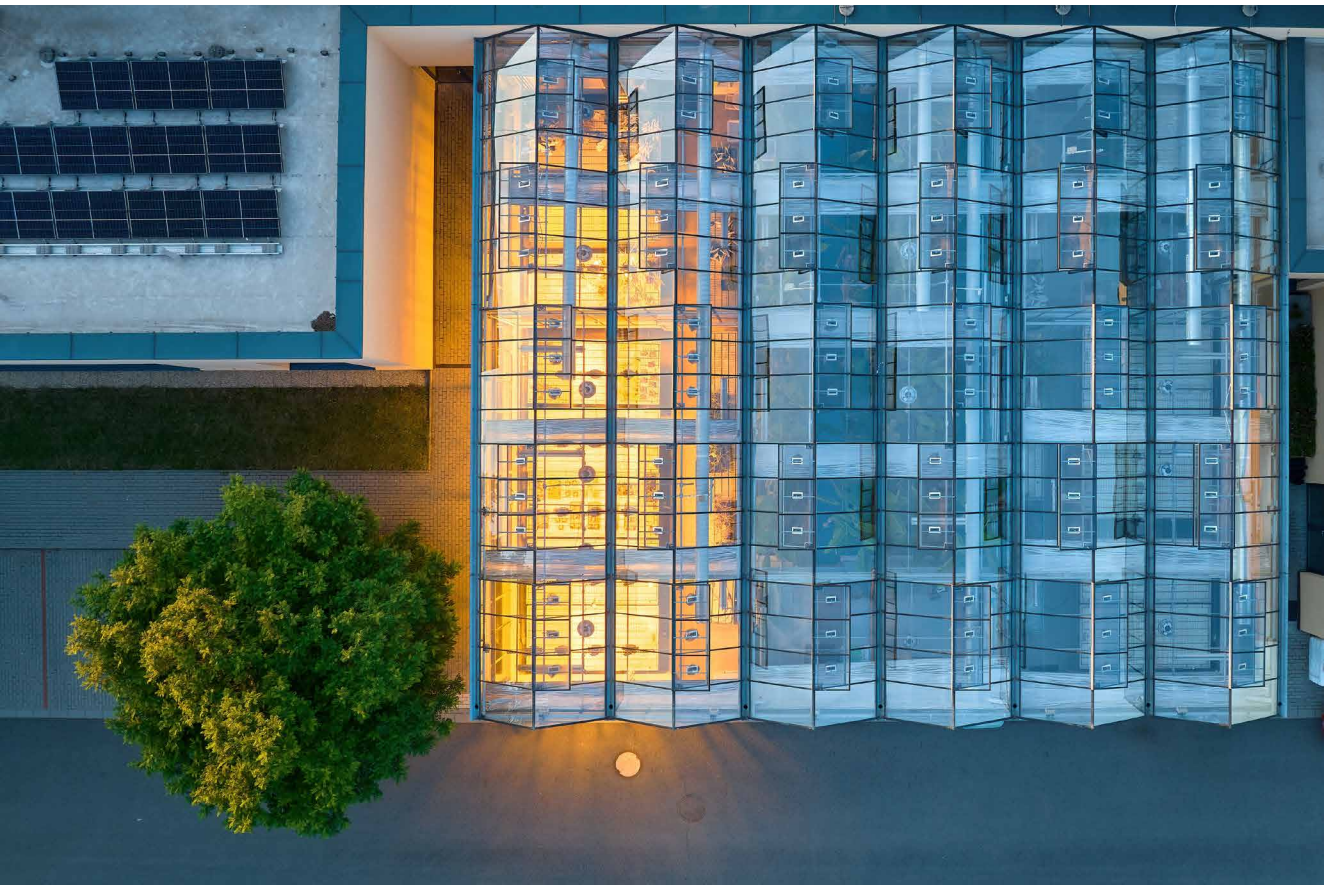
The co-financing of implementation of national activities commenced in 2019. The latest value of the annual sum totals EUR 85,000 and the annual membership fee for Euro-BioImaging ERIC amounts to about EUR 42,000. Current investments in the national research infrastructure total EUR 185,000. The costs of the planned development and upgrade of the national research infrastructure in this field are assessed at EUR 4.5 million. The assessment of investing in fundamental research and development work in the period up to 2030 is 8 FTE annually. In the coming years, the co-financing of the national node will be enhanced by the resources from the Structural Funds as soon as possible.

3. National priority fields

The second large set of the Research Infrastructure Roadmap 2030 consists of a revised list of national priority fields.Slovenia will continue to build and upgrade its national research infrastructure in order to attain a critical mass of medium-sized and large research infrastructure in selected priority fields, which will supplement smart specialisation fields and contribute to a balanced development of society.

Determination of national priority fields within the research infrastructure provides the basis for an autonomous development and financing of national priorities, which are in practice frequently intertwined with substantive priority fields from international projects, the implementation of which at the national level (e.g. establishment of a national node within an international project) also presents an important contribution to the national research infrastructure. With the successful implementation of international priority projects or international integration and inclusion in large and developed international research infrastructures, Slovenia also attains critical mass and the reduction of fragmentation of the national research infrastructure in addition to global strategic orientation.

The key challenge in research infrastructure development remains the provision of sufficient, long-term and sustainable financing for the necessary upgrade and smooth operation of national centres within international priority projects (national nodes) and the direct implementation of national priorities. Current forms of co-financing, i.e. by the MIZŠ (membership fees for international projects, investment in construction of international infrastructures), within the ARRS (equipment purchase, infrastructural programmes for financing national consortia) and with the funds of the European Cohesion Policy (equipment purchase, financing of HR and centres of excellence, etc.) represent significant movements and sometimes even breakthroughs in the past decade; nevertheless, the overall impression is that financial planning was too vague and ambitious or it relied too much on random, temporary, incidental and short-term solutions. Suitable mechanisms for monitoring and assessing the direct and indirect socioeconomic effects of financial resources invested in specific RI projects, as they are known especially in developed EU countries, would be needed for better efficiency of financial resources usage



and the improved efficiency of using the existing research equipment and research infrastructure as such.

As per the list from the Research Infrastructure Roadmap 2011–2020 with ten framework national priority fields in which, from the viewpoint of attaining critical mass and scientific excellence, research infrastructure must be developed with priority in Slovenia in order to obtain a critical mass of medium-sized and large research infrastructure, the updated list consists of twelve fields that do not deviate significantly from the original framework and upgrade their content.

Important new substantive highlights are found in the fields of infrastructure for quantum and photonic materials and technologies, artificial intelligence, smart cities, forestry, storage and access to digital sources in connection with the European Open Science Cloud (EOSC) and human genomics in connection with the European '1+ Million Genomes' (1+MG) initiative.

3.1 Social & Cultural Innovation

3.1.1. Analysis of social groups and processes

The use of modern information and computer-supported technologies has enabled a rapid development in research, as well as in social sciences and humanities (SSH). Due to the rapid expansion of the range of accessible research data and information, internationalisation of databases, standards and methodologies and the development of tools for processing, editing and linking of data and information, it is possible today to respond to research questions that could not be addressed at such a level in the past. Research infrastructures in the field of social sciences contribute significantly to this, as they collect and aggregate population data from a large number of countries over long periods of time, and their objective is a deeper understanding of social and cultural issues at the European and global level and the search for data-supported strategic solutions for multi-layered economic, technological and cultural challenges.

By combining classical and digital platforms for obtaining data on social processes, the role of social science research is enhanced, as one of the key information sources for recognising, planning and attaining important social objectives, e.g. in the context of climate change or the pandemic. Technological solutions alone are usually not enough to form efficient strategies for attaining these objectives, as the success in realising long-term measures of governments usually depends on the support and participation of various social groups, including analytical predictions and the modelling of effects which individual aspects of the solutions adopted will have on these groups. In this sense, interdisciplinary cooperation between social science infrastructures and other fields is also growing, for example between the energy policy and sustainable development (ESS) or health (SHARE). Enabling strategic planning remains one of the key objectives of social science infrastructures, the theoretically supported and methodologically reliable indicators of which were developed intentionally for in-depth and dynamic monitoring of social processes.

The research infrastructure in Slovenia must be further enhanced within the established international projects ESS, SHARE, CESSDA and the new international project (GUIDE), which, individually and combined in an ecosystem, ensure extensive databases of longitudinal and comparative indicators regarding all key aspects of social life, such as the political system, migrations, prosperity, health, work and life balance, climate change, culture and values, and many others. Through such cooperation, methodologically

verified solutions and standards will be established at the national level that will be developed within international partnerships and this is particularly important because these infrastructures are in the process of transition from traditional to digitally supported methods of collecting population data. Digital resource development (repositories of data and publications) also contributes significantly to the infrastructure in the field of social sciences and humanities, which is indirectly addressed with investments in the horizontal e-infrastructure. The standards and principles adopted by the international community with regard to scientific publishing within social sciences and humanities must also be transposed into the Slovenian environment, which is the objective of the OPERAS international project.

The investment in infrastructure in this field is particularly included in the assessed investment in the relevant five international infrastructure projects described in the second chapter.

3.1.2 Humanistic RI

The prerequisite for humanistic digital research infrastructures is the digitalisation of materials, which is why this needs to continue in the field of the extensive corpus (also of older) monographs, periodicals, journals, aids and other sources and documentation at the national and regional levels. The content must be presented in a multimedia manner and thus the material must be accessible in an interactive and visual way (sound, animation, music, images, graphics and video). The latter is particularly important in the context of the application of scientific and research achievements to teaching at all levels of education (e-education) and their popularisation. The second aspect of humanistic digital research infrastructure development includes user-friendly programme solutions, a technological platform to access diverse material, analytical tools and interpretative systems, which are developed particularly within the DARIAH research infrastructure in cooperation with interested national institutions.

In addition to DARIAH, the plan for humanities also includes a continuation and enhancement of activities within the CLARIN and E-RISH international projects and cooperation in the RESILIENCE international project must also be further upgraded. Sistory, an online research and education portal, has been established within DARIAH, connecting researchers, material and the technical infrastructure in the field of historiography. Language resources and tools for the Slovenian language being developed within CLARIN, which connects organisations and centres involved in the development of

and research into applied linguistics, corpus linguistics, the development of linguistic tools and databases and machine translation, play an important role in the relevant national infrastructure. A composite part of this research infrastructure also consists of computing capacities or networks that provide permanent and public access to the existing resources and language tools.

The field of art is also included in the context of humanistic research infrastructure, which must be connected accordingly to cultural heritage protection, and this has been developed in particular within the E-RISH international project. Comprehensive preservation of cultural heritage demands a research approach with interdisciplinary implications, but it is also an important link in the tourism (economic) and broader cultural sector. Transdisciplinary projects, structured formation of educational content about cultural heritage at formal and informal levels and cooperation with the business sector are necessary for the improvement of research into heritage. Research and development work will include data capture, analysis and interpretation of digitalised data, areas and buildings of cultural heritage, which require an interdisciplinary approach and high-tech equipment, including experience in artificial intelligence. The RESILIENCE international project supplements the field of humanities with a research infrastructure for theology and religious studies, the objective of which is to build a national platform connected within and in accordance with the standards for high-capacity and accessible international research infrastructures.

The investment in infrastructure in this field is particularly included in the assessed investment in the relevant four international infrastructure projects described in the second chapter.

3.2 Energy

3.2.1 Sustainable energy sources and energy efficiency

Sustainable energy supply is one of the global social challenges. A research infrastructure is of national importance in this field, as well as in the context of the development of knowledge and technologies that ensure the country's energy independence. The actors involved in energy technology development in Slovenia have yet to be connected optimally, and the research infrastructure development must particularly be ensured in the following fields:

- infrastructure for research in energy generation, transfer and transformation, especially for alternative and renewable energy sources, its conversion and final consumption. The transition to hybrid and electric

mobility is closely linked to efficient electricity conversion. New research in power electronics, diagnostics in converter systems and new findings in the field of their control will enable the production of devices with improved energy efficiency and their integration into advanced systems for efficient mobility. By increasing the proportion of renewable sources, energy storage systems based on electrochemical, electromechanical and other physical principles will have to be included in the power system. Advanced systems of power electronics will be needed for efficient energy conversion. The infrastructure must thus enable research into energy sources, the development of technologies and devices that will enable the economic sustainability of alternative energy source use, testing of these devices and algorithms of their control to achieve high efficiency of operation with the least possible burden for the environment due to CO2 emissions;

- infrastructure in the field of reactor and related energy technologies. The Reactor Infrastructure Centre with the TRIGA Reactor and the Hot Cells Facility, which is managed by the Jožef Stefan Institute, operates in this field in Slovenia. As Slovenia acquires more than one third of its power from the Krško Nuclear Power Plant and, in response to ever more vocal initiatives to construct a second block, this proportion could further increase, the TRIGA Reactor is already exceptionally important

for the training of highly skilled personnel who manage its safe and reliable operations and ongoing modernisation, and even more so the development of new 3rd and 4th generation reactors with much better efficiency and the possibility of reusing long-lived radioactive waste and its transformation into short-lived radioactive waste. Research, development and testing of new low-carbon energy technologies and approaches for knowledge generation and the transfer into industrial production of these technologies require their upgrading or replacement with new and the establishment of a technological polygon which, among other things, would enable the study of connecting reactors with decentralised and smart networks;

- infrastructure for the development of solutions that enable reliable and stable functioning of electric networks with a large proportion of dispersed power production from alternative and renewable energy sources, in which each power consumer can also be a producer;
- infrastructure related to sustainable construction, which includes development of energy-efficient methods and technologies that improve the energy efficiency of processes, products and substances. In Slovenia, several actors from different sectors research and innovate in these fields. This context also includes the concept of a smart city, which uses integrated information and communication technologies (ICT) to support the implementation of urban services. Great changes are taking place due to the tendency to move closer to smart cities, especially in the field of smart logistics, mobility and supply chains, which is one of the main areas in terms of meeting human material and immaterial needs. Technologies involving traffic and transport are already on a high technological level, just before practical application. In compliance with the plans for Society 5.0, which will be user-friendly and provide for sustainable development, quality of life, etc. and be based on technology and a profitable business model, and while observing the adopted standards, it is necessary to prepare a selection of mutually connected objectives that will enable the preparation of a network of services and measures for attaining the set objectives, and compromise solutions to approximate the common objective to the optimal solution as much as possible;
- infrastructure for introducing and testing of innovative (eco)technologies and processes for sustainable management of materials for the requirements of energy efficiency in construction and agriculture. The research infrastructure must enable development of methods for increasing the exploitation of conventional energy sources (energy products) and reducing the negative environmental impact of using these sources (environmental cleanliness) and technologies for sustainable construction and sustainable living.

3.3 Physical Sciences & Engineering

3.3.1 Advanced materials and technologies

The development of a research infrastructure for researching materials will be further promoted, i.e. in the following fields:

- infrastructures for the synthesis, study, characterisation and control of substances or their properties at the level of atoms and molecules (nanolevel), including laser-based methods, and infrastructures for research on transport and localisation of nanostructured artificial and biological materials in relation to their interaction with living nature and infrastructure for the development, synthesis, and chemical and physical characterisation of new "smart" metal-based materials. Several research groups work in this field in Slovenia, specially within the Jožef Stefan Institute, Universities of Ljubljana and Maribor, and the Institute of Mathematics, Physics and Mechanics, while their research results impact the technological development in several fields, including, and above all, energy (hydrogen technologies) and ICT;
- integrative environment for the realisation of joint R&D projects (industrial, higher education and research sectors), which may lead to technological breakthroughs. Infrastructure in this field will enable an interdisciplinary approach of the actors with different backgrounds to direct business-oriented projects towards the development of (new) business organisations and business models, i.e. towards the transformation of an innovative idea from top-level basic knowledge to an industrial prototype and market product and the formation of spin-off companies;
- infrastructure for analytical capacities for the research of inorganic and, above all, organic materials, requiring a special approach that allows an insight into their structure and chemical composition without damaging them, such as: (1) transmission and scanning electron microscopy and various tactile microscopies used in practically all scientific disciplines; and (2) high-energy focused beam infrastructure (ion accelerator) that allows elemental and isotopic mapping of biological tissues, research on hydrogen dynamics in substances, in fusion research, in research into the properties of archaeological and artistic objects, etc., and a controlled movement of the beam also enables the processing of a substance at the nanometer level according to a pre-developed plan.

Three centres of excellence were also co-financed in this field in the 2009–2013 period: the Centre of Excellence in Nanoscience and Nanotechnologies

(NiN), the Centre of Excellence for Advanced Non-Metallic Materials with Technologies of the Future (NAMASTE) and the Centre of Excellence for Polymer Materials and Technologies (POLIMAT). Investments in the upgrade of the national infrastructure in this field in the past period are also included in the context of integration in the CERIC international RI project described in the second chapter.

3.3.2 Nano, quantum and photonic materials and technologies

This is a new priority field separated from other materials, which includes the field of nano, quantum and photonic materials and technologies. Micro-, nanoelectronic and photonic technologies are the fundamental driving force of state-of-the-art technological development and deeply affect all areas of human activity. There is no technologically advanced product or service that is not based on at least one of these three technologies. Some time ago, the EU placed these technologies among the key enabling technologies (KETs), and their presence in individual countries is a clear indication of technological development and global competitiveness.

Compared to other European countries, Slovenia lags behind in the financing of quantum technologies (QT). QT intertwine different research disciplines (quantum physics, optics, electrical engineering, computer science) and industrial activities (measuring and testing, control systems, laser technology, communications, computer hardware and software). To enhance the QT sector, the EU launched the Quantum Flagship, a ten-year umbrella project, the budget for which exceeds EUR one billion and involves more than

5,000 researchers. In general, QT is divided into four application domains: (1) computation, (2) simulation, (3) communication, (4) sensing/metrology. The research and technological potential of QT in Slovenia grows in all four domains and is recognised at the national and international levels. Social and economic impacts are numerous: secure communication, defence, agriculture, AI, finance, cybersecurity, logistics. QT enabling factors are an appropriate infrastructure, staff development and technology integration (nanomaterials, photonics, AI). The devices based on the application of individual quantum particles and the exploitation of quantum entanglement have a great potential for breakthrough technological changes. The development of science in this priority field will contribute to addressing the most complex challenges of the future. Fields of special national importance include, for example, anti-eavesdropping communications, various quantum-based devices for use in micro-, nano- and quantum electronics and computing, inertial navigation in buildings, narrow gorges, caves, tunnels and below sea level, fast solution of

the most difficult optimisation problems in transport and logistics, efficient simulations of complex materials with improved properties (better fertilisers, conductors with lower losses, etc.) and large biologically important molecules for new medicinal products, sensors for accurate non-invasive diagnostics in healthcare and environmental monitoring, including early detection of earthquakes. A breakthrough can only be attained with interdisciplinarity, which links materials science, chemistry, physics, artificial intelligence, modelling and analyses of large quantities of data with numerous aspects of life sciences. It requires a development of techniques for the synthesis and analysis of materials that can be used to achieve new multifunctional properties. The use of quantum computers can drastically improve the performance of certain AI approaches (e.g. machine learning) that are based on optimisation, and on the other hand, the use of AI can improve the quantum computing process (e.g. application of machine learning for correction of quantum errors). The key equipment required for development of the field: equipping a cold atom laboratory, the development of new laser control technology and a laboratory of quantum optics and quantum telecommunications, a team for quantum computing and key He3 coolers as infrastructure for the development of quantum devices and experimental quantum physics. The needs for suitable general infrastructure must also be met: dust-free and temperature-controlled rooms, EM interference protection, vibration isolation, optical tables, access to quantum computers and their connection to high-performance computing (computing and data capacities) for artificial intelligence and other selected problems. Quantum optics and photonics are gaining ground as technologies of the future on a global scale, as they are key elements of future information technologies (quantum computing, communications, cryptography and high-speed Internet), sensors with currently unimaginable resolution and sensitivity (e.g. autonomous mobility sensors) and quantum simulators (simulations of multifunctional materials, reaction mechanisms, development of new active ingredients). This field is growing fast in Slovenia at the level of basic and applicative science. The equipment to support these fields is demanding, but the development of this field is impossible without it. We propose to particularly support wave technology infrastructure with technological capacities for research and development of advanced optical fibres, wave structures, microfluidic systems and similar structures, for which considerable interest has already been shown, both by the academic sphere and the business sector.

Photonics in combination with micro- and nanoelectronics is one of the focus technologies for the development of smart cities and smart buildings and homes, as the vast majority of sensor and control devices rely on photonic detectors and sources. Furthermore, photonics, which is the basis for

functioning of cable and wireless optical communications networks, is the centre of all current information and communication technologies. Quantum photonics or the manipulation of processes with individual photons is currently one of the most promising directions in the development of quantum communication systems. These technologies very quickly spread in the field of medical diagnostics and therapeutics, as they enable fast, precise and contactless procedures. The synthesis of new complex materials and finalisation of numerous high-tech products are also based on the manipulation, regulation and micro- and nanostructuring of materials with optical methods. Photonics with micro- and nanoelectronics is one of the S4 priority areas. This is the field in which strong connections and cooperation between the academic sphere and the high-tech industrial sector already exist.

3.3.3 RI for applications in space

The use of space technologies is becoming an increasingly important and accessible part of everyday life. It is spreading as regards the application modes and the range of users. Slovenia is an associate member of the European Space Agency (ESA) and a participating Member State in the European Space Programme. In this context, it is also involved in space policy making at the EU level and in projects such as Galileo and Copernicus. As part of the expansion and rapid growth of the space sector in Europe and the world, companies are also emerging and developing in Slovenia that either use technologies provided by space and related ground infrastructure or develop these technologies.

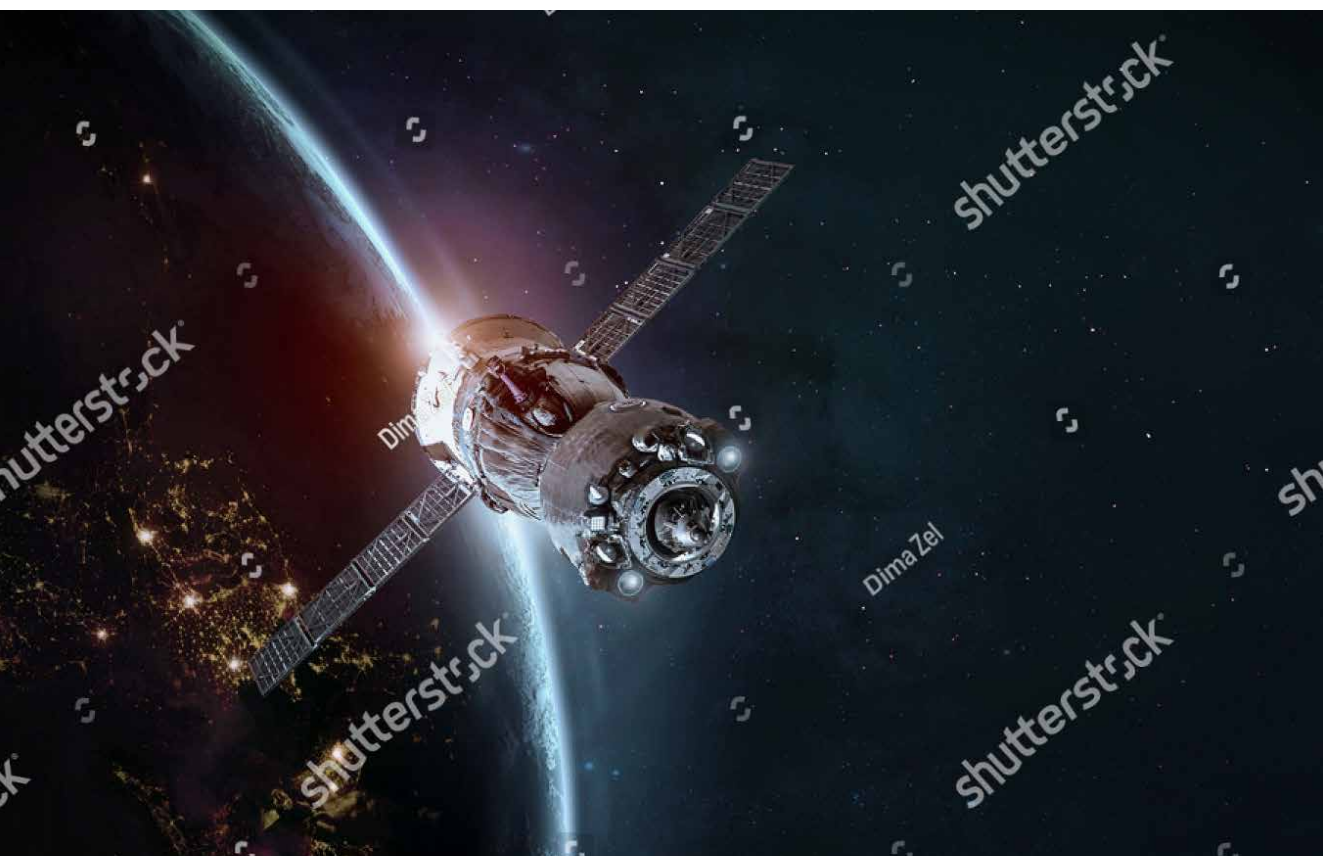
In 2020, Slovenia acquired a research and development infrastructure with the Nemo-HD (CO Vesolje-SI) and Trisat (University of Maribor) satellites, which enables the development and testing of new space technologies in a real space environment and in laboratories for simulating orbital physical conditions on Earth. Slovenia has established a basic infrastructure of ground stations for satellite communications, testing and integration of satellite components and capacities for processing satellite data. At the national level, we need a research infrastructure that can connect the existing capacities, knowledge and stable conditions for the maintenance and long-term development of the achieved capacities. The inclusion of our researchers in the ESA programmes must be enabled, and cooperation in Horizon Europe, EUSPA and the fast-growing new space economies must be encouraged. It is necessary to achieve a critical mass of researchers, interdisciplinarity of research and connectivity with Slovenian industry and the ESA for more

demanding projects, and to accelerate the establishment of new companies in this field.

Research infrastructure for space applications must, among other things, enable: (1) space technology testing in a real space environment and the simulation of the extreme physical conditions prevailing in space, (2) research and development of new materials of interest to space technologies, (3) development of new sensors, and (4) development of new technologies for satellite and stratospheric communication.

These objectives are, at least indirectly, also supported by astrophysics, which provides the foundation for much basic research (elementary particles), high-tech industry (optics, communications, artificial intelligence) and, due to unique challenges, also supports the development of the most innovative technologies. Slovenia has a high-quality research and pedagogical core with many connections abroad (ESA). This also includes the existing participation in the international CTA project.

Investments in the construction of such research infrastructure and in the maintenance of the existing capacities are expected together with national contributions and opportunities enabled by Slovenia's participation in the ESA and the EU programmes and projects.



3.4 Environment

3.4.1 Environmental sciences

It is difficult to present environmental sciences completely separately and without any connection to other priority applied fields, as environmental factors and consequences are present in practically every applied science or social segment. This is also horizontally affected by global climate change and extraordinary natural phenomena (e.g. earthquakes, floods, fires, glaze ice, landslides, tsunamis), which can be life-threatening and cause large-scale material damage. Environmental sciences are closely related to energy, urbanism, agriculture and forestry, industry, health and food, etc. Key research infrastructure includes:

- infrastructure for addressing environmental problems (de-pollution or environmental chemistry). Such infrastructure enables technological research into the mass balance of pollutants in industrial processes, fossil fuel combustion, circulation of elements and nutrients in wastewater treatment plants, technologies for removing pollutants from waste and contaminated areas, gas desulphurisation processes, and monitoring and prevention of harmful gases and their removal in emissions from incinerators, reuse of raw materials, etc. The upgrade of such infrastructures will enable the characterisation of pollutants and new laboratory simulations, as well as the development of technologies and methods for minimisation and de-pollution of the environment. This context also includes the so-called green chemistry, which includes the planning of processes, reagents and materials while taking into account the principles of atom economy, efficient catalytic methodologies compared to stoichiometric reagents, immobilisation of reagents and catalysts, safer reaction media (water, ionic liquids) instead of volatile organic solvents, implementation of solvent-free reactions and the planning of such chemical processes that consume little energy and leave behind least waste. It is also important to develop methods and processes that enable the use of biomass and its conversion into useful chemicals and materials;
- infrastructure for evaluating society's resilience to extraordinary natural phenomena. Databases, high-performance computing environments, sensors for capturing data on buildings and the built environment, tools for capturing big data, and various observatories for testing components of the built environment with regard to various extreme natural phenomena have to be developed. The establishment of such research infrastructure will create the conditions for providing high quality information in this field, which will be the basis for establishing a new value system and

consequently the preparation and implementation of measures to improve community resilience to extraordinary natural phenomena with various stakeholders, including amendments to relevant legislation. This would expand the concept of smart cities and communities from normal conditions to the field of ensuring community resilience to reactions with regard to extraordinary natural phenomena;

- infrastructure in the field of sustainable forest management, particularly in relation to climate change and other current global challenges. For Slovenia, as a relatively very forested country, this is of national importance. The anticipated scientific objectives in the field of climate change, forest ecosystems and biodiversity are well defined, and the educational aspect is more limited to training of the researchers in the use of modern methodologies and tools. The results will be useful for better forest management, as well as for sectoral policy makers in agriculture, the environment and the economy. This particularly includes the upgrade of the research infrastructure: databases, maintenance of research sites, reference samples of gene banks and other necessary research equipment;
- infrastructure for research into the link between environmental factors and health. Environmental factors represent some 25 per cent of the conditions (stressors) for the morbidity of the modern population with non-communicable diseases. The sectoral support research infrastructure is dispersed in Slovenia and, as a result, the access to top research infrastructures, which would enable the implementation of world-class research, has been curtailed. Due to diet, products, water, air, indoor spaces and occupations, the European population is exposed to many chemicals and mixtures. In many cases, the impact of the foregoing on health is not yet known. People are also exposed to noise, heat, air pollution and stress. The research infrastructure would help advance scientific knowledge, development of new technologies and the transfer of results into everyday practice. Such RI would connect the existing infrastructure (particularly the Jožef Stefan Institute, UKC LJ and NIB) and thus support and integrate research into and knowledge of environmental and analytical chemistry, toxicology and ecotoxicology, assessments of human and environmental exposure, risk assessments, epidemiology, biostatistics and bioinformatics, and environmental and pharmacokinetic modelling.

Investments in infrastructure in this field are, for the most part, also included in the mentioned investments in international infrastructure projects relating to the environment, i.e. eLTER, EPOS and LifeWatch, which are described in the second chapter.

3.5 Data, Computing & Digital RI

3.5.1 Computer networks, cloud computing services and high-performance computing

The amount of digital data generated and processed by researchers in almost all areas of research is growing rapidly. As a result, the need for more efficient computer networks and a high-performance supercomputer infrastructure at the national level and at the level of public research and infrastructure institutions is also increasing. Increasing the need for information services in the research process requires constant investments in information services and infrastructure. In addition to the development of information infrastructures for science through investment, cooperation in the development, maintenance and management of these infrastructures must also be ensured at the national level.

Network connections for public research organisations in Slovenia are provided by the Arnes public institute. All public research organisations in Slovenia are connected to a common network through optical connections owned by the Republic of Slovenia and managed by Arnes. The backbone network of the Arnes public institute, which connects various places, is provided through leased connections from commercial providers. The latter also have international links to the GÉANT, the Trans-European Research and Education Networking Association.

Due to the increase in the amount of data in research processes and the computerisation of research processes, Slovenian researchers will have to be provided with secure, stable and powerful cloud computing services. For the needs of the Slovenian research community, public infrastructure institutions at the national level will have to provide cloud computing services at all three levels: infrastructure as a service (IaaS), platform as a service (PaaS) and software as a service (SaaS). The national cloud computing infrastructure must enable researchers to carry out research tasks smoothly and participate in international research infrastructures, consortia and projects.

Researchers in Slovenia began making connections for the requirements of processing large amounts of data on supercomputers as early as 2009, when the Jožef Stefan Institute together with Arnes established the Slovenian Initiative for the National Grid (SLING). The established initiative has also become a national platform for integrating into international connections and infrastructures in the field of supercomputing. SLING was transformed into a consortium of the Slovenian National Supercomputer Network and, as a

platform for cooperation, also made a decisive contribution to the successful realisation of the HPC RIVR project. Through the SLING consortium, Slovenian researchers participate in international activities: EGI, PRACE, CECAM and also in the EuroCC (National Competence Centre within the EuroHPC). In 2021, the Vega supercomputer was established at the IZUM public infrastructure institution, which was partly co-financed by EuroHPC JU, the European High Performance Computing Joint Undertaking. With the establishment of the national supercomputing centre at the IZUM institution, Slovenian researchers were given the opportunity to access a suitable research supercomputing infrastructure. The national and international cooperation established so far and the provided national supercomputing infrastructure form the basis for the establishment of a national supercomputing centre at the IZUM public infrastructure institution, the development of a complementary supercomputing infrastructure for public research institutions, continuation of national and international SLING activities, improvement of the competences of Slovenian researchers for big data processing and integration with quantum computing.

3.5.2 Storage and access to research results

Large amounts of research data, publications, software, laboratory notes, research protocols, interactive and multimedia materials, etc. are generated in the research process. If research is publicly funded, its results must also be open and accessible to the public. In Slovenia, it is necessary to systemically arrange and connect the research infrastructure for storage and access to research results if we want that research to achieve the status of being replicable, with the option provided for the results to be re-used in new research. Open access and permanent storage of the results of publicly funded research must be ensured. A distributed system of data archives and repositories must be established, which will be able to use common disk space to store research data at the Arnes public institute and the Vega supercomputer system installed at the IZUM institution. It is also important to connect the distributed system of archives and repositories with the SLING infrastructure, so that the researchers within this infrastructure can process research data, run open access software and workflows that are the result of previous research. Such a distributed system of repositories and archives must be connectible with the SICRIS system and research infrastructures at the EU level, which will enhance the visibility and impact (citation) of Slovenian science in the world.

The National and University Library (NUK), which has been developing the so-called Digital Library of Slovenia (dLib.si portal) since 2005 to enable

access to Slovenian written cultural heritage, has also provided a uniform open and free access to scientific publications since 2006. A portal for submitting electronic publications (SVAROG) to the repository has also been set up, which will only need to be adapted to the needs of archiving the materials of scientific research institutions and universities. The Digital Library of Slovenia is already connected to the COBISS central bibliographic service and the SICRIS research activity monitoring system. The connectivity of both systems with the SICRIS system will improve the transparency and efficiency of the evaluation of scientific work (immediate free availability of complete reference texts in project applications).

In 2013, a national open access infrastructure was established for the needs of the open science ecosystem. The infrastructure consists of six repositories and a national portal that aggregates metadata and, in part, the content from repositories and other sources. The repositories are connected to COBISS.SI and SICRIS through the dCOBISS repository, which, on the basis of aggregated data on open publications in repositories, enables financiers to examine the compliance of contractual obligations against the actual openness of scientific publications. The openscience.si national portal aggregates content from repositories and other Slovenian collections for the needs of an aggregation search engine, a recommendation system and a content similarity detection.

There are 13 repositories and data archives in Slovenia that enable the storage of research data. Certain data archives are sectoral (Social Science Data Archives, CLARIN.si, SIDIH, Sistory, Bioportal, eGeologija), while others are either institutional (Slovenian university repositories), interinstitutional (DIRROS and REVIS repositories) or part of the public administration data infrastructure (OPSI, NIJZ data portal and siStat). Certain archives are in the process of being established (e.g. ELIXIR) or have data available in databases generated during projects (e.g. various websites at ZRC SAZU). The databases are not publicly available and cannot be used in other projects. The majority of repositories and data archives have some datasets available in the public domain, while other datasets are only available to logged-in users or at the archives location. Two data archives (Social Science Data Archives and CLARIN.si) were certified by the Core Trust Seal. These archives have processes in place to support the life cycle of research data.

Most research organisations collect data during projects that are not stored in data archives or repositories. Publicly funded research data should be as open and accessible as possible with as few restrictions as possible. Open data must be searchable, accessible, evaluated, understood, reusable and, if possible, interoperable, in accordance with certain quality standards. As

much as possible, research data must be prepared and openly accessible in such a way as to ensure the broadest possible re-use and exploitation for research and other purposes. If necessary, due to exceptions of a legal or ethical nature or for other legitimate reasons, data may be shared by means of a regulated access with restrictions. The data should be accessible to the public as soon as possible after its generation, but at the latest at the end of the project or when a scientific publication is first published. To enable faster publication of research results, open review support processes need to be implemented in national open access infrastructure repositories.

The COBISS national bibliographic system is the basis for the operation of the SICRIS, Slovenian Current Research Information System. Researchers' bibliographies contain plentiful and normatively arranged metadata about the scientific works of Slovenian researchers. It is important to ensure that COBISS records are upgraded with metadata on research results in accordance with established metadata standards. The COBISS typology also needs to be supplemented to cover all types of research results.

Individual systems within the national open science ecosystem must be properly certified as per the requirements set by the EOSC and included in the EOSC service catalogues. In accordance with the requirements of the European Open Science Cloud (EOSC), compatibility, quality and interoperability of metadata, services, workflows and digital objects stored in the national infrastructure must also be ensured. For the successful unique identification of research results, a national system for assigning permanent identifiers must be set up, following the example of other countries. The system for assigning persistent identifiers must be compliant with the policies and architecture of the PID (Persistent Identifier) proposed by the EOSC in order to ensure the interoperability and exchange of digital objects within the EOSC service ecosystem. Slovenian researchers must be enabled access to all services offered by the EOSC through a single user interface within the national open science ecosystem.

3.5.3 Artificial intelligence for science

With the increased capabilities of automatic learning and acquiring knowledge from the increasing quantities of available data, the use of artificial intelligence (AI) in science is becoming relevant in this context and is developing rapidly, especially the use of machine learning methods for analysing scientific data and discovering scientific laws. An even more important aspect is the use of semantic technologies to describe and store the existing knowledge

and access scientific data and models, which allows for a higher degree of automation of science as well as adequate support for open and reproducible science. With this approach, it would be possible (as Slovenian scientists are among the leaders in Europe) to accelerate the development of more efficient and productive science and the development and use of new technologies that would have a long-term positive impact on the economy and society in general. AI is recognised as one of the most important enabling technologies of the future with a direct impact on various fields of smart specialisation from factories of the future through smart buildings and cities to virtually all other fields. Machine learning enables efficient processing of large quantities of data and the automatic retrieval of important information contained in this data. This requires a very powerful computer and other infrastructure that enables the collection and processing of such data. The field of AI paves the way for important solutions to improve the adaptability of modern society and the economy to unexpected changes (e.g. natural disasters) and long-term worrying trends (e.g. demographic trends), such as robotisation, smart factories and other concepts of Industry 4.0 and Society 5.0. Their components include optimisation processes that enable multi-criteria optimisation as per

the economic, environmental, energy and safety criteria. The enabling fund of the Internet of Things (IoT), Big Data Processing, Location Analytics (LA) and AI enable real-time data capture, its automatic merging and separation of features to predict and optimise real-world entity behaviour.

AI is also the basis for the so-called digital twins, copies of physical objects, people, systems or processes that are capable of presenting the relevant static and dynamic properties of the originals in the virtual world. The development of digital twins is one of the most important development trends, enabling the implementation of data-supported decision-making processes that rely on statistical facts and patterns detected by AI methods rather than on human intuition. This also includes the development of new radar technologies for remote sensing of the Earth's surface, which cannot be attained with optical sensors, while their applications help detect climate and geological conditions and assess the situation on and below the Earth's surface. One of the key foundations of digitalisation and the digital transformation, which addresses economic and non-economic entities or the modern challenges of society as a whole, is modern cloud technologies or cloud-native architecture, edge computing and fog computing.

Researchers in Slovenia are achieving excellent results in the field of AI, but it is important to ensure suitable critical mass of research infrastructure for further development, which includes high-performance computer hardware and software, peripheral hardware (sensors, actuators, robots, autonomous vehicles, suitable test sites, etc.), and highly qualified support personnel.

3.6 Health & Food

3.6.1 Biotechnology, biomedicine and biological sources

Understanding the basic biological processes at the level of humans, animals and plants and the understanding of biodiversity are among the most important scientific and social challenges of the new millennium and are also the basis for the development of research in biotechnology, biomedicine and health. The understanding of these processes enables a more responsible social management. Modern scientific and development research in this field builds on knowledge of a range of genomes, including human, and on the development of computing and materials and new technologies based on them. Modern technologies, knowledge and instruments used in research processes in the field of biotechnology, biomedicine and pharmaceuticals

contribute to a comprehensive understanding of life processes, protection against diseases and their effective and efficient treatment. Modern research in this field integrates the knowledge and approaches of various sciences, from molecular, structural and cellular biology to biotechnology, including chemical and biological synthesis, light and electron microscopy, mass spectroscopy, X-ray diffraction, NMR and other analytical methods, and functional genomics, proteomics, metabolomics, systems biology and medicine, and bioinformatics. For this to take place, access is required to a wide and orderly collection of biological resources. Scientific discoveries in these fields are frequently transferred to industry or clinical practice, where the development of technologies makes an important contribution to a better quality of life for individuals and the protection of the environment. The process of transferring into practice can be time consuming, but it offers exceptional yields and the employment of a highly skilled workforce. At the same time, it contributes greatly to the realisation of a low-carbon society.

Priority should be given to investing in the development of a research infrastructure in the field of biomedicine, including post-genomic infrastructure and biotechnology. In Slovenia, two internationally important pharmaceutical companies, Krka and Lek, operate in the fields of biomedicine and biotechnology, but smaller high-tech companies are developing rapidly. In the 2009–2013 period, two centres of excellence were co-financed in this field: the Centre of Excellence for Integrated Approaches in Chemistry and Biology of Proteins (CIPKeBiP) and the NMR Centre of Excellence for Studies in Biotechnology, Pharmacy and Physics of Matter (CO EN-FIST), which have enhanced the knowledge base and research infrastructure in this field. The existing research equipment in this field is managed in particular by the Jožef Stefan Institute, the National Institute of Chemistry, the National Institute of Biology, the Biotechnical Faculty, the Faculty of Pharmacy and the Faculty of Medicine of the University of Ljubljana, and the Faculty of Medicine of the University of Maribor. In the field of medicine and health, research in the field of genomics, cell analysis, personalised medicine and systems medicine is becoming increasingly relevant, with the aim of introducing it into clinical practice, for example, by establishing clinically useful workflows (also part of translational medicine).

Biological resources are a basic tool for researchers in many fields of life and environmental sciences and are also important for the pedagogical process. In Slovenia, plant, animal and microbial resources, fungal and virological collections, herbaria, DNA collections, their genes and products, and databases of in-situ living collections (e.g. forest gene reserves) are very dispersed and poorly connected. They are managed mainly by the Biotechnical Faculty,

the Agricultural Institute of Slovenia, the Slovenian Forestry Institute, the National Institute of Biology, the Faculty of Medicine and clinical institutions (UKC Ljubljana, UKC Maribor) and the Institute of Mediterranean Agriculture and Oliveculture of the Koper Science and Research Centre of the University of Primorska. These and other biological resources need to be connected, technologically upgraded and internationally integrated. It is necessary to technically and methodologically improve them in such a way that they meet modern safety requirements and measures regarding the operators and the environment, while observing applicable ethical criteria.

In the field of medicine and public health, organised collections of human DNA samples should be established for which whole genome sequencing, including genomes of the healthy population (national reference genome), is permitted in accordance with the legislation, ethical permits, consents of the participants and the observance of the GDPR. This is necessary for the activation of the Slovenian Genome Project, which would be comparable in its scope with the national genome projects of more developed European countries. The objective is to sequence approximately one per cent of the Slovenian population (patients and healthy volunteers), which means about 20,000 Slovenian human genomes, whereby the material costs of sequencing one genome would approximately

amount to EUR 1,000 to which human resources (FTE) and appropriate equipment, which is renewed every five years, must also be added. In terms of biodiversity and native plant and animal species, the aim is also to sequence more than 1,000 representatives of selected plant, animal and microbial species.

Slovenia is participating in the European "1+Million Genomes" Initiative (1+MG), which combines 22 EU countries, the United Kingdom and Norway, with the objective to make available at least one million sequenced human genomes for research purposes in the EU by 2022. Slovenian research groups are involved in the European Reference Genome Atlas (ERGA) biodiversity initiative and are also active in other fields that require genomic infrastructure capacities. As per the European 1+MG initiative and the Beyond 1 Million Genomes (B1MG) project, which sets up a European genomic infrastructure for medicine, the fields of rare diseases, cancer and complex diseases are very topical in connection with genomics and translational medicine, and so is the collection of data on healthy population (national reference genome). Genomics and functional genomics have the potential for a revolution in the study of life from several angles: the development of more targeted and adapted prognostic and diagnostic tools, medicinal products, treatments

and interventions, the understanding of biodiversity, enabling progress in agriculture and environmental protection. Slovenian researchers from various research groups in the field of genome study are coordinated by the Faculty of Medicine of the University of Ljubljana. No suitable infrastructure for efficient genome sequencing that would be accessible to Slovenian researchers has been established in Slovenia. Most researchers therefore perform the most powerful genome analyses abroad. This situation has several negative consequences for Slovenian science. For example, the international competitiveness of Slovenian researchers is reduced and the funds for development and operation of national science are used to purchase services within the infrastructures of other countries. With no appropriate infrastructure, it is not possible to establish specific knowledge in the field of genome study and the innovation potential of Slovenian science is therefore reduced. The genomics infrastructure should include at least the following capacities: sample collection and storage, high-performance genome analysis (sequencing), and storage and data analysis. This infrastructure must operate on the principles of an open infrastructure for open science. All Slovenian researchers must have access to the established infrastructure under the same conditions. The infrastructure for genomics must be financed

in such a way that users (researchers) do not bear the costs of genome analysis, and access to the infrastructure is provided primarily on the basis of demonstrated research excellence.

Investments are also needed in infrastructure to protect and promote health, which includes healthy eating, regular physical activity, reduction of sedentary life, quality sleep and mental health care. All of the above contributes to maintaining health or better health and wellbeing, greater quality of life and the sustainability of health systems. With appropriate prevention at all stages of life, we can prevent the development of many diseases or conditions that are becoming more common in modern society. Prevention is important for health at all stages of life.

Investments in the upgrade of the national infrastructure in this field have been included in the past period particularly in the context of integration into international RI projects ELIXIR, EATRIS and EuBI, but it will have to be further upgraded with the participation in international projects BBMRI, EMBRC and Instruct, which are described in the second chapter.

3.6.2 Safe and healthy food

Food safety and its impact on the health of individuals and the general health of society is becoming an increasingly important and interdisciplinary field. It raises biological, sociological and anthropological issues that are of high priority in Europe. In Slovenia, it is necessary to connect a relatively large group of researchers and institutions performing research activities in this field, such as the University of Ljubljana (the Biotechnical Faculty, Faculty of Health Sciences, Faculty of Medicine, Veterinary Faculty and the latter's National Veterinary Institute), the University of Primorska, the University of Maribor (the Faculty of Medicine and the Faculty of Agriculture and Life Sciences), the Jožef Stefan Institute and National Institute of Chemistry, as well as the Institute of Public Health, which will enhance the ability to transfer and manage new specific technologies and the development of new technologies and solutions in the field of food. The research infrastructure must enable research and development:

- for the quality and safety of foodstuffs that will meet higher standards in the field of food and nutrition:
    i. processes and bioprocesses with the possibility of solutions for faster technological breakthrough of new products and services;
    ii. food in relation to consumer habits to provide new solutions for managing food and nutrition problems;

- food in relation to health, which sets new paradigms for understanding food and promises new insights:
    i. in this context, agriculture, forestry and veterinary medicine are of key strategic importance. Modern and sustainable agricultural plant and animal production, forest management and animal health are crucial for each country. The supply of healthy food produced with modern and environmentally friendly technologies must be at the heart of future research and sustainable development, which requires appropriate development and an upgrade of knowledge and the research infrastructure in modern agriculture, development of sustainable food production technologies, and care for the environment and public health. To promote the economically relevant and sustainable development of agriculture, forestry and veterinary medicine, the transfer of excellent knowledge into innovation or to the users is essential.

The primary goals are on the one hand research-related and a technological transfer, and enhanced cooperation with industry on the other.

It will also be important to establish an interdisciplinary research infrastructure in the field of food production, nutrition and health that will enable the participation of researchers from various scientific fields in the resolution of open problems related to health and nutrition, especially in food production, nutrition, social sciences and informatics. The infrastructure will have a high applicative potential for cooperation with the business sector, especially with the food industry. Slovenia has a wide network of partners from the academic and research spheres, as well as hospitals, the NIJZ and companies in this field. The aim is to connect heterogeneous sources of data on foodstuffs and nutrition (both in terms of composition and safety), the dietary habits and physical activity of the population of Slovenia and patients, the health of Slovenian citizens (in terms of genomics and environmental impacts) and the social aspects of nutrition and health in the country and to evaluate them with regard to international standards.

The investments in the infrastructure in this field are also included in the relevant investments in the METROFOOD international infrastructure project regarding safe and healthy food, which are described in the second chapter.

4. Connections between the NRRI and the Smart Specialisation Strategy

Below is a presentation and definition of the links between the NRRI 2030 and the Smart Specialisation Strategy, which is a necessary basis for co-financing from the European Cohesion Policy as one of the most important sources for (co)financing RI in Slovenia.

The Smart Specialisation Strategy is the foundation for focused development investments in the fields in which Slovenia has a critical mass of knowledge, capacities and competences, and the innovation potential for placement on global markets and thereby for enhanced visibility.

In 2015, the Government of the Republic of Slovenia adopted the Slovenian Smart Specialisation Strategy (S4) as an implementation document of the strategic documents adopted so far, which included the Slovenia's Development Strategy 2006–2013, RISS 2011–2020, the Slovenian Industrial Policy (SIP), the Digital Agenda and other strategies relating to nature protection, energy, education and similar. Thus, the S4 integrated and specified the guidelines into a uniform and consistent framework that enabled the implementation of targeted and complementary measures.

In the 2014–2020 programming period, the S4 was a prerequisite for the release of funds from the Operational Programme for the Implementation of the EU Cohesion Policy in the Period 2014–2020 under Priority Axis 1 "International competitiveness of research, innovation and technological development in line with smart specialisation for enhanced competitiveness and greening of the economy". In the field of research infrastructures, it dictated that the development of research infrastructures follow the ESFRI plans and the Research Infrastructure Roadmap (NRRI 2011–2020), especially in terms of establishing centres or partner facilities that represent the functional integration of the Slovenian infrastructure into the international infrastructure. From the viewpoint of implementing or drawing the European Cohesion Policy funds, this meant that the projects, which were compliant with the S4 guidelines and simultaneously defined in the NRRI 2011–2020, received support. For the purposes of drawing funds from the

Vir: SVRK; Osnutek S5 2022

European Cohesion Policy 2014–2020, a conversion table was drafted within the NRRI revision 2016 that showed the overlapping of priority areas between the NRRI and S4. It was revealed that, despite the different nomenclature, the research fields of the NRRI and S4 actually overlap and strive for the same goal, which is the prioritisation of priority areas taking into account the effective use of a research infrastructure in which conditions are established for a transparent and non-discriminatory manner of access to the infrastructure for other research organisations and partners, execution of independent research, development of knowledge and understanding, broad access and effective transfer of research results, acquisition of competences for effective participation in international research networks and programmes, attraction of top foreign researchers to Slovenia, and economic growth.

Certain implemented (landmark) NRRI projects, in which the Republic of Slovenia is involved and actively participates, were co-financed in this way. These are the projects that have shown interest in, and the need to upgrade, the research infrastructure to enable smooth and competent research work, both nationally and internationally. These projects include CERIC, CLARIN, DARIAH, EATRIS, ELIXIR, EPOS and LifeWatch and were co-financed within the RI-SI project.

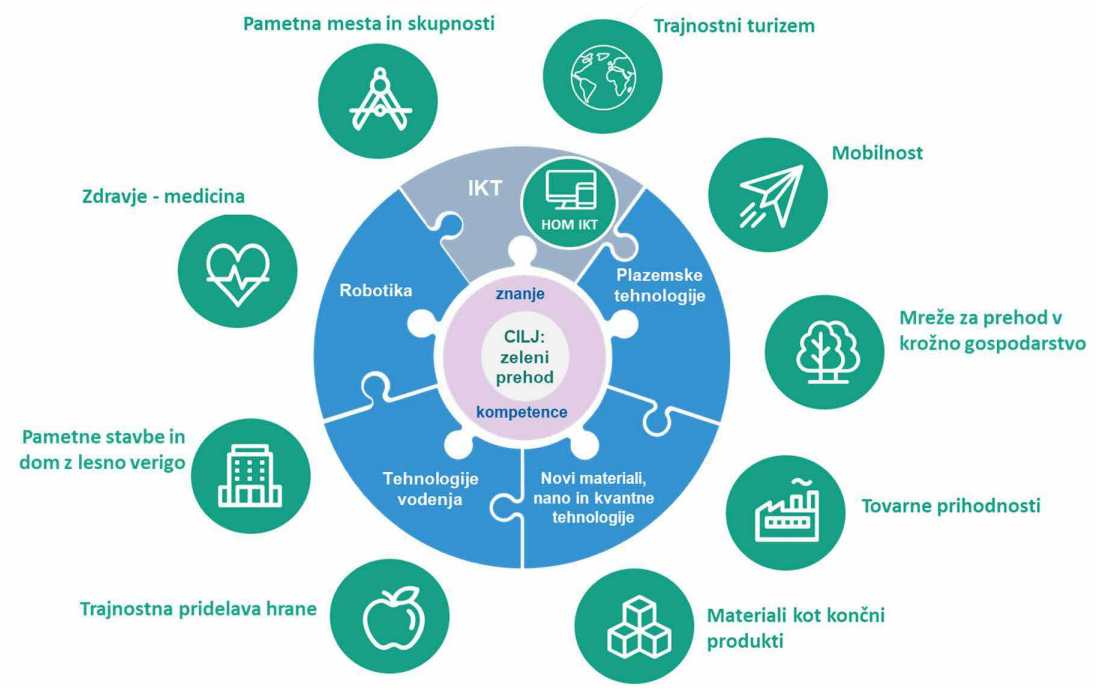
As part of the upgrade of the national infrastructure, a national project from the priority national area of high-performance computing and networking, HPC RIVR, was co-financed, which was subsequently successfully integrated into the European EuroHPC project and further upgraded computing capacities to the petascale level through the VEGA project.

The Smart Specialisation Strategy remains the basis for implementation of the European Cohesion Policy in the 2021–2027 programming period as well. The European regulations provide for its renewal and consider it as an enabling condition for Policy objective 1: "A smarter Europe by promoting innovative and smart economic transformation". For this reason, the Government Office for Development and European Cohesion Policy started the renewal of S4 in the first half of 2020 and named it S5. The activities were mainly focused on the renewal of necessary analytical bases and the entrepreneurial discovery process (EDP). Together with the key sectors, the Ministry of Economic Development and Technology (MGRT), the Ministry of Education, Science and Sport (MIZŠ), the Ministry of Public Administration (MJU) and all nine SRIPs (strategic research and innovation partnerships), working material was prepared, which was the result of the entrepreneurial discovery process from September 2020 to February 2021. Further focus or refinement of focus areas and their product directions was performed on the basis of quantified justifications of market potentials prepared by SRIPs for the proposed focus areas and product directions, as well as on the proposals and justifications of other relevant stakeholders from the public debate.

The original S4 was structurally based on three priority areas (Healthy living and working environment, Natural and traditional resources for the future, (S) Industry 4.0) and nine areas of application (Smart cities and communities, Smart buildings and homes, including wood chain, Networks for the transition to the circular economy, Sustainable food production, Sustainable tourism, Factories of the future, Health – medicine, Mobility, Development of materials as end products), within which the focus areas and technologies and product directions were defined.

At the time of drafting the NRRI 2030, the S5 document was still in the process of preparation, but through focusing and with the intention of emphasising priority areas (continuity), the empirical bases and the implemented entrepreneurial discovery process (EDP) justified a leaner three-level S5 prioritisation structure with a clearly focused objective and conditions for achieving this objective.

The envisaged structure of the renewed S5 is presented in the diagram below, which shows a key objective in the internal circle, the so-called green transition, which cannot be achieved without suitable knowledge, competences, and appropriate and sufficiently developed tools, i.e. key enabling technologies, including ICT. The areas in which Slovenia demonstrates a critical mass of capacities and competences to achieve this objective are represented in the external nine or ten circles of S5 priority areas.



With the current implementation of the national research and development policy and the upgrade of the RISS innovation system in connection with S4, Slovenia succeeded in improving research, development and innovation conditions, but the level of investment is still unsatisfactory. In the light of the S5 ambition to move from a follower to a co-creator of global trends in niche fields, from a component supplier to an important development partner and bearer of research, development and innovation activities, as well as of high value-added production activities within global value chains, it is extremely important to improve the research, development and innovation ecosystem. To achieve these objectives, several measures are envisaged, including the enhancement of investment in research infrastructure and research capacities, especially in connection with national strategic development priorities, which is crucial for scientific excellence and top-level research. To attain the critical mass of knowledge, capacities and competences necessary for the development of innovative and breakthrough production processes, integration into the international space is important. In this context, efforts should be made to strengthen cooperation in European and international networks of research infrastructures (e.g. in European research infrastructure consortia) with a special focus on the S5 priority areas, where stakeholders are enabled access to cutting-edge research infrastructure and the opportunity to participate in research projects. At the same time, an appropriate national research infrastructure must be provided in accordance with international requirements and standards.

From the implementation point of view, it is important to update the conversion table in such a way as to complete the priority areas and supplement international projects which the Republic of Slovenia has joined in the meantime. The table will be used as an aid in the future co-financing of the research infrastructure.

Table 2: Overlapping of priority areas between the NRRI 2030 and S5

ESFRI scientificfields	International RI projects	National priority areas of the NRRI 2030	S5 priority area
Social & cCultural Innovation	CESSDA, CLARIN, DARIAH, ESS, SHARE; E-RISH, GUIDE, OPERAS, RESILIENCE	Analysis of social groups and processes	Smart cities and communities
		Humanistic RI	Sustainable tourism
Physical Sciences & Engineering	Belle2, CERIC, CERN, CTA, FAIR, ILL	Advanced materials and technologies	Materials as end products
		Nano, quantum and photonic materials and technologies	Mobility
		RI for applications in space	Pametna mesta in skupnosti
Environment	EPOS, LifeWatch; eLTER	Environmental sciences	Networks for the transition to a circular economy
Health & Food	BBMRI, EATRIS, ELIXIR EuroBioimaging; METROFOOD, INSTRUCT, EMBRC	Biotechnology, biomedicine and biological sources	Health – medicine
		Safe and healthy food	Sustainable food
Data, computing & digital RI	PRACE	Computer networks, cloud computing services and high-performance computing	Factories of the future; smart cities and communities, sustainable tourism, mobility, health – medicine, sustainable food
		Storage and access to research	
		results Artificial intelligence for science	
Energy		Sustainable energy sources and energy efficiency	Smart buildings and homes, including wood chain

5. Financing methods

Funding a large research infrastructure poses a great financial burden, so proper resource planning and knowledge of all possible resources are required. Furthermore, it is important that the upgrade of the research infrastructure in national priority areas is considered as priority (co)financing, followed by the upgrade of the research infrastructure for the needs of operations in internationally implemented NRRI projects.

The research infrastructure will be funded from various sources. In addition to funds for membership fees in the case of implemented international projects, sustainable financing for the smooth operation of national centres (nodes) and their appropriate upgrading must to be provided, which will be further enhanced with resources from Structural Funds at least in the next financial framework. It is planned to place priority international RI projects in the multiannual financial framework for the 2021–2027 period.

Co-financing of the upgrade and operations of a large research infrastructure is initially anticipated from the European Cohesion Policy funds, i.e. the European Regional Development Fund under the Cohesion Policy as the key and most comprehensive European investment policy for growth and jobs, within Policy Objective 1 "A smarter Europe by promoting innovative and smart economic transformation" and Policy Objective 10 "Just Transition Fund in coal-intensive regions", which is expected to apply only to the Zasavje and Savinjsko-Šaleška regions.

The upgrade of the research infrastructure will also be possible through regional development programmes or territorial dialogue processes (agreement on regional development).

As part of the upgrade and establishment of the high-performance computing ecosystem in Europe, funding will be available from calls of the EuroHPC Joint Undertaking. Considering the already established high-performance Vega computer and the need for upgrading in the coming years, it is expected that the Republic of Slovenia will also participate in future tenders. To this end, part of the resources will also have to be provided from the integrated budget and/or European Cohesion Policy funds.

Under the Horizon Europe centralised programme mechanism, investment in innovation and R&D will simultaneously seek to strengthen the priority areas envisaged by S5, particularly in the sections of complementary funding within the Teaming instrument. Other complementary schemes will also be promoted, which will enable synergies through which excellence and innovation will be enhanced at the European and national level, increasing productivity and consequently improving resilience and a competitive position in global value chains of the most productive part of the Slovenian economy in connection with research and educational institutions and other actors within the five-point spiral with a special emphasis on digitalisation and greening of the areas of action.

The new Scientific Research and Innovation Activities Act (ZZrID) envisages a significant increase in funding. The integral funds of the state budget, which are within the financial plan of the ministry responsible for science and research and intended for the implementation of scientific research activities, are thus determined in the amount of at least one percent of GDP. Within the framework of the so-called stable financing of scientific research activities, it is thus also possible to envisage long-term investment in equipment, maintenance and operation.

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