

# RESEARCH INFRASTRUCTURE ROADMAP OF NORTH MACEDONIA



**RESEARCH  
INFRASTRUCTURE  
ROADMAP OF  
NORTH MACEDONIA**

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Trg Bosne i Hercegovine 1/V, 71000 Sarajevo  
Bosnia and Herzegovina  
Tel: +387 33 561 700; Fax: +387 33 561 701  
E-mail: [rcc@rcc.int](mailto:rcc@rcc.int)  
Website: [www.rcc.int](http://www.rcc.int)  
Author's: Djuro Kutlaca and Lazar Zivkovic  
Editor: Sinisa Marcic, RCC  
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# CONTENTS

<b>ABBREVIATIONS</b>	<b>5</b>
<b>EXECUTIVE SUMMARY</b>	<b>6</b>
<b>1. INTRODUCTION</b>	<b>10</b>
1.1. Scope and purpose of the document	10
1.2. What are Research Infrastructures?	10
1.3. The background and methodology of creating the Research Infrastructure Roadmap	11
<b>2. THE CURRENT LEGAL AND POLICY FRAMEWORK FOR THE DEVELOPMENT OF RESEARCH INFRASTRUCTURES</b>	<b>13</b>
2.1. Financing research activities and research infrastructures	13
2.2. Current state of development of Smart Specialisation Strategy	15
<b>3. PARTICIPATION OF NORTH MACEDONIA IN EU RESEARCH PROGRAMMES</b>	<b>17</b>
<b>4. ANALYSIS OF THE EXISTING RESEARCH INFRASTRUCTURES IN NORTH MACEDONIA</b>	<b>19</b>
<b>4.1. Overview of research infrastructures</b>	<b>19</b>
4.1.1. Ss. Cyril and Methodius University of Skopje (UKIM)	21
4.1.2. Goce Delchev University	40
4.1.3. St Kliment Ohridski University, Bitola	42
4.1.4. Mother Teresa University, Skopje	46
4.1.5. Institute for Advanced Composites and Robotics	47
4.1.6. South East European University	47
4.1.7. Macedonian Academy of Sciences and Arts (MASA)	49
<b>4.2. Access Policy</b>	<b>51</b>
<b>4.3. Research e-Infrastructures</b>	<b>54</b>
4.3.1. Faculty of Computer Sciences and Engineering, Ss. Cyril and Methodius University in Skopje	55
4.3.2. National Research and Academic Network of North Macedonia – MARNet	55
4.3.3. COBISS.MK network	56
<b>4.4. Participation of institutions from North Macedonia in RI projects</b>	<b>56</b>
<b>4.5. Membership in ESFRI Roadmap and other Large European Research Infrastructures</b>	<b>67</b>
METROFOOD-RI Infrastructure for Promoting Metrology in Food and Nutrition	68
GEANT Pan-European Network	69
EOSC Association – European Open Science Cloud	69
CEESDA	70
EGI: Advanced computing for research	70
OpenAIRE	70
EuroHPC JU	71

ESS - European Social Survey	72
SEEIST- The South East European International Institute for Sustainable Technologies	72
<b>5. CONCLUDING REMARKS AND POLICY RECOMMENDATIONS</b>	<b>74</b>
<b>APPENDIX 1: LIST OF CAPITAL EQUIPMENT AT PURCHASE PRICE HIGHER THAN 50.000 EUR</b>	<b>77</b>
<b>APPENDIX 2: SURVEY QUESTIONNAIRE</b>	<b>86</b>
<b>APPENDIX 3: DETAILED INSTRUCTIONS FOR COMPLETING THE SURVEY</b>	<b>91</b>

## ABBREVIATIONS

CESAER	Conference of European Schools for Advanced Engineering Education and Research
CESSDA	Consortium of European Social Science Data Archives
CSIC	The Spanish National Research Council
E-CRIS	Current Research Information Systems
EOSC Association	European Open Science Cloud
ERA	European Research Area
ERIC	European Research Infrastructure Consortium
ESFRI	European Strategy Forum on Research Infrastructures
ESS	European social survey
EuroHPC JU	European High Performance Computing Joint Undertaking
FASF	Faculty of Agricultural Sciences and Food
FCSE	Faculty of Computer Science and Engineering
FEEIT	Faculty of Electrical Engineering and Information Technologies
FP7	Seventh Framework Programme
GARR	Italian National Computer Network for Universities and Research
GDP	Gross Domestic Product
GERD	Gross Domestic Expenditures on Research and Development
H2020	Horizon 2020
HPC	High Performance Computing
HPDA	High Performance Data Analytics
INCF	International Neuroinformatics Coordinating Facility
IZUM	Institute of Information Science in Maribor
JRC	Joint Research Centre
MARNet	Macedonian Research and Academic Network
MASA	Macedonian Academy of Sciences and Arts
MVDSI	Max van der Stoel Institute
NOSCI	National Open Science Cloud Initiative
NRENs	National Research and Education Networks
R&D	Research and Development
RCC	Regional Cooperation Council
RI	Research Infrastructure
R&I	Research and Innovation
S3	Smart Specialisation Strategy
SEE	South East Europe
SEEM	Southeast Europe and the Eastern Mediterranean
VRE	Virtual Research Environment

## EXECUTIVE SUMMARY

Research Infrastructure Roadmap of North Macedonia presents the existing research potential of North Macedonia with the aim to set principles for the future development of research infrastructures and to propose recommendations aimed at strengthening research sector and societal development as a whole. Considering the small number of internationally relevant large research infrastructures that the North Macedonia is member of, research infrastructure in this document refers to research facilities and equipment within the scope of research institutions (universities and research institutes) whose purpose is to provide basic conditions for research activities.

The Ministry of Education and Science is responsible for the development of scientific research, higher education system and technological development. The legal framework for research activities in North Macedonia is defined by the Law on Scientific and Research Activity. However, the last few years have been characterised by insufficient attention on formulating and implementing science and technology policy. There is no actual strategic national development document in the field of research and science and the last version of the National Programme expired a few years ago.

Overall investments in research and innovation (R&I) in 2020 were rather low (0.37% of GDP). However, in 2010, the Ministry of Education and Science implemented the project "Equipping laboratories for scientific research and application activity" aimed at improving the research infrastructure capacities of the public higher education institutions and research institutes. As a result of this project, a total of 80 research laboratories have been equipped with the research equipment of a total value of approximately 23 million euros.

Despite the fact that universities in North Macedonia are mostly focused on education, there is evidence of engagement of universities in research activities, predominantly represented by the public universities. Out of a total of 62 research laboratories / institutes that responded to the questionnaire, 20 of them own single capital research equipment worth over 50,000 euros. With regards to the public universities, capital research equipment is mainly located in the Ss. Cyril and Methodius University in Skopje. The Institute for Advanced Composites and Robotics in Prilep is the only private research institution that owns single capital research equipment.

Majority of research institutions/laboratories do not have an official access policy; however, they clearly define the internal procedures for accessing research equipment/facilities. Most institutions have open access for research staff, while external users are required a special permit, which includes: the official submission of requests for access to research infrastructure and formal approval by the management. As a result of Open Access Research Infrastructure in the Western Balkans Support Programme, implemented by RCC in 2020, the following research institutions have developed Access Policies to research infrastructures: The Institute for Social, Political and Juridical Research, Ss. Cyril and Methodius University in Skopje; Institute of Economics, Ss. Cyril and Methodius University in Skopje; Faculty of Computer Science and Engineering, Ss. Cyril and Methodius University in Skopje and Rectorate of the Ss. Cyril and Methodius University in Skopje.

North Macedonia contributes to the development of European e-infrastructure by participating in international projects, international associations and institutions, thus contributing to the greater integration of North Macedonia into the ERA. Faculty of Computer Science and

Engineering, Ss. Cyril and Methodius University in Skopje is the most important institution in the economy with regards to e-infrastructure. It provides e-infrastructure support to the academic and research communities, ministries, public sector, and the industry. Macedonian Research and Academic Network (MARNet) is the member of GÉANT.

Institutions from North Macedonia have participated in 18 international projects (11 projects within H2020 and 7 projects within FP7) related to the development of research infrastructures. Thirteen projects have been implemented and 4 are ongoing.

North Macedonia is a member of ESFRI. Currently, North Macedonia participates in one ESFRI research infrastructure development project - METROFOOD-RI Infrastructure for Promoting Metrology in Food and Nutrition. Additionally, North Macedonia participates in the operations of several large European RIs that are not included in the ESFRI Roadmap but are of importance for the development of European and regional research infrastructure: GEANT Pan-European Network; European Open Science Cloud (EOSC); CEESDA; EGI: Advanced computing for research; OpenAIRE AMKE; EuroHPC JU; European Social Survey (ESS ) and SEEIST.

In order to successfully integrate into ERA, North Macedonia should recognise research infrastructures as strategically important for economic development. The visibility and quality of RIs in the wider European research scope need to be further improved and connection with the knowledge society should be enhanced. Policy coordination is most important on this path, while strong links to R&D priorities are necessary conditions so that funding could be directed to research facilities that carry out the best research and provide the most prominent socio-economic benefits.

As a result of the analysis of current situation of research infrastructures in the economy, the following policy recommendations emerge aiming to improve the quality of the existing research infrastructure in North Macedonia:

### **1. Create an Action Plan for development of Research Infrastructures**

After mapping the existing research infrastructures and RI projects in this document, it is necessary to develop an Action Plan for implementation of measures and activities to ensure further development of RI. The main purpose of the Action Plan is to outline financial implications and summarise key steps that need to be taken to implement the actions and attain the objectives of the Roadmap. The implementation of RI Roadmap is critical for North Macedonia to get closer to the forefront of science and technology and become more competitive in regional economy.

However, putting in place RI has a significant impact on national science budget (which is quite low), hence raising the question of their long-term sustainability. This requires a general debate to explore ways of combining funds from different sources more efficiently and ultimately defining goals for the Research Infrastructures.

### **2. Establish a link between the research potential identified in the RI Roadmap and future activities in designing the Smart Specialisation Strategy**

Since North Macedonia is currently in the process of designing its S3, it is important to include the RI Roadmap as an input document for the next steps that will lead to the selection of the final priority domains. The existing research infrastructures are an important guideline for mapping R&D potentials as a necessary element for defining a policy mix in the process of S3 implementation.



If North Macedonia wishes to ensure successful implementation of the S3 and to use the existing opportunities, it should provide the upgrade or construction of new research infrastructures and further develop the research-innovation potential. Regarding the investments in projects of national importance, it is also reasonable to invest in RI projects that will contribute to the reduction of the development gap in relation to the developed EU MS.

### **3. Increase investments in research infrastructures**

According to the current figures, North Macedonia records very modest level of R&D expenditures compared to EU member states, and the overall situation is even worse considering the declining trend of R&D investments in recent years. If North Macedonia wants to catch up with developed economies, it is necessary to consider greater budget allocation for R&D and creating policy measures that would stimulate higher investments in research activities by the research and business sectors.

With regards to financing research infrastructures, North Macedonia should consider implementing a second round of support to research laboratories that was originally implemented by the Ministry of Education and Science in 2010. Considering the time lapse of 10 years, research equipment is largely obsolete and additional investment is needed to enable research institutions to operate in accordance with the state of the art research equipment. The second financial support programme would contribute to strengthening the universities and other research institutions with the most modern research equipment, and supporting them in implementation of their international scientific projects.

### **4. Improve the policy framework**

The research system of North Macedonia is characterised by the absence of a science and research development strategy. The review of current strategic documents in the area of R&D has shown that there is no National Programme for Scientific and Research Activity in place in North Macedonia. The absence of this strategic document represents a certain obstacle in implementing RI Roadmap due to the lack of a strategic basis and framework. Considering the importance of this strategic document for defining strategic directions and priorities and future development of research activities in North Macedonia, the National Council for Higher Education and Scientific Research should develop a National Programme for Scientific and Research Activity of North Macedonia.

The term “Research Infrastructure” is recognised and clearly defined in the current version of the Law on Scientific and Research Activity; however, in the next amendment to this Law, it is desirable to provide a definition of “RI Roadmap” that would include its clear purpose and create a legal basis for development and adoption of this policy document.

The Ministry of Education and Science should establish partnership with the NOSCI.mk and jointly work on the inclusion of open science, open access and open infrastructures into the national legal framework for research and education.

The Ministry of Education and Science should also consider adapting the national legislation for the assessment of academic advancement and align it with the current EU trends that rely heavily on the open science principles and FAIR data.

## 5. Support the development of e-infrastructure

Strong and high-quality e-infrastructure is the basis and condition for the future development of research system in North Macedonia. In strategic terms, North Macedonia should do much more in supporting e-infrastructure than it does now. It is necessary to make better plans for the coordinated development of e-infrastructure so that the necessary funds can be timely allocated. North Macedonia should launch measures to encourage research institutions to pursue collaborative investment in e-infrastructures where everyone could show their own interest in e-infrastructure development through partnership.

The Ministry of Education and Science should foster the initiative of identifying and digitising various collections of records that exist in research centres.

Additional recommendations relate to the following:

- a. Intensify digitalisation of research and innovation sector, in particular the process of identification and digitalisation of various collections and other contents of national importance
- b. It is necessary to intensify the work on creating prerequisites for open access to research data
- c. Improve information and strengthen user support for open access and maximum use of existing infrastructures.

## 6. Consider options for more active participation in Large European Research Infrastructures

It is noteworthy to mention that despite the unenviable state of science and research North Macedonia institutions have been participating in several European RIs. However, North Macedonia should consider launching policy instruments that would result in increasing participation in large Pan-European research infrastructures. Benefits of accessing large RI for researchers and research institutions are multiple and mostly related to: capacity building, implementation of high-level research projects that cannot be implemented in-economy due to the lack of appropriate equipment, strengthening national scientific excellence, etc.

The relevant ministries should provide financial support for the membership of interested institutions from North Macedonia in Large RIs and associations, before which it is necessary to identify and propose appropriate ESFRI/ERIC RIs for which there is interest and capacity for membership.

## 7. Defining Open Access Policies for research infrastructures

As a result of Open Access Research Infrastructure in the Western Balkans Support Programme implemented by RCC Secretariat in 2020, 4 research institutions in North Macedonia have created a document on Open Access Policy to RI. Building on the experience gained in this programme, the Ministry of Education and Science should encourage other research institutions to adopt their own Open Access Policy documents. The final deliverables from this Programme could be taken into account when defining policies for providing access to RIs.

Additionally, best practices and guidelines regarding the topics helpful to those responsible for defining access policies could be found in the public document developed by the EU Commission<sup>1</sup> that provides the charter for access to research infrastructures which sets out principles and guidelines for defining access policies for RIs.

<sup>1</sup> EC (2016). European Charter for Access to Research Infrastructures, Directorate-General for Research and Innovation, Brussels

# 1. INTRODUCTION

## 1.1. Scope and purpose of the document

Research Infrastructure (RI) Roadmap is a policy document aimed at identifying national research infrastructures as an indispensable step for the future development of scientific research and promotion of research excellence in North Macedonia. This is the first version of the Roadmap that should encourage open and transparent communication with the research community assisting the Ministry of Education and Science to regularly update the Roadmap with new projects and prepare to invest in research sector in the most effective and optimal manner.

The main purpose of the Roadmap is to present the existing research potential of North Macedonia with the aim to set principles for the future development of research infrastructures and to propose recommendations aimed at strengthening research sector and thus societal development as a whole. It assists decision-makers to better leverage investments in research infrastructures to ensure their national and international relevance, as well as to ensure their availability to the entire research and business community in the national economy and beyond.

The ultimate goal of the Roadmap is to ensure a long-term commitment of decision-makers to systematic support of strong research and innovation in North Macedonia, striving for development of RIs that are relevant beyond domestic territory in highly competitive scientific areas, which will allow the research ecosystem to be shaped into a gateway for global research challenges.

The content of the document reflects the current state of play of research sector of North Macedonia with rather low total government investment in R&D and poor development of large research infrastructure. Considering the modest participation of North Macedonia in the large pan-European research infrastructures, this document is structured to map research equipment, facilities and research laboratories operating within universities and research institutes. Furthermore, research potential reflected in the participation in international research projects relevant to the development of research infrastructure is also presented.

## 1.2. What are Research Infrastructures?

Research infrastructures are intended to provide resources that enable research for several research teams and different projects within one or several research fields. Research infrastructures include major research facilities, laboratory environments, complex digital research systems and databases, etc. According to the EU Regulation<sup>2</sup>, Research Infrastructures are defined as follows: *“RIs are facilities, resources and services that are used by the research communities to conduct research and foster innovation in their fields. They include: major scientific equipment (or sets of instruments), knowledge-based resources such as collections, archives and scientific data, e-infrastructures, such as data and computing systems and communication networks and any other tools that are essential to achieve excellence in research and innovation”*.

<sup>2</sup> Regulation (EU) No 1291/2013 of 11 December 2013 - “Establishing Horizon 2020 – the Framework Programme for Research and Innovation 2014-2020

National investments in the development of RIs are important given the impact RIs have on promoting research excellence by providing access to state-of-the-art facilities and equipment, comprehensive databases and other resources. RIs constitute an important element of the European Research Area (ERA), offering unique research services to users from different economies, attracting young people to science, shaping multidisciplinary scientific communities and nurturing economic development. Although the primary objective of RIs is to produce cutting edge science, their impact goes beyond scientific research only. They are equally important and relevant for all scientific fields and an important instrument for connecting research with the business sector.

The European Strategy Forum on Research Infrastructures (ESFRI)<sup>3</sup> is a strategic instrument created in 2002 by the Member States and the European Commission to develop scientific integration of Europe and to strengthen its international outreach. ESFRI gives national authorities the opportunity to explore common and integrated activities for the best development and use of Research Infrastructures of pan-European relevance. In this way, by integrating national policies, ESFRI brings together national and EU resources to develop the ERA.

In the last decade, most EU MS in ERA have been creating and updating their Roadmaps of National RIs, following the lead of ESFRI. In line with this trend, Western Balkan economies (Montenegro and Serbia) have also recognised the importance of RIs for the national research ecosystem and economic development and finalised the process of developing their own national RI Roadmaps.

The final criteria for identifying RIs in North Macedonia reflect rather modest condition of national research infrastructures. This means that due to the very small number of internationally relevant large research infrastructures, research infrastructure in this document implies research facilities and equipment within the scope of research institutions (universities and research institutes) whose purpose is to provide basic conditions for research activities.

### 1.3. The background and methodology of creating the Research Infrastructure Roadmap

The RI Roadmap has been developed with technical assistance provided by the Regional Cooperation Council (RCC). RCC has provided technical and expert support to the Ministry of Education and Science throughout the process that resulted in the development of the final document. This support was provided in the framework of a broader action that included the provision of assistance to other Western Balkan economies with the final goal to contribute to creating the Western Balkans' Roadmap of Research Infrastructures.

The RI Roadmap was developed by implementing two research methods: desk research and field research.

Desk research was conducted by analysing existing legal framework and policy documents in the area of research, technological development and innovation in North Macedonia. All documents that were subject of the analysis are official and approved government documents available to the general public. The policy framework was analysed in the context of the current development of research infrastructures. The specific focus was on the current state of research

<sup>3</sup> <http://ec.europa.eu/research/esfri>

sector; reviewing the existing research and innovation strategies; financial framework and the current status of the process of developing smart specialisation strategy.

Field research involved sending out a survey questionnaire to the research community to collect information on existing research infrastructures and equipment of national and international relevance. The Ministry of Education and Science of North Macedonia was in charge of disseminating the questionnaires and gathering the answers that were processed and analysed by the team of external experts.

The survey questionnaire is provided in Appendix 2 and detailed instruction for launching and conducting the survey is provided in Appendix 3. The guide comprises detailed instructions for sending out the questionnaire to the research community, gathering and processing necessary data, and integrating all responses that served as the main input for selection and mapping of research infrastructures in North Macedonia.

## 2. THE CURRENT LEGAL AND POLICY FRAMEWORK FOR THE DEVELOPMENT OF RESEARCH INFRASTRUCTURES

The Ministry of Education and Science is responsible for the development of scientific research, higher education system and technological development. The legal framework for research activities in North Macedonia is defined by the Law on Scientific and Research Activity. This Law regulates the principles, purposes, scientific and research activities, entities of scientific and research activities and the manner of financing scientific and research activities. Article 2 of this Law defines the term Research infrastructures as follows:

“Scientific research infrastructures are facilities, laboratories and experimental stations, innovation centres, computer centres, scientific equipment, library information and referral centres, archival and publishing documentation, as well as everything else that contributes to scientific research”.

According to this Law, the National Programme for Scientific and Research Activity of North Macedonia (hereinafter referred to as: the National Programme) arises from the strategic national development documents. The National Programme has an important role in defining the progress directions and financing priority scientific and research activities; defining the basis, purposes, contents and scope of tasks in the field of science; coordination and implementation; planning the necessary research infrastructures; research staff planning; and defining indicators for monitoring and evaluation system.

*The National Council for Higher Education and Scientific Research is an independent professional body composed of 15 members that should prepare a National Programme for Scientific and Research Activity of North Macedonia and the National Assembly should adopt it.*

A new Law on Scientific and Research Activities is under development with the aim to increase the level of public investment in scientific and research activities.

The National Innovation Strategy 2012-2020 was successfully implemented by the Fund for Innovation and Technological Development and the Ministry of Education and Science. The Government is looking at the pros and cons of developing a new Innovation Strategy complementary to the Smart Specialisation Strategy.

Over the last few years little attention was paid to formulating and implementing science and technology policy. There is no actual national strategic development document in the field of research and science and the last version of the National Programme expired a few years ago. Bearing this in mind, it is evident that the policy framework for development of research activities and research infrastructures does not exist. As a result, the science and technology innovation mechanism remains underdeveloped and underutilised as an instrument to advance the nation's growth, economy and well-being.

### 2.1. Financing research activities and research infrastructures

While developed states of the European Union strive to achieve the gross expenditures on research and development (GERD) of 3% of GDP, in the context of North Macedonia, these

figures have been consistently low and experiencing a declining trend. Since 2014, GERD as a percentage of GDP has been falling constantly – from 0.51% in 2014 to 0.36% in 2018<sup>4</sup>. Overall investments in research and innovation (R&I) in 2020 were 0.37% of GDP. The investments in R&I consist essentially of funds allocated by the public sector (Government and Higher Education sector), with private sector participation in R&I of 0.10% of GDP<sup>5</sup>. Since 2011, The Ministry of Education and Science has been continuously stimulating and financially supporting publication of scientific papers in international peer-reviewed journals such as Web of Science and Scopus.

Researchers from North Macedonia do not have access to the world's largest scientific databases such as Web of Science and Scopus. However, the Ministry of Education and Science has been continuously providing access to electronic databases of scientific journals. By 2019, access to 14 databases was provided, one of the most important of which is Academic Search. In 2019, access was upgraded with access to Academic Complete databases. This upgrade provided access to 14 databases of electronic scientific journals with impact factor of a total of over 57,000 journals, of which over 22,000 are full-text electronic journals in PDF format, and over 5,000 highly cited journals with an impact factor, available to researchers and students from higher education institutions and public scientific institutions in North Macedonia.

Budget investments in research infrastructures (funding for the procurement of research equipment by research laboratories) have been at a very low level in the last decade. However, it is important to mention "Equipping laboratories for scientific research and application activity" project implemented by the Ministry of Education and Science in 2010 with an aim to improve the research infrastructure capacities of the public higher education institutions and research institutes. The specific goals of this project were:

- ◆ equipping and strengthening the universities and other public educational institutions with the most modern technical equipment,
- ◆ supporting research institutions in the implementation of their scientific research projects,
- ◆ supporting the organisation of practical classes for students,
- ◆ encouraging cooperation with the private sector and thus generating additional revenue for the involved institutions which would guarantee self-sustainability of these laboratories and the institution in general.

As a result of this project, a total of 80 research laboratories have been equipped with the research equipment of a total value of approximately 23 million euros. The final beneficiaries of the project were from the following research fields: Information Sciences; Technical and Technological Sciences; Medical Sciences; Natural Sciences and Mathematics; Biotechnical Sciences; Humanities and Social Sciences.

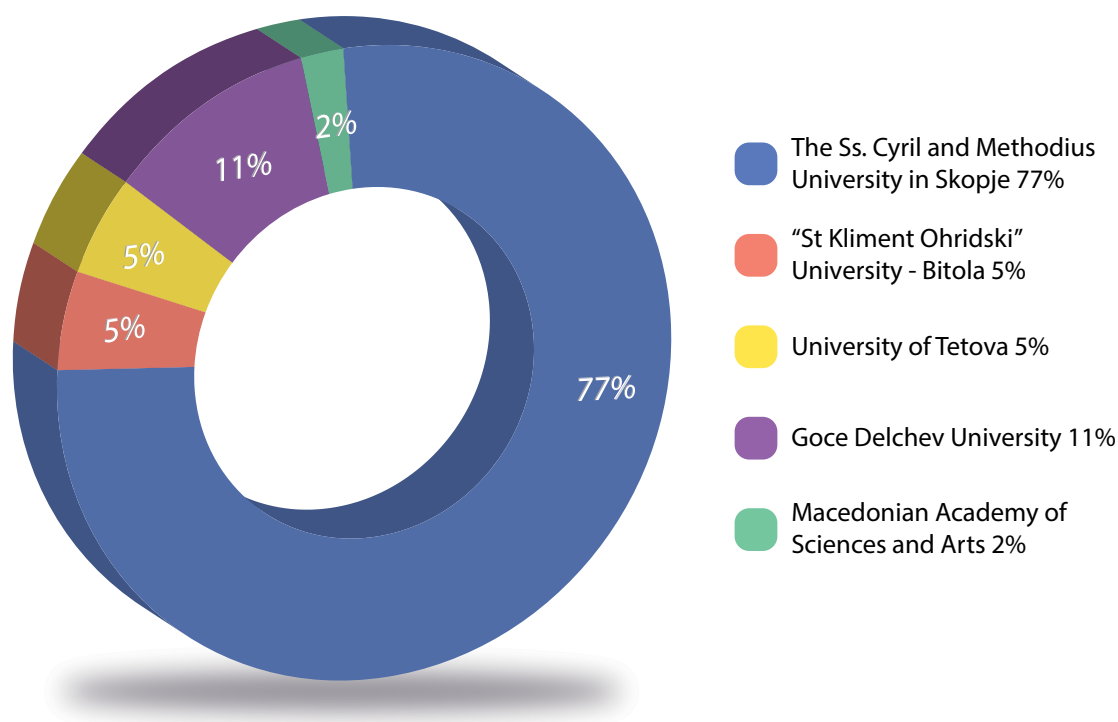
Research laboratories operating within the Ss. Cyril and Methodius University in Skopje have obtained the highest share of financial funds for their research laboratories/institutes (77%), which was expected given that it is the largest and most important higher education institution in North Macedonia. About 11% of funds were allocated to Goce Delchev University and other universities obtained 5% or less (Graph 1).

4 <https://data.worldbank.org/indicator/GB.XPD.RSDV.GD.ZS?locations=MK>

5 Source: State Statistical Office of the Republic of North Macedonia – Research and Development, 2020



**Graph 1: Share of allocated funds by Universities within the project "Equipping laboratories for scientific research and application activity"**



Source: own calculations based on the data provided by the Ministry of Education and Science

## 2.2. Current state of development of Smart Specialisation Strategy

The Smart Specialisation (S3) process in North Macedonia started in 2018. An inter-institutional working body was established, consisting of representatives of the government, relevant ministries and academic community. The entire process of development of S3 is closely followed by the JRC methodological framework for smart specialisation in the EU enlargement and neighbourhood economies (JRC S3 Framework).

Following its methodology, and with the support from GIZ, the National Centre for Development of Innovation and Entrepreneurial Learning (NCDIEL) conducted the quantitative mapping as an assessment of the potential priority domains based on economic, innovation and scientific indicators.

Furthermore, in the period from September 2020 to March 2021 a qualitative analysis was carried out by an internal team from the Economic Chamber of North Macedonia (ECNM) with the support of few external domestic experts and in close cooperation with the North Macedonia Smart Specialisation Working Group.

After processing all information obtained from a number of sources (conducted interviews, conclusions from focus group meetings, in-depth sectoral analysis and additional studies, etc.), the following vertical priority areas and subareas were proposed as a subject to further elaboration within EDP process:



1. Smart agriculture and food processing with high added value
  - Smart agriculture
  - Food processing with high added value
2. Information and Communication Technologies (ICT) sector
  - Custom Software Development
3. Smart/Sustainable buildings and materials
4. Electrical equipment & machinery parts

These four areas are proposed as vertical areas for smart specialisation, having economic capacities, as well as scientific and innovative potentials to be further elaborated in order to create a new niche market for their specialisation.

The area for smart specialisation named **Energy for the future** is considered a horizontal one, because it has strong cross-sectoral relations with other proposed priority areas and is in line with the process of greening the industry and protection of environment.

Also, **Sustainable tourism and catering**, as a preliminary proposed area with a significant contribution to the Macedonian economy and a critical mass of firms with development potentials, will be additionally explored during the EDP process in order to provide a clearer picture whether this preliminary area has enough potentials for smart specialisation. The EDP process is expected to start in the middle of 2021.

Having in mind that North Macedonia is in the process of identifying priority domains for the future, the mapping of research infrastructures takes on an important role as it provides the framework for analysis of research potential and indicates how key national research infrastructures can influence the strengthening of research and innovation as critically important elements of national development. Therefore, the process of mapping Research Infrastructures and developing RI Roadmap is an important element of the process of preparing the S3 and is the basis for the preparation of future activities of the instruments in this field.

### 3. PARTICIPATION OF NORTH MACEDONIA IN EU RESEARCH PROGRAMMES

North Macedonia has been participating in the EU Framework Programme for Research, Technology Development and Innovation for many years, since FP4-INCO COPERNICUS programme (1994-1998). According to the data from March 2021, organisations from North Macedonia have submitted 853 proposals within H2020, of which 705 were eligible and 79 were funded. This corresponds to an average success rate of 11.63 percent, compared to 13.44 percent of other associated economies. Organisations from North Macedonia have received 12.95 million euros of EC contribution. The most successful organisations in H2020 programme are: Ss. Cyril and Methodius University in Skopje (23 projects), City of Skopje (5 projects), Economic Chamber of North Macedonia (5 projects), Institute of Public Health of North Macedonia (5 projects) and Macedonian Academic and Research Network (5 projects).

The key strengths of North Macedonia in Horizon 2020 are in the fields of Energy and Health. In relation to the total number of H2020 projects, a considerable number of projects were implemented within the thematic priority "Research infrastructures" (Table 1).

*Table 1: North Macedonia in H2020: Participation and net EU contribution per priority area*

	Participation	EC contribution (EUR)
Secure, clean and efficient energy	22	3.04 mil.
Research infrastructures	15	1.66 mil.
Innovation in SMEs	14	899.14k
Health, demographic change and wellbeing	8	1.43 mil.
Information and Communication Technologies	8	1.35 mil.
Food security, sustainable and forestry, marine and maritime and inland water research	7	769.51k
Europe in a changing world - inclusive, innovative and reflective societies	7	817.23k
Climate action, environment, resource efficiency and raw materials	6	1.28 mil.
Marie Skłodowska-Curie actions	4	277.80k
Integrate society in science and innovation	3	632.45k
Make scientific and technological careers attractive for young people	3	164.97k
Secure societies - Protecting freedom and security of Europe and its citizens	2	105.25k
Smart, green and integrated transport	2	117.58k
Advanced manufacturing and processing	1	221.23k
Space	1	0
Biotechnology	1	181.5k
Transnational networks of National Contact Points	1	39.19k
Twinning of research institutions	1	238.7k

Source: Own calculations based on: <http://cordis.europa.eu>

As regards North Macedonia participation in FP7, the total of 105 institutions participated in the programme as part of 89 projects approved for financing. The total project budget (EC contribution) was 11.93 million euros.

## 4. ANALYSIS OF THE EXISTING RESEARCH INFRASTRUCTURES IN NORTH MACEDONIA

The questionnaire for providing data on research infrastructures was sent by the Ministry of Education and Science to all relevant research institutions in North Macedonia in December 2020. Questionnaires were completed at the level of research laboratories and institutes operating within the public faculties and private universities. The response rate was at a very satisfactory level as most research institutions responded to the call. As expected, the largest number of answers came from the Ss. Cyril and Methodius University in Skopje since it is the most important University in the economy. Chapter 4.1 provides an overview of the research infrastructures based on the completed questionnaires.

### 4.1. Overview of research infrastructures

Despite the fact that universities in North Macedonia are mostly focused on education, there is evidence of their engagement in research activities, predominantly of public universities. Out of a total of 70 research laboratories / institutes that responded to the questionnaire, 20 own single capital research equipment worth over 50,000 euros. With regards to the public universities, capital research equipment is mainly located at the Ss. Cyril and Methodius University in Skopje. The Institute for Advanced Composites and Robotics in Prilep is the only private research institution that owns single capital research equipment worth over 50,000 euros. The total purchase value of all evidenced capital research equipment (worth over 50.000 euro) is estimated at around 15 million euros (Table 2). However, it should be noted that the current value of the equipment is significantly lower taking into account the depreciation. The full list of research capital equipment is presented in Appendix 1.

The average age of research equipment is 9 years. The most common sources of funds for the purchase of equipment include Ministry of Education and Science, international donations and own funds.

**Table 2: General overview of the state of capital research equipment within research institutions in North Macedonia**

Universities/scientific institutions	Number of research laboratories/ institutes that completed the questionnaire	Number of research laboratories/ institutes with equipment relevant to the roadmap	Total purchase value of capital research equipment*
Ss. Cyril and Methodius University in Skopje	44	15	10.200.000
St Kliment Ohridski University - Bitola	9	1	600.000
Goce Delchev University	3	3	2.950.000
Mother Teresa University, Skopje	4	0	/
University of Tetova	1	0	/
Macedonian Academy of Sciences and Arts	1	0	/
Institute for Spiritual and Cultural Heritage of the Albanians, Skopje	1	0	/
Institute of Old Slavic Culture, Prilep	1	0	/
Institute for Advanced Composites and Robotics, Prilep	1	1	1.200.000
Integrated Business Faculty	1	0	/
International Slavic University	1	0	/
South East European University	2	0	/
Business Academy Smilevski	1	0	/
University American College Skopje	Reported that they do not have research equipment		
International Vision University	Reported that they do not have research equipment		
Institute INAKU Skopje	Reported that they do not have research equipment		
International Balkan University	Reported that they do not have research equipment		
International University of Struga	Reported that they do not have research equipment		
University for Information Science and Technology "St. Paul the Apostle"	Reported that they do not have research equipment		
<b>Total</b>	<b>70</b>	<b>20</b>	<b>14.950.000</b>

*\*(includes only equipment which individual purchase value is at least 50,000 euros)*

*Source: ToE-Team of Experts, analysis of collected questionnaires*

The sub-sections below provide basic information on research institutions in which the greatest research potential and capital research equipment has been recorded. In addition, the information on the services provided by each research laboratory/institute is presented.

#### 4.1.1. Ss. Cyril and Methodius University of Skopje (UKIM)

The Ss. Cyril and Methodius University in Skopje is the first public University in North Macedonia, founded in 1949. It is the largest University in North Macedonia representing a functional community of 23 faculties, 5 research institutes, 4 public scientific institutions - associate members, 1 associate member - other higher education institution and 7 associate members - other organisations. The Ss. Cyril and Methodius University develops study programmes in all scientific fields – natural sciences and mathematics, technical and technological sciences, medical sciences and health, biotechnical sciences, social sciences, humanities and arts. Research activities are carried out within the faculties and independent research institutes that are an integral part of the University. Over 3.100 teaching, research, associate and administrative staff participates in the teaching and scientific process at the faculties and institutes.

##### Faculty of Technology and Metallurgy

##### Laboratory for Materials and Nanostructure Analysis

The Laboratory for Materials and Nanostructure Analysis performs testing and characterisation for structural and morphological analysis of all type of materials (inorganic: metals, ceramics, composites and organic: polymers, fibres, foods, pharmaceutical compounds, natural components). The Lab also conducts analysis of organic food and biodegradable compounds since it is able to work under low vacuum and scan organic compounds.

Services provided include morphological analysis of stomic level of metals, plastics, ceramics, and all other materials; chemical composition of the scanned surfaces; calorimetric (energy) value of oils, foods, plastics; Raman - structural analysis of all type of materials; thermal analysis (thermal degradation, crystallisation and melting ) of all types of materials.

The Laboratory has capital research equipment worth over 50.000 euro. A total estimated value of research capital equipment is 304.000 euro (purchase value was 379.000 euro). The list of individual capital research equipment is provided in Appendix 1.

##### Laboratory for Food Technology and Biotechnology

Food Technology and Biotechnology Laboratory is primarily used for educational activities. It is constructed to do both research (national, regional, European and international projects) as well as routine quality control of new and innovative food processes, traditional food processes, food and biotechnological products, etc.

Services provided include analysis of products (physicochemical and microbiological properties); microscoping of products; interpretation and discussion of results and statistical evaluation and correlation of results.

Research equipment: regarding capital research equipment, the Laboratory owns High performance liquid chromatography (HPLC) whose purchase price was 53.000 euros. The future

investments in research equipment include GC with electronic nose; fluorescent microscope; rheometer and smaller laboratory equipment.

### Polymer processing lab

Polymer processing lab is a new facility established in 2021. It owns research infrastructure that is based on processing and preparative facilities mainly for polymer processing and composite materials. The main objectives are to provide fast processing and preparation of different polymer base formulations for wide spectrum of application.

Services provided: The users are all employees of the Faculty of Technology and Metallurgy and students of the polymer materials science programme. The intention is to increase the number of infrastructure users from industry who need fast preparation of different formulations and their testing.

Research equipment: The Lab is equipped with research instruments. The funds for purchase of equipment were provided by SPS NATO Science for Peace. The following research equipment was procured: Electrospinning machine, Flat and drum collectors and Coaxial electrospinning (total of 22.000 euro); Extruder (40.000 euro); Ultrasonic processor (5.000 euro) and Spin Coater (2.200 euro).

### Textile Research Laboratory

Textile Laboratory was established in 2012 at the Faculty of Technology and Metallurgy. The main objective of the laboratory is to conduct research activities and provide services for the textile industry and product development. Additionally, it is engaged in research projects with industry and works on joint projects with other universities or entities in the region and beyond.

Services provided: quantitative chemical analysis; test for colour fastness; measurement of surface colour; determination of pH of aqueous extract; determination of dimensional change in washing and drying; woven and knitted fabrics - construction - methods of analysis; determination of fabric propensity to surface fuzzing and to pilling; determination of the abrasion resistance of fabrics by the Martindale method; tensile properties of fabrics; seam tensile properties of fabrics and made-up textile articles; determination of the slippage resistance of yarns at a seam in woven fabrics; tear properties of fabrics; determination of the permeability of fabrics to air; fabric sewability; etc.

The research equipment was purchased in the framework of the project implemented by the Ministry of Education and Science in 2010. The total purchase value of procured research equipment was 156.000 euro. (The current value is estimated at 78.000 euro).

In addition to the mentioned research laboratories, the Faculty of Technology and Metallurgy also owns the following research equipment with no value attributed:

- ◆ Atomic Absorption Spectroscopy - is a spectroanalytical procedure for the quantitative determination of chemical elements using the absorption of optical radiation (light) by free atoms in the gaseous state. Atomic absorption spectroscopy is based on absorption of light by free metallic ions.

- ◆ High Current Potentiostat-Galvanostat - This equipment is fundamental to modern electrochemical studies using three electrode systems for investigations of reaction mechanisms related to redox chemistry and other chemical phenomena.
- ◆ High Temperature Electrochemical Reactor - Performing electrochemical experiments in Molten salts.

With regards to polymer chemistry and physics, polymer technology and polymer composites, the Faculty is providing the following services:

- ◆ Laser ablation of polymers and polymer nanocomposites
- ◆ UV/VIS Spectroscopy measurements of polymers and polymer composites
- ◆ Contact angle measurements of polymers and polymer nanocomposites
- ◆ Mechanical testing of polymers
- ◆ Conductivity measurement of polymers and polymer nanocomposites
- ◆ Sensor measurement of polymers and polymer nanocomposites

These services are provided by using the following research instruments:

1. IR CO2 Laser, LADEC LTD
2. UV/VIS Spectrophotometer
3. Instrument for contact angle measurements
4. Instrument for mechanical testing of polymers
5. Conductivity measurement device (Four probe resistivity meter)
6. Instrument for sensor measurement (Quartz crystal microbalance).

### Faculty of Computer Science and Engineering (FCSE)

Faculty of Computer Science and Engineering (FCSE, UKIM) is the largest e-Infrastructure provider in the economy. Through participation in many international e-Infrastructure projects and membership in the large pan-European research infrastructures, the FCSE has developed a strong technical and human potential to support the academic and research communities, as well as other user communities such as ministries, public sector and the industry and offers relevant services to them. FCSE is the member of the following Large RIs:

- ◆ EGI Federation
- ◆ EuroHPC
- ◆ EOSC Association



FCSE has been engaged in several ongoing and closed European projects aimed at development of research infrastructure:

- ◆ EGI-ACE: Advanced computing for research
- ◆ NI4OS-Europe: National Initiatives for Open Science in Europe
- ◆ VI-SEEM: VRE for regional Interdisciplinary communities in Southeast Europe and the Eastern Mediterranean
- ◆ European Grid Initiative: Integrated Sustainable Pan-European Infrastructure for Researchers in Europe: EGI-INSPIRE
- ◆ EUROCC - National Competence Centres in the framework of EuroHPC
- ◆ GN4-3: H2020-SGA-INFRA-GEANT-2018 (Topic [a] Research and Education Networking)
- ◆ GN4-2: Research and Education Networking – GÉANT
- ◆ GN4-1: Research and Education Networking – GÉANT
- ◆ HP-SEE (High-Performance Computing Infrastructure for South East Europe's Research Communities)
- ◆ SEE-GRID e-Infrastructure for Regional e-Science

### National centre for high performance computing and cloud

FCSE is a national centre for high performance computing and cloud. Services provided include:

- National top level eduoam servers
- National AAI federation, member of eduGAIN
- FINKI cloud service, service onboarded to EOSC
- High performance computing
- GPGPU computing
- Trainings regarding usage of HPC/Cloud/HPDA/AI
- National centre for HPC and cloud computing
- First academic CIRT <https://cirt.finki.ukim.mk>
- National Internet Exchange <https://ixp.mk/>
- Repository of scientific publications and scientific data

Research equipment: FCSE has capital research equipment worth over 50.000 euro. A total estimated value of research capital equipment is over 1 mil EUR (purchase value was more than 3.6 mil EUR). Most important capital research equipment include: HPC cluster; Cloud cluster; GPGPU cluster; IPX (Internet Exchange) and Airpointer Recordum – MLU Austria.

The overall e-infrastructure of the FCSE, UKIM is based on

- HPC cluster (1000 CPU cores, 2TB memory, InfiniBand QDR interconnection)

- GPGPU cluster (27648 GPU cores, 3456 tensor cores, 432 RT cores, 192 GB GPU memory)
- Cloud cluster (384 CPU cores, 1.5 TB memory, 24TB SSD storage, 144TB HDD storage)
- Servers ( >1200 CPU cores, >3TB memory)
- Storage (290TB HDD, 230TB SSD)
- Optical network of the UKIM, spanning 30km in the city of Skopje

Airpointer Recordum–MLU Austria is used to monitor ambient air quality. Students use the collected data (together with the data from MOEPP) for prediction and visualisation of air pollution in certain places and cities. More information on individual capital research equipment worth over 50,000 euros is provided in Appendix 1. Future investments in research equipment include purchase of larger GPGPU cluster and larger Storage and long-term archiving systems.

Regarding the potential membership in pan-European research infrastructures, FCSE is interested in becoming a member of PRACE (Partnership for Advanced Computing in Europe).

## Faculty of Electrical Engineering and Information Technologies (FEEIT)

### Laboratory for Electrical Measurements

The Laboratory for Electrical Measurements is the only national reference laboratory for calibration of reference standards for electrical energy and power, providing measurement traceability and unity of measurements in this segment of legal metrology. The vision of the Laboratory is to be a top scientific metrology laboratory in the field of electromagnetic quantities with a level of scientific and metrology precision that will provide domestic, regional and international recognition. The Laboratory performs calibrations and tests according to national and international standards and regulations, using cutting edge scientific methods and equipment and applying the best laboratory practice, while responding to the needs and requirements of the users, and thus providing a continuous chain of measuring traceability in the field of electromagnetic quantities in the metrological infrastructure of North Macedonia and beyond.

Services offered: Calibration of the instruments and generators for direct and alternating voltages and currents, resistance, capacitance, frequency and phase angle; calibration of reference standards and instruments for electrical energy and power; various testing in the field of electrical engineering and metrology of electrical quantities.

Research equipment: The total estimated value of capital research equipment is 120.000 EUR (purchase value was 165.000 euro). Most important research instruments include: Digit Multimeter Agilent, Multi-Product Calibrator, Three phase comparator, Multifunction Mobile Calibrator, etc.

### Laboratory for detection of irradiated food

The Laboratory for detection of irradiated food was established in 2018 at the Faculty of Electrical Engineering and Information Technologies. The Laboratory performs detection of irradiated food as part of the governmental monitoring programme.

Services offered: Detection of foodstuffs irradiated by: gamma rays from C0-60 and Cs-137, X-rays with energy of maximum 5 MeV and electron beams with energy of maximum 10 MeV.

Research equipment: The Laboratory is equipped for testing and characterisation of irradiated materials by optically stimulated luminescence and thermoluminescence methods. The current value of research equipment is estimated at 23.000 euros.

### Physics Laboratory

The Physics Laboratory is used by the physics students for practical exercises and demonstration experiments. Besides the education activities, the Laboratory is dedicated to foster collaboration with stakeholders, companies and official institutions in developing different application projects in the fields of materials physics, nuclear physics and its applications, application of ionised radiation, control of food treated with ionized radiation, deposition and studying of thin films for solar applications, design of PV and ST systems, study of renewable energy sources, etc.

Services provided: The Laboratory has instruments for precise measurements of lengths, instruments for determination of specific heat of solids, viscosity, air specific heat, efficiency coefficient of solar collector, focal length of thin lenses, photoelectric effect, Franck-Hertz experiment, electron diffraction, absorption of gamma rays with GM counter, band gap of Ge,  $\alpha$  и  $\beta$ -spectroscopy, refraction index of glass plate, polarimetry, refraction index of liquids and solutions with Abbe refractometer, diffraction on a compact disc, optically stimulated luminescence, optical characterisation with UV - Vis spectroscopy, as well as 10 personal computers and software for simulations in LabVIEW, CrystalMaker, Lumerical Software Solutions and Unity3D.

Research equipment: The Physics Laboratory has capital research equipment worth over 50.000 euro. A total estimated value of research capital equipment is 25.000 euros (purchase value was 290.000 euros). The list of individual capital research equipment worth over 50.000 euros is provided in Appendix 1. The equipment is used in the educational, scientific and research activities, for preparation of master's and doctoral theses in a number of different areas of application of ionizing radiation and material characterisation.

Future investments in research equipment include upgrading of research infrastructure with additional equipment in order to extend the scope of application of the current equipment and maintenance and renewal of the existing equipment.

### Laboratory for Wireless and Mobile Networks

The research activities performed within the Laboratory for Wireless and Mobile Networks are focused on theoretical and prototype and system development in the area of wireless communications such as: Cognitive Radio, Dynamic Spectrum Access, Radio Network Virtualisation, Edge Computing, Signal Processing and Information, Theory for Wireless Networks, Wireless Sensor Networks and e-Health. The Laboratory has been equipped solely by funding provided in the framework of research projects (EU, NATO, bilateral, and Telecom).

Services provided: The Laboratory has no direct infrastructure users. The outputs of the research activities are used by the Faculty/University for dissemination and visibility purposes, as well as networking and collaborations in the area of wireless communications.

Research equipment: The Laboratory owns capital research equipment worth over 50.000 euro. A total estimated value of research capital equipment is 150.000 euros (purchase value was more than 1 mil euros). The list of individual capital research equipment worth over 50.000 euros is provided in Appendix 1.

### Institute of Electrical Machines, Transformers and Apparatuses

The Institute of Electrical Machines, Transformers and Apparatuses is conducting testing of small and special electrical machines, as well as testing of small motors supplied and controlled via power converters.

The Laboratory is providing testing on all electric machines. Most of them can be tested in motor as well as in generator working mode. The testing is primarily intended for students and is performed on existing equipment such as: Lab-Volt (Canada) and TQ (UK).

Research equipment: The Laboratory does not have capital research equipment of high value. The total value of research instruments is estimated at 15.000 euros and it is mainly intended for students.

### Power Markets Laboratory

Power Markets Laboratory is operating under the umbrella of the Institute of Power Transmission Systems at the FEEIT in Skopje. It is established to support the educational, scientific and research activities in power systems at FEEIT, as well as the needs of the power engineering companies and public institutions.

Services provided: The Laboratory is mainly used for teaching classes and laboratory exercises for power markets and power systems related subjects. The software is used for the research needs of the staff and for specific lab exercises performed by students. Additionally, depending on the needs, some software solutions are used by master students.

Research equipment: The Laboratory possesses research equipment of small value. The research equipment and software were provided by the TEMPUS – CEFES Project.

### Automation and System Engineering Laboratory

The Automation and System Engineering Laboratory provides educational, scientific, research and application opportunities for research staff, students and external partners.

The Laboratory activities include: control system theory, modelling and simulation, industrial production automation, programmable logic controllers, SCADA systems, distributed control systems, industrial robotics, mobile robotics, machine learning and artificial intelligence, fuzzy logic control, etc.

The Laboratory had an opportunity to join the international SiNano consortium (European Academic and Scientific Association for Nanoelectronics) which has not been still utilised due to financial reasons (relatively large entrance and membership fees).

Research equipment: The Laboratory does not have capital research equipment of high value. The total estimated value of small research instruments is about 28.000 euros.

### Centre for Technology Transfer and Innovations

The Centre for Technology Transfer and Innovations (INNOFEIT) was established at the Faculty of Electrical Engineering and Information Technologies as a result of the need for more tight cooperation between the academia and the industry. The main idea was to close the gap between academic education and practical expertise and prepare the students for better coping with the industrial challenges ahead. INNOFEIT is a hub for interaction among FEEIT staff, FEEIT students and industrial partners that will foster connections and transfer of technology as well as novel innovative ideas that will aid the economic growth of the sector and the society in general. INNOFEIT is currently an important cornerstone in the Macedonian innovation ecosystem, a co-founder of the Accelerator UKIM and a selected candidate by European Investment Bank (EIB) to become a Centre-of-Excellence in its fields of interest. INNOFEIT offers a plethora of tailor-made services for companies that have a vision to do R&D and invest in innovative solutions increasing their value and having a broader impact. These include:

- ◆ Match-making of highly skilled scientists with entrepreneurs
- ◆ Contract research and solving practical problems in product development
- ◆ Collaborative research on novel and innovative ideas
- ◆ Access to state-of-the-art FEEIT laboratories (2M euros worth)
- ◆ Co-working space

INNOFEIT operates in refurbished state-of-the-art premises equipped with all necessary utensils for its normal day-to-day operation. It also has an excellent network of local and regional companies such as pre-seed and seed investment funds, accounting offices, business angels and freelancers ready to at any time assist the start-ups coming from FEEIT. INNOFEIT offers them:

- ◆ Pre-incubation
- ◆ Access to FEEIT laboratories
- ◆ Mentoring and coaching
- ◆ Access to finance and market through partner network

## Faculty of Mechanical Engineering

### Laboratory for calibration of force and torque

The Laboratory for calibration of force and torque is a modern, internationally recognised laboratory for testing and calibration. It is a part of an international network of calibration laboratories in Europe and worldwide. The laboratory performs calibration of force and torque measuring devices.

Services provided: The Laboratory provides calibration of torque wrenches; calibration of force measuring devices; calibration of press and material testing machines and calibration of other devices.

Research equipment: The total estimated value of research capital equipment is 70.000 euro (purchase value was 220.000 euro). It does not have single capital research equipment worth over 50.000 euros.

### Laboratory for testing mechanical properties, machines and vehicles

The Laboratory for testing mechanical properties, machines and vehicles is part of an international network of testing laboratories in Europe and worldwide. The laboratory performs testing of mechanical properties, machines and vehicles by using standard methods.

Services provided: The Laboratory is providing testing of mechanical properties; machine testing and vehicle testing.

Research equipment: The total estimated value of research capital equipment is 50.000 euro (purchase value was 180.000 euro). It does not have single capital research equipment worth over 50.000 euros.

## Faculty of Natural Sciences and Mathematics

### Institute of Chemistry

The Institute of Chemistry is conducting analytical chemistry applications in natural products, food and environmental chemistry. The key research capital equipment include gas chromatography (GC/FID/ECD; GCxGC/TOF-MS; GC/MS) and liquid chromatography (HPLC/DAD/MS). Both gas and liquid chromatography are complementary separation, identification and quantification techniques, the former being used for volatile compounds and the latter for all other soluble analytes and samples.

Services provided: Identification and quantification of specified organic compounds mainly from the European priority list of interest in various air, soil and water samples:

- Gas chromatographic separation with various detectors (mass spectrometer, flame ionization and electron capture detector) can be used for identification and quantification

of: volatile and semi-volatile compounds in the environment, pharmaceutical products, food packaging, etc.; pesticides, persistent organic compounds and endocrine disruptors in environmental and food samples.

- Liquid chromatographic separations using UV-Vis and mass spectrometric detectors can be used for identification and quantification of: phenolic components in food of plant origin, wines, medicinal plants, honey etc.; active compounds and impurities in pharmaceutical preparations; various pollutants, persistent organic compounds and endocrine disruptors in environmental samples; drugs, explosives and other compounds of interest in forensic samples, etc.

The infrastructure is mainly used by the researchers and educators from the Institute of Chemistry. The RI has not been used by external personnel.

Research equipment: The total purchase value of capital research equipment of the Institute is estimated at 466.000 euro. However, most of research equipment was procured more than 10 years ago. The total list of capital research equipment is listed in Appendix 1.

## Faculty of Medicine

### Institute for Immunobiology and Human Genetics

The Institute for Immunobiology and Human Genetics is engaged in basic and clinical research in immunology, genetics and immunogenetics. It is involved in population genetics studies and research regarding transplantation of solid organs and hematopoietic stem cells.

Services provided: The Institute is conducting the following research activities: molecular techniques, starting with DNA and RNA automated isolation and storage, PCR and RT-PCR amplification, hybridisation, DNA sequencing using capillary electrophoresis and DNA sequencing using NGS technology. It also uses several automated analysers for quantitative measurement of specific proteins, such as nephelometry, FLASH CLIA, FEIA and classic ELISA.

Research equipment: The Institute has single capital research equipment worth over 50.000 euro. The total value of capital research equipment of the Institute is estimated at 200.000 euro (purchase valued was 500.000 euro). Further development of genetic research and introduction of cell cultures is planned for the next 2-3 years. The single capital research equipment is listed in Appendix 1.

### Institute of Pathology

The Institute of Pathology offers specialised equipment for conducting basic research in the field of clinical pathology. Its partners and customers include universities, hospitals, public health institutions and pharmaceutical companies. The Institute facilities include 6 fully automated and equipped laboratories used for clinical utility and basic and clinical scientific research purposes.

Services offered: The Institute has been established in 1947 and keeps large amount of archival material - paraffin blocks and histoslides from that period. For more than 20 years it has been



hosting frozen section bank of tissues. All this material is available through the electronic database of pathological reports founded in 1990 and can be accessed with a written consent from the Head of the Institute of Pathology.

Research equipment: The Institute has single capital research equipment worth over 50.000 euro. The total value of capital research equipment of the Institute is estimated at 100.000 euro (purchase valued was 1.2 mil euro). The future investments are related to renewal of the existing equipment with next generation technologies as well as development of virtual microscopy and virtual 3D microscopy. The single capital research equipment is listed in Appendix 1.

### Institute of Microbiology and Parasitology

The Institute of Microbiology and Parasitology is mainly engaged in microbiological analysis of: upper and lower respiratory tract samples and adjacent localisations; analysis of genital tract, urine, samples of intestinal parasites, blood culture, aerobic and anaerobic culture with automated Bact/Alert system, faecal samples for bacterial pathogens; samples from skin, wounds, abscesses, tissues, biopsies, etc. The Institute cooperates with many microbiological laboratories in North Macedonia and the region. It plans to achieve higher level of cooperation with accessible and proven laboratories from abroad.

Services offered: The actual opportunities for developing scientific research at the Institute are limited at the moment. It provides laboratory space, some equipment, appropriate reagents, but of rather small-scale. The Institute is working on expanding the space for molecular research aiming to be much more engaged for scientific purposes in future.

Research equipment: The Institute does not have single capital research equipment worth over 50.000 euro. It owns standard research equipment and instrumentation of small value.

### Institute of Medical and Experimental Biochemistry

The Institute offers specialised equipment for conducting life science research and clinical research studies. It is continually included in several programmes for External Quality Assessment Schemes (EQAS), which provide an independent and confidential external assessment of laboratory performance. It is the first public health institution in North Macedonia included in the EQAS for virus immunology- SARS-CoV-2 antibodies. A certificate was obtained in November 2020.

Research equipment: The Institute does not have single capital research equipment worth over 50.000 euro. However, it is equipped with fully automated biochemical and immunological analysers which provide laboratory service, not only for clinical utility, but for basic and clinical scientific research purposes: analysers based on photometry; biochemical analysers based on ELISA technique<sup>1</sup>; immunological analysers based on CLIA and ELFA techniques; haematological analyser; electrolyte analyser based on ISE technique; horizontal system for electrophoresis for separation of serum and urine proteins; system for vertical electrophoresis for separation of serum proteins and urine analyses (microscopic and macroscopic).



## Institute of forensic medicine, criminalistics and medical deontology

As part of the Institute of forensic medicine, criminalistics and medical deontology, three Laboratories have been identified as relevant for research infrastructures: Forensic Toxicology Laboratory, Genetic Laboratory and Laboratory for Patohistology.

- The Forensic Toxicology Laboratory is conducting toxicological analyses. It has two screening instruments and 5 chromatographs. The main objective of the laboratory is to use validated methods for all applicative work as well as for development of new analytical methods for applicative and scientific purposes.
- Genetic Laboratory was established in 2004. Its main activities include DNA typing from forensic cases (identifications, rape cases, homicides, etc.), kinship testing, and molecular detection of SARS-CoV-2. Research activities covered by the laboratory include various types of population genetic studies (STR and mitochondrial DNA markers), gene expression analyses and differential tissue and body fluids methylation detection.
- The Laboratory for Patohistology was established in 1980. Its main activities include patohistological analysis of human tissues.

Research equipment: The Institute owns capital research equipment of high value. The total purchase value of research equipment exceeds 2 mil euros.

## Faculty of Pharmacy

### Centre for Biomolecular Pharmaceutical Analyses

The Centre for Biomolecular Pharmaceutical Analyses performs basic, applied and developmental research of biomolecules which can be applied in modern therapy of the most common diseases. The Centre was established in 2008. The Centre consists of four laboratories. The laboratories are designed in accordance with the standards for molecular-diagnostic activity, comprising: a sample preparation laboratory (pre-PCR room), a laboratory for preparation of analyses (master mix room), a laboratory for analysis of PCR products (post-PCR room) and a laboratory for analysis of cell cultures.

The Centre activities include scientific and research activity in the field of Molecular Oncology and Pharmacogenetics; educational activity – postgraduate educational training for professionals for the needs of molecular diagnostics laboratories; applicative activity –personalised medicine: molecular characterisation of malignant diseases, inherited predisposition to malignant diseases, rationalisation of the therapy with pharmacogenetic analyses, monitoring of minimal residual disease; etc.

Services provided include:

- ◆ Haematology - Qualitative analyses, detection of predictive single-nucleotide mutations and cytogenetic abnormalities; Quantitative analyses, monitoring of minimal residual disease

- ◆ Solid tumours - predictive and prognostic markers
- ◆ Hereditary syndromes - Molecular characterisation
- ◆ Next generation sequencing
- ◆ Pharmacogenetics analysis, genotyping of genes included in drug metabolism
- ◆ Microorganisms - Quantitative analyses

Research equipment: With regards to capital research equipment, the Centre was equipped with Applied Biosystems™ 3500 Series Genetic Analyser in 2012 (purchase value was 120.000 euro). It is also equipped with research instruments of small value.

### Centre for Natural Products

The Centre for Natural Products was established in 2009 within the Faculty of Pharmacy in Skopje. The Centre for Natural Products provides services in the field of natural products (Pharmacognosy, Phytochemistry and Phytotherapy), expert opinions and consulting services, and drafts expert reports, methodological procedures and laboratory analyses. It is an accredited laboratory with quality system implemented according to the ISO17025 standard.

The following analyses and services are performed within the Centre: determination of ash, foreign matter, stomatal index, swelling index, water in essential oils, fatty acids in essential oils, etc.; organoleptic essential oil testing; examination of plant material (PH. EUR.); GC/MS analysis of cannabis and different cannabis products; HPLC sample analysis; spectrophotometric analysis of the sample; identification of herbal substances and herbal remedies; etc.

Research equipment: With regards to capital research equipment, the Centre owns the following instruments: Agilent 7890A Gas Chromatograph coupled to an Agilent 5975C Quadrupole Mass Detector, Shimadzu AOC 5000 Plus Headspace autosampler and Agilent 1200 Series HPLC System. Own funds were used to procure this equipment was in 2006 and 2007.

### Centre for Drug Quality Control

The Centre for Drug Quality Control conducts laboratory (pharmaceutical-chemical) tests of pharmaceuticals. The Centre conducts tests in self-contained, competent, independent and impartial manner in compliance with monographs of current pharmacopeias, validated methods suggested by manufacturers and in accordance with the national and international standards and applicable regulations.

Services provided: Development and validation of analytical methods for quality control of pharmaceutical active substances and finished pharmaceutical products.

Research equipment: The Centre has capital research equipment of total estimated value of 325.000 euro. The list of single research equipment worth over 50.000 euros is provided in Appendix 1.

## Faculty of Agricultural Sciences and Food

The Faculty of Agricultural Sciences and Food (FASF) conducts scientific, developmental and applied professional research, including its application in practice, and implements scientific research projects of wider international interest. The Faculty cooperates with a number of companies from agri-food sector in North Macedonia. At present, FASF consists of six internal organisational units: Plant Biotechnology Institute, Animal Biotechnology Institute, Food Institute, Environment Institute, Environmental Protection Institute and Agroecconomics Institute. Each of the institutes consists of a number of smaller organisational units - departments and laboratories (accredited and non-accredited). The most relevant laboratories with regards to research infrastructures are:

- ◆ Animal Feed Analysis Laboratory
- ◆ Soil and Fertilisers Analysis Laboratory
- ◆ Milk and Dairy Products Laboratory
- ◆ Tobacco and Tobacco Products Laboratory

Services offered: The laboratories perform sample testing - testing of samples submitted by inspection bodies, legal entities and individuals. Animal Feed Analysis Laboratory is conducting analysis of: moisture, ash, protein, fat, fibre, impurities, hectolitre weight, calcium, chlorides, pH in silage, volatile fatty acids in silage, ammonia nitrogen in silage, total aflatoxins in grain and animal feed.

Research equipment: The Faculty does not have single capital research equipment of high value. However, it has research instruments of smaller value (from 600 to 12000 euro) such as: Analytical balance (Mettler Toledo AB-204-S), Electric laboratory dryer (Memert Germany UM 400); Muffle oven (Linn Elektrotherm LM 312-06); Nitrogen combustion apparatus (Gerhardt TT12 A); pH meter (Inolab); Thermometer (Testo AG 925); Elisa reader (Stat – Fax); Spektrofotometar Cary, Janway PFP7- Flame photometer, etc.

## Faculty of Design and Technologies of Furniture and Interior

### Furniture Testing Laboratory

The Furniture and Interior Testing Laboratory was equipped in 2010. Furniture testing protects the end users from unwanted injuries and deformations of the human body. Testing of windows and doors leads to protection against unnecessary energy loss in the facilities. The trained team, sophisticated equipment and continuous quality control offer tangible results for tested units.

Services offered: The Laboratory tests the following products: windows; facade systems; interior doors; breaking windows and doors; chairs; desks and tables; mattresses and beds; school furniture; opening systems; corporate furniture; parquet floors and other tests.

Research equipment: The Faculty has capital research equipment of high value. The total purchase value of the research equipment was 392.000 euro. However, the equipment is obsolete.

## Faculty of Civil Engineering

### Materials Testing Laboratory

The Materials Testing Laboratory, as an integral part of the Faculty of Civil Engineering in Skopje, is engaged in educational activities and provides services to external clients. The facilities and the equipment are mainly used in the teaching process. However, it is also utilised for research purposes within domestic and international scientific projects.

Services offered: The Laboratory tests physical and mechanical properties of the engineering materials, such as: concrete, steel, bricks and tiles, rock and soil material, asphalt and bituminous products. The Laboratory is also conducting in-situ tests on engineering structures and structural elements such as: buildings, bridges, roads, dams, etc.

Research equipment: The current value of research equipment is estimated at 50.000 euro. The Faculty is looking for donations and financial support to renew its research infrastructure. The own funds for investments in research infrastructure are limited and are primarily used to maintain the infrastructure operational for educational purposes.

## Faculty of Law Iustinianus Primus

### Centre for Legal Clinical Education for Vulnerable Groups

The Legal Clinic "Centre for Legal Clinical Education for Vulnerable Groups" is an internal organisational unit of the Faculty of Law "Iustinianus Primus" in Skopje providing legal clinical education. The Centre improves legal teaching method and provides practical knowledge and skills in the field of access to justice for vulnerable groups with focus on legal needs of vulnerable groups (Roma, LGBTI+, sex workers, prisoners and their families, persons in social risk, etc.) in field of social security, administrative procedures, rights of prisoners and consumer law.

Services offered: The main purpose and objectives of the Legal Clinic for Vulnerable Groups are attained through: organising continuous education (seminars, workshops, etc.) to improve practical knowledge and expertise of the students; provision of legal aid to vulnerable groups by developing information materials of research of their legal needs and working on specific cases; analysis of relevant court practice and that of administrative bodies; cooperation with CSOs active in the field of legal protection of marginalised groups.

### Centre for Legal Clinical Education in Criminal Law

The Legal Clinic "Centre for Legal Clinical Education in Criminal Law" is an internal organisational unit of the Faculty of Law "Iustinianus Primus" in Skopje providing legal clinical education. The Centre improves legal teaching method and provides practical knowledge and skills in the field of criminal procedure law and criminal substantive law for the students of Master's studies in Criminal Law at the Faculty.

Services offered: The main purpose and objectives of the Centre for Legal Clinical Education in Criminal Law are attained through: organising continuous education (seminars, workshops, etc.) to improve practical knowledge and expertise of the students of Master's studies in Criminal Law; conducting scientific, developmental and applied research in the field of criminal law; organising and conducting scientific and professional applied activities; publications in the field of criminal law; cooperation with domestic and foreign institutions, and higher education and scientific institutions, and other forms of international cooperation, independently and through the Faculty.

The Faculty does not have capital research equipment.

### Institute of Earthquake Engineering and Engineering Seismology

The Institute of Earthquake Engineering and Engineering Seismology is one of the oldest institutes established in 1965. The Institute has a long tradition in shake table testing, quasi-static testing, in-situ forced and ambient vibration testing. The Institute has three research laboratories: Dynamic Testing laboratory, Laboratory for Dynamics of Soil and Foundation and Laboratory for Non-destructive Testing.

Services offered:

- ◆ The Dynamic Testing Laboratory: Experimental shake table tests on physical models of buildings, historic and engineering structures; dynamic testing of materials, structural elements and joints; static and quasi-static cyclic testing of full-scale nodes, elements and joints for definition of their mechanical properties; experimental seismic shake table tests for seismic qualification of mechanical and electrical-mechanical equipment; research, development and practical application of systems for control of dynamic response and systems for passive dissipation of energy in structures exposed to earthquakes, wind and other dynamic effects; research, development and practical application of systems for seismic isolation and isolation of vibrations of structures exposed to earthquakes and vibrations caused by people, different technological processes and traffic; development of applicative software; in-situ testing by ambient vibration method of high rise structures, historic monuments, engineering and special structures for definition of dynamic characteristics – natural frequencies, mode shapes and damping coefficients; in-situ testing by forced vibration method of high rise structures, historic monuments, engineering and special structures for definition of dynamic characteristics – natural frequencies, mode shapes, damping coefficients and soil-structure interaction; monitoring and measuring of vibrations of equipment and machines in industrial structures and power plants, in non-operational and operational conditions; monitoring and measurement of vibrations of bridge structures in traffic conditions or another type of dynamic excitation in the surrounding; monitoring and measurement of vibrations of structures caused by human activities; seismic tests for qualification of different types of electrical equipment, mechanical equipment and non-structural elements.
- ◆ Laboratory for Dynamic Soil and Foundation: Scientifically based approach for evaluation of liquefaction occurrence potential; real simulation of soil materials in a laminar container; development of numerical models for analysis of stability of construction pits against static and dynamic loads, assessment of risk pertaining to landslides, analysis of water saturated

soil and different problems in the field of geotechnical – earthquake engineering; numerical simulation of multi-phase soil by use of own software; definition of strength-deformability moduli of soil specimens on direct shear apparatus; definition of seismic parameters for locations intended for construction of structures of the first category; definition of seismic potential of locations intended for construction of important structures; laboratory investigations of material curves obtained for specific locations; design and revision of more important structures pertaining to geotechnical-earthquake engineering; and analysis and solution of problems related to structural consolidation of structures.

- ◆ Laboratory for Non-destructive Tests: Monitoring of conditions, detection of damages to buildings, historic structures and monuments and measures for structural rehabilitation; diagnosis, repair, structural strengthening, reconstruction, rehabilitation, enlargements and built additional storeys on existing high rises; and analysis of high rise structures: elastic, static and seismic analysis, analysis of bearing and deformability capacity, nonlinear static analysis, nonlinear dynamic analyses for real earthquake records.

Research equipment: The Institute owns capital research equipment of total current estimated value of 3 mil euros. The single capital research equipment, at purchase price higher than 50.000 euros, is listed in Appendix 1.

### Institute of Animal Science

The main research activities of the Institute of Animal Science include: nutrition and dietetics of domestic animals as well as finding solutions to obtain animal products with improved qualities; control of herd booking and biodiversity of endemic and domestic animals; collaboration with the farmers as well as finding solutions to obtain animal products with improved qualities; research in the field of aquaculture, ichthyology and fish ecology.

Services offered: The Laboratory of the Department of Nutrition and Foodstuff Processing has a capacity for the following analysis: determination of moisture, crude proteins, crude fat, nitrogen, pH, NaCl titrimetric, some minerals such as Ca, P, Mg titrimetric, etc.

The Laboratory of the Department of Animal Husbandry has a capacity for the following analyses: determination of the chemical composition of milk (fats, proteins, lactose, non-fat dry matter, total dry matter, density); determination of added water in milk (cryoscopic method with freezing point); detection of antibiotics in milk; presence of alkaline phosphatase (reference method for determining the degree of pasteurisation of milk and dairy products with the help of Sharm Luminator), etc.

The research infrastructure users are: the Government of North Macedonia, Ministry of Agriculture, Forestry and Water Economy and Ministry of Environment and Physical Planning.

Research equipment: With regards to capital research equipment, the Institute has Milkoscan FT 6000 and Conveyor 4000 of total purchase value of 130.000 euros. However, the equipment is relatively obsolete - it was procured 20 years ago.

### Institute of Agriculture

Within its Laboratories, the Institute of Agriculture is performing the following research activities: analysis of wine and alcoholic beverages, analysis of grapes; analyses of soil, fertilisers and plant materials; analysis of seed:

- ◆ Various analyses of wine, alcoholic beverages and grapes are performed in the Laboratory. Analyses of specific gravity, density, alcoholic strength, extract, sugar, free and total SO<sub>2</sub>, pH, volatile and total acids are mainly performed in wine samples. Determination of intensity, colour, catechins, anthocyanins and total polyphenols and organic acids by spectrophotometric technic is also carried out in wine samples.
- ◆ The Laboratory for Soil Testing, Fertilisers and Plant Material carries out basic and complex analyses of soil, fertilisers and plant materials.
- ◆ The Seed Testing Laboratory is engaged in determination of seed purity, seed germination, 1000 kernel weight, seed moisture and content of other species seeds in pure seed.

Research equipment: The Institute does not have capital research equipment of high value. However, the laboratories are well equipped with research instruments of lower value:

- ◆ Seed Testing Laboratory owns the following equipment: temperature chamber (hot air oven) ST- 01/02; temperature chamber (seed germinator) Thermostable TNF 5; electronic non-automatic scale, EB-1200C and electronic non-automatic scale, BP 221S.
- ◆ Laboratory for Soil Testing, Fertilisers and Plant Material is equipped with sampling equipment (manual soil drill) and pocket GPS receivers and basic laboratory equipment (pH meter, flame photometry, spectrophotometry, drying oven, distiller, and analytical balances). Laboratory is continually engaged in national and international inter-laboratory as well as proficiency tests.

The existing equipment is out of date. In order to keep in line with the current trends, the Institute needs the following new equipment: EC metre; flame photometry; spectrophotometry; drying oven; kjeldahl digester; kjeldahl distiller; water distiller; total nitrogen; CHNS analyser; water bath; microwave digestion system; gas chromatographer with FID detector for determination of some parameters in beverages; and high performance liquid chromatographer for determination of some parameters in wine samples.

### Institute of Macedonian Language “Krste Misirkov”, Skopje

With regards to research infrastructure, the Institute of Macedonian Language “Krste Misirkov” comprises: a library centre (including several card index filing systems/collections - Macedonian lexicology, history of Macedonian language, Onomastics and Dialectology), informational and referral centre, basic research equipment, archive and publishing documentation and other resources that contribute to scientific work and research in the field of humanities.

The Institute contributes to the development of the science and Macedonian language in all of the linguistic levels, as well as in general linguistics and communicology; publishing scientific



literature in Macedonian Language, Linguistics and Communicology; and attributing to general development of the economy.

Services provided:

- ◆ Library services
- ◆ Consultation services to the students of the Institute as well as to the wider scientific community in North Macedonia and abroad
- ◆ Teaching and training services
- ◆ Organisation of public events and promotions

Research equipment: The Institute does not have any capital research equipment, only computers with basic configuration, printers/copiers and a few voice recorders. The Institute owns the library and the card index filing systems/collections which are considered invaluable national cultural heritage.

### **Institute of Macedonian Literature**

#### **Academic Library**

The library of the Institute of Macedonian Literature provides library material and information support to scientific researchers and students of the Institute, as well as scientific and higher education institutions within the St. Cyril and Methodius University in Skopje.

At present it holds a total of 7.403 monographs and 131 periodicals in the fields of literature and other fields of humanities. There are 140 own editions (100 monographs and 40 proceedings papers) of the Institute of Macedonian Literature in the Library and the authors are scientific researchers from the Institute. The Institute of Macedonian Literature in Skopje publishes three scientific journals "Spektar" (76 issues), "Context" (22 issues) and "Philological Studies" (18 issues with two volumes).

Services provided: The Library contains works of literary science and related scientific fields (language science, dramatic art, ethnology, philosophy, historical sciences, etc.), periodicals, doctoral dissertations, master's thesis, papers from scientific research projects, collections of scientific meetings and other types of library material (archival material, old manuscripts, facsimiles, etc.)

### **Institute of Folklore "Marko Cepenkov"**

The Institute of Folklore "Marko Cepenkov" is engaged in collecting and preserving local and national folklore and establishing academic relations with scientific institutions such as the Macedonian Academy of Sciences and Arts. The main aim is to broaden the spectrum of research topics that relate to the Macedonian folklore in comparison to the folklore of the Balkans and abroad.



The Institute has one of the richest archives in North Macedonia. A lot of materials in the forms of cassettes, videos, and old folk ornaments collected from field research are kept in the archive and the employees are currently working on making this data available to the general public by formatting them in digital form. Many materials in the archive have yet to get their well-deserved recognition. Field research in various locations throughout North Macedonia provided significant data which can be analysed nowadays and this data is unique and cannot be found in other similar institutions on the Balkans.

One of the goals of the Institute is to provide broader access to the collected data to researchers residing in North Macedonia and abroad.

### **Institute of National History**

The Institute of National History is a public scientific institution focused on the research of history of North Macedonia and the Balkans. Its field of work includes: knowledge-based resources, using archival documents, sources, data and information from available literature, field research, interviewing individuals, collecting photo documentation, etc.

The Institute cooperates and strengthens regional cooperation with institutions in the field of science and education. Recognising the importance of research infrastructures as necessary in the development of the knowledge triangle, composed of research, education and innovation, the Institute provides research on historical processes of North Macedonia and the Balkans as well as training for new historians through postgraduate and doctoral studies. The students have the opportunity to participate in open social debates through lectures, promotions, forums, interviews, etc. Through all these activities, the Institute contributes to the domestic and global scientific community.

The Institute's research infrastructure provides users with clear and publicly available guidelines and announcements that contain all relevant information on access processes (required documents, timelines, costs, rights and obligations arising from the access).

#### **4.1.2. Goce Delchev University**

##### **Faculty of Natural and Technical Sciences**

##### **AMBICON Research Group**

The AMBICON Lab is focused on the development of methodological base for ambient air monitoring and environmental analyses. AMBICON unites three scientific groups including ambient control and sampling group, electrons scanning microscopy group and elemental analysis group. Since 2014 the Lab is accredited in accordance with ISO 17025 for environment and samples from the environment testing areas.

Services offered: Standard gravimetric measurement method for the determination of the PM<sub>10</sub>/PM<sub>2,5</sub> mass concentration of suspended particulate matter; determination of chemical

composition of ambient particulate matter using Energy Dispersive X-Ray Fluorescence (EDXRF); direct on filter analyses of ambient air particulates mineralogy by X-ray diffractometer; particulate geometry/morphology and composition using Electron Scanning Microscopy equipped energy dispersive spectrometer (EDS); dual-wavelength transmissometer for determination of Black Carbon and Aromatic Organic Compounds in ambient particulates; personal exposure or background workplace concentration of different airborne chemical species using direct-reading instrumentation (electrochemical, PID, infrared sensor) or dosimetric tubes; thermal comfort and ventilation surveys and noise and vibration measurements and modelling including personal noise exposure (noise dosimetry).

Research equipment: The Lab has capital research equipment whose current value was estimated at 400.000 euro (the purchase value was 1.27 mil euros). It is fully equipped with all necessary instrumentation for ambient air sampling and analysis.

## Faculty of Agriculture

### UNILAB

As part of the Faculty of Agriculture this Lab is engaged in sophisticated agrochemical soil analysis, seeds, raw products, oils, wines. It is also equipped with sophisticated chemistry department for determination of macro, micro and trace elements in solids and liquid samples.

Services offered: The Lab is offering the following accredited services: soil quality - preliminary preparation of a soil sample for physical and chemical analysis (ISO 11464:2006); soil quality: dissolution to determine the total content of the elements-Part 1: Dilution with fluoride and per chloric acid (ISO 14869-1:2001(E)); water quality - application of inductively coupled mass spectrometry (ICP-MS) plasma - Part 2: Determination of 62 elements (EN ISO 17294-2:2009); soil quality determination of total nitrogen (ISO 11261:1995). In addition, over 40 methods for fertilisers, seeds, food and beverages testing are accredited and regularly offered as a service to external customers.

Research equipment: The Lab has capital research equipment whose current value was estimated at 400.000 euro (the purchase value was 780.000 euros). The list of single capital research equipment worth over 50.000 euros is provided in Appendix 1.

## Faculty of Medical Sciences

### Health Sciences Research Group

**The Laboratory for Radiopharmacy** is a unit of the Department for Pharmaceutical Chemistry at the Faculty of Medical Sciences. The research activities are directed at design, development and synthesis of new ligands, precursors and reference molecules and methods for labelling with radioactive isotopes intended for diagnostic, therapeutic purposes and basic research, covering all aspects of development of new drugs and medical products, research in the field of pharmacy,

medicine, biology, chemistry and related sciences, as well as preclinical and clinical trials of new and existing radiopharmaceuticals.

Services offered: introducing validated and accredited procedures for defining the structure and form of specific radiopharmaceuticals, and their quality control. The Laboratory for Radiopharmacy with its technical potential and personnel has been included in the first and second cycle study programmes. Its staff has been continuously educated through national and international programmes in the field of radiopharmacy and radiochemistry.

**The Laboratory for Dental Scientific Research** carries out scientific research, and educational and applied activities in several fields of dental science: restorative dentistry, dental prosthetics, dental laser therapy, oral surgery, orthodontics and dental implantology.

Services offered: The Laboratory is available to students as part of the teaching process. It is used in the process of preparing specialist topics in second cycle studies, master's thesis and doctoral dissertations, as well as by scientists who want to work on scientific research and scientific application projects in the field of dentistry and dental materials.

Research equipment: The Lab has capital research equipment whose current value was estimated at 200.000 euro (the purchase value was 900.000 euros). The list of single capital research equipment worth over 50.000 euros is provided in Appendix 1.

#### 4.1.3. St Kliment Ohridski University, Bitola

##### Veterinary Faculty

The following research activities have been conducted within the Laboratories operating at the Veterinary Faculty:

- ◆ Laboratory of Molecular Biology – Electrophoresis of DNA, RNA and Protein Samples; Gene expression analysis, Micro-array data validation, SNP-Genotyping, Pathogen detection, DNA methylation analysis, Chromatin immunoprecipitation studies.
- ◆ Milk Laboratory – Examination of: Fats, Proteins, Lactose and Total Dry matter of milk; Examination of: Individual Number of bacteria and Somatic Cells.
- ◆ Haematology Laboratory – Blood count, 22-parameters: FBC, Hb, WBC, Platelet count; Biochemical analyses of blood.
- ◆ Laboratory for Immunology/Serology Tests - antigen-antibody interaction as a diagnostic tool-enzyme-linked immunosorbent assay (ELISA).

Research equipment: The Faculty has capital research equipment. The total estimated value of research equipment is 105.000 euro (the purchase value was 229.000 euro). The research equipment was procured in 2011 as part of the project financed by the Ministry of Education and Science.

### Faculty of Biotechnical Sciences

Within the Faculty of Biotechnical Sciences research activities have been performed in the following laboratories:

- ◆ Laboratory for essential oil extraction from spice and medicinal plants and determination of biologically active substances. It is equipped with sophisticated equipment: FID and mass detector; FAST liquid chromatograph with Diode Array detector; HPLC system with Diode Array detectors post column derivatisation; Atomic Absorption Spectrometer; UV-VIS Spectrophotometer with Diode Array Detector.
- ◆ Practical Laboratory for Biology and Microbiology of animal products. It is equipped with microscopes and microscopic preparations, visual aids for examination of the structural organisation of living organisms and their diversity.
- ◆ Practical Laboratory for Chemistry, Biochemistry and Analytical Chemistry and Instrumental Methods for Control of Animals. It is equipped with basic laboratory equipment for conducting successful practical work as well as modern chemical and biochemical analysis equipment.
- ◆ Laboratory for Milk and Dairy Products. The Laboratory conducts research activities in the field of milk and dairy technology, milk and dairy products quality and safety and sensory analysis of dairy products. It is equipped with instruments for analysis of physical and chemical composition of milk and equipment for individual production of sour-milk products and processed food (cheese), at disposal to all students from all study programmes at the Faculty.
- ◆ Laboratory for Meat and Meat Products. The Laboratory conducts research activities in the field of meat technology and meat preparations and sensory analysis of meat products. It is equipped with instruments and devices for analysis of chemical composition of meat and equipment for individual production of meat preparations (sausages), at disposal to all students from all study programmes at the Faculty.

Research equipment: The laboratories were equipped in 2013 as part of the project implemented by the Ministry of Education and Science.

### Faculty of Tourism and Hospitality

Research activities of the Faculty of Tourism and Hospitality are conducted in the Laboratory of Gastronomical Research.

#### Laboratory of Gastronomical Research

The research infrastructure of the Gastronomy Laboratory is consisted of apparatuses with different purposes. The majority of appliances are used for professional food processing, storage, deep frosting and shock freezing of solid and liquid food. The Laboratory consists of modern kitchen and botanic greenhouse garden used for growing herbs and vegetables.

Services provided: The research infrastructure users can perform experiments for food invention and reinvention (for example introduction of traditional dishes in the gastronomic offer of the

region and the economy as a whole). It hosts masterclasses of distinguished and well known ecologists and technological engineers in the field of food and beverages industry.

Research equipment: The Faculty does not have capital research equipment. The total estimated value of research instruments used by the Laboratory is 55.000 euros.

### Scientific Tobacco Institute

Scientific Tobacco Institute is engaged in research activities in the field of biotechnology (tobacco breeding and other crops). The Institute is conducting the following activities: creation of new tobacco varieties, and preservation and improvement of the ones already registered; optimisation of agricultural practices; investigation of diseases, pests and weeds on tobacco; investigation of chemical composition of tobacco and tobacco products; investigation of post-harvest processes and processing of raw tobacco; investigations of economic problems in tobacco industry; soil investigations: fertility with fertilisation recommendations, pollution and irrigation water quality.

Services provided include: quality control of seeds from agricultural plants; quality control of soil, water, fertilisers and plant material; quality control of tobacco and tobacco products; control of authenticity and quality of tobacco raw material; control of plant health; etc.

Research equipment: The Institute does not have capital research equipment of high value. However, it is equipped with research instruments of smaller value: atomic absorption spectrometer, flame photometer, CEM microwave digestion system, spectrophotometers, Distillation unit, Kjeldhal Digestion units, automatic cigarette sorting scale, etc. The total value of research equipment is estimated at 180.000 euro (purchase value was 631.000 euro).

### The Public Scientific Institution: Hydrobiological Institute Ohrid

The Hydrobiological Institute in Ohrid (PSI HIO), established in 1935, is a public and governmental scientific and -research, and educational organisation of national interest. Today, PSI HIO is a modern scientific institution with an admirable number of scientists, organised into ten departments. It covers research subjects in limnology, reservoirs and rivers. Apart from its principal scientific research activity, PSI HIO has also been involved in educational activity. In this respect, it has successfully completed a cycle of postgraduate studies in Limnology, which produced the first Masters of Science in this field.

Services offered: Water quality monitoring - physical, chemical and biological parameters in open waters and drinking water supply systems; feasibility studies for environmental protection of freshwater ecosystems; fisheries management plans of lakes and rivers; biodiversity conservation studies; freshwater aquaculture studies and improvement programmes and fish stocking programmes of open freshwater bodies.

Research equipment: PSI HIO does not have single research equipment worth over 50.000 euros. However, it is equipped with research instruments such as: Kjeldahl instrument Velp (21.800 euros) used for the quantitative determination of nitrogen contained in organic substances plus the nitrogen contained in the inorganic compounds ammonia and ammonium in water and sediment samples and Spectroscopic multimeter S:can (18.000 euros) used for the analysis of

BOD, COD, BTX, TOC, DOC, Nitrate, Nitrite, TSS, Turbidity, etc. It is also equipped with the research instruments of smaller value:

- ◆ Stereo Microscope Zeiss (for observation and analysis of scales and parasites),
- ◆ Fluorescent microscope Zeiss (for analysis of bacteria),
- ◆ Light Microscope Zeiss (for observation and analysis of macrophytes),
- ◆ Inverted microscope Zeiss (for fish and fish parasites observation and analysis),
- ◆ DIC microscope Zeiss (for analysis of algae and diatoms),
- ◆ Microplate reader M965+ (for analysis of toxin and other metabolic products),
- ◆ Centrifuge DLAB (for sample preparation),
- ◆ Centrifuge DLAB hematocrite (for sample preparation of fish blood),
- ◆ van Veen grab Hydrobios (for bottom samples collection),
- ◆ Ruttner bottle Aquatic biotechnology (for sampling water),
- ◆ Ekman- Birge grab sampler Hydrobios (for sampling sediment for macrozoobenthos analysis).

### **PRI Institute of Old Slavic Culture – PRILEP**

Institute of Old Slavic Culture – PRILEP is a public research institution and an associate member of the St. Clement of Ohrid University in Bitola. It was founded in 1979 and has implemented a great number of research projects in the humanities, generally focused on the analysis of tangible and intangible cultural heritage from the Central Balkans. A great part of its research activities was focused on the research of the remains of past human activities in the area of Markovi Kuli Monument of Nature – Prilep. The Monument of Nature is managed by the Institute as provided by the law (Official Gazette of the Republic of Macedonia 49/06, p. 8-11).

Regarding the available research infrastructures, a vast collection of archive research data (strictly followed by metadata) was built. The data is generally available in:

- ◆ alphanumeric data in raw format,
- ◆ handmade large-scale architectural documentation (drawings, plans, sections, facades),
- ◆ photos, mostly available in negatives.

Still, the process of digitisation of all this data is in the initial phase with thus far data digitalised as part of the activities implemented for finding the most efficient and practical methodology and technology for this purpose.

During the recent years, great progress was made in the search for the best methodology and adequate technology to be used for documentation of the architectural cultural heritage and a high detail surveying of the relevant landscapes. This was made by building the basic human resources and integration of technology and freely available digital resources. All this was made on a national level with support provided from the domestic (Ministry of Culture and Ministry of Education and Science) and EU funds.

Part of the products of these activities is available as open access e-infrastructure. A web-implemented geographic information system was developed for six settlements from the Roman period. DIENDICURE – Digital Environments for Digital Cultural Realities (<https://diendicure.mk/>) was introduced for the first time in 2018. This system should be annually updated and upgraded as part of different project activities.

Services provided include the following:

- ◆ Research on the archaeological sites and monuments from the Roman and Medieval Period and research of the intangible cultural heritage located in the Central Balkans;
- ◆ A photographic survey using suitable terrestrial and aerial photo capturing equipment;
- ◆ A topographic and geodetic survey using total station;
- ◆ Field survey using the above mentioned equipment and the technology of photogrammetry (IBM – image-based modelling) throughout a wide range of computer-based procedures and specific software;
- ◆ Implementation and integration of data, spatial and quantitative data analysis using GIS technology;
- ◆ Mass storage of data.

Research equipment: The Institute does not have capital research equipment. The current value of research equipment is estimated at 18.000 euros.

#### 4.1.4. Mother Teresa University, Skopje

The Mother Teresa University in Skopje was founded in 2016. It offers education in the natural and social sciences through its five faculties. Having in mind that it is a very young university, its research activities have been mainly oriented toward participation at scientific conferences and EU Programme in the fields of education, training, youth and sport for the period 2014-2021 (Erasmus+).

The following research infrastructures have been identified:

- ◆ Laboratory for Anthropometric Measurements and Biomechanical analysis at the Faculty of Social Science which was equipped in 2020 with a set of research instruments (total purchase value was 20.000 euro) for the following services: assessing patient's general physical conditions, identifying deficiencies, postural problems and asymmetries on the basis of data and videos and determining how the patients' performance is being effected, orthopaedic solutions on the basis of precise data, preventing relapses, complications and involutions, etc.
- ◆ Computer Science Labs at the Faculty of Informatics performs various researches in the field of Computer Science and Engineering such as: Artificial Intelligence, Computer Networks, Next Generation of Mobile Networks, Data Mining, Machine Learning, Mathematics, etc.
- ◆ IT Centre at the Faculty of Construction and Architecture is engaged in designing and analysing structures, architectural design and plotting.



- ◆ Faculty of Technological Sciences conducts qualitative and quantitative analyses of food samples, chemical processes, development and validation of methods.
- ◆ Faculty of Technical Science is using small research instruments for education-based activities: simulations of road traffic to the finest detail - macroscopic, simulations for traffic analyses, forecasts and GIS-based data management at city, regional or national levels. Oscilloscope is used to examine an electronic part that is considered to be defective. It is also used to test newly made electrical circuits in terms of their voltage and design errors.

Research equipment: The University does not have capital research equipment. It is equipped with research instruments of small value mainly intended for educational purposes.

#### 4.1.5. Institute for Advanced Composites and Robotics

The Institute for Advanced Composites and Robotics is the private institution whose mission is to build an appropriate research infrastructure that will develop the fundamental and applied science in the area of advanced composites and robotics through the interdisciplinary approach. This will be achieved through a clear and focused work programme, attracting and building high-skilled research personnel and permanent development of the research infrastructure, following the global trends in the development of advanced composites and robotics. The Institute is orientated towards cooperation with the leading global institutes in the field of advanced composites and robotics.

Services offered: Slitting of prepress with different width from 6.35mm to 300mm; production of composite plates, pipes, complex parts with AFP / ATL robotic machines; test methods to determine the constituent content, volatiles content of composite materials; determination of porosity with optical microscopy of composite materials; mechanical tests for characteristics of composite parts (tensile and compression strength, 3pbt, ILSS, etc.).

Research equipment: The Institute has capital research equipment whose current value was estimated at 870.000 euro (the purchase value was 1.2 mil euros). The list of single capital research equipment worth over 50.000 euros is provided in Appendix 1.

#### 4.1.6. South East European University

##### Max van der Stoel Institute

Max van der Stoel Institute (MVDSI) is a scientific institute within South East European University focused on inter-disciplinary fields of social sciences and information and communication technologies. In terms of the research infrastructure, there are three main laboratories organised within the Max van der Stoel Institute: Laboratory for Distributed Systems and Data Science Group (DSG), Laboratory for Environment and Health Group (EHG) and the Virtual and Augmented Reality Lab.



- ◆ DSG is equipped with wireless mesh network testbed for research purposes. The main services provided to research infrastructure users are: Internet access through wireless networks, experimentation in a real production wireless mesh network and prototype testing and deployment.
- ◆ EHG is equipped with low emissions sustainable testbed. The actual testbed in production consist of solar photovoltaic plants (100 kWp and 15 kWp), controlled mechanical ventilation system, geothermal heat pump, solar thermal system and data monitoring system for evaluation of energy performance.
- ◆ Virtual and Augmented Reality Lab: The Laboratory is used to train and create the necessary staff for institutions and other stakeholders dealing with crisis management. The Laboratory is also at the service of the SEEU community, which can be used during the teaching and research process.

Research equipment: The Institute does not have capital research equipment worth over 50.000 euros. It is equipped with small research instruments of total value of 18.500 euros. Research instruments are intended for undergraduate, MSc and PhD students. Further, the testbeds from DSG and EHG groups are open to external users, which are enabled through participation in EU/ international programmes.

### Institute for Environment and Health (IEH)

The IEH focuses primarily on matters involving health maintenance and ecological stewardship. The mission of the IEH at SEEU is to develop technical and scientific information related to environmental topics, and provide training of human resources in order to inform the society on environmental and health matters. In addition, providing support for decision-making processes, encouragement of environmental protection, and promotion of sustainability during usages of natural resources are key responsibilities. The IEH leads the environmental efficiency programme at SEEU and is a promoter and operator of the green energy initiative through the Low Emission Sustainable Campus Testbed.

Service provided: IEH testbed in production is distributed within the university campus (29,000 m<sup>2</sup>) and consist of solar photovoltaic plants (100 kWp and 15 kWp), controlled mechanical ventilation system, geothermal heat pumps, solar thermal system and data monitoring system (including 6 smart meters) for the evaluation of energy performance (production and consumption). The main service provided is energy production and energy performance evaluation.

Total purchase value or research equipment: 70.000 Euros

#### 4.1.7. Macedonian Academy of Sciences and Arts (MASA)

##### Georgi D Efremov Research Centre for Genetic Engineering and Biotechnology

Georgi D Efremov Research Centre for Genetic Engineering and Biotechnology (RCGEB) was founded as a research unit of MASA in 1986 with the main goal of advancing scientific knowledge in the field of protein chemistry, molecular biology, genetic engineering and biotechnology through research and practical training of scientists and postgraduate students. RCGEB - MASA was one of the first institutions in former Yugoslavia to introduce DNA technologies and was for many years at the forefront of the research, application and education in these disciplines in the region.

Very soon after its foundation, RCGEB started using the recombinant DNA technologies in the diagnosis and prevention of inherited, malignant and infectious diseases, and in forensic medicine. Over all these years, RCGEB researchers have been very active in the field of “translational medicine”, and contributed to the introduction and implementation of many molecular methods that are now part of the routine work-up of patients with different genetic diseases. With a continuous support of the Government, as well as the infrastructural grant from the European Commission (REGPOT project, 2009-2012) and numerous international and national grants, RCGEB has managed to consistently upgrade the infrastructure with contemporary equipment.

At present, RCGEB is the major research, diagnostic and educational facility in the fields of molecular medicine, molecular diagnostics and “omics” technologies which have acquired national, regional, and international recognition. RCGEB is one of the few institutions from North Macedonia that has met the criteria for the Centre of Excellence due to its esteemed scientific and educational record in life sciences.

Services provided: The services provided to research infrastructure users include the following:

- ◆ Research
  - Comprehensive technological platforms for research projects in the field of molecular genetics and genomics, including bioinformatics of data from high throughput NGS analyses
  - Technological platform for research projects in the field of protein chemistry and high throughput proteomics (including bioinformatics of data from high throughput proteomics platforms)
  - Extensive know-how in the preparation and implementation of research projects in molecular biosciences
- ◆ Diagnostics
  - Diagnostic services for molecular genetics (national reference centre for molecular diagnostics of inherited, malignant and infectious diseases)
- ◆ Education
  - Education in basic and advanced molecular genetics, genomics and proteomics analyses for graduate and postgraduate students and health care professionals from the economy and abroad

- ◆ Publishing

- Editorial office and publisher of the Balkan Journal of Medical Genetics, an international journal (with IF) which publishes papers of scientists from the Balkan economies in the field of human genetics

Research equipment: RCGEB has capital research equipment whose current value was estimated at 411.000 euro (the purchase value was 1.87 mil euros). The laboratories are equipped with a range of modern and sophisticated major equipment, such as a next generation sequencing platform, microarray platform, two genetic analysers, real time PCR, several thermal cyclers, capillary electrophoresis, automated nucleic acid extraction and tissue culture facilities in the genomic part and high definition Synapt G2-SI and MALDI-TOF/TOF mass spectrometers, amino acid analyser, HPLC, UPLC and 2D DIGE with high resolution image scanner in the proteomic part. The list of single capital research equipment worth over 50.000 euros is provided in Appendix 1.

The updated equipment and infrastructure of the RCGEB will provide an opportunity for its integration into larger regional and EU research infrastructures

### Research Centre for Computer Science and Information Technologies

Research Centre for Computer Science and Information Technologies at the Macedonian Academy of Sciences and Arts in Skopje has a laboratory with computers in which 10 researchers are working. The Centre maintains an IT cluster for collaborative computational neuroscience research in mental diseases led by New York State Psychiatric Institute at Columbia University. Within this continued research programme several lines of computational science are aimed at detecting biomarkers of schizophrenia in triplet samples (schizophrenia, major depression, controls) from post-mortem brains. Machine learning and deep learning are used in image pre- and post-processing, structural modelling of white matter, as well as graphical models and other statistical descriptions of molecular expression data (RNA, DNA methylation, proteins) from human white matter.

Services provided include:

- ◆ GPU-enabled SW development workstations
- ◆ High-end workstations for image processing
- ◆ Computational capacity on Intel-based PC servers
- ◆ Network storage (> 100 TB NAS-class storage)
- ◆ VPN maintained remote-access

Research equipment: The Centre does not have capital research equipment of high value. There is a server on which there are 10 processors with 6 cores, and a high number of logical processors. Also, there is a 50 TB memory space available. The total purchase value of research equipment is 22.800 euros.

## 4.2. Access Policy

Access refers to the legitimate and authorised physical, remote and virtual admission to, interactions with and use of research infrastructures and to services offered by research infrastructures to users<sup>6</sup>. Access to research infrastructure is an important factor in creating greater synergies between researchers in a particular field of science and connecting business and research sectors in order to promote the development of research and innovation. Defining access policy to research infrastructure by research institutions is an important step towards internationalisation and strengthening scientific excellence, both within the institution itself and in the economy.

Information on the access policy of research institutions/laboratories from North Macedonia obtained on the basis of completed questionnaires is presented in Table 3. It is evident that most research institutions/laboratories do not have an official access policy; however, they clearly define the internal procedures for accessing research equipment/facilities.

Internal procedures for accessing research equipment within the higher education institutions in North Macedonia do not differ greatly from one another. Most institutions have open access for research staff, while external users are required a special permit, which includes: the official submission of requests for access to research infrastructure and formal approval by the management.

*Table 3: Access policy to research infrastructure and internal procedures*

Research Institution/Laboratory	Official access policy	Internal procedures
<b>UKIM, Faculty of Computer Science and Engineering</b>	No	External access to research infrastructure can be established upon signing agreement on research cooperation, involvement in joint projects and cooperation contract.
<b>UKIM, Faculty of Electrical Engineering and Information Technologies, Skopje</b>	No	Only employed personnel with specific authorisations and competencies have access to the equipment and the laboratory facilities. External persons may enter the Laboratory only by signing a confidentiality statement and under supervision of authorised persons.
<b>UKIM, Faculty of Technology and Metallurgy</b>	No	External access to research infrastructure can be established upon signing agreement on research cooperation, involvement in joint projects and cooperation contract.
<b>UKIM, Faculty of Natural Sciences and Mathematics, Institute of Chemistry</b>	No	The research equipment is mainly used by employees and researchers. It has not been used by external personnel so far.

<sup>6</sup> [https://ec.europa.eu/research/infrastructures/pdf/2016\\_charterforaccessto-ris.pdf](https://ec.europa.eu/research/infrastructures/pdf/2016_charterforaccessto-ris.pdf)

Research Institution/Laboratory	Official access policy	Internal procedures
<b>UKIM, Faculty of Medicine, Institute for Immunobiology and Human Genetics</b>	No	Access is allowed to employed personnel. External access to research infrastructure can be established upon signing an agreement on research cooperation, involvement in joint projects and cooperation contract.
<b>UKIM, Faculty of Medicine, Institute of Institute of Microbiology and Parasitology</b>	No	Members of the Expert Board decide on allowing external users to access research equipment. If there is consent, an external user must agree in writing on the confidentiality of the data from the institution.
<b>UKIM, Faculty of Medicine, Institute of Pathology</b>	No	Access policy and procedures for the users of the research infrastructure of the Institute of Pathology are based on presenting the research objectives and other details to the staff members and getting written consent from the Head of the Institute for doing research in any of the laboratories and departments. Considering the sensitivity of the medical information of the patients, every user needs to sign a confidentiality document before starting any research work.
<b>UKIM, Faculty of Medicine, Institute of Pathophysiology and Nuclear Medicine, Skopje</b>	No	Accessible for Institute staff only
<b>UKIM, Faculty of Pharmacy</b>	No	External users are obligated to sign collaboration agreement for research and consulting activities as well as confidentiality statement. They also need to provide information on research activities concerning the use of a particular instrument of the research infrastructure.
<b>UKIM, Institute of Animal Science</b>	No	Access is allowed to employed personnel. External access to research infrastructure is also allowed but written request is needed.
<b>UKIM, Institute of Macedonian Literature, Skopje, Academic Library,</b>	No	Access to the publications is allowed through a written request provided by external users.
<b>UKIM, Institute of Earthquake Engineering and Engineering Seismology</b>	No	Upon receiving a request for a service, the internal expert team makes a quotation for using research infrastructure.

Research Institution/Laboratory	Official access policy	Internal procedures
<b>St Kliment Ohridski University, PSI Hydrobiological Institute Ohrid</b>	No	An open-door access policy for all interested users. Access is usually provided by sending a letter of interest.
<b>Goce Delchev University, AMBICON research group</b>		
<b>Faculty of Natural and Technical Sciences</b>	No	In general, all equipment used for educational and scientific purposes is free of charge or charged based on material costs (AMBICON group has a free of charge policy while UNILAB charges material costs or applies a discount on standard pricing).
<b>University of Tetova</b>	No	Access policy is regulated following the Lakehead University Emergency Procedures document posted in each laboratory. Internal procedures for access to research infrastructure are mostly defined for students.
<b>Mother Teresa University, Skopje</b>	No	There is no access policy. Research equipment is available to education and research staff and students.
<b>Institute for Advanced Composites and Robotics Prilep</b>	No	Upon receiving a request for a service, the internal expert team makes a quotation for using research infrastructure.
<b>MASA, Georgi D Efremov Research Centre for Genetic Engineering and Biotechnology</b>	No	The RCGEB has an open access policy for the use of its expertise and facilities for scientists from the economy and abroad. The major principles for giving the access to the user(s) are based on the following: <ul style="list-style-type: none"> <li>• Collaborative research projects in the field(s) of the ongoing research activities of the RCGEB-MASA</li> <li>• Free access with consumables covered by the users; the results should be jointly published</li> <li>• Paid services</li> </ul>

Source: ToE–Team of Experts, analysis of collected questionnaires

RCC Secretariat has implemented Open Access Research Infrastructure in the Western Balkans Support Programme in the period from May to December 2020 to guide the preparation of the Open Access policies for selected Research Infrastructures in the Western Balkans, and to train management, administrative and research staff to introduce principles of Open Access to research infrastructures.

The following research institutions from North Macedonia participated in this programme:

1. The Institute for Social, Political and Juridical Research, Ss. Cyril and Methodius University in Skopje
2. Institute of Economics, Ss. Cyril and Methodius University in Skopje
3. Faculty of Computer Science and Engineering, Ss. Cyril and Methodius University in Skopje
4. Rectorate of the Ss. Cyril and Methodius University in Skopje

As a result of the programme, all beneficiary institutions have developed Access Policies to research infrastructures.

It should be also noted that with the support of the NI4OS-Europe project, the initial activities for the establishment of the National Open Science Cloud Initiative (NOSCI) in North Macedonia have already begun. The <https://nosci.mk/> web site is already published, containing useful information on all open science related principles, in Macedonian, Albanian and English. The draft version of the Declaration of the NOSCI.mk is currently being developed and will be open for all individuals and institutions interested to support the NOSCI.mk.

### 4.3. Research e-Infrastructures

Modern education and modern research today are inconceivable without relying on e-infrastructure and without using the opportunities that different components of e-infrastructure bring to laboratories, classrooms and everyday collaboration. Growing needs for e-infrastructures are driven by new technologies and infrastructures that generate considerable data amounts within all research areas.

E-infrastructure is a complex integrated environment based on information and communication technology in which researchers, teachers, students and other members of the academic and research community collaborate and jointly gain access to distributed or unique components of research and educational infrastructures, regardless of the type and geographical location of this equipment. It consists of a series of interconnected layers: advanced communication networks, computer and storage resources located in data centres, an intermediate layer, data layer, and information layer in which information systems operate and information services are provided to users. In the international context, research e-infrastructures include federation, storage, curation of large data sets (the Global Biodiversity Information Facility - GBIF, the International Neuroinformatics Coordinating Facility - INCF, the Consortium of European Social Science Data Archives - CESSDA, European Infrastructure Consortium – LifeWatch ERIC) and high performance computing and networking (GÉANT, PRACE).



North Macedonia contributes to the development of European e-infrastructure by participating in international projects, international associations and institutions, thus contributing to the greater integration of North Macedonia into the ERA.

The e-infrastructure in place in North Macedonia is presented below. Section 4.4 highlights international research infrastructure projects in which institutions from North Macedonia have been participating.

### 4.3.1. Faculty of Computer Sciences and Engineering, Ss. Cyril and Methodius University in Skopje

The FCSE, UKIM is the most important institution in the economy with regards to e-infrastructure. It provides e-infrastructure support to the academic and research communities, ministries, public sector, and the industry. FCSE is a national centre for high performance computing and cloud. More information on services FCSE provides can be found in chapter 4.1.1.

The FCSE, UKIM participated in numerous e-Infrastructure projects in the framework of Horizon 2020 and FP7 programme and is also a member of the large pan-European research infrastructures. More information on projects and Large RIs is provided in chapters 4.4. and 4.5.

### 4.3.2. National Research and Academic Network of North Macedonia – MARNet

Macedonian Research and Academic Network (MARNet) is a public institution established by the Law on establishing the Macedonian Academic Research Network enacted in September 2010. The MARnet provides services for national and international connectivity of academic research network and educational community of North Macedonia and supports their research and educational activities. Furthermore, MARNet is engaged in promoting the use of and disseminating information and communication technologies particularly in the academic and research sector; maintenance and management of the national domain system, international representation and membership; and development of the national academic network.

The MARNet e-infrastructure includes all devices owned or leased by the MARnet and all telecommunications links owned by the MARNet or leased from telecommunications providers. It is very important for the information society of North Macedonia since it provides services that aim to meet the requirements in the field of education and research.

MARnet is the member of GÉANT, the high bandwidth pan-European research and education backbone that interconnects Europe's National Research and Education Networks (NRENs). Through extensive links with networks around the world, GÉANT connects over 50 million users at 10,000 institutions across Europe and also reaches 65 countries beyond Europe.

Trying to take advantage of connections with international academic networks, MARnet aims to achieve:

- ◆ interconnection of all research, higher education and other educational institutions in North Macedonia and international connectivity with fast Internet access;



- ◆ implementation, evaluation and analysis of new services and the latest networking technologies and their implementation;
- ◆ participation in relevant international organisations and projects;
- ◆ knowledge generation and transferring;
- ◆ participation and partnership in drafting strategies for development of information society in the economy.

The main challenges that MARNET is facing is the lack of IT staff and high turnover of its employees. Thus, the key technical and expert support of MARNET is provided by the Faculty of Computer Science and Engineering, UKIM regarding networking, IT and DNS infrastructure and other services.

### 4.3.3. COBISS.MK network

The Agreement on the establishment of the COBISS.net network and the free exchange of bibliographic records, created in autonomous library information systems of Bosnia and Herzegovina, Montenegro, North Macedonia, Slovenia and Serbia was signed in 2003. In 2006, the aforementioned Agreement was also signed on behalf of Bulgarian libraries by the Bulgarian National Library. By signing special statements in 2013, the provisions of the Agreement were also indirectly accepted by a group of libraries from Albania.

The web application E-CRIS (Current Research Information Systems) was developed at the Institute of Information Science in Maribor (IZUM), which offered it to North Macedonia and other users of COBISS applications within the COBISS.Net network free of charge. The final aim of developing E-CRIS application in member economies was to establish the register of research and development providers. This register is essential for research monitoring and evaluation. E-CRIS system of North Macedonia is linked to COBISS library information systems, thus allowing direct access to the bibliographies of researchers and institutions. It includes interconnected databases comprising data on research organisations, researchers and research projects.

The information system for research activities in North Macedonia is managed by St. Kliment Ohridsk National Library, which also functions as the national E-CRIS centre. Within E-CRIS information System of North Macedonia, there are currently 3658 researchers and 192 research organisations.

## 4.4. Participation of institutions from North Macedonia in RI projects

Institutions from North Macedonia have participated in 18 international projects

(11 projects within H2020 and 7 projects within FP7) related to the development of research infrastructures. Thirteen projects have been implemented and 4 are ongoing. National institutions that have participated in these projects and thus contributed to the development of international and domestic research infrastructures are:

- ◆ Macedonian Academic and Research Network,

- ◆ Ss. Cyril and Methodius University in Skopje, Faculty of Computer Sciences and Engineering,
- ◆ Ss Cyril and Methodius University Skopje, Institute of Earthquake Engineering and Engineering Seismology,
- ◆ Institute of Public Health of the Republic of North Macedonia, Skopje
- ◆ Ministry of Information Society

The total budget of North Macedonia institutions for the implementation of projects within H2020 exceeds 2.4 million EUR (EC contribution). 9 out of 11 H2020 and 6 of 7 FP7 projects are related to the development of e-infrastructures.

The sub-sections below present the key information on the RI projects.

### 1. GN4-1: Research and Education Networking - GÉANT

- ◆ **Funding Programmes:** H2020
- ◆ **Project partners from North Macedonia:** Macedonian Academic and Research Network, Skopje, supported by FCSE, UKIM (€ 43.005)
- ◆ **Total number of partner organisations:** 40
- ◆ **Project implementation period:** 01/05/2015 – 31/08/2016
- ◆ **Scientific domain:** e-Infrastructures

The overall objective of the project was to provide a stable environment for the implementation of GÉANT as the European Communications Commons for the European Research Area, which would provide the best possible digital infrastructure to ensure that Europe remains in the forefront of research. GÉANT's extensive and long-standing contacts with large data disciplines such as biology, radio astronomy and high-energy physics help shape the evolution of the networking facilities required. This is complemented by partner contacts with research domains that are new users of high-performance networks and services, such as: digital preservation, real-time art and humanities.

The vision was to position the GÉANT partnership optimally while ensuring the continuity and improvement of the services successfully offered under the GN3plus FP7 project.

### 2. GN4-2: Research and Education Networking - GÉANT

- ◆ **Funding Programmes:** H2020
- ◆ **Project partners from North Macedonia:** Macedonian Academic and Research Network, Skopje, third party FCSE, UKIM (€ 264 792)
- ◆ **Total number of partner organisations:** 39
- ◆ **Project implementation period:** 01/05/2016 – 31/01/2020
- ◆ **Scientific domain:** e-Infrastructures

GN4-2 was the project proposed for the second Specific Grant Agreement under the 68-month Framework Partnership Agreement (FPA) established between the GÉANT Consortium and the European Commission in April 2015. This second phase of implementing the FPA was aimed to

raise European research to the next level by promoting scientific excellence, access and re-use of research data. It drove European-wide cost efficiencies in scientific infrastructure by promoting interoperability with other e-infrastructures on an unprecedented scale.

GN4-2 developments were guided by the vision of a future where a set of coherent and integrated European e-infrastructure services offer convenient, seamless access for end-users through a common service catalogue, and facilitating the adoption of services offered by new e-infrastructure developments, such as the European Open Science Cloud.

### 3. GN4-3: H2020-SGA-INFRA-GEANT-2018 (Topic [a] Research and Education Networking)

- ◆ **Funding Programmes:** H2020
- ◆ **Project partners from North Macedonia:** Macedonian Academic and Research Network, Skopje, third party FCSE, UKIM (€ 511 300)
- ◆ **Total number of partner organisations:** 39
- ◆ **Project implementation period:** 01/01/2019 - 31/12/2022
- ◆ **Scientific domain:** e - Infrastructures

The GN4-3 is the project proposed for the third Specific Grant Agreement under the 68-month Framework Partnership Agreement (FPA) established between the GÉANT Consortium and the European Commission in April 2015. This third phase of implementing the FPA is proposed to last 48 months and is a natural continuation of the work in GN4-2, building on the results and maintaining the overall objective of helping to raise European research to the next level, promoting scientific excellence, access and re-use of research data.

The structure of the present proposal emphasises updating existing services in line with requirements of the user community. This complements the proposed companion project GN4-3N, an ambitious programme increasing the footprint of the backbone network at the same time as improving its capacity, resilience and flexibility with the aim of offering 100Gbps network access to many more GÉANT partners and significantly diminishes the digital divide.

### 4. GN4-3N: H2020-SGA-INFRA-GEANT-2018 Topic [b] Increase of Long-Term Backbone Capacity

- ◆ **Funding Programmes:** H2020
- ◆ **Project partners from North Macedonia:** Macedonian Academic and Research Network, Skopje (€ 0)
- ◆ **Total number of partner organisations:** 39
- ◆ **Project implementation period:** 01/01/2019 - 31/12/2022
- ◆ **Scientific domain:** e - Infrastructures

The GN4 Phase 3 Network (GN4-3N) proposal for part b of the third Specific Grant Agreement (SGA3(b)) was made in response to the H2020-SGA-INFRA-GEANT-2018 (Topic [b] Research and Education Networking) call received on 17 October 2018, under the 68-month Framework Partnership Agreement (FPA) established between the GÉANT Consortium and the European Commission in April 2015. It is proposed to last 48 months to implement, as the call requests, a

very ambitious restructuring of the backbone network operated by GÉANT in order to provide equal access to clouds and other e-infrastructure services in the European research area and beyond. It will improve the overall resilience and reliability of the GÉANT network significantly and offer a base for future improvements in access, transmission speeds and capacity wherever needed.

The outcome of GN4-3N project will offer uniform network access and choice of services to many more partners, eliminating the "digital divide" wherever technically and economically feasible.

This project proposal is based on technical and economic studies carried out during 2017-2018 in the GN4-2 project which have given the Consortium clarity on the resourcing, financial and effort, needed to realise the huge ambition of this undertaking. It exclusively covers the engineering, procurement, acquisition and installation of the new backbone network. The day-to-day network operations as the elements of it are commissioned are the responsibility of the teams described in accompanying GN4-3 project.

The GN4-3 and GN4-3N proposals are intimately connected through common teams and the technical, management and procurement expertise built up over previous GN projects. This is what makes this ambitious proposal realistic. GN4-3N and GN4-3 have simply had to be proposed as distinct projects, due to the different funding model (with no depreciation) to be used in GN4-3N project.

## 5. EUROCC - National Competence Centres in the framework of EuroHPC

- ◆ **Funding Programmes:** H2020
- ◆ **Project partner from North Macedonia:** Ss. Cyril and Methodius University in Skopje, FCSE (€ 912.935)
- ◆ **Total number of partner organisations:** 36
- ◆ **Project implementation period:** 01/09/2020 - 31/08/2022
- ◆ **Scientific domain:** Research Infrastructures

The EuroCC project will bring together the necessary expertise to set up a network of National Competence Centres in HPC across Europe in 31 participating member and associated economies, to provide a broad service portfolio tailored to the respective national needs of industry, academia and public administrations. All of this is to strongly support and increase the national strengths of High Performance Computing (HPC) competences as well as High Performance Data Analytics (HPDA) and Artificial Intelligence (AI) capabilities and to close existing gaps to increase usability of these technologies in different economies and thus provide a European excellence baseline.

Each of the 33 national competence centres, which will be part of the EuroCC network, will act locally to map available HPC competencies and identify existing knowledge gaps. The competence centres will coordinate HPC expertise at national level and ease access to European HPC opportunities for research and scientific users, public administration, but also in different industrial sectors, delivering tailored solutions for a wide variety of users.

Faculty of Computer Science and Engineering is the National HPC Competence Centre in North Macedonia, taking the leading role in developing the roadmap, capacity building, training as

well as facilitation of access to expertise. It will interface with industry partners to enlarge the HPC application nationwide.

## 6. EGI-ACE: Advanced computing for research

- ◆ **Funding Programmes:** H2020
- ◆ **Project partners from North Macedonia:** Ss Cyril and Methodius University in Skopje, FCSE (€ 23.750)
- ◆ **Total number of partner organisations:** 33
- ◆ **Project implementation period:** 01/01/2021 – 30/06/2023
- ◆ **Scientific domain:** ICT based e-Infrastructures

EGI-ACE empowers researchers from all disciplines to collaborate in data and compute-intensive research across borders/boundaries through free at point of use services. Building on the distributed computing integration in EOSC-hub, it delivers the EOSC Compute Platform and contributes to the EOSC Data Commons through a federation of Cloud compute and storage facilities, PaaS services and data spaces with analytics tools and federated access services.

The Platform is built on the EGI Federation, the largest distributed computing infrastructure for research. The Platform pools the capacity of some of Europe's largest research data centres, leveraging ISO compliant federated service management. Over 30 months, it will provide more than 82 M CPU hours and 250 K GPU hours for data processing and analytics, and 45 PB/month to host and exploit research data. Its services address the needs of major research infrastructures and communities of practice engaged through the EOSC-hub project. The Platform advances beyond the state of the art through a data-centric approach, where data, tools and compute and storage facilities form a fully integrated environment accessible across borders/boundaries thanks to Virtual Access.

The Platform offers heterogeneous systems to meet different needs, including state of the art GPGPUs and accelerators supporting AI and ML, making the Platform an ideal innovation space for AI applications. The data spaces and analytics tools are delivered in collaboration with tens of research infrastructures and projects, to support use cases for Health, the Green Deal, and fundamental sciences.

The consortium builds on the expertise and assets of the EGI federation members, key research communities and data providers, and collaborating initiatives.

## 7. SERA: Seismology and Earthquake Engineering Research Infrastructure Alliance for Europe

**Funding Programmes:** H2020

**Project partners from North Macedonia:** Ss. Cyril and Methodius University in Skopje, Institute of Earthquake Engineering and Engineering Seismology (€ 200 000)

**Total number of partner organisations:** 31

**Project implementation period:** 01/05/2017 – 30/04/2020

**Scientific domain:** Research Infrastructures

Seismology and Earthquake Engineering Research Infrastructure Alliance for Europe (SERA) was the response to the priorities identified in the call INFRAIA-01-2016-2017 Research Infrastructure for Earthquake Hazard.

The overall objective of SERA was to give a significant contribution to improve the access to data, services and research infrastructures, and deliver solutions based on innovative R&D in seismology and earthquake engineering, aiming to reduce the exposure of society to the risk posed by natural and anthropogenic earthquakes.

The main activities of SERA were the following: involving the communities from previous successful projects including NERA and SERIES; offering transnational access to the largest collection of high-class experimental facilities in earthquake engineering; offering virtual access to the main data and products in seismology and anthropogenic seismicity; promoting multi-disciplinary science across the domains of seismology, anthropogenic seismicity, near-fault observatories and deep underground laboratories, to achieve an improved understanding of earthquake occurrence; revising the European Seismic Hazard reference model for consideration in the ongoing revision of the Eurocode 8; developing the first comprehensive framework for seismic risk modelling at European scale; developing the new standards for future experimental observations in earthquake engineering and for the design of future instruments and networks for observational seismology; developing reliable methodologies for real-time assessment of shaking and damage; expanding access to seismological observations; networking infrastructures and communities in the fields of deep seismic sounding, experimental earthquake engineering and site characterisation; providing an important contribution to the construction and validation of EPOS; providing effective communication and outreach to all stakeholders.

## 8. BELLA-S1: Building Europe Link with Latin America

- ◆ **Funding Programmes:** H2020
- ◆ **Project partners from North Macedonia:** Macedonian Academic and Research Network, Skopje (€ 0)
- ◆ **Total number of partner organisations:** 40
- ◆ **Project implementation period:** 01/05/2016 – 30/04/2019
- ◆ **Scientific domain:** Research Infrastructures

The BELLA-S1 project aimed to provide for the long-term interconnectivity needs of the European and Latin American research and education networks. The objective was to strengthen connectivity to Latin America ensuring very high capacity, cost benefits and the shortest possible route, whilst stimulating diversity over the transatlantic segment. Two project phases were implemented: phase one aimed at procuring an indefeasible right of use for a portion of the spectrum of a direct submarine telecommunications cable between Europe and Latin America; phase two aimed at deploying one or more wavelengths, as required, on the spectrum procured to interconnect the GÉANT and RedCLARA networks, and provide for the intercontinental connectivity needs of the European and Latin American research and education communities.

## 9. NI4OS-Europe: National Initiatives for Open Science in Europe

- ◆ **Funding Programmes:** H2020
- ◆ **Project partners from North Macedonia:** Ss. Cyril and Methodius University in Skopje, FCSE (€ 273 170)
- ◆ **Total number of partner organisations:** 22
- ◆ **Project implementation period:** 01/09/2019 – 28/02/2023
- ◆ **Scientific domain:** Research Infrastructures

Mission and vision of the project are to be a core contributor to European Open Science Cloud service portfolio, commit to EOSC governance and ensure inclusiveness on the European level.

The objective of the project is to support the development and inclusion of the national Open Science Cloud initiatives in 15 Member States and Associated Countries in the overall scheme of EOSC governance; spread the EOSC and FAIR principles in the community and train it; and provide technical and policy support in on-boarding of the existing and future service providers into EOSC, including generic services (compute, data storage, data management), thematic services, repositories and data sets - thus covering the whole spectrum of services related to Open Science, data and publications.

The overall approach is that national Open Science landscape in all economies will be mapped, analysed and systematised so as to facilitate both the creation of national OSC initiatives to support the overall EOSC governance, and to engage all stakeholders. A set of providers (generic e-Infrastructure providers, thematic providers, repositories) will be on-boarded into EOSC - following the best practices, policies, guidelines and tools formulated by the project, in alignment with the existing EOSC initiatives and standards. The project solutions provided will be interoperable with EOSC services and will be tested and fine-tuned by real users, and the widest community will be supported in the uptake of research data sharing and practices, in alignment with FAIR principles.

Following the work programme requirements, the project will support the operational framework for governance by focusing on coordination between relevant national initiatives, as well as data infrastructures, e-Infrastructures and thematic services, and their federation into the EOSC. The effort is mandated by national governments of 15 economies through explicit Letters of Support.

## 10. PRO-METROFOOD: Progressing towards the construction of METROFOOD-RI

- ◆ **Funding Programmes:** H2020
- ◆ **Project partners from North Macedonia:** Institute of Public Health of the Republic of North Macedonia, Skopje (€ 76,550.00)
- ◆ **Total number of partner organisations:** 17
- ◆ **Project implementation period:** 01/01/2017 - 31/12/2017
- ◆ **Scientific domain:** Research Infrastructures

The general objective of PRO-METROFOOD was to bring the emerging METROFOOD-RI ESFRI project to the level of maturity required for entering in the active project list, strengthening the



Consortium and planning the future phases. The specific objectives have been set up in close relationship with the ESFRI SWG & IG Recommendation. 4 specific objectives have been identified: OBJ1 – design strategies on the medium and long terms; OBJ2 – provide the organisational framework of METROFOOD-RI; OBJ3 – demonstrate the capability of METROFOOD-RI to supply scientific services and prepare the chart of services; OBJ4 – establish plans to coherently integrate METROFOOD-RI into the European landscape, realising coordination with EU and national initiatives and positioning at a global level. The strategic Plan was tailored to the Pan European Infrastructure current and envisaged capabilities, market opportunities and business needs. It was developed by involving funding agencies, relevant authorities supporting METROFOOD-RI and other stakeholders. A management conceptual model was developed and the framework was designed under operational, strategic and institutional aspects. In order to demonstrate the capability of PRO-METROFOOD to supply services and to test its inter-operability, pilot services were performed. In strict accordance with the METROFOOD-RI strategies, plans to coherently integrate METROFOOD-RI into the European landscape have been developed. A Communication plan and education and training programmes were developed for the different phases of METROFOOD-RI realisation (early, preparatory, implementation and operational phases).

### 11. VI-SEEM: VRE for regional Interdisciplinary communities in Southeast Europe and the Eastern Mediterranean

- ◆ **Funding Programmes:** H2020
- ◆ **Project partner from North Macedonia:** Ss. Cyril and Methodius University in Skopje, FCSE (€122,950.00)
- ◆ **Total number of partner organisations:** 16
- ◆ **Project implementation period:** 01/10/2015 - 30/09/2018
- ◆ **Scientific domain:** e-Infrastructures

VI-SEEM was a three-year project aimed at creating a unique Virtual Research Environment (VRE) in Southeast Europe and the Eastern Mediterranean (SEEM), in order to facilitate regional interdisciplinary collaboration, with special focus on the scientific communities of Life Sciences, Climatology and Digital Cultural Heritage.

VI-SEEM builds on the success of its predecessor e-Infrastructure projects that have been crucial for enabling high-quality research & ICT developments by providing networking and computational resources, application support and training, in both South East Europe and Eastern Mediterranean, and have supported the European vision of inclusive and smart growth, based on knowledge and innovation, enriching the European Research Area.

The overall objective was to provide user-friendly integrated e-Infrastructure platform for regional cross-border/boundary Scientific Communities in Climatology, Life Sciences, and Cultural Heritage for the SEEM region; by linking compute, data, and visualisation resources, as well as services, models, software and tools. This VRE provided the scientists and researchers with the support in full lifecycle of collaborative research: accessing and sharing relevant research data, using it with provided codes and tools to carry out new experiments and simulations on large-scale e-Infrastructures, and producing new knowledge and data - which can be stored and shared in the same VRE.



## 12. European Grid Initiative: Integrated Sustainable Pan-European Infrastructure for Researchers in Europe: EGI-INSPIRE

- ◆ **Funding Programmes:** FP7
- ◆ **Project partner from North Macedonia:** Ss. Cyril and Methodius University in Skopje, FCSE
- ◆ **Total number of partner organisations:** 48
- ◆ **Project implementation period:** 30/04/2010 - 30/04/2014
- ◆ **Scientific domain:** e-Infrastructures

The 48-month EGI-InSPIRE project continued the transition to a sustainable pan-European e-Infrastructure started in EGEE-III. It sustained support for Grids of high-performance and high-throughput computing resources, while seeking to integrate new Distributed Computing Infrastructures (DCIs). It established a central coordinating organisation, EGI.eu, and supported the staff throughout Europe necessary to integrate and interoperate individual national grid infrastructures. EGI.eu provided a coordinating hub for European DCIs, working to bring existing technologies into a single integrated persistent production infrastructure for researchers within the European Research Area. The project collected requirements and provided user-support for the current and new (e.g. ESFRI) users. Support also was given for the heavy users as they move their critical services and tools from a central support model to ones driven by their own individual communities. The operational tools were extended by the project to support a national operational deployment model, include new DCI technologies in the production infrastructure and the associated accounting information to help define EGI's future revenue model.

## 13. GN3 (Multi-Gigabit European Research and Education Network and Associated Services –GN3)

- ◆ **Funding Programmes:** FP7
- ◆ **Project partner from North Macedonia:** Ss. Cyril and Methodius University in Skopje; Macedonian Academic and Research Network, Skopje
- ◆ **Total number of partner organisations:** 41
- ◆ **Project implementation period:** 01/04/2009 - 30/09/2013
- ◆ **Scientific domain:** e-Infrastructures

The objective of this project was the creation of a leading edge network supporting a much enhanced range of both network and added value services targeted at end-users across the GÉANT service area. A principal goal was to create a portfolio of seamless multi-domain services. In contrast to its predecessor, GN2, much more emphasis was placed on service development and service introduction. Initiatives were implemented in the areas of multi-domain network service operation, where quick and efficient provisioning of advanced services were organised. Operational support crossing management domains and security to ensure service integrity and protection of network resources was provided. This was complemented by the development of end-user services in a federated environment which focused on the creation of generic “meta-services”, particularly in the context of security as well as further developments in the area of Roaming Services. A particular emphasis was placed on supporting and encouraging the take-up

of services among end-users by working closely with NRENs. The need to develop this theme co-operatively with other global regions was recognised by the inclusion of an activity specifically targeted to achieve this.

#### 14. GN3PLUS (Multi-Gigabit European Research and Education Network and Associated Services)

- ◆ **Funding Programmes:** FP7
- ◆ **Project partner from North Macedonia:** Macedonian Academic and Research Network, Skopje
- ◆ **Total number of partner organisations:** 58
- ◆ **Project implementation period:** 01/04/2013 - 31/03/2015
- ◆ **Scientific domain:** e-Infrastructures

This project comprised activities that ensured the continued enhancement and ongoing operation of the leading-edge GÉANT network, supporting a range of network and added-value services, targeted at users across the GÉANT service area. In the area of multi-domain network service operation, GN3plus planned to deliver fast, efficient provisioning of advanced services, develop operational support across management domains, and improve security to ensure service integrity and protect network resources. These initiatives were complemented by the development of application services in a federated environment – such as mobile and wireless roaming – supported by safe and secure Authentication and Authorisation Infrastructure. Networking Activities provided management and support for all GN3plus activities through communication, promotion, international liaison and business development. Emphasis was placed on supporting and encouraging service take-up among users by working closely with NRENs. Joint Research Activities were targeted at providing critical analyses of future network and application technologies, with a view of future deployment of emerging technologies within and outside the GÉANT community.

#### 15. HP-SEE (High-Performance Computing Infrastructure for South East Europe's Research Communities)

- ◆ **Funding Programmes:** FP7
- ◆ **Project partner from North Macedonia:** Ss. Cyril and Methodius University in Skopje, FCSE
- ◆ **Total number of partner organisations:** 16
- ◆ **Project implementation period:** 31/08/2010 - 31/05/2013
- ◆ **Scientific domain:** e-Infrastructures

Taking into account that High-Performance Computing (HPC) involvement of the South East Europe (SEE) region was very limited, HP-SEE Project focused on a number of strategic actions. First, it linked the existing and upcoming HPC facilities in the region in a common infrastructure, and provided operational solutions for it. As a complementary action, the project established and maintained the GÉANT link for Caucasus. Second, it opened this HPC infrastructure to a wide range of new user communities, including those of less-resourced economies, fostering

collaboration and providing advanced capabilities to researchers, with an emphasis on strategic groups in computational physics, chemistry and life sciences. Finally, it ensured establishment of national HPC initiatives, and acted as a SEE bridge for PRACE. In this context, HP-SEE aimed to attract the local political & financial support for long-term sustainable e-Infrastructure. HP-SEE aspired to contribute to the stabilisation and development of South East Europe by overcoming fragmentation in Europe and stimulating e-Infrastructure development and adoption by new virtual research communities, thus enabling collaborative high-quality research across a spectrum of scientific fields.

## 16. SEE-GRID e-Infrastructure for Regional e-Science

- ◆ **Funding Programmes:** FP7
- ◆ **Project partner from North Macedonia:** Ss. Cyril and Methodius University in Skopje
- ◆ **Total number of partner organisations:** 15
- ◆ **Project implementation period:** 30/04/2008 - 30/04/2010
- ◆ **Scientific domain:** e-Infrastructures

SEE-GRID-SCI leveraged the SEE e-Infrastructure to enable new scientific collaborations among SEE user communities. It has stimulated widespread integrated e-Infrastructure uptake by new cross-border/boundary user groups extending over the region, fostering collaboration and providing advanced capabilities to more researchers, with an emphasis on strategic groups in seismology, meteorology and environmental protection. The initiative thus aimed to have a catalytic and structuring effect on a variety of user communities that did not directly benefit from the available e-Infrastructures. In parallel, it enlarged the regional e-Infrastructure to cater for demands of the communities: a number of new Grid clusters and economies were added, engaging a wider range of players and expanding the provider pool. Finally, SEE-GRID-SCI helped mature and stabilised the National Grid Initiatives in the region, allowing them to join the new era of longer-term sustainable Grid infrastructure in Europe. In this context, SEE-GRID-SCI aimed to attract political and financial support for materialising the e-Infrastructure vision. In longer term, SEE-GRID-SCI aspired to contribute to the stabilisation and development of South East Europe by easing the digital divide and stimulating e-Infrastructure development and adoption by new user communities, thus enabling collaborative high-quality research across a spectrum of scientific fields.

## 17. South East European Research Area for e-Infrastructures

- ◆ **Funding Programmes:** FP7
- ◆ **Project partners from North Macedonia:** Ss. Cyril and Methodius University in Skopje; Ministry of Information Society
- ◆ **Total number of partner organisations:** 20
- ◆ **Project implementation period:** 01/04/2009 - 31/03/2012
- ◆ **Scientific domain:** e-Infrastructures

SEERA-EI project connected national-level programme managers and provided an open forum for information exchange in order to enable coordination of national programmes in e-Infrastructures, and set the framework for a common regional agenda. The project gathered and exchanged information regarding programmes and carried out a state-of-the-art analysis; produced set of best practices and guidelines for national e-Infrastructure programmes; and identified areas for joint regional activities, ranging from short-term soft actions, mid-term policy-level actions, to preparatory activities for long-term actions. SEERA-EI reduced fragmentation of national programmes, created a harmonised approach to national-level initiatives in e-Infrastructures, ensured local commitment, and paved the way towards common regional vision, strategy and sustainable cooperation, enabling collaborative high-quality research across a spectrum of scientific fields.

### 18. SERIES (Seismic Engineering Research Infrastructures for European Synergies)

- ◆ **Funding Programmes:** FP7
- ◆ **Project partners from North Macedonia:** Ss. Cyril and Methodius University in Skopje, Institute of Earthquake Engineering and Engineering Seismology
- ◆ **Total number of partner organisations:** 21
- ◆ **Project implementation period:** 01/03/2009 - 28/02/2013
- ◆ **Scientific domain:** Research Infrastructures

European Seismic Engineering Research suffers from extreme fragmentation of research infrastructures (RI) between participating economies and limited access to them by the S&T community of earthquake engineering, especially that of Europe's most seismic regions. SERIES project addressed these problems in a sustainable way via a 4-year programme of activities. The scope covered all aspects of seismic engineering testing, from eight Reaction Wall Pseudo dynamic (PsD) facilities and ten Shake Table labs, to EU's unique Tester of Bearings or Isolators, its two major Centrifuges and an instrumented Site for wave propagation studies. Transnational Access was offered to a portfolio of world class RIs: EU's largest PsD facility, four diverse Shake Tables and the two Centrifuges. Networking set up a public distributed database of past, present and future test results, installed distributed testing capabilities at all PsD labs, fostering development of up-and-coming ones at Europe's most seismic regions, drafted and applied protocols for qualification of RIs and engaged the entire European community of earthquake engineering via the best possible instances: the European Association of Earthquake Engineering, EU's seismic code makers and their national groups, the European Construction Industry, as well as all relevant S&T associations or networks.

## 4.5. Membership in ESFRI Roadmap and other Large European Research Infrastructures

In line with the low levels of public spending for R&D over the last decade, the research community of North Macedonia has not had a distinctive presence among the global RIs. However, it is important to emphasise that despite unfavourable general conditions, institutions from North Macedonia are full or associated members of several large research infrastructures in Europe.

North Macedonia is a member of the ESFRI. Currently, North Macedonia participates in one ESFRI development of research infrastructure project - METROFOOD-RI Infrastructure for Promoting Metrology in Food and Nutrition. More information on this project is provided below.

### METROFOOD-RI Infrastructure for Promoting Metrology in Food and Nutrition

- ◆ **Funding Programmes:** H2020
- ◆ **Project partners from North Macedonia:** Institute of Public Health of the Republic of North Macedonia, Skopje (€ 100 762,50)
- ◆ **Total number of partner organisations:** 20
- ◆ **Project implementation period:** 01/12/2019 - 31/05/2022
- ◆ **Scientific domain:** Research Infrastructures

METROFOOD-RI Infrastructure for Promoting Metrology in Food and Nutrition is a pan-European Research Infrastructure aimed to promote scientific excellence in the field of food quality and safety. It provides high-quality metrology services in food and nutrition, comprising an important cross-section of highly interdisciplinary and interconnected fields throughout the food value chain, including agrifood, sustainable development, food safety, quality, traceability and authenticity, environmental safety, and human health. The METROFOOD-RI has been selected to the ESFRI Roadmap2018 as mature enough to be implemented within the next ten years. The Action is aimed to support METROFOOD-RI to grow from its current status (research-based network of facilities and skills) to a mature, centrally-coordinated, integrated RI, with the legal, financial and technical maturity required for implementing it. The main objective is to develop the organisational, operational and strategic framework of METROFOOD-RI. Activities include legal, governance, financial, technical, strategic and administrative aspects carried out in 15 work packages, organised in 3 blocks dedicated respectively to: the organisation of the legal entity that will manage the future RI, i.e. ERIC; defining the operation and operational standards at the level of the whole RI and for the National Nodes, as well as the role of the RI as service-oriented organisation; defining the long-term activities for the future RI and updating the Strategic Research & Innovation Agenda, in response to the actual and future challenges in the agrifood sector and for the society. The main outcome will be the establishment of legal and financial commitment for the future ERIC, ensuring long-term common commitment, decision-making and funding engagement. Continuous relations with stakeholders and the user community will be kept in order to ensure the addressing of their needs at the best, and to focus strategies and planned services.

North Macedonia participates in the operations of several Large European RIs that are not included in the ESFRI Roadmap but are very much important for the development of European and regional research infrastructure:

- ◆ GEANT Pan-European Network
- ◆ EOSC Association – European Open Science Cloud
- ◆ CEESDA

- ◆ EGI: Advanced computing for research
- ◆ OpenAIRE AMKE
- ◆ EuroHPC JU
- ◆ ESS - European Social Survey
- ◆ SEEIST

More information of each Large RI is provided below.

### GEANT Pan-European Network

The Macedonian Academic Research Network (MARNet) is a member of GEANT.

GEANT is the high bandwidth pan-European research and education backbone that interconnects 42 National Research and Education Networks (NRENs), reaching over 50 million users in 10,000 institutions across Europe, and more than 100 economies worldwide through links with other regions. The core backbone is capable of multiple 100 Gbps transmission over each fibre link, and Terabit connectivity can be achieved by a single node. The safe and rapid connection of users to each other, to the increasing amounts of data generated by research, and to the high-performance computing capacity required by collaborative research form the foundation of the GÉANT partnership. GÉANT services offer convenient, fast and reliable access to European High Performance Computing facilities, cloud services for the research and education community, access to scientific data and publications and other services from the European e-infrastructure providers, whenever and wherever needed.

### EOSC Association – European Open Science Cloud

The member of EOSC Association from North Macedonia is Faculty of Computer Science and Engineering, Ss Cyril and Methodius University in Skopje.

The EOSC Association was established as a legal entity on 29th July 2020 with four founding members: GÉANT, Conference of European Schools for Advanced Engineering Education and Research (CESAER), the Spanish National Research Council (CSIC) and the Italian National Computer Network for Universities and Research (GARR). The Association will sign a Memorandum of Understanding with the European Commission to progress the EOSC partnership, which will bring together all relevant stakeholders to co-design and deploy an European Research Data Commons where data are findable, accessible, interoperable and reusable (FAIR), and also as open as possible.

The European Open Science Cloud (EOSC) initiative will offer researchers a virtual environment with open and seamless services for storage, management, analysis and re-use of research data, across borders/boundaries and scientific disciplines by federating existing data infrastructures.

EOSC is being co-created in a series of funded projects and initiatives from Member States and Associated Countries.

## CEESDA

The member of CEESDA from North Macedonia is the Macedonian Social Science Data Archive (MK DASS). The MK DASS is an organisational unit of Institute for Sociological, Political and Juridical Research (ISPJR) of Ss. Cyril and Methodius University in Skopje. It is a national service provider appointed by the Ministry of Education and Science in April 2019.

Consortium of European Social Science Data Archives (CESSDA) provides large-scale, integrated and sustainable data services to the social sciences. It brings together social science data archives across Europe, with the aim to promote the results of social science research and supporting national and international research and cooperation. The CESSDA provides a seamless social science data archive service for the whole of the ERA, which is capable of supporting the research needs of the next generation of social scientists wherever in Europe they may be, or beyond. The CESSDA Consortium is currently composed of 21 members and one observer. CESSDA also has partners in a number of economies outside of the consortium.

Benefits of the CESSDA membership for the scientific community in North Macedonia are:

- ◆ Access to the CESSDA data catalogue (21 000 studies in English language and 9000 in other languages from across Europe);
- ◆ Participation in the CESSDA training activities;
- ◆ Monitoring and implementation of international standards;
- ◆ Participation in international projects.

## EGI: Advanced computing for research

The member of the EGI from North Macedonia is Faculty of Computer Science and Engineering, Ss Cyril and Methodius University in Skopje.

The EGI Federation is an international e-Infrastructure set up to provide advanced computing and data analytics services for research and innovation. The EGI e-infrastructure is publicly-funded and comprises hundreds of data centres and cloud providers spread across Europe and worldwide. It delivers advanced computing services to support scientists, multinational projects and research infrastructures. The EGI Services are provided by EGI's federated cloud providers and data centres. The services can be requested by everyone involved in academic research and businesses via the EGI Marketplace.

## OpenAIRE

The member of the OpenAIRE from North Macedonia is Ss Cyril and Methodius University in Skopje.

OpenAIRE has a large network in every member economy and beyond. It consists of Open Science experts in Higher Education Institutions, data centres, and infrastructure consortia which provide regular training and advice at national level about all aspects of Open Science. It actively



promotes the concept of Open Science and supports new ways of communicating science and embedding new workflows in daily practice. In 2018, OpenAIRE established a legal entity called OpenAIRE A.M.K.E. to ensure a permanent presence and structure for a European-wide national policy and open scholarly communication infrastructure.

Services provided include the following:

- ◆ **Aligning policies:** OpenAIRE AMKE fosters the open science dialogue for policies and their implementation in Europe and beyond. The network of 34 National Open Access Desks (NOADs) operates an European Helpdesk supporting a coordinated transition to Open Science.
- ◆ **Providing open science services:** OpenAIRE AMKE provides interoperability services that connect research and enable researchers, content providers, funders and research administrators to easily adopt open science.
- ◆ **Building global common standards for linking research:** OpenAIRE AMKE links research outcomes (e.g. publications, data, software) to their creators (e.g. researchers, institutions, funders), enabling discoverability, transparency, reproducibility and quality-assurance of research.
- ◆ **Monitoring (open) science:** Facilitating transparency in research impact assessment. OpenAIRE AMKE builds the European Research Information system that encompasses all research and enables ready-made reporting, monitoring and analysis.
- ◆ **Training for open science:** Fostering the culture change for Open Science practice.
- ◆ **Building global bridges:** Connecting Europe to the global open research environment. It works with similar initiatives around the world to promote and share common access policies and protocols for all research results.
- ◆ **Facilitating Open Innovation:** Facilitating innovation for scholarly communication, opening new horizons for research.

## EuroHPC JU

North Macedonia is a member of EuroHPC JU, represented by the Faculty of Computer Science and Engineering, Ss Cyril and Methodius University in Skopje.

The European High Performance Computing Joint Undertaking (the EuroHPC JU) is a legal and funding entity established by Council Regulation (EU) 2018/1488 and located in Luxembourg. In total 32 European countries are currently taking part in the initiative and pooling their resources with the EU and private partners to enable the EU to become a world leader in supercomputing. The EuroHPC JU allows the EU and EuroHPC participants to coordinate their efforts and pool their resources with the objective of deploying in Europe world-class exascale supercomputers, able to perform more than one trillion (10<sup>18</sup>) operations per second and developing innovative supercomputing technologies and applications. By making Europe a world leader in high performance computing (HPC), the EuroHPC JU seeks to provide computing solutions, improving cooperation in advanced scientific research, boosting industrial competitiveness, and ensuring European technological and digital autonomy.



The EuroHPC JU is composed of public and private members:

- ◆ Public members: the European Union (represented by the EU Commission).
- ◆ Member States and Associated Countries that have chosen to become members of the Joint Undertaking: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Montenegro, the Netherlands, North Macedonia, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, and Turkey.
- ◆ Private members: representatives from the two participating private partners, the European Technology Platform for High Performance Computing (ETP4HPC) and the Big Data Value (BDVA) associations.

With funding from the EuroHPC JU, EuroCC and CASTIEL H2020 projects will build a European network of 33 national HPC competence centres. The two projects will bridge the existing HPC skills gaps while promoting cooperation and the implementation of best practices across Europe.

### ESS - European Social Survey

The ESS is an academically driven cross-national survey that has been conducted across Europe since its establishment in 2001. Every two years, face-to-face interviews are conducted with newly selected, cross-sectional samples. The ESS was awarded European Research Infrastructure Consortium (ERIC) status on 30th November 2013.

North Macedonia joined the European Social Survey (ESS) for the first time in the 10th Round. This initiative was supported by the main public and private universities with social science departments in the economy, which appointed their representatives for the National Network of ESS in North Macedonia. The participation in the ESS is of great importance for research community in social sciences enabling them to have an open access to database of comparable data on large number of social science topics in European countries. The use of these data will increase the quality of scientific publications and will result in increase of interdisciplinary research among researchers within higher education institutions and in the economy.

Round 10 of ESS in North Macedonia will be conducted by the Institute for Sociological, Political and Juridical Research in Skopje. As a result of the COVID-19 pandemic, the Round 10 fieldwork, originally due to be collected in face to-face-interviews from late 2020 was not possible. If health conditions permit, the fieldwork is going to be conducted in 2021.

### SEEIST- The South East European International Institute for Sustainable Technologies

The South East European International Institute for Sustainable Technologies (SEEIIST) is a regional project gathering the following Parties: Albania, Bosnia and Herzegovina, Bulgaria, Kosovo\*, North Macedonia, Montenegro, Serbia and Slovenia.

The main missions of the SEEIIST Project are:

\* This designation is without prejudice to positions on status, and is in line with UNSCR 1244/1999 and the ICJ Opinion on the Kosovo declaration of independence.

- ◆ Science for Peace
- ◆ Scientific Excellence
- ◆ International Collaboration
- ◆ Sustainable development of society
- ◆ Education
- ◆ Technology Transfer
- ◆ Development of powerful digital network
- ◆ High performance computing and Big Data handling

On 28 May 2020, a Call for Expression of Interest was announced for participation in the process of establishing the Institute (specifically at the Biomedical Centre focused on treatment of cancer with hadronic therapy). On 9 September 2020, the team of scientists working on the SEEIIST development project submitted an application for the ESFRI Roadmap, requesting € 240 million in financial assistance from the European Commission to build and equip SEEIIST.

North Macedonia is among the few economies in South East Europe that has decided to participate in the international public call for the location for the construction of the International Institute for Sustainable Technologies (SEEIIST) on its territory. The decision was made in December 2020, and an expert team has been formed to prepare an application/candidacy with which the economy will participate in the international public call.

## 5. CONCLUDING REMARKS AND POLICY RECOMMENDATIONS

In order to successfully integrate into the ERA, North Macedonia should recognise research infrastructures as strategically important for economic development. The visibility and quality of RIs in the wider European research scope need to be further improved and connection with the knowledge society should be enhanced. Policy coordination is most important on this path, while strong links to R&D priorities are necessary conditions so that funding could be directed to research facilities that carry out the best research and provide the most prominent socio-economic benefits.

Having in mind that research advancements are extremely dynamic, RI Roadmap should be considered as a continuous process resulting in a more comprehensive inclusion of existing research infrastructure in the future.

As a result of the analysis of current situation of research infrastructures in the economy, the following policy recommendations emerge aiming to improve the quality of the existing research infrastructure in North Macedonia:

### **Create an Action Plan for development of Research infrastructures**

After mapping the existing research infrastructures and RI projects in this document, it is necessary to develop an Action Plan for the implementation of measures and activities to ensure further development of RI. The main purpose of the Action Plan is to outline financial implications and summarise key steps that need to be taken to implement the actions and attain the objectives of the Roadmap. The implementation of RI Roadmap is critical for North Macedonia to get closer to the forefront of science and technology and become more competitive in regional economy.

However, putting in place RI has a significant impact on national science budget (which is quite low), hence raising the question of their long-term sustainability. This requires a general debate to explore ways of combining funds from different sources more efficiently and ultimately defining goals for the Research Infrastructures.

### **Establish a link between the research potential identified in the RI Roadmap and future activities in designing the Smart Specialisation Strategy**

Since North Macedonia is currently in the process of designing its S3, it is important to include the RI Roadmap as an input document for the next steps that will lead to the selection of the final priority domains. The existing research infrastructures are an important guideline for mapping R&D potentials as a necessary element for defining a policy mix in the process of S3 implementation.

If North Macedonia wishes to ensure successful implementation of the S3 and to use the existing opportunities, it should provide the upgrade or construction of new research infrastructures and further develop the research-innovation potential. Regarding the investments in projects of national importance, it is also reasonable to invest in RI projects that will contribute to the reduction of the development gap in relation to developed EU MS.

### **Increase investments in research infrastructures**

According to the current figures, North Macedonia records very modest level of R&D expenditures compared to EU member states and the overall situation is even worse considering the declining trend of R&D investments in recent years. If North Macedonia wants to catch up with developed economies, it is necessary to consider greater budget allocation for R&D and creating policy measures that would stimulate higher investments in research activities by the research and business sectors.

With regards to financing research infrastructures, North Macedonia should consider implementing a second round of support to research laboratories that was originally implemented by the Ministry of Education and Science in 2010. Considering the time lapse of 10 years, research equipment is largely obsolete and additional investment is needed to enable research institutions to operate in accordance with the state of the art research equipment. The second financial support programme would contribute to strengthening the universities and other research institutions with the most modern research equipment, and supporting them in implementation of their international scientific projects.

### **Improve the policy framework**

The research system of North Macedonia is characterised by the absence of a science and research development strategy. The review of current strategic documents in the area of R&D has shown that there is no National Programme for Scientific and Research Activity in place in North Macedonia. The absence of this strategic document represents a certain obstacle in implementing RI Roadmap due to the lack of a strategic basis and framework. Considering the importance of this strategic document for defining strategic directions and priorities and future development of research activities in North Macedonia, the National Council for Higher Education and Scientific Research should develop a National Programme for Scientific and Research Activity of North Macedonia.

The term “Research Infrastructure” is recognised and clearly defined in the current version of the Law on Scientific and Research Activity; however, in the next amendment to this Law, it is desirable to provide a definition of “RI Roadmap” that would include its clear purpose and create a legal basis for development and adoption of this policy document.

The Ministry of Education and Science should establish partnership with the NOSCI.mk and jointly work on the inclusion of open science, open access and open infrastructures into the national legal framework for research and education.

The Ministry of Education and Science should also consider adapting the national legal framework for the assessment of academic advancement and align it with the current EU trends that rely heavily on the open science principles and FAIR data.

### **Support the development of e-infrastructure**

Strong and high-quality e-infrastructure is the basis and condition for the future development of research system in North Macedonia. In strategic terms, North Macedonia should do much more in supporting e-infrastructure than it does now. It is necessary to make better plans for the coordinated development of e-infrastructure so that the necessary funds can be timely allocated. North Macedonia should launch measures to encourage research institutions to pursue

collaborative investment in e-infrastructures where everyone could show their own interest in e-infrastructure development through partnership.

The Ministry of Education and Science should foster the initiative of identifying and digitising various collections of records that exist in research centres.

Additional recommendations relate to the following:

- Intensify digitalisation of research and innovation sector, in particular the process of identification and digitalisation of various collections and other contents of national importance
- It is necessary to intensify the work on creating prerequisites for open access to research data
- Improve information and strengthen user support for open access and maximum use of existing infrastructures.

### **Consider options for more active participation in Large European Research Infrastructures**

It is noteworthy to mention that despite the unenviable state of science and research North Macedonia institutions have been participating in several European RIs. However, North Macedonia should consider launching policy instruments that would result in increasing participation in large Pan-European research infrastructures. Benefits of accessing large RI for researchers and research institutions are multiple and mostly related to: capacity building, implementation of high-level research projects that cannot be implemented in-economy due to the lack of appropriate equipment, strengthening national scientific excellence, etc.

The relevant ministries should provide financial support for the membership of interested institutions from North Macedonia in Large RIs and associations, before which it is necessary to identify and propose appropriate ESFRI/ERIC RIs for which there is interest and capacity for membership.

### **Defining Open Access Policies for research infrastructures**

As a result of Open Access Research Infrastructure in the Western Balkans Support Programme implemented by RCC Secretariat in 2020, 4 research institutions in North Macedonia have created a document on Open Access Policy to RI. Building on the experience gained in this programme, the Ministry of Education and Science should encourage other research institutions to adopt their own Open Access Policy documents. The final deliverables from this Programme could be taken into account when defining policies for providing access to RIs.

Additionally, best practices and guidelines regarding the topics helpful to those responsible for defining access policies could be found in the public document developed by the EU Commission<sup>7</sup> that provides the charter for access to research infrastructures which sets out principles and guidelines for defining access policies for RIs.

<sup>7</sup> EC (2016). European Charter for Access to Research Infrastructures, Directorate-General for Research and Innovation, Brussels

## APPENDIX 1: LIST OF CAPITAL EQUIPMENT AT PURCHASE PRICE HIGHER THAN 50.000 EUR

Institution	No.	Name of research equipment.	Purchase Price (EUR)	Year of Purchase	The source of funds for the purchase of equipment	Estimated Duration of Equipment (yrs.)	Estimated Number of Users
<b>UKIM, Faculty of Technology and Metallurgy, Laboratory for Materials and Nanostructure Analysis</b>	1	Scanning Electron Microscope – JEOL IT200	120.000	2020	Funds/international donations IAEA Agency (MAK1003 TC project)	20-30 yrs	30-50
	2	Raman SPELEC spectrometer with potentiostat for cyclic voltammetry and amperometry	57.705	2021	Funds/international donations IAEA Agency (MAK1003 TC project)	25-35 yrs	50-70
	3	Calorimetric Bomb IKA 600	44.000	2020	Funds/international donations IAEA Agency (MAK1003 TC project)	25-30 yrs	30-50
	4	Differential Scanning Calorimeter with Thermogravimetry	67.000	2021	Funds/international donations IAEA Agency (MAK1003 TC project)	30-35 yrs	50-70
	5	Thermogravimetry and Dynamo-mechanical analysis	75.000	2005	Funds from international projects FP 6 – ECO PCCM project	30-35 yrs	30-50
<b>UKIM, Faculty of Technology and Metallurgy, Laboratory for Food Technology and Biotechnology</b>	6	High performance liquid chromatography (HPLC)	53.000	2009	Funds from international projects	30+	1 per day
	7	FISCHER AUTODEST MODEL 800 Vacuum distillation apparatus	200.000				
<b>UKIM, Faculty of Technology and Metallurgy, Textile Laboratory</b>	8	Fabric assurance by simple testing F.A.S.T. 1-4 and press tester	51.000	2011	Resources of the Ministry of Education and Science	10	8

Institution	No.	Name of research equipment.	Purchase Price (EUR)	Year of Purchase	The source of funds for the purchase of equipment	Estimated Duration of Equipment (yrs.)	Estimated Number of Users
<b>UKIM, Faculty of Computer Science and Engineering, National centre for high performance computing and cloud</b>	9	HPC cluster	~1.000.000	2010	Resources of the Ministry of Education and Science	15 years	>100
	10	Cloud cluster	~2.500.000	2018	Donation	15 years	>100
	11	GPGPU cluster	~50.000,00	2020	Own funds / Donation	10 years	>50
	12	IPX (Internet Exchange)	~50.000,00	2019	Own funds / Donation	15 years	
	13	Airpointer-MLU Austria	90.000	2011	Resources of the Ministry of Education and Science	15	1
<b>UKIM, Faculty of Electrical Engineering and Information Technologies, Physics Laboratory</b>	14	Dating system Riso TL/OSL	88.700	2016	Funds/international donations International Atomic Energy Agency – IAEA	15	6
	15	Equipment for deposition and studying of thin films for solar cells application, including the set of real size PV and ST systems with equipment for studying their performance	52.500	2008-2019	FFunds from international projects (HORIZON2020) Funds/international donations International Atomic Energy Agency – IAEA	20	6
	16	Set of laboratory exercises for Physics in the first study cycle (consisting of 16 different experiment sets)	62.000	1990-2010	Own funds Funds/international donations (IAEA)	20	200 per year
<b>UKIM, Faculty of Electrical Engineering and Information Technologies, Laboratory for Wireless and Mobile Networks</b>	17	Cloud RAN platform infrastructure	78.000	2018	NATO FALCON project (SPS - G5269)	5 years - 10 years	N/A
	18	Signal and Spectrum Analyser Rohde & Schwarz FSW8	72.389	2014	NATO ORCA project (SfP 984409)	> 10 years	N/A



Institution	No.	Name of research equipment.	Purchase Price (EUR)	Year of Purchase	The source of funds for the purchase of equipment	Estimated Duration of Equipment (yrs.)	Estimated Number of Users
<b>UKIM, Faculty of Electrical Engineering and Information Technologies, Laboratory for Electrical Measurements</b>	19	Multi-Product Calibrator 5500A Fluke	60.000	1996	Ministry of Science of R. North Macedonia	30	5
<b>UKIM, Faculty of Electrical Engineering and Information Technologies, Laboratory for Detection of Irradiated Food (LDIF)</b>	20	Riso TL/OSL dating system DA-20	90.000	2016	Funds/international donations (funds from international institutions in national projects)	15	6
<b>UKIM, Faculty of Natural Sciences and Mathematics, Institute of Chemistry</b>	21	Gas chromatograph GC/FID/ECD	60.000	2020	Donation from Norway (UNOPS project)	10	7
	22	Gas chromatograph GCxGC/TOF-MS	300.000	2010	Government project	10	5
	23	Gas chromatograph GC/MS	106.000	2007	Donation from OPCW	10	5
	24	Liquid chromatograph HPLC/DAD/MS	180.000	2008	Funds from FP7 project, European Commission	10	7
<b>UKIM, Faculty of Medicine, Institute of Pathology</b>	25	Autostainer PT Link 48	50.000	2017	Own funds	10 years	30/year
	26	BenchMark Ultra	50.000	2021	Donation	10 years	30/year
	27	Transmission electron microscopy JEOL 1400 and supportive technique	800.000	2011	Resources of the Ministry of Education and Science	30 years	10/per year
	28	NGS MySeq DX	100.000	2017	Own funds	10 years	3/per year
	29	ABI 310	150.000	2011	Resources of the Ministry of Education and Science	10 years	

Institution	No.	Name of research equipment.	Purchase Price (EUR)	Year of Purchase	The source of funds for the purchase of equipment	Estimated Duration of Equipment (yrs.)	Estimated Number of Users
<b>UKIM, Faculty of Medicine, Institute of Microbiology and Parasitology</b>	30	Bact/Alert	50.000	2017	Own funds	10 year	
	31	Imunnolite	50.000	2018	Own funds		
	32	Amplex	50.000	2019	Donation	10 year	
	33	Real Time PCR	50.000	2010	Resources of the Ministry of Education and Science	10 year	
	34	VITEK	50.000	2003	Own funds	1-2 year	
	35	VIDAS	50.000	2000			
<b>UKIM, Faculty of Medicine, Institute for Immunobiology and Human Genetics</b>	36	MiniSeq Illumina NGS platform	50.000	2020	Public Funds	7	3
	37	S5 studio ThermoFisher NGS platform	50.000	2018	Donations	7	3
	38	Ion Chef automated liquid handler	50.000	2018	Donations	5	3
	39	Attune NeXt flow cytometer	50.000	2018	Resources of other ministries	6	2
<b>UKIM, Faculty of Pharmacy, Centre for Drug Quality Control</b>	40	GC Clarus 500, Perkin Elmer	50.000	2004	Own funds	N/A	3
	41	HPLC/DAD Agilent 1100 series	50.000	2005	Own funds	N/A	10
	42	RP-HPLC/DAD/FLD Agilent 1200 series	50.000	2007	Own funds	N/A	10
	43	UPLC/DAD/RID Nexera Shimadzu	50.000	2011	Government of North Macedonia	N/A	10
	44	UPLC/DAD-MS/MS Nexera, Shimadzu	100.000	2011	Government of North Macedonia	N/A	10
	45	AAS AA-7000, Shimadzu	50.000	2012	Government of North Macedonia	N/A	3
	46	UPLC/DAD Agilent 1260	55.000	2016	Own funds	N/A	10
<b>UKIM, Faculty of Pharmacy, Centre for Biomolecular Pharmaceutical Analyses</b>	47	Applied Biosystems™ 3500 Series Genetic Analyser, Thermo Fisher Scientific	120.000	2012	Ministry of Education and Science	20	
	48	Miniseq system for NGS, Illumina	50.000	2017	Own funds	20	

Institution	No.	Name of research equipment.	Purchase Price (EUR)	Year of Purchase	The source of funds for the purchase of equipment	Estimated Duration of Equipment (yrs.)	Estimated Number of Users
<b>UKIM, Faculty of Pharmacy, Centre for Natural Products</b>	49	Agilent 7890A Gas Chromatograph coupled to an Agilent 5975C Quadrupole Mass Detector (Agilent Technologies, USA) and Shimadzu AOC 5000 Plus Headspace autosampler (Shimadzu Corporation, Japan)	105.000	2006	Own funds	20	
	50	Agilent 1200 Series HPLC System equipped with quaternary pump G1311A, autosampler G1329A, degasser G1322A, column thermostat G1316A and UV-Vis detector with a series of diode G1315D (Agilent Technologies, USA)	80.491	2007	Own funds	20	
<b>UKIM, Faculty of Design and Technologies of Furniture and Interior, Furniture Testing Laboratory</b>	51	KS 3040/650 PC-xp K.Schulten GmbH&Co. KG	107.400	2009	(2014) Faculty of Forest Sciences 03-325/1 19.08.2014	20 yrs.	10
	52	WEINMANN (SEAD-BACK TEST SYSTEM, SIDE TO SIDE TEST SYSTEM FURNITURE, MATTRESS TESTING PRUFTECHNIK, IMPACT TEST)	285.551	2009	(2014) Faculty of Forest Sciences 03 325/1 19.08.2014	20 yrs.	10
<b>UKIM, Institute of Animal Science</b>	53	Milkoscan FT 6000 Foss electric, Danmark, ID 0311-2000-02 and Conveyor 4000 Foss electric, Danmark, ID 1711-2000-03	129.188	2000	Ministry of Agriculture, Forestry and Water Economy	20	1

Institution	No.	Name of research equipment.	Purchase Price (EUR)	Year of Purchase	The source of funds for the purchase of equipment	Estimated Duration of Equipment (yrs.)	Estimated Number of Users
<b>UKIM, Institute of Earthquake Engineering and Engineering Seismology</b>	54	Shake table	1.800.000	1980	Own funds (IZIIS)	40-still on going	50+
	55	MTS digital controller for shake table	430.000	2011	Funds from international projects (SERIES project)	20+	
	56	Instrumentation set up (accelerometers, LVDT's, LP's, SG's)	90.000	2018	80% Funds from abroad donations (DAAD)	20+	
	57	NI-PXI DATA Acquisition system	50.000	2006	international donations (DAAD)	20	
	58	Other Data Acquisition systems	70.000	2012	90% Own funds 10% from international projects (NATO SPS)	20	
	59	Triaxial apparatus for static and dynamic testing	60.000	2011	Funds from international projects (UREDITEME)	20	60
<b>St Kliment Ohridski University, PSI Hydrobiological Institute Ohrid</b>	60	Boat "Lehmar"	458.185	1999	Donation World Bank	20	1
	61	BOB 2 with full equipped	81.712	2013	IPA Project	10	1
<b>St Kliment Ohridski University, Veterinary Faculty, CNAD (Centre for scientific and applied activities);</b>	62	PCR System: Agilent Stratagene MX3005P QPCR System: Agilent 2100 Bioanalyzer +Laptop;	54.524	2011	Resources of the Ministry of Education and Science	10	
<b>Goce Delcev University, Faculty of Natural and Technical Sciences, AMBICON Research Group</b>	63	Scanning Electron Microscope TESACN VEGA 3 + EDS Oxford analytics + Sample preparation equipment	500.000	2011, 2014	Ministry of Education and Science (90%) + Own Funds (10 %)	10+	50
	64	X-RAY Diffractometer Shimadzu XRD 6000	150.000	2011 + 2015	Ministry of Education and Science (90%) + Own Funds (10 %)	10+	10

Institution	No.	Name of research equipment.	Purchase Price (EUR)	Year of Purchase	The source of funds for the purchase of equipment	Estimated Duration of Equipment (yrs.)	Estimated Number of Users
<b>Goce Delcev University, Faculty of Natural and Technical Sciences, AMBICON Research Group</b>	65	Fluorescence X-RAY spectrophotometer Shimadzu EDX 900	80.000	2011 +2015	Ministry of Education and Science (80%) + Own Funds (20%)	10+	20
	66	Scanning Probe Microscope SPM970	70.000	2011	Ministry of Education and Science	10+	2
	67	Particle Size Analyser SALD 3101	100.000	2011	Ministry of Education and Science	10+	5
	68	Highly sensitive Radon determination equipment for water, air and soil samples	70.000	2018	Own funds	10+	4
	69	Specific smaller equipment, consisting of sampling, analytical and measurement equipment + reference materials	300.000	2012-2020	Own Funds	5 +	30
<b>Goce Delcev University, Faculty of Medical Sciences, Health Sciences Research Group</b>	70	RADIOPHARMACY Liophiliser	50.000	2011	Ministry of Education and Science	10+	/
	71	Isotope isolation chamber	100.000	2011	Ministry of Education and Science	5 +	/
	72	Phosphorus/Instant imaging system	50.000	2011	Ministry of Education and Science	10+	/
	73	HPLC	100.000	2011	Ministry of Education and Science	10+	/
	74	Additional smaller equipment, consisting of analytical, sample preparation and storage equipment	200.000	2011	Ministry of Education and Science	10	/
	75	DENTAL MEDICINE LAB CAD CAM System	200.000	2011	Ministry of Education and Science	10+	Education only
	76	Dental Lasers	50.000	2011	Ministry of Education and Science	10+	Education only

Institution	No.	Name of research equipment.	Purchase Price (EUR)	Year of Purchase	The source of funds for the purchase of equipment	Estimated Duration of Equipment (yrs.)	Estimated Number of Users
<b>Goce Delcev University, Faculty of Medical Sciences, Health Sciences Research Group</b>	77	Additional smaller equipment, consisting of lasers, motors, mixers and dryers.	100.000	2011	Ministry of Education and Science	10+	Education only
<b>Goce Delcev University, Faculty of Agriculture, UNILAB</b>	78	Gas Chromatography PACKAGE 450/320-MS TRIPLE QUAD GC/MS/MS	80.000	2015	Ministry of Education and Science	10+	5
	79	ICP MS - Agilent	150.000	2008	Ministry of Education and Science	10+	5
	80	ICP OES Shimadzu	50.000	2015	Ministry of Education and Science	10+	5
	81	Additional smaller equipment, consisting of analytical, sample preparation and storage equipment	500.000	2011-2018	Ministry of Education and Science (80%) Own Funds (20%)	10+	5
<b>Private scientific institution Institute for Advanced Composites and Robotics Prilep</b>	82	Slitting equipment Type - NSU-300D-2R	181.500	2013	Own funds	20	5
	83	AFP/ATL Robot Machine Type - AFP Libra - MRFP-4T64	916.082	2018	Other sources-Agreement on business cooperation with the owner	20	7
	84	Diode Laser Type - LDM 3000-100	109.337	2018	Other sources-Agreement on business cooperation with the owner	20	7
<b>Georgi D. Efremov Research Centre for Genetic Engineering and Biotechnology, Macedonian Academy of Sciences and Arts</b>	85	DNA Microarray Scanner system (High-Res-Microarray), Agilent	98.000	2009	EU grant (REGPOT)	10	10
	86	MiSeq personal sequencer, Illumina	120.000	2012	EU grant (REGPOT)	10	30

Institution	No.	Name of research equipment.	Purchase Price (EUR)	Year of Purchase	The source of funds for the purchase of equipment	Estimated Duration of Equipment (yrs.)	Estimated Number of Users
<b>Georgi D. Efremov Research Centre for Genetic Engineering and Biotechnology , Macedonian Academy of Sciences and Arts</b>	87	3130 Genetic Analyser with computer, Applied Biosystems	91.100	2009	Own funds	10	30
	88	3500 Genetic Analyser, Applied Biosystems	120.000	2012	EU grant (REGPOT)	10	30
	89	2D DIGE scanner and electrophoretic system, Ettan DIGE Imager, LKB Austria	118.000	2009	EU grant (REGPOT)	10	10
	90	Mass spectrometer MALDI TOF TOF, Axima Performance, Shimadzy	570.000	2012	Resources of the Ministry of Education and Science	10	20
	91	High Definition Mass Spectrometry, Synapt G2-SI, Waters	660.000	2016	Public Funds	10	20
	92	Aminoacid analyser, Biochrom 30, LKB Austria	94.000	2006	Own funds	10	10



## APPENDIX 2: SURVEY QUESTIONNAIRE

This survey questionnaire contains several sets of questions that serve as an input for the identification and evaluation of research infrastructures potential in Bosnia and Herzegovina. The aim of the questionnaire is to map the research infrastructure as the first and indispensable step in the process of designing the Research Infrastructure (RI) Roadmap.

According to the definition of European Commission, Research Infrastructures (RI) are facilities that provide resources and services for research communities to conduct research and foster innovation. They include:

- ◆ major scientific equipment or sets of instruments;
- ◆ collections, archives or scientific data;
- ◆ computing systems and communication networks;
- ◆ any other research and innovation infrastructure of a unique nature which is open to external users.

Research infrastructures can be centralised, that is, based in a single location. They can also be distributed or virtual, and can form mutually complementary wholes and networks.

Please note that the questionnaire is designed for research centres, laboratories and departments operating within public and private organisations (universities and faculties, public and private research institutes) accredited for research and innovation.

### 1. General information

#### 1.1. Data about respondent

Full name

Name of your institution

Institution's address

Your position in the institution

Your email address

Institution's website address

## 1.2. General information about research infrastructure or important research equipment and facilities

1. Name of research infrastructure
2. Host institution
3. Research Infrastructure's address
4. Research infrastructure's website
5. Thematic categorisation of RI by field of science\*
6. Type of RI\*\*
7. Main scientific domain
8. Other scientific and technological domains served by RI
9. Total number of RI users
10. Name and position of a person responsible on behalf of research infrastructure:
11. Year of establishment of RI:
12. Founder Institution(s) Ownership Share (%)

\*Thematic categorisation of RI types by field of science.

The ESFRI sets the following 6 thematic areas:

1. energy;
2. environment;
3. health and food sciences;
4. physical sciences and engineering
5. social and cultural innovation;
6. e-infrastructures

E-Infrastructure for scientific research—provides computing services for the scientific community.

\*\*Four types of RI are commonly distinguished:

1. single-site facilities;
2. distributed facilities;
3. mobile facilities;
4. virtual facilities

## 1.3. Description of Research Infrastructure. Please provide basic information and objectives of the research infrastructure

## 1.4. Please list the services provided to research infrastructure users

## 2. Data on research equipment

### 2.1. Estimated value of research equipment

Total estimated value of research capital equipment (in EUR):

purchase value: EUR

current value (amortisation): EUR

### 2.2. List of capital equipment at purchase price higher than EUR 50.000

Name of research equipment	Purchase Price (EUR)	Year of Purchase	The source of funds for the purchase of equipment	Estimated Duration of Equipment (yrs.)	Estimated Number of Users
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					
10.					
...					
n					

Please enter only the equipment the purchase value of which is above EUR 50,000.

In the column "The source of funds for the purchase of equipment" please enter the funding source. If there are two or more sources, please indicate each one with the participation share:

- a. Own funds
- b. Resources of the Federal Ministry of Education and Science
- c. Resources of other ministries
- d. Public funds
- e. Donations
- f. Funds from international projects
- g. Funds / international donations
- h. Other sources - specify which!

### 3. Information on access, collaboration and impact

#### 3.1. Information on access

Please provide short description of access policy and procedures for users of this research infrastructure.

##### 3.1.1. Information on external users

Users of RI

Please specify the name of Institution, department

Research groups from your economy

Research groups from Western Balkan economies

Research groups from EU and other countries

#### 3.2. Information on cooperation

Please list the international co-operation agreements and partnerships in which this RI has been involved.

##### 3.2.1. Integration into larger RIs

Is RI connected or integrated into larger RIs (international) or is it a member of any European RI?

Yes

No

If yes, please specify the details:

The name of larger RI:

Membership conditions:

Membership fee, who finances it:

Active

Joined

Additional information:

#### 3.3. Engagement in projects related to research infrastructure development

Have you been engaged in a project aiming at the development of research infrastructure?

Yes

No

If yes, please specify the details:

Title of the project:

Time duration:

Link to web address:

Please add new rows if necessary.

### 3.4. Plan for the Future

Please describe in detail the plan for the next period, at least for 2-5 years:

Future investments in research equipment:

Is integration into larger research  
infrastructures considered:

Other relevant information:

## APPENDIX 3: DETAILED INSTRUCTIONS FOR COMPLETING THE SURVEY

The entire process of launching and conducting survey needs to be carried out in broad cooperation with the scientific and research community. The process of surveying need to be complemented with the integration of infrastructure data from other sources i.e. memberships in international research infrastructure organisations, research infrastructures on national level developed from domestic and EU funds etc.

The text below provides detailed instructions for completing survey questionnaire.

The survey questionnaire consists of 3 sections:

1. General information
2. Data on infrastructure and equipment
3. Information on Access, Collaboration and Networks

The questionnaire should be filled in for one research infrastructure and all data and descriptions should be given for the specific infrastructure that is subject of the questionnaire. Detailed instructions for completing the questionnaire are provided in the text below.

### Instructions for completing Part 1: General information: Tables 1.1., 1.2., 1.3., 1.4.

Table 1.1. should include the main information about respondent. The second Table 1.2 refers to the general information about research infrastructure which is the main focus of the questionnaire.

In the field "Thematic categorisation of RI types by field of science", research infrastructure should be grouped thematically. The ESFRI Roadmap 2016 sets the following 6 thematic areas:

1. energy;
2. environment;
3. health and food sciences;
4. physical sciences and engineering
5. social and cultural innovation;
6. e-infrastructures.

Research infrastructures should be linked to one of these defined categories.

In the next field "Type of RI", there are four types of RI that are commonly distinguished:

1. Single-site facilities;
2. distributed facilities;
3. mobile facilities;
4. virtual facilities.

Each research infrastructure should belong to one of these 4 types.

Table 1.3. should provide a detailed description of research infrastructure (general information on research infrastructure) and it's main purpose and objectives.

Table 1.4. should specify and explain specific research services provided to users and external researchers. It is necessary to list the services available to researchers that the research infrastructure offers.

### Instructions for completing Table 2.1:

Total value of research equipment used within the research infrastructure should be entered in Table 2.1. It is important to enter two types of values: the purchase value and the current value which takes into account the depreciation of equipment.

### Instructions for completing Table 2.2:

Table 2.2 should list only capital research equipment at purchase price higher than EUR 50,000.

Funding sources should be entered in the column "The source of funds for the purchase of equipment" funding source should be entered. If there are two or more funding sources, each one should be indicated with the participation share. One of the following funding sources should be inserted:

- ◆ Own funds
- ◆ Resources of Federal Ministry of Education and Science
- ◆ Resources of other ministries
- ◆ Public funds from Bosnia and Herzegovina
- ◆ Donations
- ◆ Funds from international projects
- ◆ Funds / international donations
- ◆ Other sources - specify which!

### Instructions for section 3: Information on Access, Collaboration and Impact

Section 3 consists of 4 open questions and sub-questions and it requires information on access, collaboration and impact of research infrastructure.

#### Instructions for completing section 3.1.

Short description of access policy and procedures for users of research infrastructure should be provided in section 3.1. If there is no official access policy, please describe internal procedures that are being used. In addition, the estimated number of users of research infrastructure should



be also inserted since that it is very important information for determining the importance of the selected research infrastructure for the research community at the national and international level. All external organisations and institutions that used research equipment provided by research infrastructure so far should be listed in section 3.1.1.

### Instructions for completing section 3.2.

Recognition of research infrastructure and scientific impact on the international level should be emphasised in the sections 3.2 and 3.3 of this questionnaire. This information is of particular interest for determining the relevance of research infrastructure on an international level.

Information on cooperation with other research institutions is important for determining the relevance of research infrastructure as well as the level of interaction with other actors in the research community. In section 3.2, all international research projects, partnerships or agreements that the research infrastructure has been involved in the last 10 years should be listed. Please note that only research projects that included the use of research equipment should be inserted. Information on the potential integration into international or pan-European research infrastructures should be provided, if there is any, in 3.2.1.

### Instructions for completing section 3.3.

The section 3.3 refers to the engagement in research projects (H2020, FP7, other programmes) which aimed at establishing research infrastructures on national or international level.

### Instructions for completing section 3.4.

The last section (3.4.) refers to future plan of RI management. The respondent needs to briefly specify the future investment, integration into wider RI and other relevant information as considered important.

good.  
better.  
regional.



RegionalCooperationCouncil

**Regional Cooperation Council Secretariat**

Trg Bosne I Hercegovine 1/V

71000 Sarajevo, Bosnia and Herzegovina

T: + 387 33 561 700

[www.rcc.int](http://www.rcc.int)

