European Commission

Support to Greece for policies developing research infrastructures and the R&I ecosystem

Final Report

PSF COUNTRY

HORIZON EUROPE
POLICY SUPPORT FACILITY

Independent
Expert
Report

Research and Innovation

Support to Greece for policies developing research infrastructures and the R&I ecosystem

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Support to Greece for policies developing research infrastructures and the R&I ecosystem

Final Report

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2022

Directorate-General for Research and Innovation
Horizon Europe Policy Support Facility

EN

Table of contents

List of figures

List of boxes

LIST OF ACRONYMS

ACSPRI	Australian Consortium for Social and Political Research Incorporated
ATHENA	Athena Research Centre in Information Technologies, Communications and Knowledge
AUA	Agricultural University of Athens
AUTH	Aristotle University of Thessaloniki
BELSPO	Belgian Federal Science Policy Office
CERN	European Organisation for Nuclear Research
CERTH	Centre for Research and Technology Hellas
CLIMPACT	National Network for Climate Change
DG RTD	Directorate General for Research and Innovation
DTB	Digital Transformation Bible
EC	European Commission
EIB	European Investment Bank
EOSC	European Open Science Cloud
EPANEK	Operational Programme Competitiveness, Entrepreneurship and Innovation
ERA	European Research Area
ERC	European Research Council
ERDF	European Regional Development Fund
ERIC	European Research Infrastructure Consortium
ESFRI	European Strategy Forum on Research Infrastructures
ESIF	European Structural and Investment Funds
EU	European Union
FACS	Fluorescence-Activated Cell Sorting
FORTH	Foundation for Research & Technology Hellas

FP	Framework Programme
FTE	Full-Time Equivalent
GHG	Greenhouse Gas (emissions)
GLAM	Galleries, Libraries, Archives, and Museums
GRNET	National Infrastructures for Research and Technology
GSRI	General Secretariat for Research and Innovation
HCMR	Hellenic Centre for Marine Research
HEAL-LINK	Hellenic Academic Libraries Link
HOSI	Hellenic Open Science Initiative
ICCS	Institute of Communication and Computer systems
ICT	Information and Communication Technology
ICTS	Unique Scientific and Technical Infrastructures (Infraestructuras Científico-Técnicas Singulares, in Spanish)
IP	Intellectual Property
IPR	Intellectual Property Rights
KET	Key Enabling Technologies
KPI	Key Performance Indicators
LRI	Large Research Infrastructures
LSRI	Dutch Large-Scale Research Infrastructures
LTS	Long-Term Sustainability
MA	Management Authority
MEYS	Ministry of Education Youth and Sport
MOU	Memorandum of Understanding
NCRTI	National Council for Research, Technology and Innovation
NECP	National Energy and Climate Plan
NGO	Non-Governmental Organisation
NKUA	National and Kapodistrian University of Athens

NMR	Nuclear magnetic resonance
NRI	National Research Infrastructure
NTUA	National Technical University of Athens
NOW	Dutch Research Council
OECD	Organisation for Economic Cooperation and Development
OP	Operational Programme
OP JAC	Czech Operational Programme Johannes Amos Comenius
PET	Positron Emission Tomography
PSF	Horizon Europe Policy Support Facility
R&I	Research and Innovation
RI	Research Infrastructure
RRF	Recovery and Resilience Facility
S3/RIS3	Smart Specialisation Strategy
SDG	Sustainable Development Goals
SLA	Service Level Agreement
SME	Small and Medium-sized Enterprise
SSH	Social Science and Humanities
SWOT	Strengths, Weaknesses Opportunities and Threats
UN	United Nations
VAT	Value Added Tax
TAU	Technical Assistance Unit

Policy Support Facility Panel

John Womersely (United Kingdom), Chair, has over three decades of experience as a successful leader and manager of large national and international scientific and technical organisations, and an expert on science and innovation policy at UK, European and international levels. He is a visiting professor at the University of Oxford. A graduate of Cambridge and Oxford, he played a leading role in particle physics both in Europe and the United States, including leading a major international experiment at Fermilab, before working as a scientific advisor to the Department of Energy in the US. From 2011 to 2016, he led the Science and Technology Facilities Council, the United Kingdom's funding agency for particle physics, astronomy and for large research facilities, where he delivered flagship projects including the Square Kilometre Array telescope, the Hartree Centre for high performance computing, and the Science and Innovation campuses at Harwell and Daresbury. From 2016 to 2021 he served as Director General of the European Spallation Source, a €3B project to build a neutron scattering facility ten times more powerful than anything available today, to address key research challenges for society and the economy.

Alasdair Reid (Belgium), Rapporteur, has over 25 years' experience of advising governments in designing, implementing and evaluating regional, inter-regional, national and European development programmes and strategies for economic development and research and innovation. He has advised the European Commission, the OECD, the World Bank, the Nordic Council of Ministers, national and regional governments and agencies. He has been rapporteur for two previous PSF exercises (Lithuania and Armenia) and has worked extensively in Greece since the mid-1990s, notably in the framework of ERDF R&I policies. Alasdair is an expert on research infrastructure policies, both at the strategic and implementation levels (e.g. supervising over €350m of EU Structural Fund co-financed investments in research and innovation infrastructure in Lithuania). He has co-ordinated or contributed to European level projects on e-infrastructure services and the EOSC portal and the CATRIS catalogues of services; as well as the RI-PATHS (www.ri-paths.eu) project which co-developed in partnership with four major RIs (CERN, DESY, Alba Synchrotron and Elixir) a common European framework for the assessment of the socio-economic impact of RIs. In 2019, he was a member of the ESFRI ad hoc working group on key performance indicators for research infrastructures. In 2020, he was a team member of the socio-economic impact assessment of the European Southern Observatory, and in 2021 worked on the evaluation the Belgian STEREO III programme in earth observation.

Ilaria Nardello (Italy), Expert, is an international manager and a researcher, with experience in the development, operation and sustainability of RIs, notably in the marine and biological science fields. Ilaria's experience includes time as the National Coordinator of Ireland's Marine Biotechnology Programme. She also led the establishment of the European Research Infrastructure Consortium (EMBRC-ERIC), as Executive Director, between 2015 and 2019. She has expertise in long-term sustainability planning of RIs. She has also chaired the Biological and Medical Sciences (BMS) Research Infrastructures Strategy Forum, including all the RIs in the ESFRI Health & Food domain. She is focused on supporting a virtuous articulation of the industry-research-policy pillars and unlocking their potential to leverage science driven innovation and socio-economic development (e.g. through her work for the ENRIITC network of RIs and Industry. Through her participation in the ERIC Forum implementation project, she is currently investigating and developing a reference framework for socio-economic indicators in ESFRI Research Infrastructures.

Anastassis Perrakis (The Netherlands), Expert, is a Group Leader in Structural Biology in the Division of Biochemistry at the Netherlands Cancer Institute and Professor of "Macromolecular Structures" in Utrecht University. Over the last 30 years, he has carried

out research and worked at a range of RIs including at the DESY synchrotron, at the EMBL Hamburg outstation and as a staff scientist and team leader at the EMBL Grenoble outstation, where he pioneered the use of a microX-ray beam for macromolecular crystallography experiments in the European Synchrotron Radiation Facility (ESRF), a key European infrastructure. He was part of the team that started and followed-up the Instruct ESFRI initiative for Integrative Structural Biology. Since 2015, he has coordinated the iNEXT (as deputy) and iNEXT-Discovery Horizon 2020 framework grants to provide joint access to X-rays, NMR and cryo-EM, and the first European programme to offer Biophysics access across Europe. At national level, he established RIs at the Netherlands Cancer Institute (NKI). He has also been a member of advisory and evaluation boards of the ESRF, the UK Diamond Light Source, and the ALBA synchrotron (Spain).

Ángel Munoz-Martin (Spain), Expert, is currently the director of Research Infrastructures at Universidad Autonoma de Madrid. His main duty is to support researchers by offering them access to unique instrumentation and know-how, and to guarantee the sustainability of this support for present and future needs. He has over 20 years' experience in research infrastructures, having covered multiple roles: user of core and large facilities, facility instrumentation developer and local contact for external users and several management positions concerning research infrastructures. Besides the activity at his host institution, Angel has participated in several advisory committees for the IAEA, funding agencies, regional governments and research institutions, always related to research infrastructures.

The panel of experts was supported by three **national peers**:

- **Michele Oleo** (Belgium) is Senior Policy Advisor in the Department of Economy, Science, Innovation in Flanders.

- **Isabel Bolliger** (Switzerland) is Scientific Officer for Strategy at the Swiss National Science Foundation and co-author of OECD Global Science Forum report on "Optimising the operation and use of national research infrastructures report".

- **Jan Hrusak** (Czech Republic) is Special envoy on Research infrastructures at the Ministry (MEYS), Advisor to the Council at the Czech Academy of Sciences and Senior scientist, at the J. Heyrovský Institute of Physical Chemistry in Prague.

The project was overseen by the PSF Team in the EC's Directorate-General for Research and Innovation (DG R&I) unit A1 European Semester & Country Intelligence. **Vladimir Manolov** coordinated the exercise and ensured liaison with the Greek authorities.

The PSF contractor supported the panel's work with thanks due to **Susana Elena Pérez**, project manager, **George Strogylopoulos**, national support expert, **Nikos Paliogiannis,** analytical support expert and **Kimmo Halme**, senior expert for quality review.

The Greek Authorities provided data and background documentation useful for the experts' work and supported the visits to Greece by inviting the representatives of government institutions and stakeholders to meet the group. The **General Secretariat for Research and Innovation** (GSRI) coordinated and ensured the involvement of other ministries, agencies and bodies and kindly made available facilities for the meetings.

EXECUTIVE SUMMARY

Following a request from the Greek General Secretariat for Research and Innovation (GSRI), this report summarises the findings of the Horizon Europe Policy Support Facility (PSF) expert panel concerning the Greek national research infrastructures (NRIs) initiative. The review addressed the following three areas:

- RIs governance and management efficiency:
  - Assessment of the development, operation and sustainability of the research infrastructures (RIs).
- National framework for the RIs:
  - Institutional framework assessment;
  - Potential for further development of common processes and tools; and
  - Connections between the policy processes related to RIs and to national Smart Specialisation Strategy (S3) with the aim of ensuring alignment.
- Indicators for monitoring and assessment of the RIs
  - Development of recommendations for indicators to be used for monitoring and evaluating the NRIs, including international benchmarking.

The PSF panel was asked to provide policy recommendations to increase the contribution of the NRIs to the Greek R&I ecosystem with a view to:

- enhancing socio-economic impacts, innovation potential exploitation, technology transfer, access policy efficiency and business collaboration,
- reinforcing international value chains and European networks and facilitating effective internationalisation policies,
- boosting the scientific and technological excellence of the RIs and their role in attracting and retaining talents.

To respond to the request, the panel has compiled evidence over a 10-month period, from December 2021 to September 2022, using a number of sources and methods:

- A survey of the 28 NRIs, conducted with the support of the GSRI, that compiled information on key dimensions of the NRIs' activities and asked them to reflect on their strengths and future development.

- The survey results were analysed and summarised in the PSF Greece background report (including a summary 'fiche' for each NRI[1]) which also provided an overview of the evolution of Greek R&I policy priorities and instruments, the national RI road-mapping process and the competitive call process that led to the selection (in two rounds) of the 28 NRI projects.

- The survey results and background report informed the work of the PSF Panel and notably the preparation for the first mission to Greece in late March-early April 2022. During this mission, the panel met with NRI coordinators and Greek policy makers responsible for overseeing the NRI projects

- Following the first mission, the PSF Panel drew up an initial analysis of the NRIs grouped in six thematic fields. During the second mission, in early June 2022, the findings were discussed with the NRI coordinators in thematic working groups. The results of this mission informed the panel's final conclusions and recommendations presented in this final report.

The policy framework for investment in research infrastructures

RIs provide resources and services for research communities to conduct research and foster innovation in their fields. A core principle is to have in place an access policy that includes a procedure for covering the cost of providing access to equipment and services to external users (academic, public and industrial researchers). Decisions on public investment in RIs are conducted within a medium to long-term frameworks, notably through research infrastructure roadmaps that prioritise, based on scientific, economic or societal needs, over a given time horizon investments in new RI or the upgrading of existing RIs.

While RIs may primarily address the needs of researchers, they generate diverse type of impacts ranging from scientific excellence, development new skills, influencing policy developments, contributing to business innovation and helping to address societal challenges. Stakeholders, particularly funders and government bodies, are interested in understanding the wider benefits of investment in RIs.

RIs are a core element of the European Research Area (ERA) and the ERA Policy Agenda 2022-2024 Action 8 aims to "strengthen sustainability, accessibility and resilience of RIs". To reach this goal, the European Commission has worked collaboratively with member states and the scientific community, notably within the framework of the European Strategy Forum on Research Infrastructures (ESFRI), to develop existing and new pan-European infrastructures and ensure their effective networking. Greece (as of May 2022) participates in 29 out of 63 ESFRI landmarks and projects (46% of the total). Greece is most active in four ESFRI domains, namely data, computing and digital research infrastructures (75% of total ESFRI RIs), environment (73%), social and cultural innovation (64%) and health & food (50%). Funding for RI projects comes from both European and national levels. Under Horizon 2020, Greek participants were awarded EUR 72.5 million (3.1% of the total) under the thematic priority Research Infrastructures, which is relatively higher than the overall Greek participation (2.5% of the EU net contribution). Of this total, EUR 33.7 million (46.5% of the total) was awarded for participation to e-infrastructures and European Open Science Cloud (EOSC) projects pointing to a significant Greek expertise in this field.

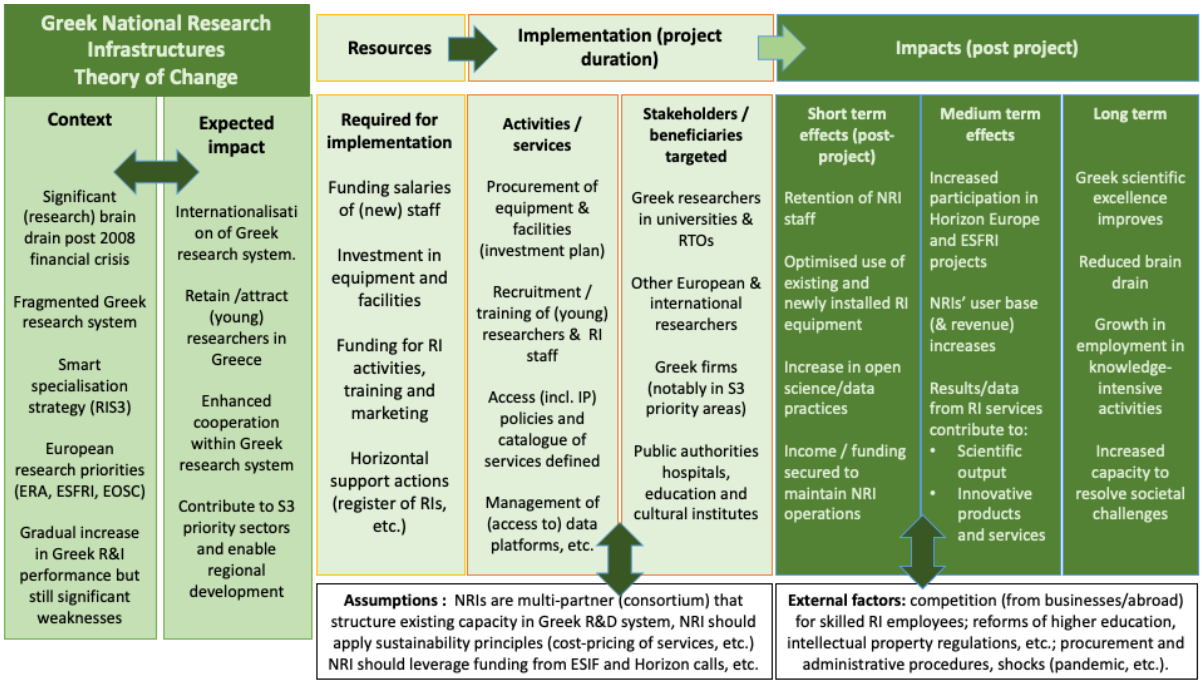
[1] European Commission, Directorate-General for Research and Innovation, Country support to Greece for policies developing research infrastructures and the R&I ecosystem: background report, Publications Office of the European Union, 2022, https://data.europa.eu/doi/10.2777/438164

During the 2014-2020 period, the **Greek R&I policy** was framed by a national and 13 regional S3. The national S3 defined **eight priority areas**: agri-food; healthcare & pharmaceuticals; information & communications technology (ICT); energy; environment & sustainable development; transport & logistics; materials & construction; and tourism, cultural & creative industries. The strategy recognised that the NRI were a key structural element of the R&I ecosystem due to their role as 'enablers of innovation'. In 2014, the GSRI, supported by the National Council for Research, Technology and Innovation (NCRTI), developed a National Roadmap for Research Infrastructures which set the strategic objectives and guiding principles for the NRIs development.

The GSRI, supported by the National Council for Research, Technology and Innovation (NCRTI), developed a Multiannual Budgeting Plan, covering 28 National Research Infrastructures, selected through competitive calls. The NRIs involve 212 participating organisations located in 11 Greek regions, which were awarded a total budget of EUR 93 million allocated across the eight RIS3 priority areas. The multiannual budgeting plan was the precondition for the fulfilment of the ex-ante conditionality for ESIF financing of the NRIs through the EPANEK 2014-20 Operational Programme.

The PSF panel's review covers both the coherence of the overall policy framework and the degree to which the development of the 28 NRIs has progressed by early 2022.

To summarise the expected impact of the NRIs, the PSF panel developed **a theory of change** (see the diagram below). Based on this theory of change, a set of overall conclusions are provided addressing the NRIs contribution to the internationalisation of the Greek R&I system, the impact on human resources, the effects in terms of increased cooperation in the Greek research system and finally the NRIs contribution to the smart specialisation strategy (S3) priorities.



Greek NRI Policy Theory of Change

Conclusions on the programme implementation and institutional framework

- the NRI policy has been implemented in an effective manner and has provided a significant contribution to the structuring of Greek R&I capabilities in line with the national S3 priorities. While it remains too early to judge the full impact, there has been good progress in implementing the activities and promising progress towards the short-term effects (see theory of change model below).

- The spreading of funding across 28 projects (which in turn distributed the funding over a significant number of partners) has reduced the overall effectiveness of the investment. There are grounds for future consolidation of NRIs operating in related fields to improve overall effectiveness.

- The culture of service provision, a core mission for NRIs, requires further reinforcement to enable all the NRIs to develop in line with EU/international practices. Several NRIs operated more as research consortia than research infrastructures.

- The coherence and synergies with other national and regional funding programmes proved difficult to assess. In general, the synergies with other national and regional funding programmes and initiatives were not steered in a strategic manner (e.g., through cross-departmental/ministerial coordination).

- At national level a more pro-active management of the portfolio of NRIs would have been beneficial, and the non-implementation of the planned support measures is regrettable in terms of fostering exchange of experience and common procedures and processes.

- The long-term sustainability of the majority of NRIs is not guaranteed, due to a variety of factors, notably the absence of a single legal entity, gaps in funding that undermine staff retention and operations, lack of funding for equipment maintenance and renewal.

Conclusions on the NRIs contribution to the Internationalisation of the Greek R&I system

- There is an absence of a clear strategic prioritisation of Greek participation to ESFRI and other international RIs. The current 'laissez-faire' policy (letter of support, no government funding) means that there is a proliferation of activities by individual organisations to participate to relevant European and international RIs and partnerships without these organisations necessarily having the means to ensure they can meet the longer-term commitments.

- The NRI status does not directly provide Greek participants with any additional 'credibility' in their efforts to engage with European partners. There has been no coordinated initiative to promote the Greek NRI network at European level (joint branding, single access point website, etc.) that would support individual efforts of NRIs to position themselves in the European landscape.

- NRIs that are nodes of ESFRI landmarks are in general more advanced and the participation in ESFRI projects has provided significant know-how and insights helping them to develop access policies, etc.

- The fact that the NRIs currently operate as consortiums rather than creating a legal entity restricts the potential for their positioning in European scientific and industrial research partnerships.

Conclusions on the impact of NRIs on attracting and retaining researchers in Greece

In broad terms, the policy objective of investing in the NRIs to create an attractive environment for (young) skilled scientists and engineers has been achieved. However, this positive outcome does not guarantee a long-term impact for the Greek R&I system. In particular, the following factors need addressed:

- The ability of the NRIs to recruit qualified personnel is undermined by low salaries and the recruitment procedures of the universities and research centres hosting NRIs.

- The NRIs have recruited a significant number of researchers but this places a strain on their capacity to sustain employment in the event of a gap in funding.

- On the other hand, most of the NRIs have not yet recruited the core facility staff and RI management teams to operate facilities and provide services to users.

Conclusions on the NRIs impact on enhanced cooperation within Greek research system

The 2014 roadmap underlined the need for "*a culture of sharing expensive scientific equipment and e-infrastructures*" and the need "*to shape a Greek R&D ecosystem around nuclei of excellence with considerable capacity*". The PSF panel findings suggest:

- All NRIs operate based on consortium agreements, varying in terms of sophistication and ambition. The consortium model has, in the main, sufficed during the preparatory phase, but will be sub-optimal for the future long-term sustainability of the NRIs.

- The distributed RI model adopted by the NRIs has been important in reinforcing the credibility of regional research teams and in providing users with a better nation-wide view of available equipment and expertise.

- This has enabled progress towards the objective of enhanced utilisation of existing scientific equipment and infrastructure as well as optimising new investments within the distributed RI (avoiding duplications, fostering critical mass).

Conclusions on the NRIs contribution to S3 priority areas

The NRI programme has contributed to structuring research (and to a lesser extent innovation) capacity, in important domains for Greek scientific and economic specialisations and future socio-economic development. The NRIs focus mainly on serving the needs of researchers from the partners and from other universities. However, about half of the NRIs consider start-ups, SMEs and large companies as most important user groups. The extent to which NRIs have developed effective strategies for identifying and engaging with their (existing and prospective) user base varies. Indeed, many NRIs do not yet have in place a single centralised point of access for users. However, the assessment of the 28 NRIs identified promising examples of three main types of impacts.

Enabling Science

- A substantial improvement in access for researchers to state-of-the-art equipment, facilities, data & services has been achieved. Despite the need for further development on access policies and service provision to users in most cases, the NRIs have begun to provide access to equipment, facilities, data platforms and software for researchers.

- Most NRIs report an increase in scientific output. The panel's assumption is that much of the reported publications were in the pipeline of activity of the researchers involved in the NRI project rather than being directly attributable at this stage to the NRI project.

- In line with the priority to help tackle the brain drain of researchers, skills enhancement of (young) researchers via training and capacity building actions has been a focus of activities of the majority of NRIs with promising results reported.

Problem solving and fostering innovation

- A series of examples of businesses that have received support from NRIs were identified across the range of priority S3 sectors. However, there remains significant scope for increasing the use of NRI services by, and thereby their impact on, businesses and other user groups (public sector, NGOs).

- Business interviewed underlined that access to NRIs' equipment combined with the expertise and guidance of the NRI staff was extremely valuable for their R&D activities. However, the NRIs need to further reinforce their capacities for effective business engagement and translation of results (including IP management policies, etc) into product and process innovations in the business sectors.

Shaping science and society interactions

- There is a good potential for the NRIs to contribute in the future to supporting citizens' understanding of science as well as enhanced access to data and digital resources resulting from NRI activities on environmental monitoring, historical and cultural collections, transport and logistics tracking, etc.

- There has been an effort by the NRIs to develop and broaden national 'communities of practice' in their field of activity (e.g., in synthetic biology or personalised medicine).

- There is a need for further steps to embed FAIR data and open access to publications. The NRIs can help reinforce open science by aligning their data management policies with European best practices.

Conclusions on the sustainability of the 28 NRIs

The PSF panel considers that the sustainability potential varies significantly across the 28 NRI, with certain projects further away from, and in some cases, unlikely to develop into fully-fledged NRIs. While we did not carry out an in-depth individual evaluation of each NRI, we summarise our assessment of the 28 NRIs current development with respect to six criteria:

- Maturity of governance structure and management procedures

- Quality of user access policy

- Strategic outlook – the extent to which an NRI provides exceptional and unique facilities and a critical mass of expertise needed for top-class research.

- European collaboration - the extent to which an NRI has strong ties with European counterparts and potential to attract users and/or funds from Europe

- Impact on research excellence including education/training and attraction of researchers

- Impact on innovation (on one or more S3 priorities)

A 'traffic light' table in the report provides an at the glance overview for each of the 28 NRIs **giving them guidance as to the areas on which further effort is required** to meet the expected capabilities and functions of an NRI in the future.

Recommendations for the future development and sustainability of the Greek NRIs

The panel's recommendations are made in the context of the adoption of the new Operational Programme (OP) for Competitiveness in June 2022 under which a further round of support for NRIs is planned (of the same order of magnitude as in the 2014-2020 period). In addition, the Recovery and Resilience Facility (RRF)[3] will support upgrading of research centres. The recommendations are formulated to ensure that the past investment in the NRIs is optimised in the 2021 to 2027 period and that the NRIs are put on a footing of long-term sustainability that fosters scientific excellence while contributing to meeting national socio-economic and societal challenges, in line with the new S3 for 2021-2027.

Recommendations on the national strategic policy framework for NRIs	Recommendations for enhancing NRI operational effectiveness
1. Adjust selection criteria for future funding of NRIs to foster transdisciplinary co-operation and the consolidation of the NRI landscape and ensuring that the NRIs mission is aligned with core aim of enabling user access. 2. Put in place a medium-term funding framework, including a performance-based element; that encourages NRIs to further develop their business case and favours sustainability. 3. Update the national RI strategy and roadmap, including policy guidelines on open science and digital and data infrastructures, and ensure a continuous dialogue on and monitoring of the RI landscape (strengths/gaps/needs). 4. Adopt a set of key performance indicators that reflect the specific role of the RIs in the national R&I system. 5. Support co-operation of the NRIs with ESFRI and EU RIs as the benefits for the NRIs are significant with respect to the organisation of access services, cost models, uptake of EU funding, etc.	1. Establish a NRI coordination and technical assistance unit to provide support services and training to NRI staff. 2. NRIs should adopt a legal form that guarantees an effective financial and operational management. 3. NRIs should have a dedicated core staff responsible for the overall strategic and operational management including transparent access policies. 4. Enhance open science and FAIR data management capacities of the NRIs 5. NRIs should reinforce their capacity to engage with and deliver services to industry and societal user

Overall, the PSF panel recommends a continuation of public funding for a portfolio of NRIs in Greece. Assuming a total budget of approximately EUR 100 million for NRIs under the new OP for Competitiveness, the panel recommends that no more than 20 NRIs should be funded, and that funding is awarded for a five-year period with an interim performance review, based on self-monitoring report, and a peer review of each individual NRI and an evaluation of the NRI policy at the end of the five years.

The panel considers that NRIs may require higher or lower budgets (e.g., depending on the type and focus of NRIs and the need for (re)investment in facilities and equipment) and expect NRIs to justify their future funding needs, as well as identifying additional sources of

[2] See: http://www.antagonistikotita.gr/epanek_en/events.asp?cs=21
[3] See: https://greece20.gov.gr/en

revenue they expect to leverage. We recommend that a performance-based element should be included in the funding package.

The GSRI (in consultation with other relevant ministries and agencies) should update the national research infrastructure strategy and roadmap to provide a strategic and longer-term (e.g., 2030) framework for investment. A landscape analysis should inform both the longer-term RI planning (e.g. proposals for future investment in identified infrastructure needs or gaps) and provide data for the development of a national research infrastructure registry (and online portal). The NRIs should be required to develop, as part of their own strategic plan, an internationalisation strategy which would provide evidence for selecting those NRIs to be considered Greek 'flagships' on a European level (e.g. ESFRI participation).

The panel recommends the establishment of a monitoring and evaluation framework that serves a dual purpose: the management of the NRI portfolio at a strategic level, including reporting to the government on the contribution of the NRI to national S3 priorities; and a tool to steer the development of the NRIs.

1. Scope and context of the PSF Country Review

1.1. Scope and objectives of the review

On 22 June 2021, the Greek General Secretariat for Research and Innovation (GSRI)[4], addressed a letter to the European Commission's Directorate-General (DG) for Research and Innovation, requesting the support of the Policy Support Facility (PSF) for an independent review of Research and Innovation (R&I) policy in Greece, to further support and upgrade the National Research Infrastructures (NRIs). In line with this request, a panel of experts was appointed by DG R&I to conduct the review by addressing the following three topics and sub-topics:

- Research infrastructure (RI) governance and management efficiency
  - Policy assessment of the development, operation and sustainability of the RIs.
- National framework for the RIs
  - Institutional framework assessment, including recommendations for measures and mechanisms for future sustainability.
  - Potential for further development of common processes/tools (e.g. intellectual and industrial property, human resources, access policy, public procurement, creation of spin-offs and start-ups, technology parks).
  - Synergies between the policy processes related to RIs and to national Smart Specialisation Strategy (S3) in view of ensuring alignment.
- Indicators for monitoring and assessment of the RIs
  - Development of recommendations for indicators to be used for monitoring and evaluating the NRIs, including international benchmarking.
  - For each of topic, the PSF panel was asked to provide policy recommendations to increase the contribution of the NRIs to the Greek R&I ecosystem with a view to:
  - Enhancing socio-economic impacts, the exploitation of innovation potential, technology transfer, access policy, and business collaboration;
  - Reinforcing international value chains and European networks, and facilitating effective internationalisation policies;
  - Boosting the scientific and technological excellence of the RIs and their role in attracting and retaining talents.

[4] The GSRI is the Greek public agency responsible for drawing up and promoting a comprehensive strategy for research and innovation. The GSRI supports activities of the research community and business through competitive research programmes with an emphasis on both economic growth and social justice. The GSRI supervises research centres and technology bodies within the Greek R&I. More information at https://gsri.gov.gr/en/

The process of conducting the review is summarised in the figure below.

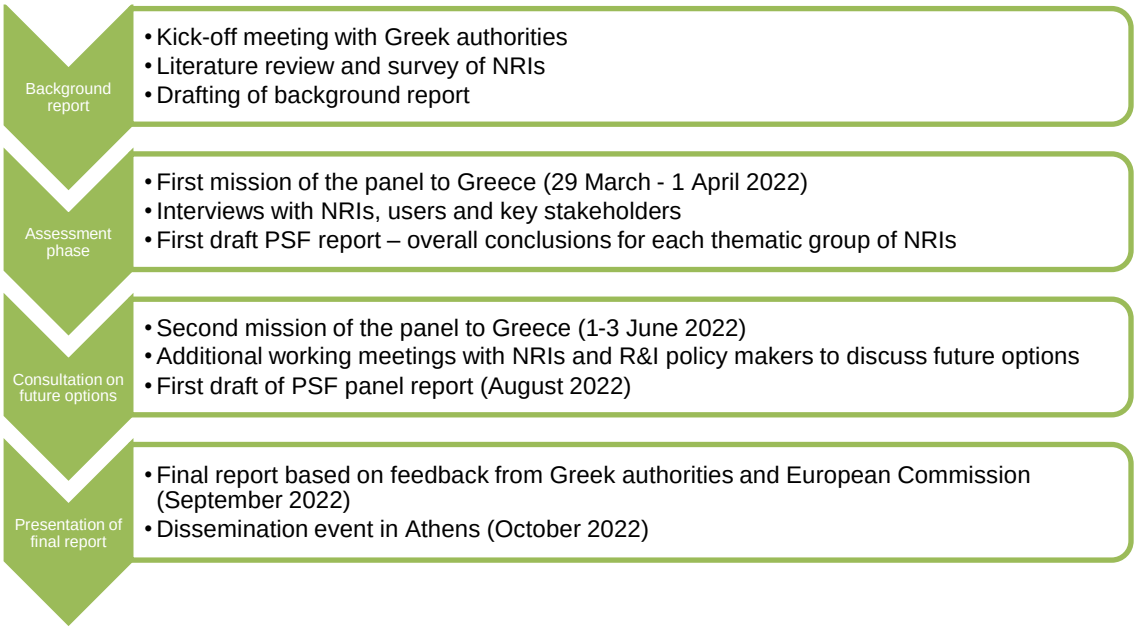


Figure 1. Key steps in the PSF Country Review – Greece

The PSF panel has not conducted a fully-fledged evaluation of the 28 NRIs nor has it carried out a peer review of the scientific excellence of the research carried out within these infrastructures. Both these types of analysis are beyond the scope and remit of the current exercise. However, the panel's work has built on a substantive evidence base including:

- A survey sent to all 28 NRIs and completed by 27 of them between December 2021 and January 2022;
- A background report prepared by two national experts in the spring of 2022 that reviewed the policy framework and available evidence on the NRIs' selection and implementation, which summarised and drew conclusions from the NRI survey results. The report is publicly available and made an important contribution to the panel's work[5];
- A series of interviews with Greek national stakeholders, the NRI coordinators and selected users (researchers, businesses, public-sector organisations) during the first panel mission to Greece at the end of March 2022;
- Working sessions with thematic groups of NRI coordinators as part of the second mission in June 2022 during which the panel's initial conclusions were discussed.

This evidence base enabled a thorough review of the progress of each NRI in terms of their development of a governance framework, operational procedures and access policies for users as well as initial results. The panel was thus able to assess the strengths and areas

[5] European Commission, Directorate-General for Research and Innovation, Country support to Greece for policies developing research infrastructures and the R&I ecosystem: background report, Publications Office of the European Union, 2022, https://data.europa.eu/doi/10.2777/438164

for improvement of each NRI, and the overall policy framework, conclusions and recommendations were presented at a dissemination event in Athens on 7 October 2022.

The PSF panel thanks all Greek stakeholders and representatives of the NRI projects (Annex 1 - mission agendas) for their constructive contribution to the review.

1.2. Research infrastructures: key concepts and policies

European scientific excellence is supported by globally competitive RIs that contribute to the advancement of science in different fields as well as creating direct and indirect impacts on the economy and society. RIs play a key function in enabling scientific discoveries, supporting technological development and fostering innovation.

1.2.1. What is a research infrastructure?

The European Commission defines research infrastructures as:

> "Facilities that provide resources and services for the research communities to conduct research and foster innovation in their fields, including the associated human resources, major equipment or sets of instruments; knowledge-related facilities such as collections, archives or scientific data infrastructures; computing systems, communication networks and any other infrastructure of a unique nature and open to external users, essential to achieve excellence in R&I; they may, where relevant, be used beyond research, for example for education or public services, and they may be 'single sited', 'virtual' or 'distributed'."[6]

RIs range from the large-scale, single-sited facilities and distributed infrastructures of pan-European relevance to those operating at a national or regional level. They can be categorised in four broad types[7]: international scale (usually the only RI of its kind nationally and with an international reputation and high visibility across countries), national (one of only a few infrastructures operating with a mainly national focus, though it may attract international users and work collaboratively with stakeholders abroad), regional (infrastructure capability replicated in several regions, but likely to be the only one its kind in a single region) and institutional (small scale, widely replicated infrastructure, used and managed by a single university or research centre).

RIs are one of the multiple 'policy-mix' interventions that governments use to achieve a defined set of objectives. In this context, policy makers and/or funding agencies commonly set strategic objectives as part of the policy frameworks within which RIs operate. Most national RI roadmaps focus on only the international and national RIs but regional RIs may also be hubs in distributed national RIs.

Initial investments in RIs – and a significant share of operating costs and funding for research projects that make use of them – are commonly sourced through a combination of regional, national and European public budgets. A professionally managed RI should have

[6] Regulation (EU) 2021/695 of the European Parliament and of the Council of 28 April 2021 establishing Horizon Europe – the Framework Programme for Research and Innovation, laying down its rules for participation and dissemination, and repealing Regulations (EU) No 1290/2013 and (EU) No 1291/2013 (Text with EEA relevance). ELI: http://data.europa.eu/eli/reg/2021/695/oj

[7] Adapted from the categorisations used in the UKRI 2020 landscape analysis report and 2021 Australian National Research Infrastructure Roadmap.

in place an access policy, which ideally respects the nine fundamental principles of the European charter of access for RIs, adopted in 2016[8], which informs policies on how a RI regulates, grants and supports access to users. Access should be dependent on the scientific excellence, originality, quality and technical and ethical feasibility of a proposal, evaluated through a peer review conducted by internal and/or external experts. In return, users have an obligation to acknowledge the contribution of the RI in any output (publication, patent, data, etc.) deriving from research conducted. While the term 'open access'[9] is sometimes used, this does not imply 'free' access. Indeed, RIs adopt a variety of financing models to cover costs of granting access and to contribute to financial sustainability.

The funding sources and investment/financing needs vary significantly between different RI types, the scale of the RI, the thematic fields (e.g. RIs for social sciences and humanities commonly require lower capital investment) and between the different lifecycle stages[10] of an RI. Broadly speaking, decisions on public investment in RIs are conducted within one or more of the following planning frameworks[11]:

- Research infrastructure roadmaps that, over a given time horizon and based on scientific, economic or societal needs, prioritise investments in new RIs or the upgrading of existing RIs;

- National and/or European (multi)annual budgetary and programming periods (commonly between four and seven years) during which specific RI investments (and operating costs) may be approved for funding by the public sector, potentially in partnership with charitable foundations and/or industry;

- The lifecycle stage of a RI (or part of a RI, major facility, large-scale equipment or instruments, etc.) from creation to decommission, the complexity of which will vary depending on the scale and type of the RI from anywhere between several years to a decade or more.

Proposals for the creation or significant upgrading of very large national or international-scale research infrastructures (e.g. CERN, the European Spallation Source, the Einstein Telescope, etc.) will often be included in European and national roadmaps, but the decision on their funding will be the subject of complex negotiations. The final investment package is often designed on a case-by-case basis, with different parties contributing on an asymmetric basis depending on their interest and capacity. For large RIs, the capital investment may be approved at governmental level on an 'extra-budgetary' (exceptional) basis and only the operating expenses (including membership contributions) are drawn from the annual R&I budgets of the ministry or funding agency.

[8] See European Commission, Directorate-General for Research and Innovation, *European charter of access for research infrastructures: principles and guidelines for access and related services*, Publications Office, 2016, https://data.europa.eu/doi/10.2777/524573

[9] We avoid the use of this term in this report and use instead the term access policy to avoid confusion with the open science principles of open access to publicly funded scientific publications and research data.

[10] For an explanation of the lifecycle stages of an RI, see for instance: https://www.ceric-eric.eu/project/ramiri-handbook/chapter-2/

[11] Griniece, E., et.al., RI-PATHS, https://doi.org/10.5281/zenodo.3950043

In the Czech Republic, a 'research infrastructure' is defined in a national legislative act on the 'Support of research, development and innovation from public funds':

> "Infrastructure shall mean any supporting activities for research and development covering services or activities carried out by special research facilities, organisations providing research and development administration and funding or verification or dissemination of research and development results."

While a 'large research infrastructure' is defined by the same legal act as:

> "A research infrastructure, which is a research facility essential for comprehensive research and development with heavy financial and technological demands and which is approved by the Government of the Czech Republic and established by one research organisation also for the use of other research organisations."

The main characteristics of large research infrastructures are:

- Uniqueness: they represent an exceptional and unique facility gathering a critical mass of technological devices, knowledge and expertise needed for top-class research and technology development;
- Open access: they are operated by a research organisation for the use of other entities from the research community and provide external users with services based on proposals evaluated by experts;
- Excellence: R&D results from using a large RI respond to scientific and socio-economic challenges and are of high quality and relevance from a 'value for money' point of view;
- National impact: they have at least national importance, significance and impact;
- International reach: they are inter-linked with other RIs within macro-regional, pan-European or global networks having significant international impact.

The government support to RIs come through dedicated funding but also via the development of roadmaps establishing research infrastructure priorities linked to the national R&D policy[12] and innovation strategy 2019-2030[13]. The Czech RI strategy and policy document was prepared by the Ministry of Education Youth and Sport (MEYS) and adopted by the Government (issued in 2010, updated in 2015, and 2019[14]). It includes the origins of the RI agenda, evaluation mechanisms, strategy outlook, landscape analysis, and overview of (48) large RIs within six scientific areas: physical sciences and engineering, energy, environmental sciences, biomedicine/health and food, social sciences and humanities, and ICT/e-infrastructures.

Box 1. The Czech policy framework for research infrastructures (MEYS official presentation and the references therein)

[12] See: https://www.vyzkum.cz/FrontClanek.aspx?idsekce=913172&ad=1&attid=972609
[13] See: https://www.vyzkum.cz/FrontClanek.aspx?idsekce=867922
[14] See: https://www.vyzkumne-infrastruktury.cz/en/2019/11/update-of-roadmap-of-large-research-infrastructures-of-the-czech-republic/

1.2.2. Impacts from investment in research infrastructures

In recent decades, investment in new – and the upgrading of existing – RIs has helped to reinforce the European R&I system, with a strong emphasis on increased collaboration between RIs and enhanced access to RI facilities for a broader range of users. RIs are not only of importance in generating new knowledge but also favour a more efficient way of working for scientists, promoting multidisciplinary research and contributing to economic development at both national and regional level.

While RIs may primarily address the need of researchers, they create diverse type of impacts beyond the scientific realms (e.g. publications, discoveries, patents). They also promote new skills and knowledge among people working at or using the RI. They influence policy developments (e.g. new regulations, standards) and help to address societal challenges (e.g. climate change, energy efficiency). They contribute directly to the economy (e.g. suppliers, local labour market) and support businesses in their product and process innovation, for instance by procuring specialised equipment and instruments. They also foster an 'innovation ecosystem' in the cities and regions around large facilities. Furthermore, RIs increasingly develop outreach activities and support citizen-science and science education and thereby a better public awareness and engagement with science.

Stakeholders, particularly funders and government bodies, are interested in understanding the wider benefits of the RIs. Therefore, the design, planning and further development of RIs requires the commitment of national and regional governments to define clear objectives, align them with policy objectives at European level, and understand the impact pathways that could emerge from the RI activity.

The design and measurement of varied pathways emerging from RI activities requires periodic measurements, the monitoring and reporting, of both outputs and outcomes. In 2019, ESFRI set up a working group to define a common approach to monitor RIs performance based on Key Performance Indicators (KPIs). The document[15] provides a long-list of KPIs that can be tailored to the different types of RIs e.g., considering their level of maturity, their resources, whether they are single-sited or distributed, virtual or physical.

Building on work done by the European Strategy Forum on Research Infrastructures (ESFRI) and the OECD's Global Science Forum[16], the RI-PATHS project, funded by Horizon 2020, developed a framework to assess the socio-economic impacts of RIs, including a toolkit and guidebook[17] for policy makers, funders and RI managers. The toolkit is structured around a set of high-level impact pathways:

- Impacts as a result of RIs pursuing their primary mission: enabling science;
- Impacts as a result of RIs interacting with business or other users for problem-solving;
- Impacts through RIs shaping science with and for society (scientific diplomacy, citizen science, etc.).

Examples of such impacts are provided in the box below.

[15] See: https://www.esfri.eu/latest-esfri-news/report-esfri-working-group-monitoring-ris-performance
[16] See: https://www.oecd.org/sti/inno/global-science-forum.htm
[17] See: https://ri-paths-tool.eu/en

The activities of a RI will lead to effects for users, a wider community of stakeholders, the economy and society at large. The RI-PATHS project identified 13 high-level impact pathways derived from joint work with several leading European RIs. Two examples of possible impact pathways are described below.

- Pathways leading to learning and training thanks to the use of RI facilities and services: This pathway focuses on the impacts originating from the fact that an RI engages directly or indirectly with its users. It covers aspects related to user training (e.g. transmission of knowledge and know-how from RI staff to users, training on the usage of specific equipment, tools, processes, methods etc.), allowing them to (independently) access and benefit from the RI's resources. It may also include feedback loops from users to RI managers and operators, to improve internal processes and expand the service offering and delivery based on user needs.

- Pathway on communication and outreach: Science communication raises awareness of science, with secondary effects achieved in understanding the services RIs provide to the public and private sectors, and more generally RIs' contributions to society. This pathway is primarily directed toward society and it may include, broadly, dissemination activities that target the media, and any other communication channels that would increase RIs' visibility and position in the political, societal and economic context.

The case of ALBA Synchrotron[18]: indirect impacts

ALBA is a third-generation synchrotron light facility – a single-sited RI located in Cerdanyola del Vallès (Catalonia). It consists of the accelerator system providing 3 GeV electron beam energy and currently eight experimental beamlines to carry out experiments in several scientific fields (e.g. chemistry, pharmaceutical, automotive, aerospace, etc.).

Within the RI-PATHS project, ALBA took part as a pilot case to assess their socio-economic impact. The exercise aimed to evaluate how much industry (and innovation) benefited from experiments carried out by ALBA users on beamlines. After collecting information via two surveys of researchers and users and analysing data, the pilot concluded that experiments carried out by academics and researchers have positive impacts on industry even if they don't directly involve the industrial sector. Companies can find applications in a diverse range of fields, such as polymers (e.g. packaging), automotive, food, geo-science, etc. The innovation output developed thanks to the experiments carried out at ALBA allowed companies to improve their R&D capabilities, develop new products, improve their technical know-how and improve the quality of the service provided.

The case of ELIXIR – BIODATA.PT: the need to contextualise impact indicators

BIODATA.PT is the Portuguese Infrastructure of Biological Data funded by the Portuguese state budget and European Structural Funds. It is the national node of the ELIXIR initiative providing distributed infrastructure dedicated to life-science data. A recent study[19] mapped existing indicators from impact frameworks to gain a more systematic, structured, and deeper understanding of the performance and impact of this national-level RI, and to use this new knowledge to inform its further development and long-term sustainability.

Building on the RI-PATHS approach, they identified three pathways – learning and training

[18] See: https://zenodo.org/record/3946391/files/Validated%20impact%20assessment%20framework.pdf
[19] See: https://f1000research.com/articles/11-278/v1

by using RI facilities and services, provision of specifically curated/edited data, and creating and shaping scientific networks and communities – that could be applied in the monitoring the impact of BIODATA.PT activities.

The study emphasised the need to adjust global performance and impact indicators to the context of a national project (e.g. with a scope that simultaneously enables science and covers problem-solving and science and society issues in the establishment of a national RI) or to a particular activity with a narrower scope (e.g. a training programme, a community, a data portal).

Given the broad range of possible socio-economic impacts that a distributed RI may have – such as ELIXIR – a pragmatic approach is to focus on tracing pertinent impacts looking primarily at activities with notable funding streams at the national level.

Box 2. Socio-economic impacts of RIs (Source: authors based on material from the RI-PATHS project)

1.2.3. European research infrastructure policies and initiatives

The European Union (EU) aims to develop and strengthen a fully functional and operational European RI ecosystem[20], which efficiently integrates European, national, as well as regional RIs of various sizes and thereby plays a central role in Europe's ability to provide science-based solutions to societal challenges[21]. RIs are a key element of the European Research Area (ERA)[22], agenda, initially launched in 2000 and updated in 2020[23], as they attract the best researchers from across the world, contribute to knowledge-sharing and innovation, foster regional development by concentrating skills and innovation talent around strategic scientific assets. To reach this goal, the European Commission has worked collaboratively with Member States and the scientific community, notably within the ESFRI framework, to develop new pan-European infrastructures and ensure the effective networking of existing ones.

The ERA Policy Agenda 2022-2024[24] has defined a set of updated priorities to strengthen the European R&I landscape including Action 8: to strengthen the sustainability, accessibility and resilience of RIs in the ERA. The action comprises a set of activities to boost the RI ecosystem through a strategic analysis leading to broader and more sustainable access for all countries to European RIs and their services. Action 8 also calls for the revision of the European Charter of Access to Research Infrastructures. Key issues addressed include funding models that ensure sustainability, enhanced socio-economic impact, and greater focus on specific scientific and political needs.

RIs also play a crucial role in facilitating joint and multidisciplinary research to address global challenges such as climate change, industrial change and the digital transition, social inequality, the green transition for a more resilient future, etc. European RIs use high-quality scientific data to address the multidisciplinary character of the societal challenges and the UN Sustainable Development Goals (SDGs). The European Open Science Cloud (EOSC)

[20] Council conclusions on the New European Research Area, 1 December 2020. 13567/20
[21] See: https://european-union.europa.eu/priorities-and-actions/eu-priorities_en
[22] See: https://research-and-innovation.ec.europa.eu/strategy/strategy-2020-2024/our-digital-future/european-research-area_en
[23] COM/2020/628 final A new ERA for Research and Innovation. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2020:628:FIN
[24] See: European Commission, Directorate-General for Research and Innovation, *European Research Area policy agenda: overview of actions for the period 2022-2024*, Publications Office of the European Union, 2022, https://data.europa.eu/doi/10.2777/52110

and its open science agenda has become central to the RI policy process as it fosters improved access for European researchers to open data and services from different inter-disciplinary sources[25]. In the RI landscape, the EOSC offers a horizontal, pan-European, inter-operable and federated ecosystem of standards, technologies and services, along with rules of engagement, enabling access to and reliable re-use of research outputs including those generated or collected by other research infrastructures[26].

A key policy priority set by the European Commission, in 2016, is the Long-Term Sustainability (LTS)[27] of RIs, which requires actions to address the following topics:

- Ensuring scientific excellence;
- Attracting and training the managers, operators and users of tomorrow;
- Unlocking the innovation potential of RI;
- Measuring socio-economic impact of RI;
- Exploiting better the data generated by the RI;
- Establishing adequate framework conditions for effective governance and sustainable long-term funding for RIs at every stage in their lifecycle;
- Structuring the international outreach of RI.

Established in 2002, the ESFRI is a key element of the ERA and facilitates multilateral initiatives leading to the better use and development of research infrastructures at EU and international levels. It promotes scientific integration in Europe and strengthens international outreach by providing a multi-annual, EU-level planning framework for RIs in coordination with Member States. Since 2006, ESFRI has published periodic roadmaps that help to (i) foster European leadership in diverse scientific fields, (ii) address societal challenges and prepare the necessary economic, social and environmental transitions, and (iii) develop a European RI system capable of supporting and enabling R&I's contribution to meeting Europe's wider policy goals.

The ESFRI Roadmap 2021[28] recognises European RIs as important knowledge and innovation hubs and is boosting their role as drivers of economic growth, environmental transitions and place-based innovation, and as decisive instruments for regional development and social well-being. The new update underlines the merits of the 'open science' concept and highlights the quest to address global challenges (SDGs). It is a key document that presents the lifecycle of several ESFRI projects that reached an advanced degree of implementation (graduating to the so-called 'landmark list'). ESFRI Landmarks provide unique, world-class services facilitating R&I and provide collaborative spaces for doing science where leading scientists and experts meet and exchange know-how. They provide a unique environment for the long-term development of European R&I excellence across all fields of science including energy, environment, health and food.

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[25] See: https://www.esfri.eu/sites/default/files/White_paper_ESFRI-final.pdf
[26] See: https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/horizon/wp-call/2021-2022/wp-3-research-infrastructures_horizon-2021-2022_en.pdf
[27] See: doi:10.2777/76269
[28] See: https://roadmap2021.esfri.eu/

The European Research Infrastructure Consortium (ERIC) is an organisation that facilitates the establishment and operation, on a non-commercial basis, of new or existing RIs of European interest. The advantages of being part of ERIC include legal recognition in all EU countries and exemptions from VAT and excise duty. Furthermore, the process to become an ERIC is faster than creating an international organisation and there is flexibility in adapting to the specific requirements of each infrastructure.

ERIC is a legal entity set up by a decision of the European Commission and recognised in all EU Member States. Its basic internal structure is flexible and defined in the statutes by its members. ERIC is recognised, by the country hosting its seat, as an international body or organisation for the purposes of the directives on value added tax (VAT) and excise duties. It also qualifies as an international organisation for the purpose of the directive on public procurement. Key requirements include[29]:

- It must be a European joint-venture (allowing the participation of countries from outside Europe).
- The infrastructure is necessary to carry out research programmes and projects.
- It represents added value in the development of the ERA and significant improvement in the relevant scientific and technological fields.
- Effective access is granted to the European research community in accordance with the rules established in the statutes.
- It contributes to the mobility of knowledge and/or researchers within the ERA.
- It contributes to the dissemination and optimisation of the results.

Box 3. What is an ERIC?

The ERIC Forum[30] ,funded under Horizon 2020 (2014-2020), aims to advance operations of ERICs and to contribute to the development of ERIC-related policies. Its objectives are to:

- strengthen coordination and networking;
- support the organisation of meetings and thematic workshops focusing on shared challenges such as the development of internal procurement rules, harmonised reporting, VAT exemption practices, insurance and pension policies, and the training of representatives from governance bodies;
- support ERICs in their preparatory phase, based on best practices;
- support communication and outreach activities and strengthen the representation of ERICs as stakeholders in consultations and other policy actions that could affect them.

An observatory to monitor the implementation of ERIC is foreseen under Horizon Europe (2021-2027), the current Framework Programme (FP) for Research and Innovation, which

[29] See: https://ec.europa.eu/info/research-and-innovation/strategy/strategy-2020-2024/our-digital-future/european-research-infrastructures/eric_en
[30] See: https://www.eric-forum.eu

is the main instrument used by the European Commission to support European-level research infrastructures. Other financial means mobilised to support investment in and operations of RIs include the European Investment Bank (InnovFin scheme[31]) and European Structural and Investment Fund (ESIF). Under Horizon 2020, the Commission aimed to optimise "the use of national facilities by integrating them into networks and opening their doors to all European researchers"[32] through enhanced transnational access, thus generating a variety of impacts in different domains (scientific, social, economic, etc.). The support was organised through specific calls:

- INFRADEV calls: facilitate and support the implementation, long-term sustainability and efficient operation of the research infrastructures;
- INFRAIA calls: bring together researchers from academia and industry, ensuring access to RIs for optimal use and joint development;
- EINFRA calls: support the development of e-infrastructures;
- INFRASUPP: contribute to establishing clusters and fostering cooperation;
- INFRAINNOV: foster engagement and cooperation with industry;
- INFRAEOSC: implement the European Open Science Cloud (EOSC);
- INFRAEDI: support the creation of a world-class European Data Infrastructure (EDI).

Under Horizon Europe, RIs remain a component of the Excellent Science pillar. A budget of EUR 2.186 billion is foreseen for RIs for the period 2021-2027. The work programme[33] addresses the global environmental, social and economic challenges, in line with the renewed ERA. The planned calls support the development of scientific instrumentation, software and methods, and promote collaboration and co-creation with industry in order to deliver breakthrough technological and societal innovations. The work programme is structured as follows:

- Developing, consolidating and optimising the European research infrastructures landscape, maintaining global leadership (INFRADEV);
- Enabling an operational, open and FAIR EOSC ecosystem (INFRAEOSC);
- RI services to support health research, accelerate the green and digital transformation, and advance frontier knowledge (INFRASERV);
- Next generation of scientific instrumentation, tools and methods and advanced digital solutions (INFRATECH);
- Network connectivity in research and education, enabling collaboration without boundaries (INFRANET).

[31] See: https://www.eib.org/en/products/mandates-partnerships/innovfin/index.htm
[32] Developing the European infrastructures for 2020 and beyond: https://ec.europa.eu/programmes/horizon2020/en/area/research-infrastructures
[33] See: https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/horizon/wp-call/2021-2022/wp-3-research-infrastructures_horizon-2021-2022_en.pdf

1.2.4. Greek participation in European-level research infrastructure calls

Greek involvement in Horizon 2020 was significant with a net EU contribution of EUR 1.71 billion (2.5% of total funding awarded under the programme) and close to 3000 signed grants (8.18% of the total) involving 1003 unique Greek participants.

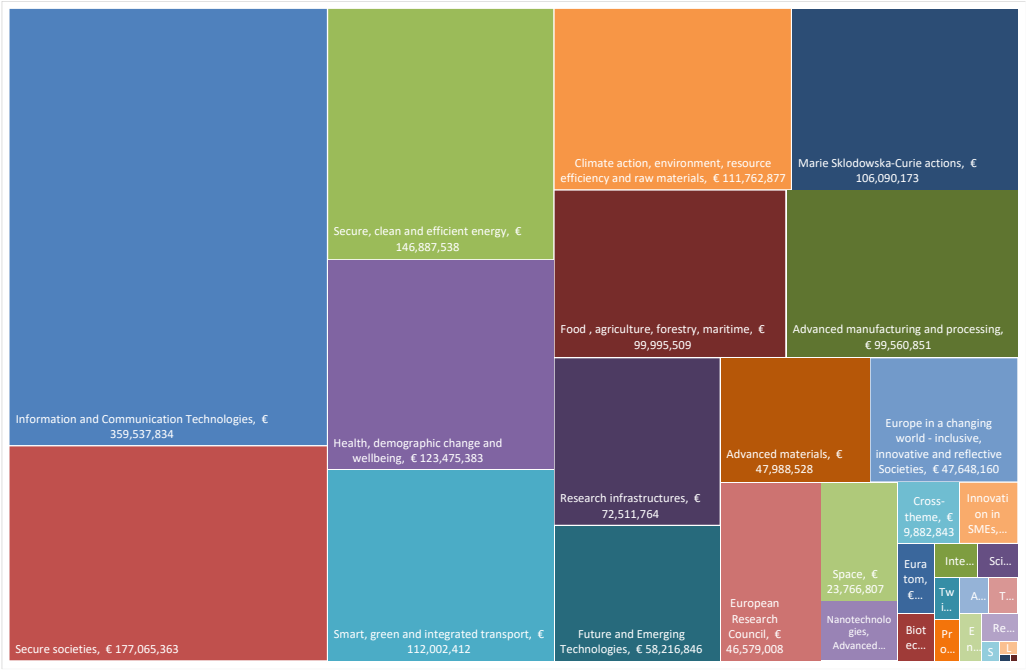

Figure 2. Horizon 2020 net contribution to Greek participants by thematic priority (Source: Horizon 2020 dashboard, data extracted 12 May 2022)

Greek participation was notably strong in the societal challenges and industrial leadership pillars. Looking at the net contribution by thematic priority (Figure 2) the notable Greek specialisation in ICT is evident followed by priorities related to secure societies, energy, health, transport, climate and environment as well as food, agriculture and maritime.

Funding for the thematic priority 'Research Infrastructures' amounted to EUR 2.34 billion (or 3.4% of the EU's net contribution to all Horizon 2020 projects). Greek participants were awarded EUR 72.51 million (3.1%), which is relatively higher than the overall Greek participation (2.5% of the EU net contribution). In total, 54 Greek organisations participated in 163 Horizon 2020 RI projects. However, the funding was heavily skewed as the top five participants were awarded EUR 45 million (62% of the total): ATHENA Research Centre in Information Technologies, Communications and Knowledge (ATHENA); National Infrastructures for Research and Technology (GRNET), Foundation for Research & Technology (FORTH), Hellenic Centre for Marine Research (HCMR), and the National and Kapodistrian University of Athens (NKUA).

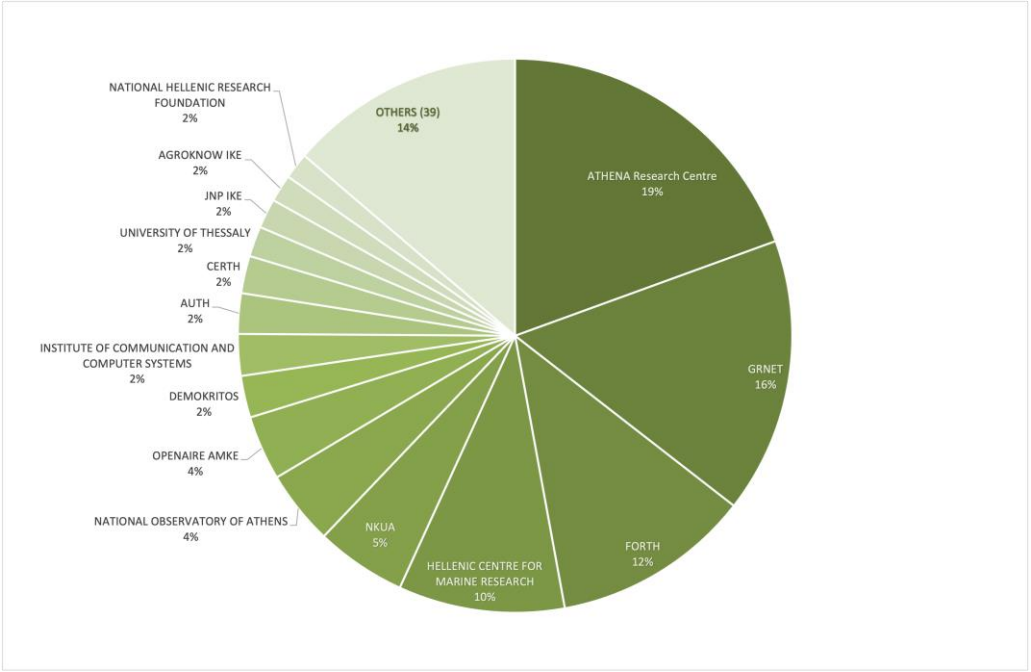

Figure 3. Horizon 2020 funding for research infrastructure projects by Greek organisation (Source: Horizon 2020 dashboard, data extracted 12 May 2022)

In terms of the focus of the participation, EUR 33,748,129 (46.5% of the H2020 total) was awarded to e-infrastructures or EOSC calls, 6.25% of the total funding for these calls, pointing to a particularly significant Greek expertise in this field. Projects related to the development of EOSC accounted for about EUR 14 million with notable Greek leadership in OpenAIRE[34] (which developed into the founding of one of the only Greek-based not-for-profit R&I partnerships at European level[35]) and strong participation in the INFRAEOSC calls, especially by the ATHENA Research Centre and GRNET.

Greek participation in the other RI fields (notably INFRADEV, INFRAIA and INFRASUPP) under H2020 generated a net EU contribution of close to EUR 36 million which represented 2.32% of the total EU funding for these topics. Projects funded under INFRADEV calls were aimed at the development and long-term sustainability of new pan-European research infrastructures, while those under INFRAIA calls looked to open key national and regional research infrastructures to all European researchers from both academia and industry, as well as ensure their optimal use and joint development. INNOSUP projects focused on policy support and included those supporting the development of catalogues of RI services in which Greek participants played a key role (notably MERIL, eInfraCentral and CatRIS projects) as well as support for ESFRI activities. In other cases, ESFRI projects and EOSC developments have inspired – acted as a blueprint – for the development of NRI governance and operational models (e.g. ENIRISST cites CESSDA-ERIC).

[34] See: https://www.openaire.eu/affiliated-projects

[35] OpenAIRE was established in 2018 to ensure a permanent presence and structure for a European-wide national policy and open scholarly communication infrastructure. OpenAIRE is a non-profit partnership (NPP) incorporated under the provisions of Greek Law (articles 741 onwards of the Greek Civil Code) and Law No 4072/2012.

Following the first Horizon Europe RI calls, in 2021, 29 projects were awarded funding with a total investment of EUR 204 million[36]. In April 2022, a second call for funding was launched which made available EUR 162 million for RI projects, for which 79 proposals were received[37]. Greek participation in the first Horizon Europe RI calls suggests a continuation of the strong performance recorded under Horizon 202038.

1.2.5. Greek involvement in ESFRI projects

Greece is (as of May 2022) participating officially in 29 out of 63 ESFRI 'landmark RIs' and projects developing new RIs (46% of the total). As illustrated in Figure 4 (see Annex 2 for a full list), Greece is most active (observer, member or prospective member) in four ESFRI domains, namely data, computing and digital research infrastructures (75% of total ESFRI RIs in this domain), environment (73%), social and cultural innovation (64%), and health and food (50%). It is least active in physical sciences and engineering (13%).

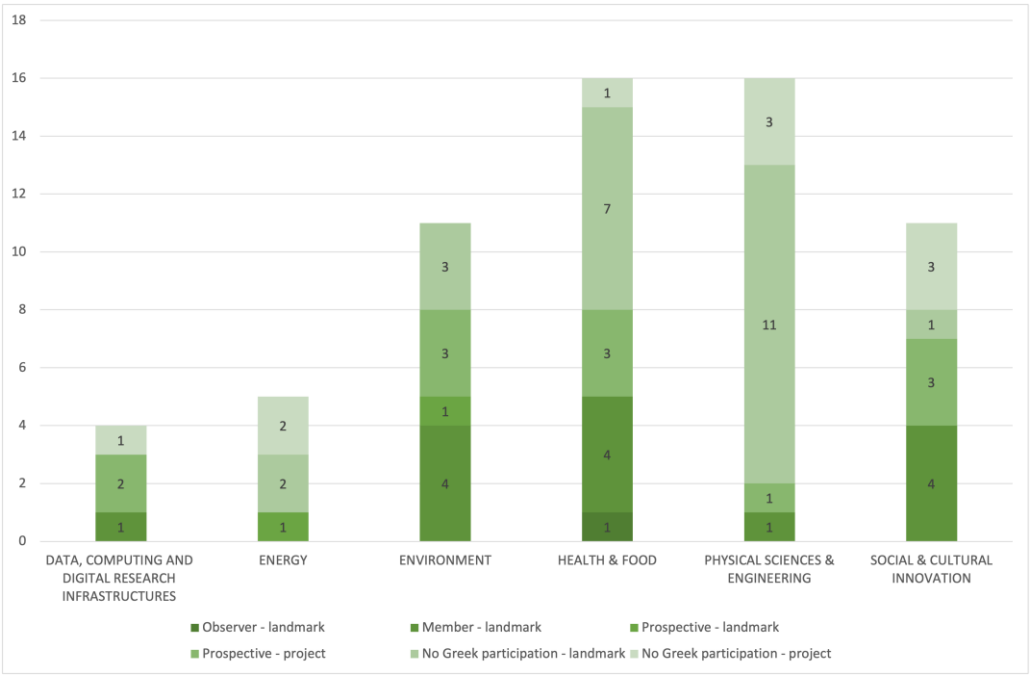

Figure 4. Greek participation in ESFRI Roadmap 2021 projects and landmarks by domain (Source: https://roadmap2021.esfri.eu/projects-and-landmarks/browse-the-catalogue/?countries=EL)

The highest Greek participation in ESFRI landmarks is seen in environment, health and food, and social and cultural innovation with four landmarks each. Greek participation in ESFRI landmarks/projects is in distributed RIs except for the HL-LHC project at CERN.

[36] See: https://rea.ec.europa.eu/news/european-commission-signs-first-grant-agreements-under-horizon-europe-2022-07-19_en

[37] See: https://rea.ec.europa.eu/news/european-commission-makes-eu162-million-available-strengthen-research-infrastructures-europe-2022-05-02_en

[38] According to the Horizon dashboard by September 2020, Greek participants to RI calls had been awarded just over EUR 11 million, placing Greece in seventh place behind Germany, Italy, France, Belgium, the Netherlands, and Spain.

There is Greek participation in at least 37 ESFRI landmarks/projects. Similarly high participation was observed in the H2020 preparatory projects, funded under INFRADEV or INFRAIA calls (e.g. OpenAIRE is involved in SoBigData++ and Greek partners are active in MIRRI). Moreover, the ATHENA Research Centre is coordinating the Horizon Europe funded ESFRI support project (STR-ESFRI3), after being a member of the consortium in the previous two editions[39]. This underlines the well-established position of Greek partners in both ESFRI projects and coordination activities.

1.3. The Greek National Research Infrastructure initiative – 2014-2020

During the period 2014-2020, about EUR 1.1 billion were available in Greece from the ESIF programmes co-funded by the European Regional Development Fund (ERDF). Actions to support research and innovation were implemented through seven pillars:

1. Interconnection of companies with research bodies
2. Innovation/business research
3. Strengthening of human resources/basic research
4. National Research Infrastructures
5. International cooperation
6. Science and society/policy support
7. Addressing societal challenges

The formulation of a national strategy for smart specialisation (RIS3) and a multiannual budgeting plan for research infrastructures were an ex-ante condition[40] for ESIF R&I financing. These strategic documents aimed to build on the competitive position of Greece in specific research areas by maximising the potential for R&D investment in the identified priority areas[41]. The RIS3 recognised NRIs as a key structural element of the R&I ecosystem due to their role as 'enablers of innovation'.

Between 2014 and 2020 one national and 13 regional RIS3 were developed. The national RIS3 provided the main guidance for defining and implementing R&I policy during the period. It prioritised, through an entrepreneurial discovery process, areas where Greece had achieved – or could achieve – a competitive advantage; identifying opportunities for business to make use of new knowledge and integrate it into global value chains. The national RIS3 identified eight priority areas: agri-food; healthcare and pharmaceuticals; information and communications technology (ICT); energy; environment and sustainable development; transport and logistics; materials and construction; and tourism, cultural and creative industries.

[39] See: https://cordis.europa.eu/project/id/101058092
[40] Ex-ante Conditionality (EAC/1-2) Research and Innovation Infrastructures, see: http://www.gsrt.gr/Financing/Files/ProPeFiles88/ex-ante-1-2_Nov%202016%20V.11.pdf
[41] See: https://gsri.gov.gr/trechousa-ekdosi-tis-ethnikis-stratigikis-exypnis-exeidikefsis-2014-2020/

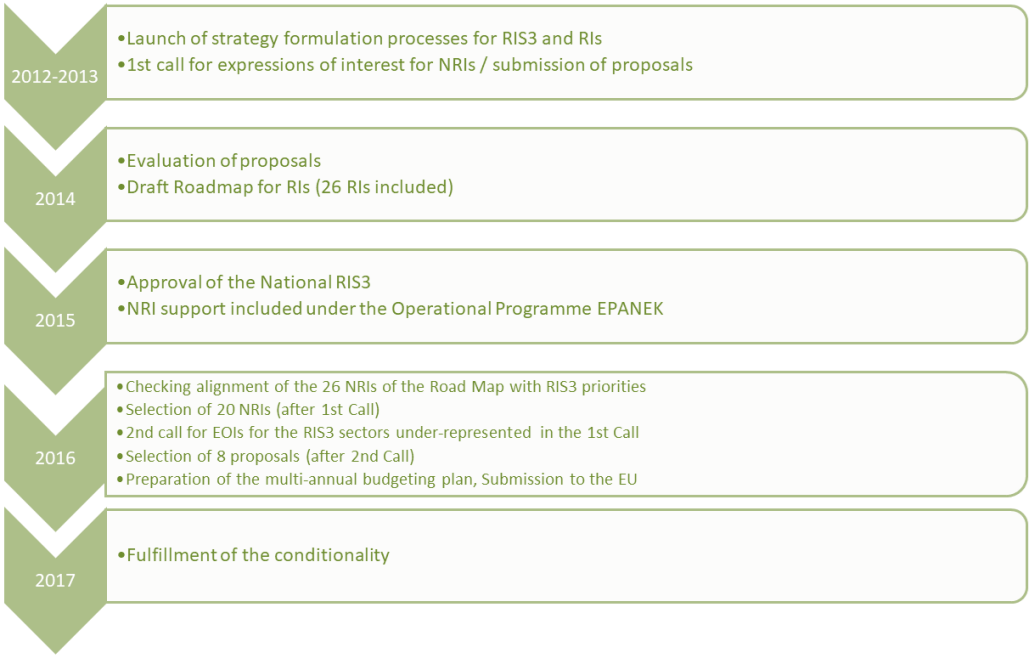

Figure 5. Steps for fulfilling the ex-ante conditionality for research infrastructures (Source: GSRI)

The RIS3 offers structured financing in four main pillars (a more detailed description of these is provided in an earlier Background Report):

- Pillar 1: Collaboration between academia and enterprises, notably through the Research-Create-Innovate programme42.
- Pillar 2: Research infrastructures including funding for the NRIs.
- Pillar 3: Financing of postdoctoral and doctoral students aimed at retaining researchers in the country.
- Pillar 4: Venture capital – EquiFund[43].

Pillar 2 was the basis for the creation of the NRIs. This strategic choice was made because RIs have the potential to support high-level research activities in specific scientific fields, while strengthening the connection between research, education and innovation. They were expected to attract talent and investment from both domestic and international companies and to provide critical infrastructure to help validate innovative business ideas as well as support broader policy objectives in a more coordinated way. NRIs were also expected to contribute to regional development through the employment and training of scientists/researchers, thereby developing highly valued skills. The NRIs have the potential to 'pair' with European level RIs in their corresponding field, which helps foster transnational cooperation and access for researchers to facilities, thus promoting excellence.

[42] See: https://gsri.gov.gr/en/protovoulies-draseis/research-create-innovate/
[43] See: https://equifund.gr/

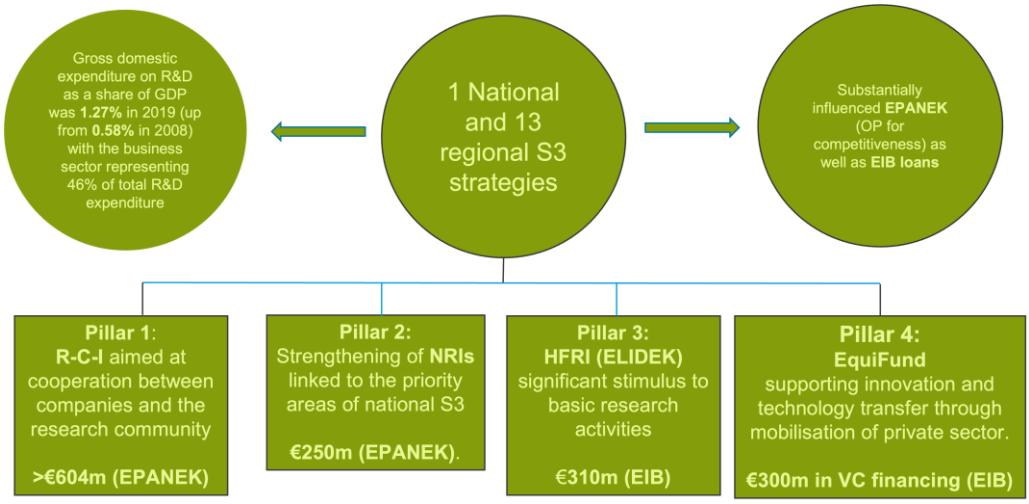

Figure 6. Schematic representation of the four RIS3 pillars (Source: Background Report)

In 2013-2014, the GSRI, supported by the National Council for Research, Technology and Innovation (NCRTI)[44], developed a first draft of a National Roadmap for Research Infrastructures[45]. The roadmap was further developed in the Multiannual Budgeting Plan for National Research Infrastructures[46]. This plan aimed to strengthen low-performing regions (mainly border and island regions) and support all regions in implementing their respective RIS3 priorities. It sought to enhance knowledge production and further promote excellence in Greek research bodies, while at the same time generating critical mass and tackling the issue of fragmentation among geographically distributed NRI networks. The multiannual plan covered not only needs in terms of facilities but also equipment, human resources and other elements required for the NRIs' operation and use.

The GSRI launched two calls in 2013 and 2016 resulting in the selection of 28 NRIs (20 in the first call and eight in the second[47]) involving 212 organisations located in 11 Greek regions, with a total budget of EUR 93 million allocated across the eight RIS3 priority areas.

[44] See: https://gsri.gov.gr/en/esetek-english/
[45] See: http://www.gsrt.gr/DigitalLibrary/Files/Files/ContentFiles253/%CE%9567_NATIONAL%20ROADMAP%20FOR%20RESEARCH%20INFRASTRUCTURES%202014.pdf
[46] See: http://www.gsrt.gr/Financing/Files/ProPeFiles20203/ex-ante-1-2_Nov%202016%20V.11.pdf
[47] For more information on the rules of RI selection, see the Background Report Subsection 3.2

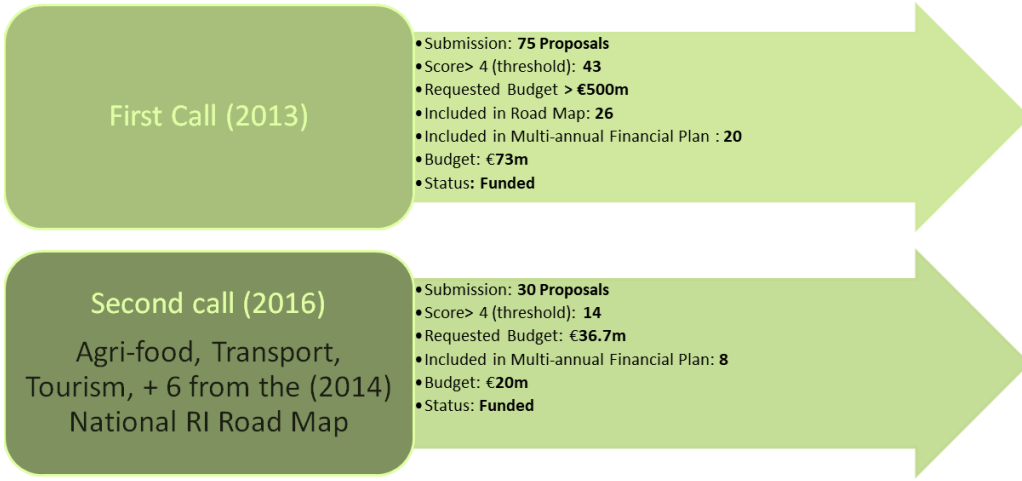

Figure 7. Summary of the calls for NRIs (Source: GSRI)

The NRIs were funded via the Investment Priority 1a of the ERDF co-financed Operational Programme (OP) Competitiveness, Entrepreneurship and Innovation 2014-20 (EPANEK)[48]. Hence, while the strategic planning and selection of NRIs was under the coordination of GSRI, the operational implementation was overseen by the EPANEK Management Authority (MA), including monitoring of NRI implementation, financial control, etc. As can be seen from the following table, the creation of NRIs was only one element in the overall investment programme to support research infrastructures and research centres.

Measure	Planned (€)	Announced calls (€)	Legal commitments (€)	Payments (€)	Funded projects	Participating organisations
Support for National Research Infrastructures	93,000,000	95,538,798	92,029,351	87,327,921	28	213
Strategic development of research centres	31,860,000	31,860,000	30,469,530	30,290,797	30	30
Regional excellence	45,000,000	87,160,763	87,160,763	14,951,584	44	58
Total	169,860,000	214,559,561	209,659,644	132,570,302	102	301

Figure 8. Measures under the Investment Priority 1a (Source: GSRI – EPANEK)

[48] http://www.antagonistikotita.gr/epanek_en/index.asp

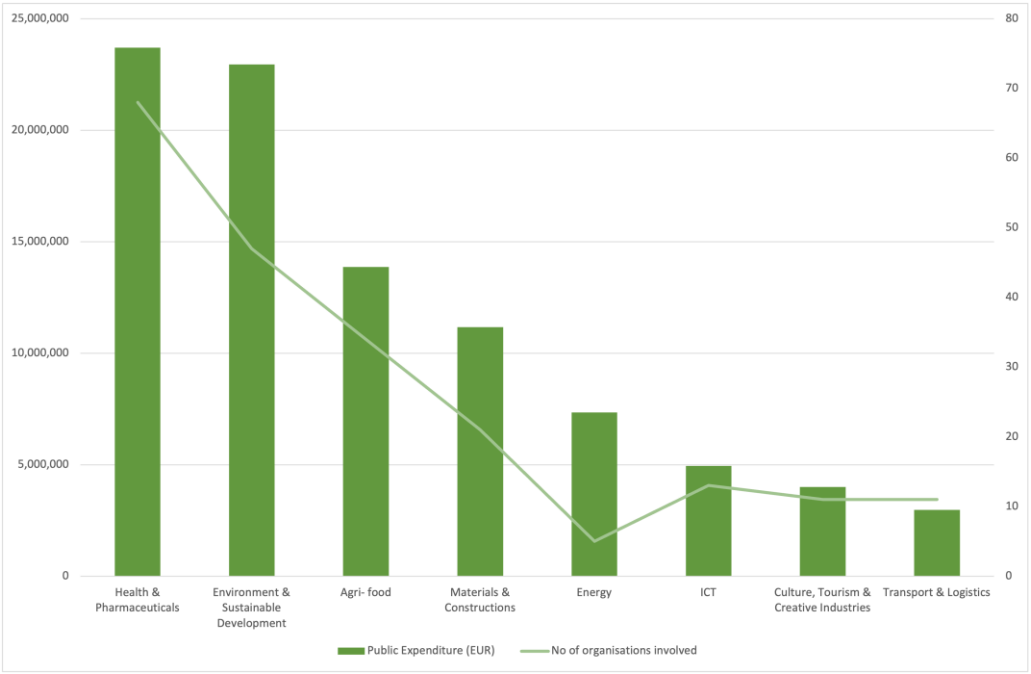

Figure 9. Distribution of NRIs per RIS3 sector (Source: Data GSRI, diagram authors)

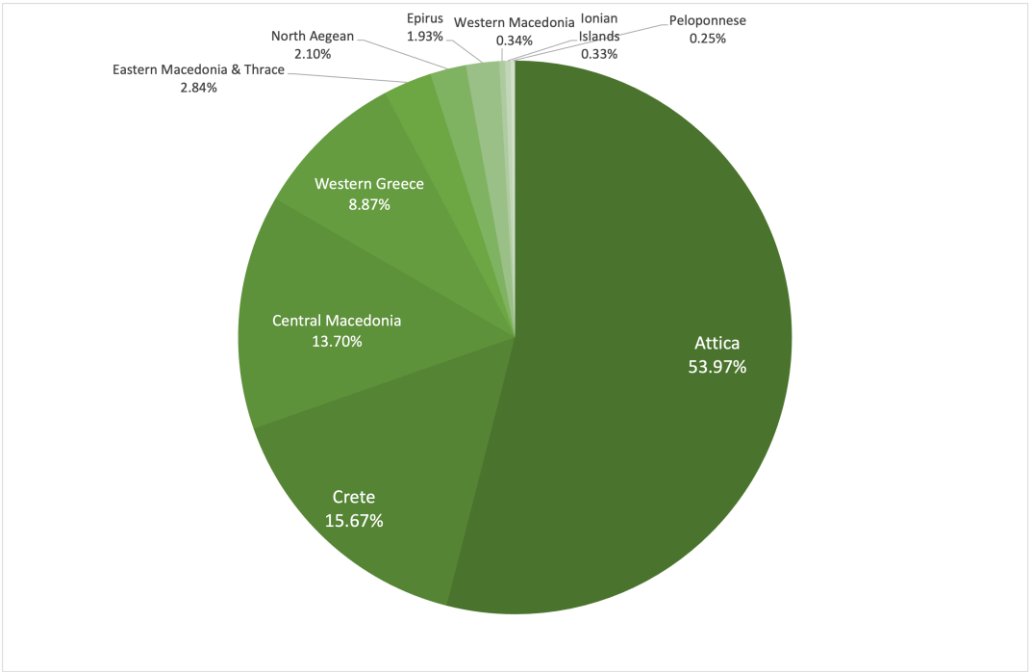

Figure 10. Distribution of approved Public Expenditure per Region (Source: Data GSRI, diagram authors)

According to the available expenditure data, the original financing plan was fully or almost fully implemented for most of the NRIs[49]. Further information on the financing of the NRIs is provided in the Background Report as well as in the following sections.

The diagram below provides a reader's guides to this report. For those who are interested in a detailed understanding of the development of the NRIs, section 2 examines in detail the implementation of the NRI projects grouped in six thematic areas:

- Agri-food (four NRIs)
- Energy (two NRIs)
- Environment and sustainable development (six NRIs)
- Health and pharmaceuticals (eight NRIs)
- Physical sciences and materials (four NRIs)
- Data and digital research infrastructures (four NRIs)

For those who wish to focus on the cross-cutting conclusions and recommendations, sections 3 and 4 provide a succinct presentation of these points.

A reader's guide to the report

[49] The latest available data were collected up to 31 December 2021. Some of the NRIs were given an extension during 2022 to complete their projects

The 28 Greek National Research Infrastructures

National Research Infrastructure	NRI full title	# of partners	Approved Budget (€)	Website
Food Innovation	Infrastructure on Food Bioprocessing Development and Innovation Exploitation	6	3,000,000	https://www.foodinnovations.gr/
FoodOmicsGR	A consortium for comprehensive molecular characterisation of food products	8	2,998,998	http://foodomics.gr/
OMIC-ENGINE	Synthetic Biology: from omics technologies to genomic engineering	9	4,000,000	https://www.omicengine.com/
PLANT-UP	Upgrading the Plant Capital	7	3,865,625	http://plant-up.com
FuVEP	Centre of Excellence for Future Vehicle Environmental Performance	3	3,662,591	https://fuvep.com
PROMETHEUS	A Research Infrastructure for the Integrated Energy Chain	2	3,680,263	
CMBR	Centre for the study and sustainable exploitation of Marine Biological Resources	7	4,000,000	https://cmbr.hcmr.gr/
HELPOS	Hellenic Plate Observing System	8	3,965,844	
HIMIOFoTS	Hellenic Integrated Marine and Inland Water Observing Forecasting and Offshore Technology System	7	3,991,975	https://www.himiofots.gr
INVALOR	Research Infrastructure for Waste Valorisation and Sustainable Management of Resources	7	3,899,713	https://www.invalor.org/

National Research Infrastructure	NRI full title	# of partners	Approved Budget (€)	Website
PANACEA	Panhellenic infrastructure for atmospheric composition and climate change	14	3,999,950	https://panacea-ri.gr
RePHIL	Hellenic Research Fleet / reconstruction of the research vessel PHILIA	2	3,133,006	https://www.rephil.eu
BBMRI-GR	Strategic expansion of the Greek Biobanking Infrastructure	9	497,210	http://biobank.bioacademy.gr/
BIOIMAGING-GR	A Greek Research Infrastructure for Visualizing and Monitoring Fundamental Biological Processes	11	4,000,000	https://bioimaging.g
EATRIS-GR	Infrastructure for preclinical and early-phase clinical development of drugs, therapeutics and biomedical devices	7	499,897	http://htri.gr/
ELIXIR-GR	Managing and Analysing Biological Data	17	3,991,100	https://www.elixir-greece.org/
INFRAFRONTIER	The Greek Research Infrastructure for Molecular and Behavioural Phenotyping of biological model organisms for chronic degenerative diseases	3	4,000,000	https://www.infrafrontier.gr/
INSPIRED	The National Research Infrastructures on Integrated Structural Biology, Drug Screening Efforts and Drug target functional characterisation	14	3,818,820	https://www.inspired-ris.gr/
OPENSCREEN-GR	An Open-Access Research Infrastructure of Chemical Biology and Target-Based Screening Technologies for Human and Animal Health, Agriculture and the Environment	7	3,025,090	https://openscreen.bio.demokritos.gr/
pMedGR	The Greek Research Infrastructure for Personalised Medicine	3	4,000,000	https://www.precisionmedicine.gr

National Research Infrastructure	NRI full title	# of partners	Approved Budget (€)	Website
INNOVATION.EL	National Infrastructure in Nanotechnology, Advanced Materials and Micro / Nanoelectronics	7	4,000,000	https://innovation-el.net
DeTANeT	Detector Development and Technologies for High Energy Physics	3	500,000	
CALIBRA	Cluster of Accelerator Laboratories for Ion Beam Research	1	3,422,200	http://www.inp.demokritos.gr/calibra
HELLAS-CH	The HiPER, ELI and LASERLAB Europe Synergy & IPERION-CH	12	3,997,016	https://hellasch.iesl.forth.gr
APOLLONIS	National Infrastructure for Digital Arts, Humanities and Language Research and Innovation	11	4,000,000	https://apollonis-infrastructure.gr/
ENIRISST	Intelligent Research Infrastructure for Shipping, Supply chain, Transport and Logistics	11	2,974,891	https://www.enirisst.gr/
HELIX:	National Digital Infrastructures for Research	3	3,859,823	https://hellenicdataservice.gr/main/
SoDaNet	CESSDA_GR - The Greek RI for social sciences	7	1,066,340	https://sodanet.gr/

Source: GSRI, presentation authors

2. NRI development and state of play

This section summarises the findings of the panel on the implementation (to end 2021) of the 28 NRIs. For each thematic group, the analysis addresses five key topics:

- Strategic focus of the Greek NRIs
- Governance and operational management
- NRI funding, staffing and operations
- Service provision and user access policies
- Results, impact and sustainability

2.1. Agri-food NRIs

The agri-food sector is a mainstay of the Greek economy and was one of the key priorities of the 2014-2020 national RIS3. The strategy aimed to transform the sector through the development of R&I with a view to entering specialised premium priced, fresh and processed markets for agricultural and food products. It sought to promote differentiation based on the superior quality and special characteristics of the products, such as the taste and aroma, their nutritional value and their contribution to a healthy lifestyle, as well as their connection with the local history and culture. Greece's unique landscape makes it one of the most species-rich European countries with more than 7000 native plant taxa, of which approximately 20% are endemic.

The country's scientific specialisation in agricultural and biological sciences is relatively strong. Greece is ranked 39th in the world (H-index of 218) and 14th in the EU27 over the period 1996-2021 with a notable specialisation (taking account of the number of citable publications) in food science and aquatic science (ranked 31st in the world and 12th in the EU27 for both), ecology, evolution, behaviour and systematics (40th and 15th), agronomy and crop science (32nd and 12th), and plant science (41st and 15th)[50].

Food companies are the largest manufacturing sector in the country and the second-largest employer, providing jobs to a third of the workforce. Greece's main food exports include olives and olive oil, fish, flour-based products, honey, and processed items including meats, sweets, preserves, and dairy[51]. The agri-food industry is also the leading innovator, with 21.7% of companies recording product and/or process innovation[52].

During 2014-2020, the agri-food sector was awarded 216 projects under the R-C-I programme, second only after the ICT sector. Agri-food tech companies also account for a significant share of start-ups, as of May 2022, in the Elevate Greece database: 41 start-up agri-food companies, with almost 270 employees. They have received investment in excess of EUR 19.4 million, with the dominant technology cited being the Internet of Things[53] (application of large-scale data analysis, etc.), followed by robotics, cloud computing,

[50] Source: https://www.scimagojr.com/
[51] Source: https://www.mdpi.com/2079-7737/10/2/72
[52] Source: Greek Smart Specialisation Strategy 2021-2027 – final draft
[53] Data used from https://elevategreece.gov.gr/startup-database/ in the report was extracted on 12 May 2022

drones, financial technologies, imaging, networks, etc. Most of these start-up companies are in the B2B field (49%), followed by B2C and only 6% in B2G. From a territorial perspective, 47% of start-ups in the agri-food sector are in the Attica region, underlining the need to further strengthen the start-up ecosystem for agri-food businesses operating in other regions[54].

The 2021-2027 S3 retains agri-food as a priority, noting the continued strong performance in investment activity, contribution to employment, as well as exports. The sector is well placed in international value chains, has significant future growth prospects and is in line with key European strategic priorities. The S3 also notes that there are significant opportunities for high value-added synergies between the agri-food and health industries from emerging markets for biopharmaceuticals and herbal medicines.

Greek participation in Horizon 2020 under the thematic priority 'Food security, sustainable agriculture and forestry, marine and maritime and inland water research' accounted for 206 grants (7% of total Greek grants) and close to EUR 100 million in funding, with agricultural science the most predominant field of science[55]. Of the total funding, ten organisations accounted for half of the net EU contribution, notably: the Agricultural University of Athens (AUA), Aristotle University of Thessaloniki (AUTH), National Technical University of Athens (NTUA) as well as research institutes such as the Centre for Research and Technology Hellas (CERTH) and the Hellenic Centre for Marine Research (HCMR).

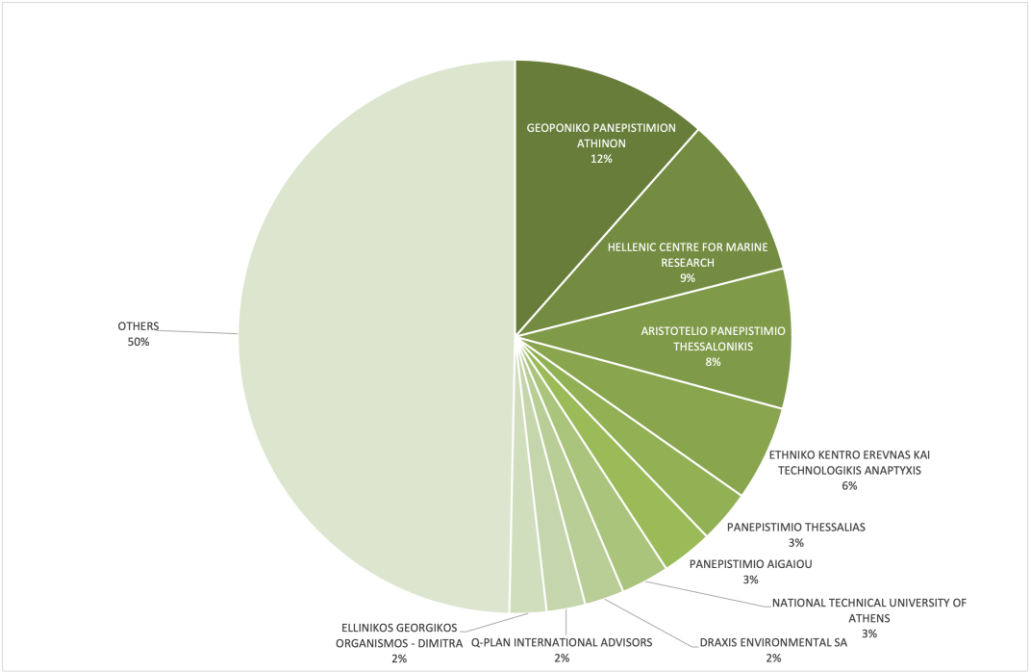

Figure 11. Greek beneficiaries of agri-food calls under Horizon 2020 (net contributions) (Source: Horizon 2020 dashboard, data extracted 12 May 2022)

[54] See: https://www.tovima.gr/2021/11/08/international/plans-to-strengthen-agri-food-startups-through-elevate-greece-is-being-studied/
[55] Source: Horizon Europe Dashboard, consulted 12 May 2022

2.1.1. Strategic focus of the Greek NRIs in the agri-food field

The four NRIs in this field[56] cover a broad scope of analytical capacities, from plant and synthetic biology to food production. The potential applications of the R&D conducted with the support of the NRIs ranges from the analysis of seeds and genetic (plant) materials to the commercialisation of new foods, drinks and (natural) cosmetic and pharmaceutical products. The four NRIs mobilise 30 partners (17 distinct organisations) and close to EUR 14 million in approved funding. There are a significant number of research teams and laboratories involved from each participating organisation, which is a pointer to the inter-disciplinary nature of the research field.

National Research Infrastructure	NRI full title	No. of partners	Approved budget (€)	Actual expenditure (€)	Budget execution
Food Innovation	Infrastructure on food bioprocessing development and innovation exploitation	6	3,000,000	2,965,070	98.8%
FoodOmicsGR	A consortium for comprehensive molecular characterisation of food products	8	2,998,998	2,883,921	96.2%
OMIC-ENGINE	Synthetic biology: from 'omics' technologies to genomic engineering	9	4,000,000	3,935,285	98.4%
PLANT-UP	Upgrading the plant capital	7	3,865,625	3,861,836	99.9%
Total		30	13,864,623	13,646,112	98.4%*

Figure 12. NRIs in the agri-food field – key figures Source: GSRI, calculations authors; *average budget execution

The stated missions of the four NRIs point to both common and distinguishing themes:

- **Food Innovation**: supports research, education and innovation in the agri-food sector by implementing breakthrough research and providing access to first-class facilities, knowledge and advanced services to researchers and professionals from the academic, domestic and industrial sector.

[56] As an example of additional RIs of a similar scale that have been funded but which are not included in the NRI 'portfolio', the FOODBIOMES RI is funded under the EPANEK 2014-2020 OP and was awarded EUR 3.9 million for the preparatory stage during the period December 2020 to May 2023. See: https://foodbiomes.eu/

- **FoodOmicsGR**: provides a reference and centre of excellence for the analysis of the molecular/elemental content of food products, with a focus on small molecule analysis (metabolomics).

- **OMIC-ENGINE**: strives to establish a national reference point in synthetic biology, with an emphasis on the agri-food sector.

- **PLANT-UP**: develops an infrastructure of excellence that focuses on systematically recording, preserving, protecting and exploiting the wealth of Greek plant biodiversity.

All NRIs highlight the importance of creating a nationally (and internationally) recognised 'infrastructure of excellence' or 'reference centre' in their specific field of operation. The mission statements and aims and objectives described on the NRI websites and in responses to the PSF questionnaire (see the Background Report) provide more insight into the expected outcomes (project results and longer-term impacts) which are summarised in Figure 13 against the three main RI-PATHS impact pathways[57].

NRI	Enabling science	Problem-solving	Science and society
Food Innovation	Research actions, training and educational activities for researchers Development of advanced services and state-of-the-art facilities accessible to users	R&D services offered to SMEs, large companies, research centres and public bodies Enhanced technology transfer process to industry by sharing data, methods, knowledge and skills Improved sustainability of food products and processes	Cooperation actions with research organisations, industry and European research infrastructures
FoodOmicsGR	Facilitate R&D activities in areas such as control of authenticity, geographic origin, nutritional interventions, ageing population and well-being Maintain (open access) database (sample banks) of Greek food constituents	Development of novel products using bioactive compounds from Greek flora, fauna and marine organisms Classification and characterisation of food products (health claims)	Promote and protect Greek produce (PDO, PGI) and international recognition – in line with EU requirement for reference centres for authenticity in the agri-food chain

[57] See: https://ri-paths-tool.eu/en/impact-pathways

NRI	Enabling science	Problem-solving	Science and society
OMIC-ENGINE	Create a new synthetic biology research environment with open access to services, research, facilities and scientific know-how for students, researchers. Develop a regional centre of excellence dedicated to synthetic biology education programmes	Expand synthetic biology research and technology applications for industry. Address practical issues of the agricultural-biologicals market of national and European relevance	Contribute to building a Greek synthetic biology community Public engagement to raise awareness of the importance of synthetic biology (e.g. health benefits of functional and traditional foods)
PLANT-UP	Access to state-of-the-art technologies for conservation, pest protection and exploitation of Greek plants Recording the biodiversity, genetic and chemical diversity of Greek plants (biobanks, etc.) Develop human resources in relevant fields of plant research	Support to industrial-scale production of natural products and derivatives of high added value (e.g. food supplements and cosmetic preparations) Develop tools for the prevention and management of plant pests and diseases in agricultural and natural ecosystems	Preserving and capitalising on Greek biodiversity – including disseminating information to the broader public

Figure 13. NRIs in the agri-food field – declared aims by type of impact pathway (Source: authors based on NRI documentation)

Under ‘enabling science’, there is a strong emphasis on improving access to existing or new research facilities for researchers (and other users). FoodOmicsGR and PLANT-UP also focus on developing databanks that can provide support to research in their respective fields and other services (e.g. authenticity certification for industry). A common thread is the importance given to developing human resources via young researchers and educational programmes.

Industrial applications and contract R&D services are addressed by all four NRIs but to varying degrees (e.g. access to facilities is not provided to industry in all cases). There is an emphasis on industrial applications that promote Greek traditional and novel products (food and cosmetics) based on Greek natural biodiversity. OMIC-ENGINE demonstrates this by its focus on synthetic biology, providing potentially complementary applications for the agri-food and other bio-based industries.

The NRIs address the third type of impact pathway, but in a less clearly articulated manner. All four NRIs have a stated aim to create and shape scientific networks and communities (e.g. in synthetic biology) and influence policy making (agenda setting, regulations, expert participation to national committees, etc.) in their fields. Dissemination and public engagement (outreach) goals, such as encouraging STEM education and 'popularising' scientific results, are also identified but could be further developed.

From an external perspective, the four Greek agri-food NRIs are involved in several of the relevant EU level agri-food RIs and partnerships. For example, FoodOmicsGR is affiliated with the ESFRI project MetroFood-RI[58], a distributed infrastructure for promoting metrology in food and nutrition. Biomic_AUTH, coordinator of FoodOmicsGR, leads the Thessaloniki-based node of MetroFood. The collaboration acts as a model for the NRI to foster further collaboration with international partners. PLANT-UP is not affiliated with an ESFRI RI but has connections to several through its partner institutes including MetroFood and DiSSCo RI. An example of another approach is OMIC-ENGINE which has been active in signing memorandums of understanding (MOUs) to develop co-operation with other European and international partners in the synthetic biology field. OMIC-ENGINE is also, via the coordinator (University of Thessaly), a partner in the BioRoboost. This Horizon 2020 project is fostering synthetic biology standardisation through international collaboration, with the aim of generating the most comprehensive collection of up-to-date information on standards in the biological and non-biological realm.

Food Innovation RI reports many international connections due to the past cooperation of the partner institutes with research teams and businesses. It has also started discussing with EU-IBISBA RI (an ESFRI project) and will strengthen this collaboration with the aim to create: "A European gateway for local researchers and professionals from the academic and business sector that will facilitate their access to more advanced services and collaboration opportunities with the European ecosystem of biotechnology."

The collaboration with ESFRI RIs or in European projects is complicated by the lack of a legal entity, meaning that either multiple Greek partners are involved or the NRI coordinator takes a leading role. The development of structured cooperation with European-level RIs and other national RIs remains to be further developed by all NRIs.

2.1.2. Governance and operational management

The NRIs operate based on a distributed RI model with a coordinator and a number of hubs. In the absence of a single legal entity framework, their current operational model is based on a project consortium set-up (MOUs, consortium agreements) with specific governance structures. These structures include a general assembly (meeting once or twice a year), plus a steering committee/operational board that coordinates the more operational implementation of the NRIs. The frequency of meetings of the steering committees varies, with some NRIs (e.g. Food Innovation and OMIC-ENGINE) operating on a work-package basis like a standard research project consortium.

Advisory boards to guide the development of an RI business case or strategy are in place with a varying emphasis on user needs, e.g. the FoodOmicsGR IEAB has 11 members including scientists, consumer organisations, businesses and other stakeholders interested in the activities; while for Food Innovation the advisory committee has only two external scientists (one from academia and the other from industry).

[58] See: www.metrofood.eu

NRI	Lead partner	Governance framework
Food Innovation	University of Patras	Steering committee (coordinator and representative of each partner), academic committee (research, education and dissemination activities), external advisory committee.
FoodOmicsGR	AUTH	General assembly (delegates of all institutions), five-person steering committee, international expert advisory board
OMIC-ENGINE	University of Thessaly	General assembly assisted by an independent advisory board, plus steering committee (coordinator and hubs), executive committee (work-package leads)
PLANT-UP	NKUA	Board of directors, executive committee, access committee, international scientific council, anti-discrimination committee

Figure 14. Agri-food NRIs – governance frameworks (Source: authors based on NRI documentation and questionnaire responses)

In short, the governance set-ups reflect a project consortium model with differing degrees of emphasis and effort given to steering the NRI as a single entity and the development of a common strategic agenda beyond the project lifetime. In all cases, the intention to extend cooperation between the current NRI project was stressed in questionnaire responses and interviews. For instance, FoodOmicsGR partners have indicated their unanimous intention to continue common action and seek ways to operate as a consortium under the same name. OMIC-ENGINE developed a strategic vision document, analysing the internal and external environment as well as the strategic options for the development of the NRI, and setting the scientific and operational priorities and an action plan for the development and sustainability of the RI[59]. Moreover, OMIC-ENGINE aligns with European practice by using the ESFRI key performance monitoring indicators (KPIs) and target setting to track progress. Advice on the legal and governance framework for continuing operations is highlighted by all four NRIs as a main requirement for future sustainability.

2.1.3. NRI funding, staffing and operations

The funding is spread across 17 organisations (see Figure 59) with the top five organisations (universities), including the four NRI coordinators, accounting for 65% of the total funding. The share of the coordinator in the total funding per NRI varies between AUTH with 30% of funding for FoodOmicsGR, 39% (NKUA – PLANT-UP) to 47% (University of Patras – Food Innovation and University of Thessaly – OMIC-ENGINE). The median funding provided per organisation per NRI varies from EUR 120,000 (OMIC-ENGINE) to EUR 330,000 for PLANT-UP. Overall, FoodOmicsGR has the most evenly distributed funding pattern (difference between average and median funding per partner) while OMIC-ENGINE has the most skewed funding distribution. The funding patterns illustrate the distributed nature of the infrastructures with a coordinator plus several hubs (usually between four and five). That said, the relatively small amounts for some partners raise questions about the effectiveness of over-stretching the distributed nature of the NRIs.

The distribution by category of expenditure for the four NRI also highlights some notable differences with Food Innovation in particularly allocating a much higher share of funding to

[59] See: https://www.omicengine.com/post/the-role-of-synthetic-biology-in-the-bioeconomy-roadmap

personnel and other costs and a much lower share to ‘direct’ (equipment and consumables) budget items (10% compared to an average of 48% on direct costs of the three other NRIs).

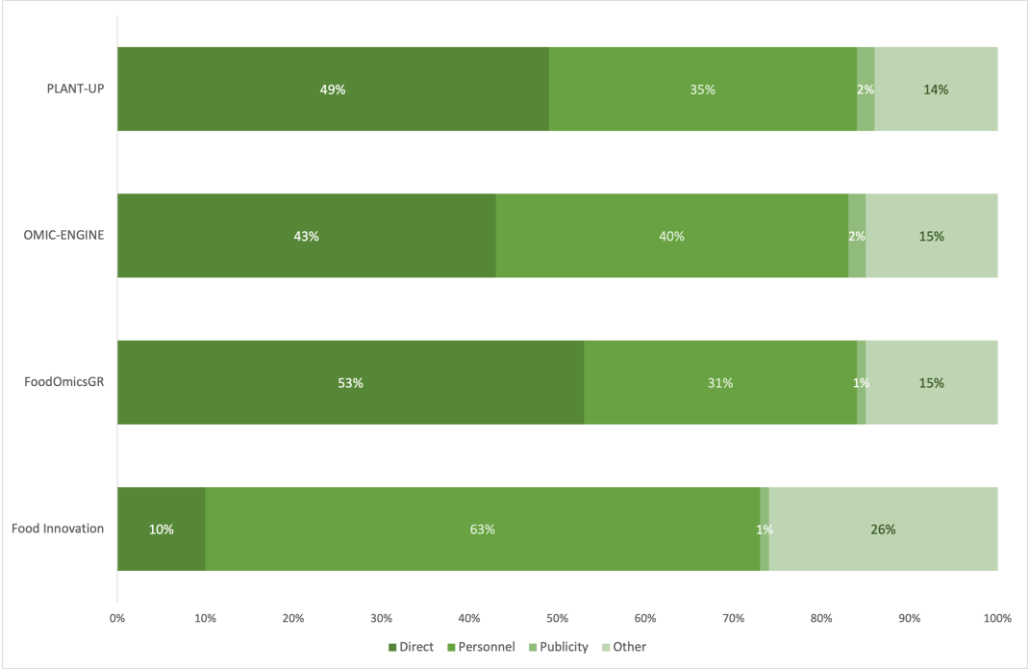

Figure 15. Distribution of budget by category of expenditure (Source: GSRI, calculations authors)

The differences in budget allocation hints at different operating models. In the case of Food Innovation, the lower equipment investment is partly due to the prior existence of well-equipped laboratories with a significant number of scientific instruments that, as a whole, “covered the needs of the preparatory phase of the infrastructure”. It also reflects an operational model more akin to a portfolio of R&D projects than a distributed RI, also suggested by the work-package structure where distinct research activities are undertaken on different themes by partner institutes.

Other NRIs used funding to develop facilities. For instance, FoodOmicsGR notes that investments by the four partner institutes have resulted in “new equipment that is second to none in Greece and is in line with other large RI initiatives enabling cutting-edge research”. PLANT-UP used the funding to upgrade and complete existing specialised equipment and to develop research protocols that provide a foundation for a portfolio of analyses they can provide to third parties as services.

The purchase and installation of new equipment, while a main result of most NRIs, also raises the issue of financing to maintain or further improve the NRIs facilities and capacity to provide services. As OMIC-ENGINE notes, a main future need is the “upgrading of acquired equipment considering how fast instrumentation becomes obsolete in this scientific area”. Similarly, Food Innovation RI notes the “availability and the maintenance of equipment and machinery play a catalytic role in the sustainability of the infrastructure”.

Turning to investment in human resources, staffing profiles of the NRI vary considerably although overall the data available makes it difficult to compare across the NRIs on a like for like basis. As an example, OMIC-ENGINE supported 20 senior and 57 new/young

individual researchers, equivalent to 63.97 FTE researchers from 2018 to 2021, with new researchers representing 84% and women representing 75% of the FTE total.

National RI	a) Number of researchers working in improved research centre facilities (FTE)	b) Number of young researchers (FTE)	Difference (a-b) (FTE)	Direct personnel expenses	Per researcher
Food Innovation	83.33	78.01	5.32	€1,739,169	€20,871
FoodOmicsGR	48.03	40.5	7.53	€863,187.96	€17,983
OMIC-ENGINE	74.14	72.02	2.12	€1,515,183	€20,437
PLANT-UP	69.92	52.66	17.26	€1,309,660	€18,731

Figure 16. Human resource indicators – agri-food NRIs (Source: EPANEK-GSRI, calculations authors)

FoodOmicsGR reports that the project has achieved five 'repatriations' of researchers at the PhD level. Food Innovation notes that low salaries in Greece resulted in a less interest from candidates abroad. Nevertheless, there were cases of young scientists who returned to Greece with the aim of obtaining a PhD degree or undertaking a post-doctoral position. Food Innovation also reports the example of a qualified scientist who joined the NRI after a successful eight-year career in a large Greek food company.

Overall, the NRI development appears to have boosted the capacity to recruit (young) researchers despite the issues highlighted in interviews and questionnaires concerning the challenging human resource framework at universities (and to a lesser extent) research centres), salary levels, and lack of permanent positions (or absence of bridging funding). Aside from salaries, attracting researchers from abroad is also complicated by national legislation requiring accredited degrees, as highlighted by OMIC-ENGINE.

Moreover, more attractive salaries in the private sector pose an issue for talent retention, as an example, the research manager of FoodOmicsGR, who returned to AUTH following nine years at Imperial College (UK), was subsequently attracted by a competitive offer to become the head of analytical research for a large Greek life-science company.

An additional key issue highlighted by all NRIs was the difficulty in recruiting both managerial and technical staff to run and operate the facilities in the longer term. PLANT-UP highlighted that "our main future needs for the operation of the NRI are basically related to the human resources for its operation, administration, marketing and promotion; otherwise, all the investments are useless". OMIC-ENGINE stressed the need for human resources contracted for long enough periods to ensure the NRI's viability, including dedicated personnel for operating and training researchers to use large/sophisticated equipment. Food Innovation underlined that in the event of a shift to a single legal entity, this will require a dedicated management team covering functions such as finance, strategic planning and business development, public relations, quality assurance and human resources. **Business/revenue models that enable the recruitment of such staff are therefore a main factor underpinning future sustainability.**

2.1.4. Service provision and user access policies

The way that NRIs structure the 'service provision' varies from one to another. In particular, the development of a well-presented catalogue of services with easily understandable open access procedures and/or pricing frameworks is still a work in progress.

Food Innovation has developed a catalogue of services (presented on their website and available as a downloadable file) in four broad categories: access to facilities, R&D services, education and training, and technology transfer services. The R&D services cover six main areas, ranging from food product development to biorefinery design, and appear to be linked to the specific expertise and facilities of the various partner institutes. Training and education services are being developed and deployed with three courses pre-announced to date (which appear to be more seminars than full training courses). The NRI has a large focus on knowledge/technology transfer to the agri-food sector with 36 technologies opened to industrial partners via a call for expression of interests. This strategy does not seem to be fully bearing fruit and issues about intellectual property (IP) rights and the transfer process remain to be addressed.

FoodOmicsGR presents sets of services for two key target groups – researchers and the business sector – with four main categories of service: consultancy, data analytics, sample analysis, and quantitative determination of key target molecules. Services for both researchers and businesses are presented as providing 'one-stop-shop' approaches covering a range of methods and expertise. A catalogue of services is available for download, although this is largely a PowerPoint presentation of the NRI and the partner institutes equipment and services. A 'good practice' element of this service presentation is the inclusion of three application cases, **something that could be further developed by all four agri-food NRIs.**

OMIC-ENGINE structures its service provision under three main fields: research, education, and industry. Research services are split between open access and a novel concept of pilot projects designed to encourage use of the facilities. Seed projects developed through the OMIC-ENGINE RI are intended to demonstrate innovation in a plethora of research fields including analytical methods, technology development as well as the launch of new products and services in the agri-food sector. OMIC-ENGINE provided funding, based on the seed project's timeline (between 2-8 weeks) at collaborating laboratories of up to EUR 200 for transportation fees; EUR 80 per day for the researcher's accommodation, EUR 400 per week for lab supplies and equipment expensed on the host laboratory. To date, five such seed projects have been implemented.

PLANT-UP presents services in six broad fields of activity which appear to be more aligned to the specialisations of partner institutes than a well-structured service provision. They note that the absence of a single legal structure deprives the NRI of the flexibility to offer direct services to the private sector and that "most of the partners have not obtained an official permit to offer services".

Indeed, based on the questionnaire responses, the NRIs focus, in terms of users, tends to be other academic or research centre researchers. For instance, FoodOmicsGR notes that a major percentage of the users of services include researchers from partner universities/centres, notably to analyse samples of food and food ingredients (eggs, oils, blood, honey, insects, etc.). Overall, there remains scope to further enlarge the user base both in terms of access to researchers from non-partner institutes (including international researchers which was made difficult during the Covid pandemic) and from businesses or public-sector agencies requesting analyses and contract-based R&D.

2.1.5. Results, impact and sustainability

Despite the relatively early stage of development of the NRIs, they all report results which point towards the potential for a scaling of impacts over time if the various sustainability criteria are addressed (see Figure 17). These range from impact on scientific results, education and training to support to Greek agri-food and natural pharmaceutical/cosmetic businesses.

Despite the difficulties mentioned above, PLANT-UP does provides services to private companies or individuals requesting original and specialised analysis of products and raw materials of interest to the Greek economy, such as extra virgin olive oil and cannabis. PLANT-UP also collaborates closely with Pharmagnose SA, a Greek spin-off company dedicated to the valorisation of Greek plant biodiversity and natural products, which has provided a significant number of contracts valued at more than EUR 300,000.

The protocols developed within the frame of PLANT-UP (e.g. phyto-protection, biological biomarker determination) have led to solutions in the pharmaceutical industry (e.g. biomarkers associated with atheromatosis), as well as the plant protection/agrochemicals industry (e.g. development of new plant pest detection techniques, plant protection products/protocols), and environmental impact studies of current products, etc.

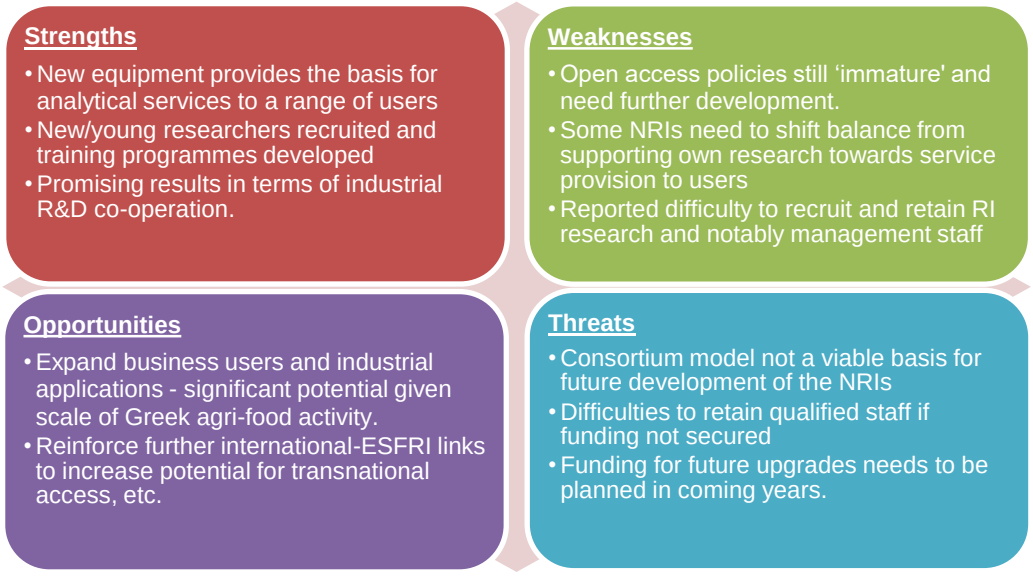

Figure 17. SWOT analysis of the agri-food NRIs

Similarly, **FoodOmicsGR** notes that over 60 protocols – 20 of which have a TRL level of between 6-8 – have been developed and a detailed characterisation of the content of more than 30 Greek foods (wine, olives, virgin olive oil, carobs, dairy products such as milk yoghurt, cheese) and other commodities and local specialties has been carried out. FoodOmicsGR partners collaborate with SMEs in the nutrition/wellness areas including spin-offs and start-ups as well as leading businesses in agri-food (olive oil, dairy, meat and other commodities) and regional authorities.

Food Innovation RI reports various contracts concluded with agri-food companies by the NRI's partner institutes including with foreign firms (Singapore, USA and Brazil) as well as for a Greek agricultural cooperative. **OMIC-ENGINE** lists a range of projects carried out

jointly with businesses, for instance using funding from the Research-Create-Innovation call (2021-2024) to develop agri-food products and processes. It has secured EUR 12 million including EUR 4.12 million from collaborative research projects with 30 industrial partners.

In terms of future sustainability, all four NRIs underlined that the absence of a single legal entity holds them back. Most, if not all, funding is secured via the ESIF operational programmes, including complementary investments in some cases from regional operational programmes. The recruitment and retention of NRI management staff, viewed as a necessary condition for future development, is particularly challenging. Funding to pay for equipment upgrades is also a challenge. For instance, in the case of PLANT-UP, it was noted that they have developed a list of services for a plant clinic, but this requires investment in larger equipment which is difficult to acquire in the current set-up. According to interviewees, there is no similar RI in Europe and there is a potential to promote Greek expertise and take the lead on this topic at EU level.

2.2. Energy NRIs

In line with the EU's binding climate and energy legislation and targets for 2030, Greece has adopted a National Energy and Climate Plan (NECP) covering the period 2021 to 2030[60]. Greece has already implemented reforms to drive decarbonisation, aiming to reduce its greenhouse gas (GHG) emissions by 56% by 2030 compared to 2005, and to have a climate neutral economy by 2050[61]. The sector making the single largest contribution (36%) to greenhouse gas emissions is the energy industry. However, this is also the sector in which the greatest reductions have been made in the period 2005-2019 (45%). The second highest sector by contribution (19%) is transport where, in comparison, the reduction has been only 21% for the same period[62.]

During 2014-2020, Greek participation in Horizon 2020 under the thematic priorities 'Secure, clean and efficient energy' and 'Smart, green and integrated transport' accounted for 479 (283 and 196 respectively) grants (17.2% of total Greek grants) and close to EUR 259 million in funding (147 and 112 respectively), with social sciences and engineering and technology the most predominant fields of research[63.] Of the total funding received under these thematic priorities, seven organisations accounted for half of the net EU contribution including the Centre for Research and Technology Hellas (CERTH) (18%), the Institute of communication and computer systems (ICCS) (10%), the NTUA and the AUTH.

The S3 for 2021-2027 retains sustainable energy and transport as priority sectors, noting the continued strong performance in indicators related to – in the case of energy – investments, educational level of employees and the percentage of employees in the R&D department, and – in the case of transport – contribution… The energy sector is also characterised by a significant level of start-ups. Their activities and sub-ecosystems are at the heart of many European strategies, such as the Europe Green Agreement, the EU Action Plan for the Circular Economy, Horizon Europe, as well as the NCEP. The

[60] See: European Parliament briefing: EU progress on climate action –How are the Member States doing? Climate action in Greece, June 2021
[61] International Energy Agency
[62] National energy and Climate Plan. Hellenic Republic Ministry of the Environment and Energy, December 2019
[63] Source: Horizon Europe Dashboard, consulted 17 May 2022

development of activities in the transport sector is identified as a priority in the National Development Programme 2021-2025[64].

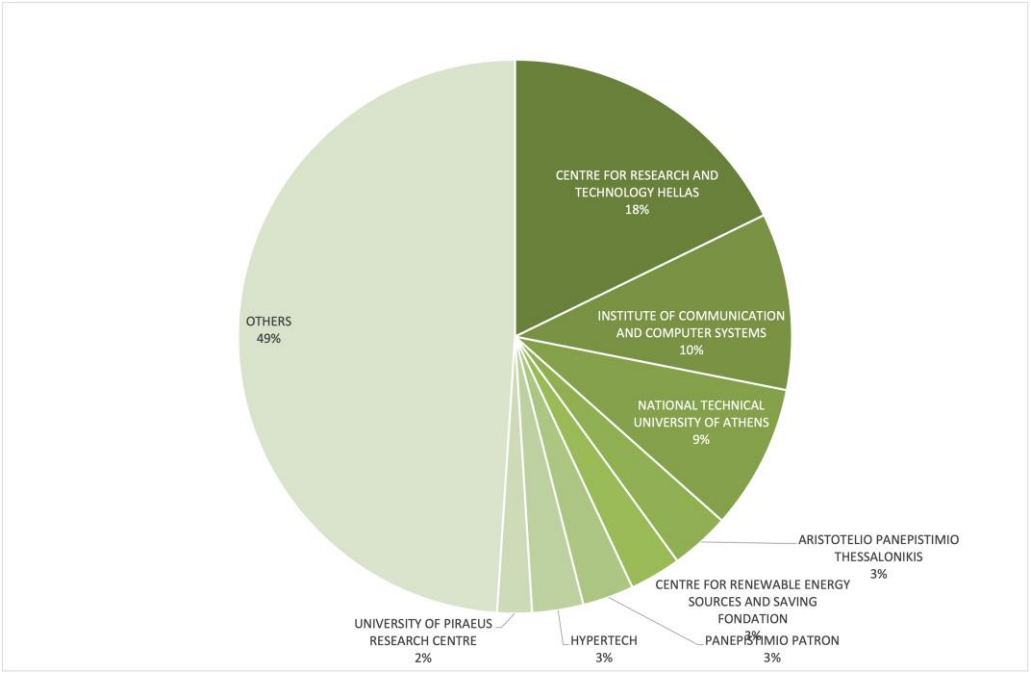

Figure 18. Greek beneficiaries of H2020 energy and transport calls (net contributions) (Source: Horizon 2020 dashboard, data extracted 17 May 2022)

2.2.1. Strategic focus of Greek NRIs in the energy and transport fields

There are two NRIs within these thematic fields: FuVEP, the Centre of Excellence for Future Vehicle Performance, which focuses on engine, powertrain, exhaust and fuel; and PROMETHEUS/ARCHIMEDES[65] RI for the Integrated Energy Chain. These RIs have the potential to impact a wide range of sectors including automotive, industrial, power generation, the construction sector, tourism, and agriculture. The two NRIs involve five partners from five different institutions, three of them included in the top five Greek performers in the energy and transport sectors based on Horizon 2020 net contributions. Approved funding for the two NRIs is more than EUR 7.3 million, with the actual spending to date around 80% of the total approved. The missions of the two NRIs are as follows:

- **FuVEP:** to accelerate the transformation of vehicles towards minimal environmental impact and to meet humanity's transport needs with minimal effect to the environment.

- **PROMETHEUS/ARCHIMEDES:** to become the reference point for sustainable energy processes and applications in Greece, with emphasis on thermal energy using low, medium and high temperatures.

[64] https://www.forin.gr/downloads/download/67217/fek-a-174-10-09-2020
[65] The ARCHIMEDES Research Infrastructure has been included in the National Roadmap of Research Infrastructures and funded within the PROMETHEUS Project, resulting in one project with two hubs: CPERI-CERTH hub (PROMETHEUS) and NCSR "D" hub (ARCHIMEDES). In this document, PROMETHEUS, unless otherwise specified, refers to both.

National Research Infrastructure	NRI full title	No. of partners	Approved budget (€)	Actual expenditure (€)	Budget execution
FuVEP	Centre of Excellence for Future Vehicle Environmental Performance	3	3,662,591	3,072,434	83.9%
PROMETHEUS	Research Infrastructure for the Integrated Energy Chain	2	3,680,263	2,806,087	76.2%
TOTAL		5	7,342,854	5,878,521	80.0%*

Figure 19. NRIs in the energy field – key figures (Source: GSRI, calculations authors, *average budget execution)

The two NRIs seek to create a nationally (and ultimately internationally) recognised 'infrastructure of scientific and technological excellence' in their specific field of operation. Both NRIs are aligned with the main EU Green Deal priorities, including rolling out cleaner, cheaper and healthier forms of private and public transport, contribution to international standards, efficient use of resources, pollution reduction, climate neutrality, environmentally friendly technologies, industrial innovation and decarbonisation. The mission statements and aims and objectives described on the NRI websites and in responses to the PSF questionnaire provide more insight into the expected outcomes (both the results during the project lifetime and longer-term impacts). The table below summarises the expected outcomes applying the three impact pathway categories of the RI-PATHS project.

NRI	Enabling science	Problem-solving	Science and society
FuVEP	Research actions, training and educational activities for researchers Development of advanced services and state-of-the-art facilities accessible to users Scientific publications in international magazines and/or conferences with peer reviews Increase of employment of new scientific staff Organisation of collaborative	The establishment of a research platform to assist in investigating a series of issues that could improve the energy and environmental implications of the internal combustion engine R&D services and consultancy offered to the automotive industry and public bodies, providing solutions to reduce transport impacts on the environment	Cooperation actions with research organisations, industry and European research infrastructures Organisation of dissemination events (workshops, seminars, conferences) Design and implementation of a series of networking activities that could improve the positioning of FuVEP and its member-labs globally

NRI	Enabling science	Problem-solving	Science and society
	research activities that upgrade the technical and scientific skills of the staff and contribute to the formation of new interdisciplinary network		
PROMETHEUS/ ARCHIMEDES	Conduct high-level basic and applied research to develop novel technologies and products Improve its academic excellence and maintain its international status as a centre of excellence Participate actively in European and national competitive research projects	Pursue scientific and technological excellence in selected advanced areas in response to the needs of the Greek and European industrial and productive sector Provide technical assistance/services to industrial partners and research organisations Initiate the operation of new spin-off companies	

Figure 20. Energy and transport NRIs - declared aims by type of impact pathway (Source: authors based on NRI documentation)

Under 'enabling science', the two NRIs emphasise the use of the capabilities funded by the NRI project to conduct excellent science. FuVEP also focuses on training researchers and the development of advanced services accessible to users. Industrial support is considered by the two NRIs, although to differing degrees: both pursue scientific excellence partly to be able to respond to the needs of business and industry, but while PROMETHEUS aims to provide technical assistance or services, FuVEP extends its support to R&D for private clients as well as consulting services for industry and public bodies. There are also differences in the degree of implementation as FuVEP has already put in place an internal structure defined to consider these relations and how to manage them, with an established procedure for the submission of proposals and an internal structure to manage them, while PROMETHEUS has not yet put such processes in place. FuVEP has set clear expected outputs to address the impact pathway on society. However, some of these actions have been clearly delayed due to restrictions imposed during the Covid-19 pandemic.

From an external and strategic perspective, the two NRIs maintain, to a different extent, collaborations, agreements, etc. with national and international stakeholders. FuVEP is involved in several relevant EU and international level partnerships. Its client and collaborator list includes the private sector (car manufacturers and component suppliers, fuel and lubricants producers) and EU and international institutions (European Commission, European Environment Agency, Joint Research Centre, European Committee for Standardisation). In addition, the member labs have enhanced their presence at European level by actively participating in different networks and associations, notably in the transportation sector.

PROMETHEUS is involved in several networks and associations (such as Hydrogen Europe, the CSP Joint Programme of EERA, the European Automotive Research Partners Association, EARPA, and others) and collaborates with energy- and transport-related companies, such as Global Sol Energy or CYRUS (Greek start-up company).

Currently, these collaborations are carried out by individual researchers associated with an NRI or by their host institutions. In the case of FuVEP, the lack of a single legal entity means that either multiple Greek partners are involved or the NRI coordinator takes a leading role.

2.2.2. Governance and operational management

Both NRIs operate according to a distributed RI model with a coordinator and a number of hubs. FuVEP has developed a well-structured governance model. It comprises strategic and operational levels. The strategic level includes the general assembly, a coordination committee, an advisory board, a scientific committee and the executive team. The operations level includes the scientific hubs – the NRI's own labs. Every hub appoints a contact point responsible for planning and delegating activities within each hub. The model adopted for planning and implementation of relevant activities is based on a matrix management organisation: each research hub distributes its resources (researchers and infrastructures) according to the common plans and each project is developed by implanting common project management rules. All information regarding activities at the operation level is recorded and saved in a common repository.

In the absence of a single legal entity, its current operational model is based on a project consortium set-up under a MOU. In this context, a new legal framework for continuing operations is highlighted as a main requirement for sustainability.

PROMETHEUS has a simpler governance structure as the hubs operate independently, although there is a scientific committee with two representatives of each partner. This absence of NRI-level governance aligns with the stated intent of the partners to develop each hub separately in a possible next phase.

NRI	Lead partner	Governance framework
FuVEP	AUTH	Strategic level: general assembly, coordination committee, advisory board, scientific committee Executive level: executive team, scientific hubs, each hub with a contact point Common project management rules, common repository for documentation
PROMETHEUS	CERTH	Scientific committee

Figure 21. Energy NRIs – governance frameworks (Source: authors based on NRI documentation and questionnaire responses)

2.2.3. NRI funding, staffing and operations

The share of total funding per NRI to the coordinator is around 80% (See Figure 22). Despite this apparent asymmetry in funding between coordinators and the rest of the partners, the relatively small number of participating institutions – as compared with many other NRIs – makes the amount invested in each of them still considerable and allows for

investments in medium/large-sized equipment. The budget distribution by category of expenditure for the two NRIs is broadly similar. In both cases, direct costs (investments in equipment and consumables) represent more than 60% of total expenditure, followed by personnel costs (20-30%). FuVEP spends a noteworthy amount on publicity compared to PROMETHEUS, perhaps because of its more established activity.

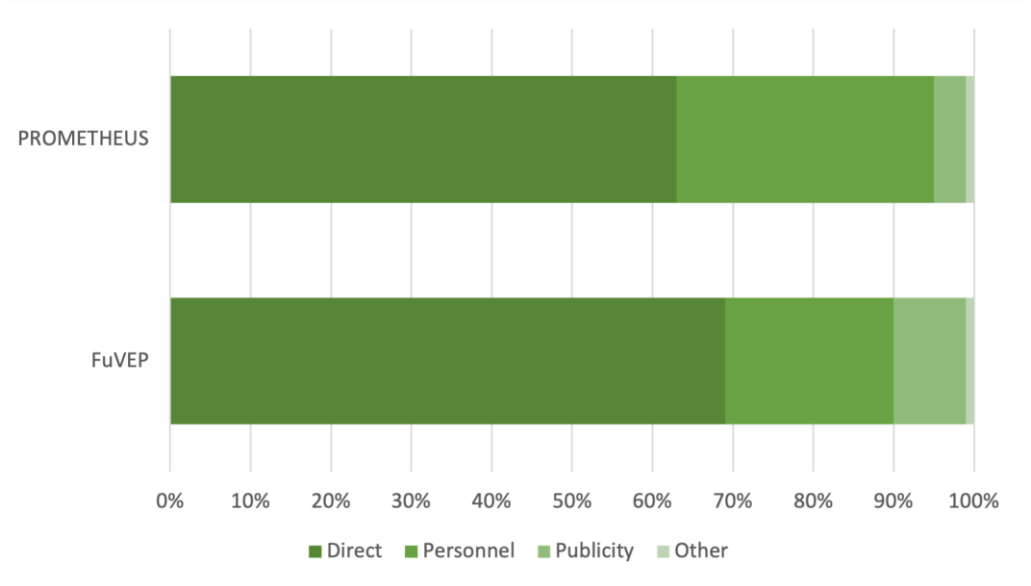

Figure 22. Distribution of budget by category of expenditure (Source: GSRI, calculations authors)

National RI	a) Number of researchers working in improved research centre facilities (FTE)	b) Number of young researchers (FTE)	Difference (a-b) (FTE)	Direct personnel expenses	Per researcher
FuVEP	27.26	19.75	7.51	€636,431	€23,347
PROMETHEUS	29.73	28.33	1.4	€846,215	€28,463

Figure 23. Human resource indicators – energy NRIs (Source: EPANEK-GSRI, calculations authors)

The FuVEP team includes staff from across the three universities, with seven professors, ten senior researchers, more than a dozen PhD students and over 15 engineers, technicians and administrative employees. FuVEP has the scale and structure to continue to evolve further in the future but recruitment and retention of qualified staff able to operate the facilities is difficult in the context of the university recruitment procedures (temporary contracts and pay scales).

PROMETHEUS is embedded in CERTH and the project has faced difficulties in the recruitment of permanent staff. For example, hiring a specialist scientist can take a “great deal of effort” and requires additional funds to those provided by the NRI. Two post-doctoral scientists were hired from the NRI funding (one of them from abroad), for a limited time and for the needs of the first phase of the NRI only. It was underlined that for future

NRI operation it will be very important to be able to recruit an adequate number of technical staff, with experience in hydraulic, electronic, electromechanical installations, on a permanent basis. The ARCHIMEDES project team, based at Demokritos, includes the scientific lead plus four research staff, two post-doctoral researchers and a mechanical engineer.

2.2.4. Service provision and user access policies

The way the service provision is structured varies from one NRI to another. In particular, the development of a well-presented catalogue of services with easily understandable open access procedures and/or pricing frameworks is not optimised in all cases.

FuVEP has developed a catalogue of services (presented on their website[66] as 'Solutions'), covering services in vehicle performance, powertrains, exhaust, fuels and lubricants. Each section of the catalogue shows the NRI capabilities, including some examples, and a contact email for further information. FuVEP is already a trusted partner in the industry (e.g. for Euro standard testing) with most industrial users coming from outside Greece, which is stimulating an 'ecosystem' in the Thessaloniki region. In particular, FuVEP works in partnership with two spin-offs of the LAT[67] both working on emissions testing. As FuVEP focuses primarily on the needs of industrial users, the research activities need to be performed by well-trained internal personnel (in partnership with users' own technicians).

PROMETHEUS is still acquiring or commissioning the main equipment for the NRI so there is no catalogue of services yet. The NRI management presented a list of NRI users, ranging from other academic and research centre teams to industrial partners for a range of applications (solar fuels, thermal storage, waste treatment, electrical batteries and vehicle emissions testing). At Demokritos, where the ARCHIMEDES hub is located, there is a list of services[68] provided using existing infrastructure, but with no apparent link to the NRI. The potential applications, and hence users, cover a broad range of sectors, from process heat in the industrial sector to heating and cooling for building, hotels for tourism, etc.

2.2.5. Results, impact and sustainability

The two NRIs show different degrees of development. While PROMETHEUS is still in the stage of commissioning a large part of the acquired equipment, FuVEP can be considered a consolidated facility, with significant experience acquired over the last 40 years, a good understanding of the market (industry links), excellent scientific track record, and strong collaboration with private and public institutions.

From the technical and scientific points of view, a first challenge for FuVEP is keeping up with the shift from the internal combustion engine to electric vehicles. A second challenge is to move to modern facilities (at Thessintec[69]) out of the temporary buildings FuVEP uses at AUTH. A third challenge is the lack of intermediate staff: NRI managers who can translate the vision into action, securing funding/contracts and enabling scientists and technical staff to focus on running the RI (research, testing, etc.). In addition, ensuring the continuity of all staff is critical. For this, at least 20% of the budget will need to come from public funds; the remaining 80% could be obtained from competitive projects and industrial customers.

[66] See: https://fuvep.com/
[67] See: http://exothermia.com/ and https://www.emisia.com/
[68] See: http://www.solar.demokritos.gr/services_en.html
[69] See: https://www.thessintec.eu/

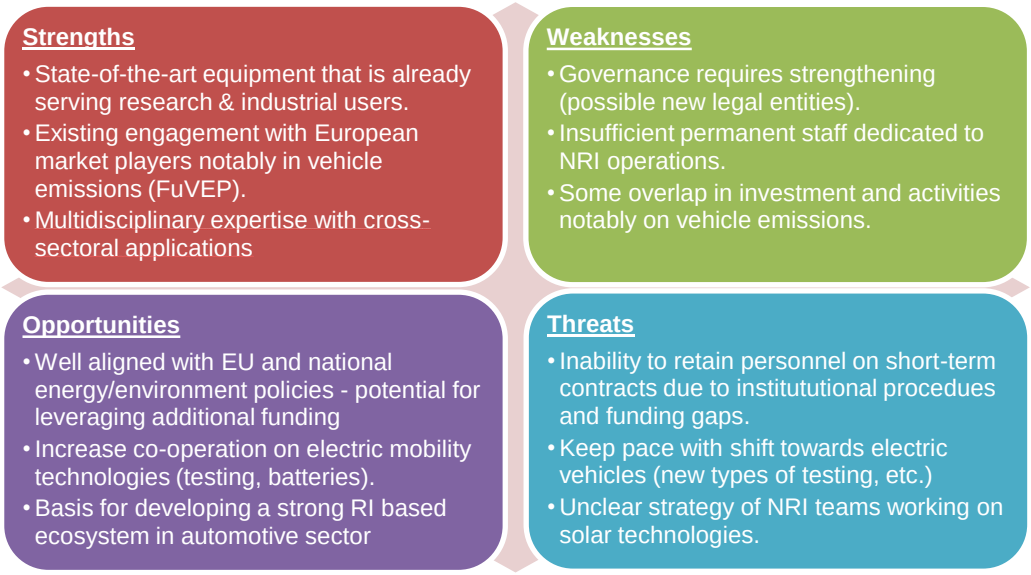

Figure 24. SWOT analysis of the energy NRIs

PROMETHEUS is finishing the commissioning of the equipment for the NRI project, which is expected to contribute to a much faster development of technological and scientific innovations and stimulate more service projects in the framework of bilateral contracts with both local and international industrial partners. As the operability of the PROMETHEUS facilities needs to be maintained and continuously upgraded to better match and efficiently fulfil current research needs, further operations and maintenance costs for R&D and IT equipment will have to be met. This includes equipment consumables and spare parts, support services provided by equipment vendors (including software licence updates), facilities management, as well as technical support, administrative and research personnel.

Finally, in terms of sustainability, FuVEP underlines that, in the absence of a single legal entity, the NRI's development remains challenging. The ability to contract services – either under national or EU programmes or with the private sector – and to manage the revenue generated from such contracts needs to be as simple as possible to support expanded services and to attract and retain top NRI staff. On the contrary, the PROMETHEUS partners do not support or call for the creation of a new legal entity. Indeed, they propose splitting the NRI into two (ARCHIMEDES and PROMETHEUS) as they operate independently. On the other hand, FuVEP and PROMETHEUS share common interests and complement each other in areas such as emissions reductions for internal combustion engines and energy storage (batteries, hydrogen), and both NRIs recognise that there is room for increased cooperation.

2.3. Environment and sustainable development NRIs

The six NRIs in the **environment and sustainable development** field cover a range of diverse scientific disciplines, including biology, air, sea and earth sciences, as well as chemical and mechanical engineering. These NRIs serve a broad portfolio of application sectors, from ecological preservation to natural disaster mitigation and prevention, waste re-utilisation, and food supply. They include education and training capabilities for both the public and private sector, as well as R&I capacity and support services.

In the SCIMAGO[70] country rankings for environmental sciences (all disciplines), Greece was ranked 27th globally and 12th in the EU27 during the period 1996-2001. Greek environmental researchers perform even better in subject areas such as environmental engineering (22nd globally) health, toxicology and mutagenenis (24th), pollution (23rd), waste management and disposal (22nd), and water science and technology (26th). Greek science is also relatively well placed in the field of earth and planetary sciences (31st globally) with relatively higher performance in fields such as atmospheric science (22nd), geotechnical engineering (15th), and oceanography (24th). The data points to areas of scientific excellence.

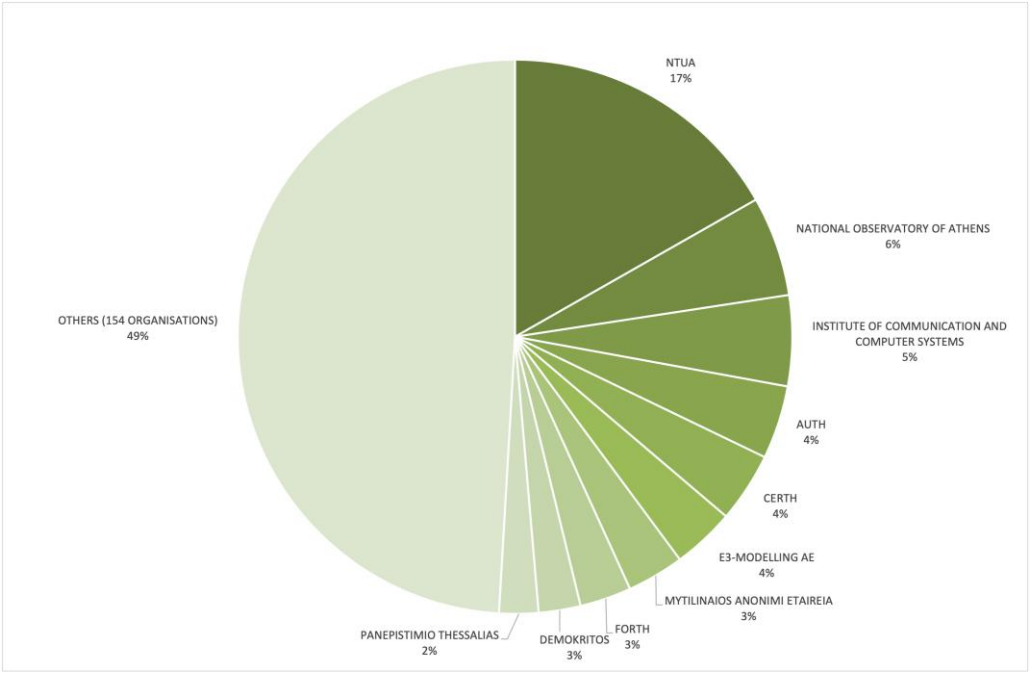

Figure 25. Greek beneficiaries under the thematic priority environment of Horizon 2020 (net contributions) (Source: Horizon 2020 dashboard, data extracted 12 May 2022)

During 2014-2020, Greek participation in Horizon 2020 under the thematic priority 'Climate action and environment' accounted for 161 grants (5.6% of total Greek grants) and over EUR 111 million in funding (6.6% of the total H2020 funding awarded to Greece), with natural sciences being the most predominant field[71]. The funding, awarded to 164 organisations, was distributed relatively equally between private-sector companies (32%),

[70] See: https://www.scimagojr.com/countryrank.php?area=2300&order=h&ord=desc
[71] Source: Horizon Europe Dashboard, consulted 12 May 2022

higher-education institutes (32%) and research organisations (27%); the public sector received 7% of the total funding. Of the total funding awarded to Greek organisations under the environment thematic priority, ten organisations accounted for half (51%) of the net EU contribution, with notably the NTUA receiving close to 17%, followed by the National Observatory of Athens, the Institute of Communication and Computer Systems, AUTH and the CERTH, all receiving between 4-6% of total funding.

The national RIS3 2014-2020 identified the field of 'Environment and sustainable development – climate change' as a critical area and an important priority for all regions. This includes the development of new clean technologies and their promotion. The infrastructures in this field relate to the monitoring of coastal zones and water resources; sustainable exploitation of marine living resources; biodiversity (terrestrial and marine ecosystems) protection; seismology and seismic protection, climate change and atmospheric research, water resources, and waste management and utilisation. The need to integrate the existing infrastructures in geological and atmospheric sciences is specifically mentioned in the strategy, as a means to achieve the necessary coordination for natural hazard prevention. The strong interdisciplinary character and horizontal nature of this field, especially for the agri-food sector, is underlined.

The environment and circular economy sector performed strongly in the period 2014-2020 in terms of production (share of gross value-added) and its contribution to domestic employment (e.g. employees in the sector have a higher average educational level)[72]. However, during the same period, this sector was awarded only 102 projects through the R-C-I calls, a relatively low share of the total. According to the Elevate Greece database (data as of May 2022) between 10-15% of Greek start-ups were recorded in the environment and sustainable development field:

- 48 start-up companies registered in the environment and energy technology sector (green-tech, clean-tech), with 218 employees and a total investment of EUR 3.5 million. The dominant technology is clean-tech, in terms of the larger companies with the most investment, followed by cloud computing/AI, hardware and big data analytics.

- 14 start-up companies in the maritime industry sector account for almost as many employees (212) and EUR 0.9 million in invested funds, with similar dominant technologies (AI, networks and software).

Other business sectors may also include companies relevant for the environment and sustainable development sector (e.g. a firm working on innovative disease-prevention tools for aquaculture health in the life sciences). Indeed, the sector is transversal to applications across business sectors.

The difficulty in gauging the size of this field, either from the scientific or commercial standpoint, should not diminish the clear horizontal, cross-sectoral relevance of this field. In fact, the role and importance of this field/sector and its specific R&I ecosystems for the European economy in the coming years are strongly highlighted in the EU Circular Economy Action Plan and European Green Deal; both strategies will make a key contribution to the green transition across Europe. At national level, the needs and priorities of the sector are included in the National Plan for Energy and Climate, which has a distinct political priority. This field is also supported by the National Action Plan for the Circular Economy, which includes five axes: 1) actions for sustainable production and industrial

[72] RIS3 2021-2027

policy, 2) actions for sustainable consumption, 3) actions for less waste with higher value, 4) horizontal actions (governance, legislative, organisational, etc.), and 5) specific actions for commodities, which must be addressed as a matter of priority. The individual actions in these areas are estimated to offer significant new business opportunities, complementing and strengthening many of the domestic value chains.

The vision of the RIS3 2021-27 is the transition to a new development model that is socially, economically and environmentally sustainable, based on knowledge utilisation in the production of high value-added products and services, with the prospect of integration into international value chains. 'Environment and circular economy' remains a key priority area for the new period with significant funding from the ESIF programmes – including rural development in areas such as municipal and industrial waste, recycling, energy, biodiversity, etc. – and the availability of additional resources from the RRF for 'green' R&I.

2.3.1. Strategic focus of Greek NRIs in the environment field

The six NRIs cover a broad range of analytical capacities relating to different domains of environmental sciences – including the marine and freshwater research, atmosphere and geosphere sciences – and covering aspects of pure research as well as implications on societal challenges, such as environmental degradation (CMBR, HIMIOFOTS, PANACEA), climate change (PANACEA, CMBR), circularity of economy (INVALOR), natural hazards (HELPOS), and food production (CMBR). At the time of reporting, one of the RIs is still under construction (RePHIL). All RIs, to varying extents, have connections with the private sector, either as users or co-developers. In particular, CMBR is a pillar of the national aquaculture sector and recognised internationally, while INVALOR is dedicated to applied research and services in the waste valorisation field for both the private and public sectors.

National Research Infrastructure	NRI full title	No. of partners	Approved budget (€)	Actual expenditure (€)	Budget execution
CMBR	Centre for the study and sustainable exploitation of Marine Biological Resources	7	4,000,000	4,000,000	100%
HELPOS	Hellenic Plate Observing System	8	3,965,844	3,705,319	93.4%
HIMIOFoTS	Hellenic Integrated Marine and Inland Water Observing Forecasting and Offshore Technology System	7	3,991,975	3,947,566	98.9%
INVALOR	Research Infrastructure for Waste Valorisation and Sustainable Management of Resources	7	3,899,713	3,899,713	100%
PANACEA	Panhellenic infrastructure for atmospheric	14	3,999,950	3,953,701	98.8%

National Research Infrastructure	NRI full title	No. of partners	Approved budget (€)	Actual expenditure (€)	Budget execution
	composition and climate change				
RePHIL	Hellenic Research Fleet/ reconstruction of the research vessel PHILIA	2	3,133,006	3,130,631	99.9%
Total		45	22,990,488,00	22,636,930,00	98.5%*

Figure 26. NRIs in the environment and sustainable development field – key figures (Source: GSRI, calculations authors, *average budget execution)

The six NRIs mobilise 45 partners, from 18 distinct organisations, and close to EUR 23 million in approved funding. In many cases, an even higher number of research teams and laboratories are involved from each participating entity, which points on one hand to the interdisciplinary and distributed nature of the research infrastructures and, on the other, to the possibility that service provision may be overly fragmented and may need some consolidation or integration activity. Most of the NRIs are a unique reference in their specific field of operation, at the national level. Their reputation is well established also at the international level, and these NRIs have established structural connections with European RIs, as it is the case for CMBR, PANACEA, HELPOS.

The mission statements and aims and objectives provide more insight into the expected outcomes during the project lifetime and longer-term impacts). The table below summarises the outcomes applying the three RI-PATHS impact pathways.

NRI	Enabling science	Problem-solving	Science and society
CMBR	Interdisciplinary research activities with cultivation of new species, study of the dynamics of bio-communities in relation to environmental conditions Continuous recording of environmental parameters Training and educational activities for researchers Development of state-of-the-art access services for research users Access to unique Eastern-Med ecosystems	R&D services offered to industry, including national SMEs and foreign multinational companies Enhanced training to industry by sharing data, methods, knowledge and skills Improving the sustainability of marine food production through integrated food-web approaches and 'omic' technologies Development of automated management methodologies for multipurpose offshore	Extensive scientific networking capacity and establishing standards for a community of practice, through participating in multiple pan-EU RIs, as members Promoting engagement between science, society and policy, regarding marine environment quality and productivity

NRI	Enabling science	Problem-solving	Science and society
		platforms (for energy and aquaculture)	
HELPOS	Open access to distributed, multidisciplinary infrastructure for research, with a network of experimental laboratories Continuous, high-quality data acquisition and real-time restitution Storage/analysis/sharing capacity for large-scale observations and simulations	New developments in seismic engineering	Extensive scientific networking capacity and establishing standards for a community of practice Promoting engagement between science, society and policy regarding seismic activity and earthquake monitoring and analytical processes
HIMIOFoTS	Access to data from inland and marine water telemetric stations and platforms	Potential for monitoring and forecasting on the state of some parameters reporting inland and marine waters	Potential to create a single-entry point to Greek water bodies, both fresh waters and marine waters Potential to establish a public-utility resource for water-state forecasting
INVALOR	Dissemination of results related to the circular economy	Extraction/addition of value to residuals biomass, municipal wastes and industrial-process by-products Techno-economic and environmental assessment of alternative technologies Applied technological research	Supporting the circularity of industrial production and reducing wastes
PANACEA	Interdisciplinary research activities related to air quality monitoring Continuous recording of environmental parameters Training and educational activities for researchers Real-time monitoring of air quality and access to extensive research datasets Development of state-of-the-art access services for research users	Test beds for innovative technological development of instruments, hardware and software for scientific research	Extensive scientific networking capacity and establishing standards for a community of practice Promoting engagement between science, society and policy, regarding atmospheric quality and climate monitoring and analytical processes, facilitating decision-making processes

NRI	Enabling science	Problem-solving	Science and society
RePHIL	Support to training and education activities in marine research Access to essential infrastructure for marine environmental monitoring and research activities	Engineering solutions	Supporting marine monitoring programmes related to fishery and environmental protection policies

Figure 27. Environment and sustainable development NRIs – declared aims by type of impact pathway (Source: authors based on NRI documentation)

Under 'enabling science', there is a strong emphasis on improving access to existing or new research facilities for researchers (and other users). HELPOS and PANACEA and HIMIOFoTS have a clear mandate to monitor, store and provide real-time data from an extensive network of telemetric stations distributed in the country, forming a complex surveillance system of international value for seismic and atmospheric research activities. To some extent, this monitoring activity is also part of the remit of CMBR and RePHIL, for the marine environment. Training and education of early career scientists as well as of industry is also a prominent part of the main activities of the above-mentioned RIs.

Industrial applications and contract R&D services are addressed by all six NRIs but to different extents. In this respect, INVALOR and CMBR can certainly be viewed as champions and real enablers for their respective application sectors, i.e. valorisation of industrial by-products and aquaculture.

These six NRIs are also engaged in the third type of impact pathway in different ways: the engagement of a triple helix model is relatively well established for the RIs dedicated to environmental monitoring and research, such as HELPOS, PANACEA, CMBR, while HIMIOFoTS and RePHIL have clear potential to deliver on this dimension. INVALOR occupies a quite specific niche that has an important societal remit, however the size and type of their operations – mainly focused on the industrial sector – may limit their impact in this direction.

The networking capacity (national and international) of some of these RIs constitutes a clear asset for delivering for 'science and society' benefits. In particular, PANACEA, CMBR and HELPOS have clear connections with ESFRI RIs and participation in European projects. These experiences are helping to shape their service provision, their ability to deliver excellent science, their potential to reach wider user bases, their results and outreach potential, and ultimately, their financial sustainability.

Collaboration with ESFRI RIs is complicated for most RIs as they lack the funding for the membership fees on a continuous basis – this should be addressed at the policy level, given the broad advantages that this kind of cooperation produces.

2.3.2. Governance and operational management

All six NRIs operate based on a distributed RI model with a main coordinator and a number of nodal entities operating services in other locations. In all cases, their governance and operational model is based on a project consortium MOU or consortium agreement, which provides for a specific governance structure. As a rule, these structures include a general

assembly (meeting once or twice a year), plus a steering committee/operational board that coordinates the more operational implementation of the NRIs.

NRI	Lead partner	Governance framework
CMBR	Hellenic Centre for Marine Research	Distributed Well planned governance but not fully implemented yet: coordinator, steering committee, executive committee, scientific advisory board (private and public, all external, thee national and three international representatives), project manager, liaison officer, access officer, business development officer
HELPOS	National Observatory of Athens	Distributed Eight entities with their various department for a total of 13 members; GA, president, two internal bodies assisting the GA, steering committee, tech committee Six members tied with a MOU, two others are collaborating, anticipating that they will become members
HIMIOFOTS	Hellenic Centre for Marine Research	Distributed Eight partners, the governance was guaranteed by the project; the governance is designed but only partly running; a user advisory board is planned including some private users; MOU
INVALOR	University of Patras	Distributed Seven partners
PANACEA	University of Crete	Distributed 14 members Governance inspired by ACTRIS and ICOS: coordinator, steering committee, general assembly, external advisory board; GA meets once a year, associated with big scientific conference where they plan the next years steps
RePHIL	Hellenic Centre for Marine Research	Distributed Two partners Yearly meeting between the institutes and the operational teams meet as required

Figure 28. Environment and sustainable development NRIs – governance frameworks (Source: authors based on NRI documentation and questionnaire responses)

In some instances, such as CMBR and HELPOS (and PANACEA to some extent), the governance is better structured, e.g. with external advisory bodies, clearly inspired by their experiences with/in European RIs. On the other hand, the other three NRIs have limited governance systems in place, partly due to the smaller size of the consortium, such as the case of RePHIL. However, a lack of vision of the development from a project to a NRI in the longer term could also be the source of limited investment in governance.

All the RIs have expressed, in PSF questionnaires and interviews, the intention to extend cooperation between the current NRI project duration. In this context, advice on the legal and governance framework for continuing operations is highlighted by all four NRIs as a main requirement for sustainability. Guidance from other RIs or the integration of the smaller NRIs into the more organised ones, may be part of the solution. This could apply to RePHIL which has the same lead partner as CMBR and a compatible scope.

2.3.3. NRI funding, staffing and operations

The funding spread across the 18 organisations (see Figure 29) with the top five organisations (universities), including the four NRI coordinators, accounting for 72% of the total funding. The share of the coordinator in the total funding per NRI varies between 87% for HCMR in RePHIL and 35% for the University of Crete in PANACEA. The median funding provided per organisation and per NRI varies from EUR 1,337,709 for HCMR, which coordinates three of the NRI projects in this field, to EUR 30,000 for the University of Ioannina, which is involved in only one NRI; the other three project coordinators have a median funding value of EUR 700,000 (University of Crete, in PANACEA), EUR 580,000 (National Observatory of Athens, in HELPOS); 167,625 EUR (University of Patras, in INVALOR).

It is interesting to note that HCMR takes a lion's share of the funding, representing alone 36% (EUR 8.2 million) of the total funding allocated to all the projects, while the other NRIs in the top five in terms of funding allocation are around 10%. HCMR, on the other hand also participates in five of the six projects; the only other entity that participates in as many projects is the NKUA, however with a much smaller budget share (5% or EUR 1 million).

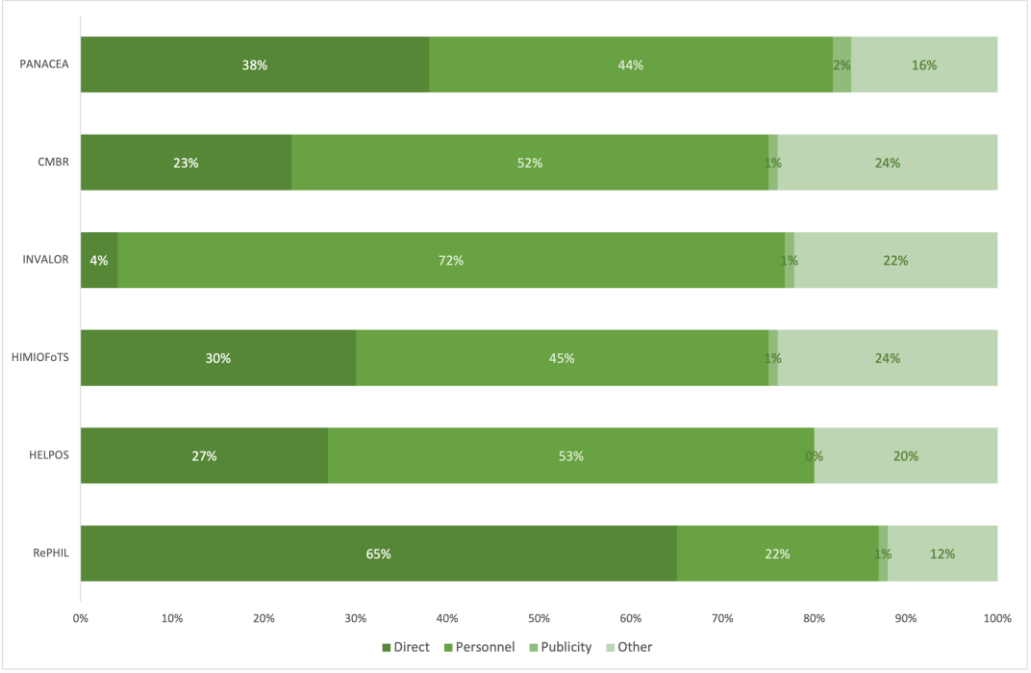

Figure 29. Distribution of budget by category of expenditure (Source: GSRI, calculations authors)

The budget distribution by category of expenditure for the six NRIs also highlights some notable differences in NRI operational models. It is evident that the main action of RePHIL

has required a major investment (65% of the budget) for the infrastructure (research vessel) maintenance/upgrade. At the opposite end of the spectrum, INVALOR has allocated most of its budget (72%) to personnel operating the existing infrastructure. The other RIs have budget allocations similar to each other, with half of the total going to personnel and between 23% and 38% to RI maintenance/upgrades. In all cases, very little budget (0-1%) is spent on publicity, and the rest is in the category 'other', between 12%-24%.

In the case of INVALOR, the lower equipment investment is possibly partly due to the prior existence of well-equipped laboratories with a significant number of scientific instruments that covered the needs of the preparatory phase of the infrastructure. It also seems to reflect an operational model more akin to a technology infrastructure supporting a portfolio of R&D projects, at medium-to-high Technology Readiness Level, than a research infrastructure; this was also confirmed by other assessments during their interview.

National RI	a) Number of researchers working in improved research centre facilities (FTE)	b) Number of young researchers (FTE)	Difference (a-b) (FTE)	Direct personnel expenses	Per researcher
CMBR	83.38	68.38	15	€1,717,648	€20,600
HELPOS	63.17	48.85	14.32	€1,599,149	€25,315
HIMIOFOTS	78.37	57.08	21.29	€1,660,567	€21,189
INVALOR	108.4	102.83	5.57	€2,738,274	€25,261
PANACEA	92.12	89.29	2.83	€1,653,138	€17,945
RePHIL	20.23	17.21	3.02	€641,658	€31,718

Figure 30. Human resource indicators – environment NRIs (Source: EPANEK-GSRI, calculations authors)

Turning to investment in human resources, staffing profiles of the NRI vary considerably, although the available data makes it difficult to compare across the NRIs on a like for like basis. What emerges clearly from the interviews is that rarely do these resources cover the costs of permanent staff or enable the hiring of personnel on a permanent basis. While the funding has allowed for the recruitment of new staff (young researchers), the brain-drain at the end of the funding period seems unavoidable in the absence of follow-on funding. This leads to a net loss for both the NRIs and the country, given the investment in training of human resources who seek better opportunities abroad or in the private sector.

2.3.4. Service provision and user access policies

In terms of usage, the NRIs current focus is towards other academic or research centre users. However, there remains scope to further enlarge the user base in terms of access to researchers from non-partner institutes and for international users. In this respect, the participation in EU projects and European RIs can guide and support transnational access, in terms of opportunities as well as harmonised practices.

PANACEA shows a mature understanding of the benefits of hosting the RIs and admits to finding strength in unity, especially for technology advances and synergies with other disciplines that broaden the scope of research activities. The RI reflects on its ability to provide organised and uniform access to the facilities through the joint management of resources and access policies and practices.

Access to the NRIs is allocated according to the typical transnational approach of the Horizon 2020 INFRAIA projects, which also means that the access is subsidised. However, the NRIs lack a plan to charge fees for access and to differentiate between academic/industry. Also, the vision for potential incentives for involving the private sector as users of the RI is limited to some free access. It is notable, on the other hand, that some of the NRIs, like CMBR and INVALOR, are references for the private R&D sector and are well accustomed to providing services in this area, with INVALOR acting similarly to a technological core facility for innovation. Still, some marketing actions should be envisaged to further attract users without or with limited subsidies.

2.3.5. Results, impact and sustainability

This group of NRIs appears to be delivering on the project monitoring indicators for results, i.e. number of users, publications, proportion of users from inside/outside Greece. In various cases, the results reported exceed the required target for the project KPI evaluation framework. For example, HELPOS described a publication record above target and a balanced participation of younger and female researchers. Intellectual property is being handled through an attribution request and licence system. RePHIL highlighted that it had doubled the number of scientists and the interdisciplinarity of their research, as well as the number of NGOs it hosts, and the use of the research vessel by the private sector (for fish farming, tourism, archaeology, sea-bed mining), and its capacity to monitor key parameters (fish stock, ecological status of the marine environment) required by the government. Meanwhile, HIMIOFOTS mentioned that its Poseidon website attracts some 1-2 million users per month. PANACEA reported having gained a reputation as a reliable reference at the national level for environmental monitoring practices in air-pollution events (e.g. wild-fires) and is exceptionally well networked internationally, alongside CMBR and HELPOS.

In some cases, the NRIs reported monitoring additional indicators, acquired through their participation in EU projects and RIs. For example, CMBR adopted RI performance measurements based on KPIs developed during Aquaexcel[73] and those used by European RIs such as EMBRC-ERIC. HIMIOFOTS reported taking inspiration from the EU-funded RI-PATHS framework for their indicators, i.e. trying to measure the socio-economic impact in addition to the basic KPI monitoring requirements of their national RI project. PANACEA continues to be attentive to the main metrics of scientific production, including open science practices relevant to the new ERA Agenda, industry collaboration, and gender balance.

In terms of impact, all six NRIs have an impact at the societal level and, to a varying degree, on the economy. In addition to their ability to offer jobs, some of the NRIs – PANACEA, HELPOS, CMBR – have a particular impact on policy, helping to support the decision-making process. Others, such as HIMIOFOTS and RePHIL, show potential as the environmental monitoring they will do is critical and unique at the national level. Some of the NRIs also have a clear impact on industrial development and are a reference for some business sectors, such as in the extraction of additional value from raw/waste materials (INVALOR), and in serving the growing national and international aquaculture and molecular aquaculture sector (CMBR). Indeed, the lead-partner of CMBR is home to four

[73] See: https://aquaexcel.eu/

spin-offs who actively engage with industry to push its research agenda and curiosity-driven innovation.

In terms of sustainability, most of the NRIs have a mature understanding of the benefits of hosting the project and combining forces, especially for technology advancement. According to PANACEA, synergy with other disciplines broadens the scope of research activities, while CMBR and HELPOS improve the ability to provide organised and uniform access to the facilities through the joint management of resources and access policies and practices. On the other hand, some bottlenecks were observed, which point to areas in need of support:

- The implementation of a governance model, which has been carefully planned in the construction phase of CMBR, HELPOS and PANACEA, but still needs to be completed for the others, thus posing a threat to the NRIs' sustainability.

- Another threat is the inability to retain employees because of funding continuity issues and lower salary levels compared to other EU countries and the private sector.

- The ability to attract users from both the public and private sectors appears to be on target, and all NRIs reported strong usage of their units/facilities, however the ability to attract users depends largely on public subsidies. A more business-like mindset is needed alongside an international marketing strategy to boost awareness and potential revenue, thus ensuring their future (financial sustainability).

- Most of the RIs reported advances in knowledge and technology transferred to users, public and private, but without clear licensing rules. Indeed, many of the NRIs reported the need for guidance and support in defining the rules for accessing and sharing the IPR generated, either as foreground or as a result of a collaborative project.

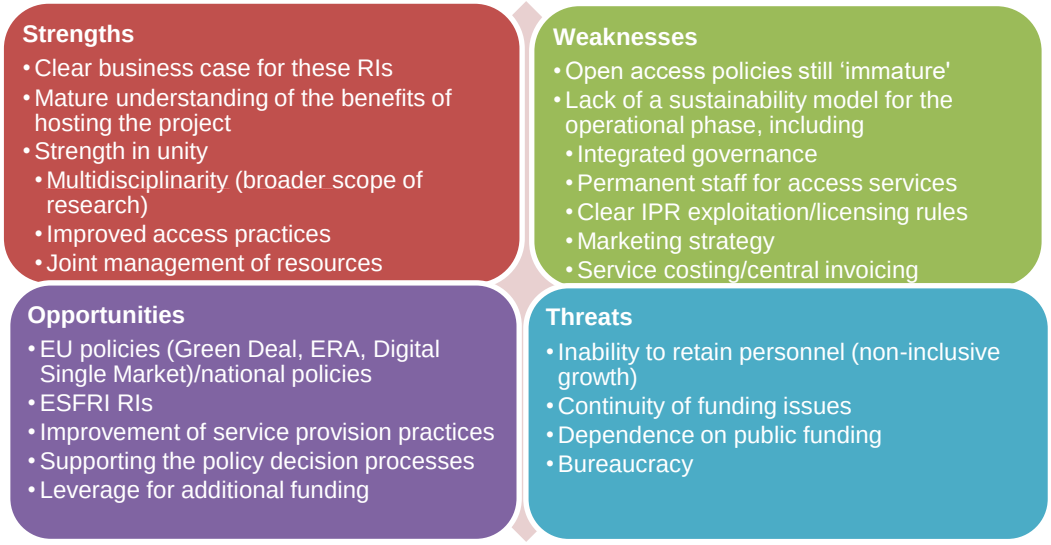

Figure 31. SWOT analysis of the environment and sustainable development NRIs

In summary, the financial sustainability of these NRIs is undermined because a clear mid-term business model is missing, which could guide their development in the next funding phase. While this is understandable in the early stages of their lifecycle, part of the new funding round should be set aside for the development of a business plan. In addition, the

possibility to create an NRI-specific employment scheme, addressing salary continuity and levels would merit appropriate consideration. The ability of the NRIs to be fully integrated in supranational networks (offering access to best practices, increased visibility and better funding prospects) should be supported at the government level, with a medium- to long-term funding perspective.

2.4. Health and pharmaceuticals NRIs

The health and pharmaceuticals sector (also referred to as the biomedical, life sciences or health sector) is arguably the most research-intensive in Greece, and accounts for well over 50% of the total peer-reviewed research papers from the country[74]. The translational aspects of this research effort are also prominent: companies in the sector account for a significant share of start-ups – 75 companies or 13.5% of the total – recorded in the Elevate Greece register[75]. These companies offer 673 jobs and the total funding for the 38 companies that declare relevant data in the same database, is EUR 59.5 million. A large part (42%) of this investment is in just two companies, one of which focuses on mobile applications (Intelligencia) and the other on Data Analytics (Vivante). Two-thirds of these 38 start-up companies remain small, having received funding of less than EUR 1 million.

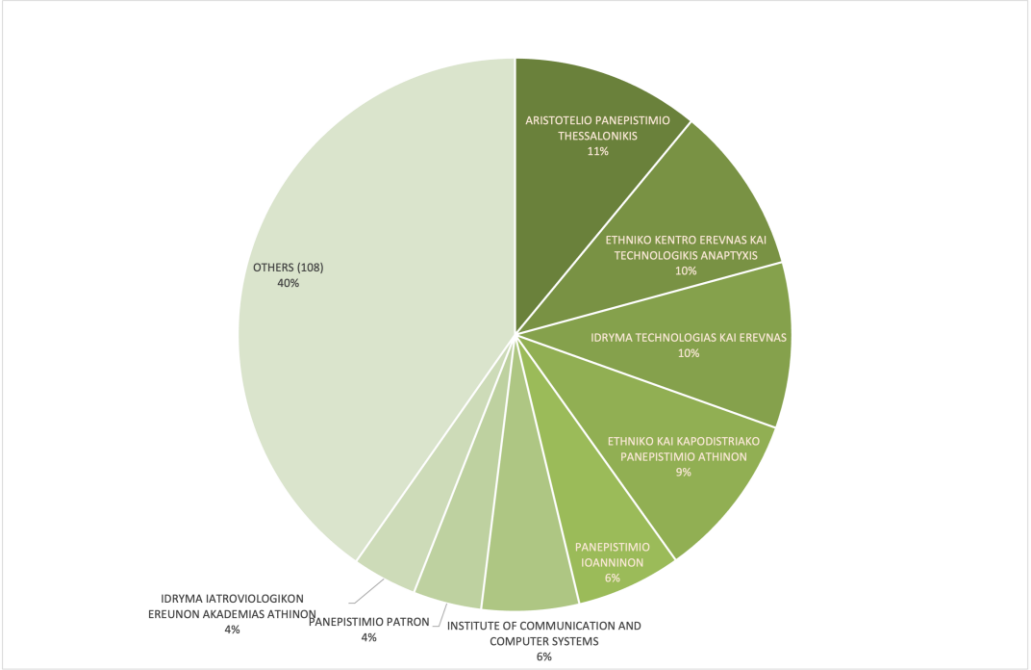

Figure 32. Greek beneficiaries of health-related calls of Horizon 2020 (net contributions) (Source: Horizon 2020 dashboard, data extracted 22 May 2022)

During the period 2014-2020, Greek participation in Horizon 2020 under the thematic priority 'Health, demographic change and wellbeing' accounted for 329 grants (7% of total Greek grants) and EUR 123.6 million in funding[76]. It is notable that, while Greece ranks in 11th position 11th in terms of the net EU contribution under the health thematic priority, it

[74] See: https://www.scimagojr.com/countryrank.php
[75] See: https://elevategreece.gov.gr/ (data as of 22 May 2022)
[76] Source: Horizon Europe dashboard, consulted 12 May 2022

only ranks 18th when SME participation is considered. Of the total funding received under this thematic priority, just six organisations accounted for half of the net EU contribution, while an additional two organisations bring that to 60% of the total.

The S3 2021-2027 programme retains health and pharmaceuticals as a priority for Greece, with emphasis on: “Biomaterials, tissue engineering, functional foods and nutraceuticals, diagnostic techniques, drug-delivery mechanisms, customised medication, biosensors, bioinformatics and nanomedical applications, telemedicine.” Not all these S3 priorities are directly reflected in the NRIs.

2.4.1. Strategic focus of the Greek NRIs in the biomedical field

The eight NRIs that come under this thematic field cover a broad range of analytical capacities relating to a wide spectrum of actions relevant to biomedical research. The bioinformatics initiative (ELIXIR-GR) has the broadest scope covering research activities from fundamental biological sciences all the way to clinical applications. Biological imaging support (BIOIMAGING-GR) mostly focuses on basic science, supporting mainly the research field of cell biology, which generates the highest impact compared to other research disciplines in the biomedical basic research sector2. Moving towards translational research, the availability of mouse models for understanding the link between molecular pathways and disease (INFRAFRONTIER-GR/PHENOTYPOS) and access to ‘omics’ technologies (pMedGR), are well-placed for enabling medical applications. Services directly related to the drug development pipeline are offered in the process of screening for bioactive compounds (OPENSCREEN-GR) and in methods for structure-based ‘hit to lead’ development (INSPIRED). Infrastructure for the support of pre-clinical applications in translational research is also available (EATRIS-GR), while coordinating Greek biobanking initiatives (BBMRI-GR) is also relevant to the support of pre-clinical and clinical transitions for biomedical research.

These NRIs have mobilised a large variety of universities and research institutes (17 distinct organisations), and they have received about 25 million in approved funding. All these infrastructures are distributed, though the number of and sharing between partners varies quite widely. The strategic choice to distribute service centres for these infrastructures is understandable to achieve political goals. It is also a scientifically sound decision. However, some degree of consolidation of resources could be desirable as the infrastructures programme matures. As the Greek biomedical sector develops, it would be appropriate to distinguish between equipment that should have a purely institutional scope (e.g. a ‘plate-reader’ or a ‘bench-top ultracentrifuge’), services that have a national scope and are best served in a single or just a few sites (e.g. compound libraries and robotics for drug screening or a mouse model archive), and those services that by their nature have a distributed scope for regional or national access (e.g. access to confocal microscopes or biobanks).

National Research Infrastructure	NRI Full Title	No. of partners	Approved budget (€)	Actual expenditure (€)	Budget execution
BBMRI-GR	Strategic expansion of the Greek Biobanking Infrastructure	9	497,210	492,210	99%

National Research Infrastructure	NRI Full Title	No. of partners	Approved budget (€)	Actual expenditure (€)	Budget execution
BIOIMAGING-GR	A Greek Research Infrastructure for Visualizing and Monitoring Fundamental Biological Processes	11	4,000,000	3,997,482	99.9%
EATRIS-GR	Infrastructure for preclinical and early-phase clinical development of drugs, therapeutics and biomedical devices	7	499,897	499,897	100%
ELIXIR-GR	Managing and Analysing Biological Data	17	3,991,100	3,983,335	99.8%
INFRAFRONTIER-GR	The Greek Research Infrastructure for Molecular and Behavioural Phenotyping of biological model organisms for chronic degenerative diseases	3	4,000,000	3,738,666	93.5%
INSPIRED	The National Research Infrastructures on Integrated Structural Biology, Drug Screening Efforts and Drug target functional characterisation	14	3,818,820	3,513,862	92%
OPENSCREEN-GR	An Open-Access Research Infrastructure of Chemical Biology and Target-Based Screening	7	3,025,090	3,025,090	100%

National Research Infrastructure	NRI Full Title	No. of partners	Approved budget (€)	Actual expenditure (€)	Budget execution
	Technologies for Human and Animal Health, Agriculture and the Environment				
PMedGR	The Greek Research Infrastructure for Personalised Medicine	3	4,000,000	3,432,234	85.8%
Total		71	23,832,117	22,682,776	96%*

Figure 33. NRIs in the health and pharmaceuticals field – key figures (Source: GSRI, calculations authors, *average budget execution)

The stated missions of the eight NRIs are summarised below:

- **ELIXIR-GR** is the Greek node of ELIXIR, a distributed e-Infrastructure aiming at the construction of a sustainable European infrastructure for biological information. ELIXIR-GR supports life-science research and its translation to medicine, biological sciences and society. It offers a catalogue of tools, services and benchmarks, ensuring best practices as well as sustainability and interoperability with other biological and medical science infrastructures.

- **BIOIMAGING-GR** is a distributed research infrastructure for visualising and monitoring fundamental processes of life. It aspires to facilitate open-access, high-end biological imaging in a range of methods to scientists in Greece and neighbouring countries. It offers services in basic methods, but also to develop new services and provide a networking and training platform.

- **INFRAFRONTIER-GR (PHENOTYPOS**) focuses on providing services relevant to the generation and characterisation of mice with modified genetic material resulting in enhancement or suppression of the expression of genes of interest. The NRI seeks to host projects aiming at understanding basic biological principles, as well as any revealing mechanisms of disease.

- **pMedGR** aims at supporting research and innovation towards next-generation healthcare applications, providing the infrastructure for obtaining molecular profiles through high-throughput 'omics' technologies. These can help in re-designing ongoing and prospective clinical trials, linking more efficient and cost-effective health and disease future practices.

- **OPENSCREEN-GR** integrates high-capacity screening platforms for screening a collection of 60,000 commercial and proprietary compounds collected from Greek chemists and brings together the chemical biology community to collaboratively develop novel molecular tool compounds with external users from various disciplines of the life sciences.

- **INSPIRED** is a distributed infrastructure focusing on structural biology, combining studies on bioactive (macro)molecule interactions and biomarker identification, and offering access to biophysical methods (including X-rays, NMR and other) to researchers in the field of biology, diagnostics and pharmacology.

- **EATRIS-GR** aims to provide services to support pre-clinical translational research for developing early-phase clinical drugs, therapeutics and biomedical devices, and focusing on small molecules but aspiring to expand its portfolio towards advanced therapy medical products (ATMPs) and vaccines.

- **BBMRI-GR** aspires to become an integrated infrastructure for Greek human biobanks and collections, currently integrating seven major biobanks all over Greece, covering haematological and neurodegenerative diseases, cancer, lung disorders, and rare diseases.

The mission statements and aims and objectives described on the NRI websites and in responses to the PSF questionnaire provide more insight into the expected outcomes (results during the project lifetime and longer-term impacts). The figure below summarises the expected outcomes applying the three broad RI-PATHs impact pathways.

NRI	Enabling science	Problem-solving	Science and society
ELIXIR-GR	Contribute to helping the life-science research community across Europe share and store their research data in an organised network. Offers a collection of unique tools and databases that focuses on biomedical research and marine biology.	Bring together Europe's laboratories and data centres to help coordinate the collection, quality control and storage of large amounts of biological data produced by life-science experiments.	Support life-science research and its translation to medicine, biological sciences and society. Training is offered to all stakeholders in the form of hands-on workshops and online training courses.
BIOIMAGING-GR	Enhance the research potential of the biomedical research community, by cutting-edge imaging (next-generation fluorescence microscopy, electron microscopy, PET, micro-CT, fMRI, intravital imaging, microfluidics, ratiometric imaging, super-resolution microscopy)	Expand existing and establish new bioimaging facilities on cutting-edge imaging technologies. Networking and coordinating existing facilities towards maximum complementarity and minimum redundancy.	Enhance the innovation potential of Greece by enabling access to cutting-edge equipment and expertise, and by providing training and imaging services to the research community and industrial users.
INFRAFRONTIER-GR	Transgenic mouse models – i.e. mice with modified genetic material resulting in enhancement or suppression of the	Provide access to mouse models, data, and scientific platforms and services; archives and distributes	The mouse models of human disease offer the opportunity to develop a better understanding of molecular disease

NRI	Enabling science	Problem-solving	Science and society
	expression of genes of interest – are key for understanding basic biological principles, as well as for revealing mechanisms of disease.	scientifically valuable mouse strains, whole-organisms; systemic analysis of genotype-phenotype interactions; and bottom-up access and top-down capacities for large-scale international initiatives.	mechanisms and may provide the foundation for the development of diagnostic, prognostic and therapeutic strategies.
pMedGR	Enable the re-design of ongoing and prospective clinical trials, linking them with molecular profiles obtained through high throughput 'omics' technologies towards more efficient and cost-effective health and disease management for European citizens.	Enable precision prognosis, diagnosis and therapy, resulting in more accurate and cost-effective national health management, and catalysing synergies between national and EU funding schemes to leverage research efforts.	Better healthcare management can lead to economic viability with high socio-economic returns. Aims to bring together the industrial sector, clinicians, medical researchers, biomedical scientists and technology experts to initiate and develop innovation.
OPENSCREEN-GR	Open access to a range of technologies and tools for the systematic screening of chemical substances, 60,000 commercial and proprietary compounds collected from chemists; testing their biological effects to collaboratively develop novel molecular tools.	Provides a unique and jointly used Greek compound library, helps to develop HTS-ready assays, access to screening centres, chemical facilities, an open-access database with data and protocols, and bio-profiling.	-Bringing high-quality Europe-wide standards, an open collaborative environment, and a harmonised legal framework. -Professional training and educative programmes.
INSPIRED	Access to infrastructures for structural biology, combining studies on bioactive (macro)molecule interactions and biomarker identification, to boost biology, diagnostics and pharmacology.	Provides an access point to a distributed infrastructure that can allow specific applications and the creation of reagents that link structural biology research also to other infrastructures and an extended user community.	Services to the health sector and impact on agri-food, concerns many organisations and fosters basic research with the industry, supporting innovative actions and economic impact.
EATRIS-GR	Aims to provide access to high-quality services to support translational research nationwide, focusing on the 'small	Integrating the operational capabilities of existing cutting-edge infrastructures, providing access and high-end	Supporting academic and industrial users in Phase-I trials, bioequivalence studies of generics, clinical and

NRI	Enabling science	Problem-solving	Science and society
	molecules' platform for the preclinical and early-phase clinical development of drugs, therapeutics and biomedical devices, and aspiring to expand to ATMPs and vaccines.	services to translational research efforts at the national level, while evaluating and adopting optimised management and governance, and integrating these efforts into the EATRIS-EU network.	preclinical evaluation of new formulations, and preclinical evaluation of drugs and therapeutics are areas with high socio-economic importance.
BBMRI-GR	Collection, storage, and processing of human biological samples and related information management is essential for developing new therapeutic and diagnostic procedures.	Aggregate information on existing activities for collecting biomedical samples, promoting standards in existing biobanks, organising bioinformatics support, informing the legal access framework, and for providing training and information.	Biobank infrastructures are key for public health and better care; thus it is key to analyse the economic consequences of such an infrastructure and explain the benefits to the Greek public.

Figure 34. Biomedical NRIs – declared aims by type of impact pathway (Source: authors based on NRI documentation)

A common strategy of all these NRIs is the strong alignment with pan-European initiatives in the ESFRI roadmap, a choice that is very clearly reflected in the chosen names for these NRIs. As one might expect, the two NRIs not making the European connection show the most notable divergence from EU initiatives. pMedGR has no clear European counterpart; while INSPIRED has a strong connection to Instruct-ERIC (with Greece being an observer for several years) it has rather different missions, as it focuses on 'bioactive (macro)molecules interactions and biomarkers identification and Instruct-ERIC focuses on interpreting molecular and cellular functions and linking 'detailed atomic structure with the cellular context'. EATRIS-GR shares the name with its European counterpart, but has a notably different approach, albeit similar aspirations. The Greek node focuses on providing actual facilities for preclinical research focusing on small molecules, in that way complementing and extending both INSPIRED and OPENSCREEN-GR, while EATRIS focuses on supporting the regulatory framework, technology assessments, enabling collaboration with industry, and funding support and training. OPENSCREEN-GR aligns well in its approach with OPENSCREEN-EU but has some different policies in the IPR framework on many technicalities and IP issues pertaining to the philosophy of the compound collection and its use. BIOIMAGING-GR is well aligned in philosophy and objectives with EUROBIOIMAGING, which should allow several of its sites to develop into EUROBIOIMAGING nodes, should Greece become a member of this initiative.

ELIXIR-GR and INFRAFRONTIER-GR bring Greece as full members of their European counterparts, both through specific actions of the Biomedical Sciences Research Centre 'Alexander Fleming', albeit with different mechanisms that reflect the status of the European organisations (ERIC and GmbH legal structure, respectively), and BBMRI-GR participates in BBMRI-ERIC as a member and through the Biomedical Research Foundation of the Academy of Athens.

All facilities address local and regional needs. Many nodes of NRIs, or entire facilities, are also of national interest, although there are specific instruments in some nodes that clearly do not have a national or regional audience (in some cases). The ability of these facilities to attract international clients is rather limited, with the sole exception of INFRAFRONTIER-GR whose partners are offering significant trans-national access to international clients.

2.4.2. Governance and operational management

All eight NRIs operate based on a distributed model, with a coordination function and a number of hubs or nodes. In the absence of a single legal entity framework, the current operational model of the NRIs is rather diverse. Some of this is reflected in differing levels of maturity and implementation, but also the number of partners in the NRI, which varies from three to as many as 17. All facilities have a coordinator and a council that includes all participating institutes. The divergence is also reflected in how the council members are chosen (per partner, per facility, or both), the maturity of the functioning of an international advisory board that meets regularly, in the existence of a manager or a dedicated central administration team, in assigning specific roles to partner or facility representatives, and in the maturity and scope of agreements.

A significant issue for sustainable operations is to put in place official communications channels (to request access, for example) that are transparent, auditable and do not depend upon personal contacts. Using the personal email address of the scientific lead (or another named person) for requesting services should be avoided; this does not reflect proper operational management.

NRI	Lead partner	Governance framework
ELIXIR-GR	Fleming	Head of node, technical coordinator, training coordinator (and deputies). ELIXIR Consortium Agreement, ELIXIR Collaboration Agreement, Node Consortium Agreement are signed and available
BIOIMAGING-GR	IMBB-FORTH	Coordinator, scientific committee, node leaders, external advisory board all supported by management office
INFRAFRONTIER-GR	Fleming	Lead partner, centrally managed with two so-called ‘outposts’
pMedGR	University of Athens	Three partners with a board and consortium agreement and a central access mechanism
OPENSCREEN-GR	Demokritos	Steering committee with seven members; inter-institutional agreement ready but not signed; coordinator and manager have unclear roles; Demokritos plans to hire a permanent administrator
INSPIRED	NHRF	Coordinator supported by a steering committee and an executive committee (the exact role is not clear, especially as the scheme is described differently in different documents), overseen by an international scientific committee; inter-institutional agreement following OPENSCREEN-GR

NRI	Lead partner	Governance framework
		developments
EATRIS-GR	BRFAA	Four institutes with a consortium agreement, however, no common access mechanism
BBMRI-GR	BRFAA	Coordinator, management committee

Figure 35. Biomedical NRIs – governance frameworks and distributed character (Source: authors based on NRI documentation and questionnaire responses)

2.4.3. NRI funding, staffing and operations

The spread of funding is diverse (see Figure 61). INSPIRED has the peculiarity that the coordinating institute has only 14% of the budget, while another partner institute has 41%; from the 12 additional partners, none has more than 5% of the budget. While there may be reasons for such a distribution, it is not obvious how effective it is in delivering the scientific outputs of the NRI. Most of the biomedical NRIs (6 out of 7) have a budget of close to 4,000,000. The exception is BMMRI-GR that was funded in a later round. The six higher budget NRIs all adhered to the 60-40 ratio between personnel and equipment, that was recommended by the GSRI.

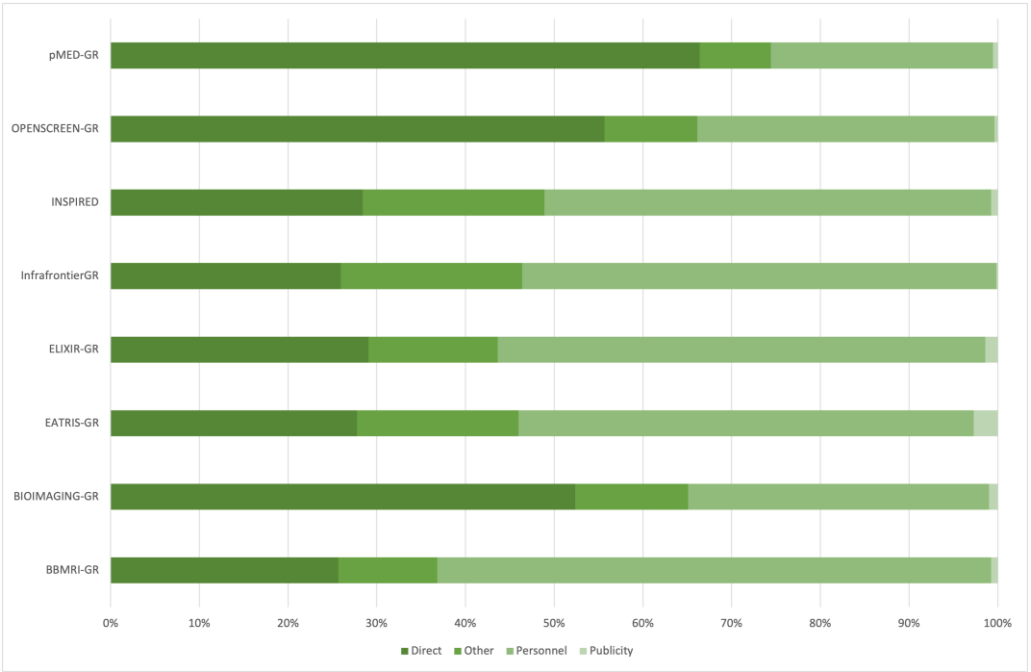

Figure 36. Distribution of budget – health and pharmaceutical NRIs (Source GSRI, calculations authors)

Some RIs have hired a significant number of new staff, with the risk of fragmenting (spreading thinly) the available funds to cover existing needs. This kind of fragmentation is not always a wise choice, as it introduces an additional challenge for the retention of expertise to support the infrastructure over the long term. Partially funding many people over a given number of years can create operational dependencies.

National RI	a) Number of researchers working in improved research centre facilities (FTE)	b) Number of young researchers (FTE)	Difference (a-b) (FTE)	Direct personnel expenses	Per researcher
BBMRI-GR	17.75	16.25	1.5	€278,126	€15,669
BIOIMAGING-GR	74.32	64.66	9.66	€1,317,106	€17,722
EATRIS-GR	11.2	10.43	0.77	€231,578	€20,677
ELIXIR-GR	85.96	82.19	3.77	€2,137,005	€24,860
INFRAFRONTIER-GR	84.43	73.58	10.85	€1,987,116	€23,536
INSPIRED	98.02	77.2	20.82	€1,625,557	€16,584
OPENSCREEN-GR	56.66	40.18	16.48	€ 1,001,166	€ 17,670
pMEDGR	38.79	32.42	6.37	€ 850,558	€ 21,927

Figure 37. Human resource indicators – health and pharmaceutical NRIs (Source: EPANEK-GSRI, calculations authors)

2.4.4. Service provision and user access policies

All eight NRIs provide centralised and functional access mechanisms through the web, except for BBMRI-GR which does not currently provide an access portal. BIOIMAGING-GR, INFRAFRONTIER-GR, pMedGR, INSPIRED, and ELIXIR-GR have a centralised system for service provision, which is generally accessible to users who already have a clear idea of the exact instrument or application they wish to use. Extensive catalogues of services are implemented through various ways and are available to expert users, but the typical target audience is experts who lack access to specific instruments. OPENSCREEN-GR offers a web-based email form that is forwarded to a personal e-mail address, which is sub-optimal. In general, it would be appropriate to develop more sophisticated and uniform procedures that require pre-registration (as often the personal data are transmitted together with the application, which can create complications with GDPR rules and regulations) while avoiding administrative burden. A common log-in system should also be implemented, as such initiatives are already present in the Greek academic sector. The practice where access is requested by email, should not be used. Some lack of transparency is also notable in the procedures for gaining access. INFRAFRONTIER-GR has a single point of entry nationally, with internal review procedures, while international access is organised by dedicated portals offer by European projects, and access is from external panels, according to each project specification. pMedGR, BIOIMAGING-GR, EATRIS-GR and INSPIRED have rather clear procedures that include some form of peer review (which in most cases is internal, not external). OPENSCREEN-GR operates with email forms and does not provide details of a review procedure. BBMRI-GR is a feasibility study and therefore has no obvious access routes on their website. ELIXIR-GR provides computational services that are extensively categorised and documented on their website.

NRI	Access from website	Catalogue of access	Access forms	Peer review	International access	External use[77]
ELIXIR-GR	Yes	Per service	N/A	N/A	Inherent	100,000[78]
BIOIMAGING-GR	Yes	Per site	Unified	Yes	No	156
INFRAFRONTIER-GR	Yes	Per service	Per service	Yes	Yes	?
pMedGR	Yes	Per service	Unified	Yes	No	11/53[79]
INSPIRED	Yes	Per method	Unified	Yes	No	?
OPENSCREEN-GR	Yes	Per service	No, email	No	No	?
EATRIS-GR	Yes	Per service	Unified	Yes, per node	No	8/257
BBMRI-GR	No	No	No	N/A	No	-

Figure 38. Biomedical NRIs access procedures (Source: NRI data compiled by authors from questionnaires and presentations.)

2.4.5. Results, impact and sustainability

ELIXIR-GR services have just above 100,000 access requests per year, 50% of which are outside Greece. It needs to be noted that when considering computational services and tools, this number is not as impressive as it may seem – for example the Protein Data Bank receives this number of access requests in less than a day. The compute cloud HYPATIA, which has been operational since May 2021, has more than 160 registered users. Importantly, ELIXIR has put a focus on training activities and is delivering well to an enthusiastic community.

BIOIMAGING-GR is an important infrastructure for many research disciplines in Greece. To date, 90-95% of the NRI use has been for internal users. There are 156 registered users from other nodes within the consortium accessing the facilities (albeit not external to BIOIMAGING-GR). There is a large variation in usage time depending on the type of the instrument, e.g. confocal microscopes that are used 18 hrs a day and seven days a week, while a more specialised instrument, such as a two-photon microscope, might be used less. There is an institutional but not centralised industrial access policy, though there has not been any real interest by industry so far. It is apparent that instruments in all nodes are being used, even if that is by internal users. The most important contribution is likely the networking aspect and training, which increase the level of expertise and boost operational

[77] External to the facility, but not to other participating facilities.
[78] This number refers to web hits per year as this is computation infrastructure
[79] Performed/requested

practices for distributed instruments. At the same time, the NRI has delivered access to unique instruments that are not present locally or regionally, which brings added value.

INFRAFRONTIER-GR perhaps has the best-developed access programme, incorporating various Horizon 2020 actions. The transgenic mouse facility is used at more than 60% of its capacity by external users, other facilities are used at about 20-40%. The demand is such that it is not felt necessary to carry out any promotional activities as the clients are already there. Issues that need to be resolved include the need for a scheme allowing the infrastructure to directly charge for offered services, a legal framework that would allow this especially in relation to industry, and the need to retain skilled staff.

pMedGR offers services to 'omics' technologies (next-generation sequencing, proteomics) which are relevant for personalised medicine. These are complemented by access to a fluorescence-activated cell sorting (FACS) machine, which is typically used in a departmental and rarely even at an institutional level, and a positron emission tomography (PET) scanner – for which there is a very loose connection to the stated mission and no service offer mentioned on the website. Notably, most equipment was bought under the framework of this programme. The main services have been requested 53 times since March 2020, which shows active interest, and 11 of these requests have been performed for free, in the framework of the access programme.

INSPIRED offers access to a variety of services in five different categories listing 45 individual services. Many of these services are provided at multiple sites, and many refer to isolated procedures on trivial instruments (e.g. disrupting cells by sonication, a procedure typically available at the departmental level). About 50 of the recorded uses of instruments are external to the facility, but from consortium members. About 15% of the activity is from genuine external users, but this varies for each instrument – e.g. more for the nuclear magnetic resonance (NMR) instrument. The central allocation mechanism for access is well developed (one could argue over-developed and bureaucratic, especially for trivial requests that are in the catalogue and could just be granted) with internal and external reviewers and a moderator to guide the process, and there is a plan for feedback based on a questionnaire. Collaborations with companies (e.g. food industry and the blue growth cluster) have been reported.

OPENSCREEN-GR did not implement a centralised access programme during this operation period, albeit individual facilities were operational. Specific equipment has not been in place until recently (a 30-month procurement time for mass spectrometry equipment was mentioned). However, now that this has largely been achieved, there will be an effort to implement the use of equipment and streamline it, with the goal of increasing usage. A central point of access has not been available via the webpages, other than an email form to one of the scientific leaders. Current access is based on collaboration and is not yet based on reviewed proposals. An internal evaluation panel is foreseen to be in operation during the next phase. There are now many industrial clients for individual nodes. The price lists are defined by each institute, and the income stays with that institute. There can be up to 50% external usage of instruments according to the agreement that has been prepared.

EATRIS-GR has received limited funding in the second round of applications. Besides that, it has introduced an operational website for access, and has issued an open call for pilot applications, which resulted in 25 proposals, eight of which have started. The integration between sites is rudimentary, as there are currently different review panels for each site, but this remains understandable at this stage.

BBMRI-GR started its preparations later than the others and with a limited budget but has made notable progress on many strategic fronts; however, a transparently open access programme needs to be implemented.

A number of common challenges for sustainability emerged from discussions with the NRI coordinators. The need to retain the relatively young and technically skilled staff who have been put in place over the past few years was a common theme, as was the desire for a legal framework that could streamline such challenges as procurement and a fee-charging mechanism for industrial customers to use. Operational funding for consumables was felt to be important, together with a way of supporting international subscription costs for Greek membership of European ERIC organisations. There was also broad support for best practices in governance and access, and when the NRI had not been able to implement these during the funding period, it was not because of any disagreement or lack of desire.

Further observations based on the strategic priorities for innovation potential are provided below. These are observations based on a limited interaction with the NRIs and should not be taken as an in-depth scientific review, but they do offer some insight into the strength of the different research themes supported by the infrastructures.

ELIXIR-GR is fully and explicitly aligned with the S3 priority in 'bioinformatics'. ELIXIR-GR appears to be a well-functioning programme and should be part of the national portfolio, subject of course to a scientific review of a future proposal. As Greece also has a very strong background in informatics and computer science and given the growing visibility of artificial intelligence (and the importance this has in the Greek strategic planning), and how well AI can blend with bioinformatics applications, this sector has many characteristics that suggest **it as a priority** for future infrastructure support.

Both **INFRAFRONTIER-GR** and **BIOIMAGING-GR** support two very high impact areas of research which have brought to Greece some of the highly competitive and prestigious ERC grants (e.g. Kollias, Tavernarakis, Lygerou, Pefani) or prestigious EMBO memberships (e.g. Kollias, Tavernarakis, Lygerou, Garinis, Georgatos, Gorgoulis, Talianidis). As these scientists lead (nationally or locally) and/or depend on these infrastructures, it is evident that these projects support – at least in part, but most likely in general – very high-impact science. It is also notable that both align well with their European counterparts, despite the appearance otherwise. Although it might appear that these two projects do not directly line up with the explicitly stated RIS3 goals, they do provide the basic infrastructure that is essential for the research to achieve most of the direct RIS3 goals in the health sector. Given the strategic position of these two projects, the coherent and good organisation, the well-established access procedures, the good access performance, the strong and even excellent international standing, and that some of the most successful Greek scientists are directly affiliated with them, both could be seen as a national priority – again subject of course to a positive review of a future proposal.

The **pMedGR** and the **BBMRI-GR** initiatives are new projects which are both addressing well (even if indirectly) the S3 goals 'diagnostic techniques' and 'customised medication'. The 'omics' technologies and the biobanking they offer could find a common roof and develop a very strong initiative with considerable potential for innovation and fundamental research in the general area of personalised medicine and diagnostics.

OPENSCREEN-GR, INSPIRED, and **EATRIS-GR** all address the goal of developing 'drug-delivery mechanisms, customised medication' covering needs in the 'early drug discovery' and 'preclinical' phases. There are some concerns that the volume of compound collections for high-throughput screening, the lack of high-content screening approaches, and the

limited track record on hit-to-lead optimisation campaigns are not developed enough to ensure the efficient utilisation of preclinical infrastructures. At the same time, a focus on collections of natural compounds from Greek flora does perhaps offer some strategic advantages. The expert PSF panel therefore suggests that a combined scientific review of these projects could be used to provide more focused advice for their future development, considering the scope of additional ongoing investment and the comparative strength of the Greek pharmaceutical industry in terms of manufacturing generics and utilising natural products. There is a possibility to combine services from these projects to create a focused infrastructure aimed at supporting lead discovery from natural products, and to examine drug repurposing, or support the discovery of new formulations that could be particularly relevant for the Greek generics industry.

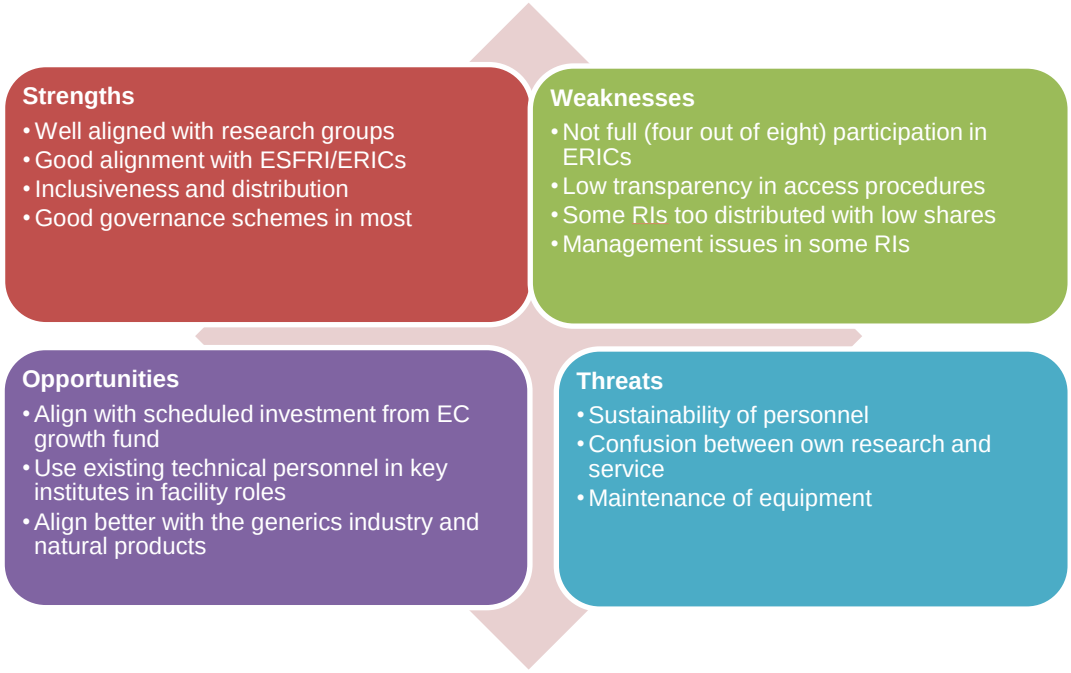

Figure 39. SWOT analysis of the health and pharmaceutical NRIs

2.5. Physical sciences and materials NRIs

The Greek RIS3 2014-2021 included a priority area for materials and in specific key enabling technologies (KETs) such as nanotechnology, photonics and micro- and nano-electronics. Some of these KETs, which originate from the physical sciences field, have an interdisciplinary character and support, in addition to the field of materials, other priority areas such as life sciences, energy, environment and culture.

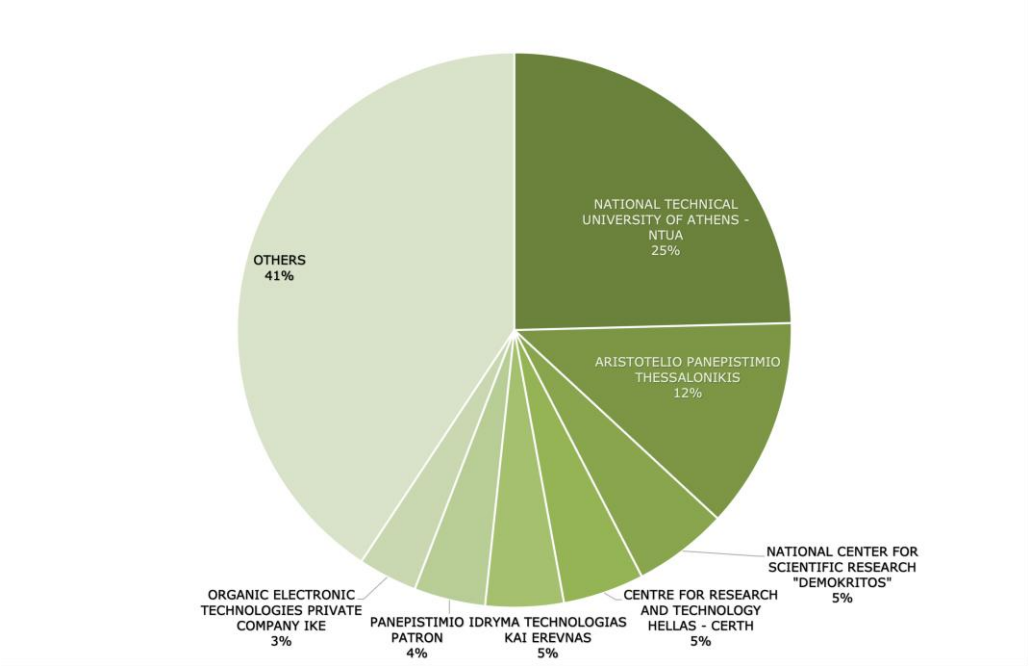

Figure 40. Greek beneficiaries of advanced materials and nanotechnologies calls of Horizon 2020 (net contributions) (Source: Horizon 2020 dashboard, data extracted 17 May 2022)

During the period 2014-2020, Greek participation in Horizon 2020 under the thematic priorities 'advanced materials' and 'nanotechnologies, advanced materials and production' accounted for 153 grants (5.3% of total Greek grants) and close to EUR 60 million in funding, with engineering and technology the most prominent fields of science[80]. Of the total funding received under these thematic priorities, 7 organisations accounted for over half of the net EU contribution including the NTUA (25%), the AUTH (12%), Demokritos (5%) and the CERTH (5%).

The S3 2021-2027 keeps advanced materials a priority, noting the continued strong performance in indicators related to investment, innovation and research and development. The sector is characterised by the existence of both start-ups and large companies.

[80] Source: Horizon Europe Dashboard, consulted 17 May 2022

2.5.1. Strategic focus of the Greek NRIs in the advanced materials field

The four NRI included in this thematic field cover a wide range of applications – microelectronics, nanotechnology, cultural heritage, environmental science, high energy physics, etc. – available facilities for preparation, modification and characterisation, device development, etc., and technologies including applied nuclear physics or photonics. The NRIs are not only offering this technology to their users, but also designing, developing and testing novel instrumentation.

National Research Infrastructure	NRI full title	No. of partners	Approved budget (€)	Actual expenditure (€)	Budget execution
INNOVATION.EL	National Infrastructure in Nanotechnology, Advanced Materials and Micro/ Nanoelectronics	7	€4,000,000	€3,956,339	98.9%
DeTANeT	Detector Development and Technologies for High Energy Physics	3	€500,000	€500,000	100.0%
CALIBRA	Cluster of Accelerator Laboratories for Ion Beam Research	1	€3,422,200	€3,301,990	96.5%
HELLAS-CH	The HiPER, ELI and LASERLAB Europe Synergy and IPERION-CH	12	€3,997,016	€3,997,016	100.0%
Total		23	€11,919,216	€11,755,345	98.6%*

Figure 41. NRIs in the physical sciences and materials field – key figures (Source: GSRI, calculations authors, *average budget execution)

The four NRIs have 25 partners from 15 different institutions; four of whom are among the top five Greek performers in advanced materials and nanotechnology, based on Horizon 2020 net contributions. Approved funding for the four NRIs is almost EUR 12 million, with actual expenditure close to 100%.

The stated missions of the four NRIs can be summarised as follows:

- **INNOVATION.EL**: promote scientific excellence and the development of knowledge-intensive products providing open access to top-notch research facilities to academic and industrial users. The goal is to become a unique regional habitat for RDI activities throughout south-eastern Europe and the Mediterranean.

- **DeTANet:** upgrade and centralise the infrastructure of modern electronics and detector development to support R&D activities in previous organisations for the benefit of research teams working with high-energy physics (HEP) and for the benefit of the Greek electronics industry.

- **CALIBRA**: establish and operate an accelerator-based research infrastructure open to the national and the European scientific community wishing to conduct excellent research, develop innovative applications of increased socio-economic impact, and provide highly specialised services to the public and private sectors.

- **HELLAS-CH**: provide access to advanced experimental facilities for state-of-the-art research on laser science, technology and applications, as well as versatile integrated tools and technologies addressing demanding research challenges in the field of heritage science (HS).

The four NRIs highlighted the importance of creating a nationally (and internationally) recognised 'infrastructure of excellence' in their specific field of operation. The mission statements (see the annex to the Background Report) provide more insight into the expected outcomes (project results and longer-term impacts). The expected outcomes are summarised applying the three broad RI-PATHS impact pathways below.

NRI	Enabling science	Problem-solving	Science and society
INNOVATION.EL	Development of advanced services and state-of-the-art facilities accessible to users. Organising thematic research training courses and hands-on workshops in the fields of expertise of consortium partners.	-Offering a broad spectrum of top-notch tools and expertise to serve academic and industrial RDI in nanotechnology and advanced materials. -Outsourcing of R&D.	Organising thematic research training courses and helpful workshops in relevant fields.
DeTANeT	Strengthening of all research activities of the Greek HEP teams related to the organisation of detection systems.	The transfer of innovative technologies that have been and are being developed in HEP to Greek industries.	The participation of Greek companies in CERN research and construction projects, which are assigned to Member States such as Greece.
CALIBRA	-Development of advanced services and cutting-edge facilities accessible to users. -Joint research activities and networking activities to enhance synergies among Greek scientists and their colleagues abroad.	Networking activities to promote interaction between the scientific community and the private sector.	

NRI	Enabling science	Problem-solving	Science and society
HELLAS-CH	Capitalise on major scientific achievements in the country, making essential experimental resources available to prominent researchers in Greece.	Serving the international, national and regional science and technology community as well as the private sector in their expertise fields.	Shed light on yet unrevealed aspects of the universal cultural heritage through new findings and tools, opening novel channels towards knowledge/ understanding of Greece's past.

Figure 42. Physics and advanced materials NRIs – declared aims by type of impact pathway (Source: authors based on NRI documentation)

Under 'enabling science', it is a clear objective of the NRIs to offer researchers access to their current or new facilities. CALIBRA and INNOVATION-EL also stated the importance of enlarging their user community by organising courses, joint research activities, and through networking. The four NRIs consider support to industry as one of their main objectives. DeTANet goes one step further; one of its main objectives is to help make Greek industry competitive at European level, and to obtain contracts from international research facilities such as CERN. This objective can also be included within the third impact pathway. Other NRIs, such as INNOVATION-EL, seek impact on society through the organisation of thematic training courses adapted at different levels. HELLAS-CH, as an infrastructure that seeks to contribute to the discovery and understanding of new aspects related to historical heritage in a country with such a rich cultural heritage as Greece, contributes effectively to bringing science closer to society.

From an external and strategic perspective, the four NRIs are involved in a number of the relevant EU- and international-level partnerships. For example, DeTANet is heavily involved with CERN in the development of instrumentation. CALIBRA represents Greece in the Nuclear Physics European Collaboration Committee of the European Science Foundation and collaborates with some peer European institutions such as GANIL/SPIRAL2 and INFN. Several of the HELLAS-CH laboratories are members of European facilities (LaserLab Europe, NFFA, E-RIS, ACTFAST) and one of its labs is collaborating with the ESFRI RI ELI, developing an attosecond beamline and other instrumentation as well as providing scientific and technological consultancy. There are also connections and collaboration schemes between the four NRI themselves; for example, DeTANet and CALIBRA or INNOVATION-EL and HELLAS-CH.

As for NRIs in other thematic fields, direct participation in ESFRI/international RIs or consortiums is complicated by the lack of a single legal entity, meaning that either multiple Greek partners are involved or the NRI coordinator takes a leading role.

2.5.2. Governance and operational management

Three of the NRIs operate based on a distributed RI model with a coordinator and several partners. Only CALIBRA is a single-sited RI. In the absence of a single legal entity framework, their current operational model is based on a project consortium set-up (MOUs, consortium agreements) under which specific governance structures have been developed.

These structures typically include a management committee or management board that coordinates the daily operation of the hubs. The three more user-oriented NRIs – CALIBRA, INNOVATION-EL and HELLAS-CH – have access committees for the evaluation of

proposals. CALIBRA and HELLAS-CH also have international advisory committees to guide the development of their strategic plans or roadmaps.

NRI	Lead partner	Governance framework
INNOVATION.EL	NCSRD	Managing committee, technical committee, access committee, outreach committee
DeTANeT	NKUA	Management board
CALIBRA	NCSRD	Management board, international scientific and technical advisory committee (ISTAC), general assembly
HELLAS-CH	FORTH	Steering committee, general coordinator, user office, proposal evaluation committee, coordinator of administrative services, international scientific advisory committee

Figure 43. Physics and advanced materials NRIs – governance frameworks (Source: authors based on NRI documentation and questionnaire responses)

The governance set-ups reflect a project consortium model with differing degrees of emphasis and effort given to steering the NRI as a single entity and the development of a common strategic agenda beyond the project lifetime. In all cases, there is an intention to extend cooperation between the partners beyond the current NRI project duration.

2.5.3. NRI funding, staffing and operations

Considering the funding distribution (see Figure 63) across the 15 organisations, the highest share across all cases goes to the NRI coordinator, varying from 100% for CALIBRA (only one participating institution) to 37% in the case of INNOVATION-EL, which is the NRI with the most evenly distributed funding pattern. DeTANet and HELLAS-CH are in between (57% and 58%, respectively). HELLAS-CH has, however, the most skewed funding distribution. Its funding pattern illustrates the internal configuration of the infrastructure, with just two institutions (FORTH and HMU) providing access to external users, and the rest of the partners participating only in joint research activities.

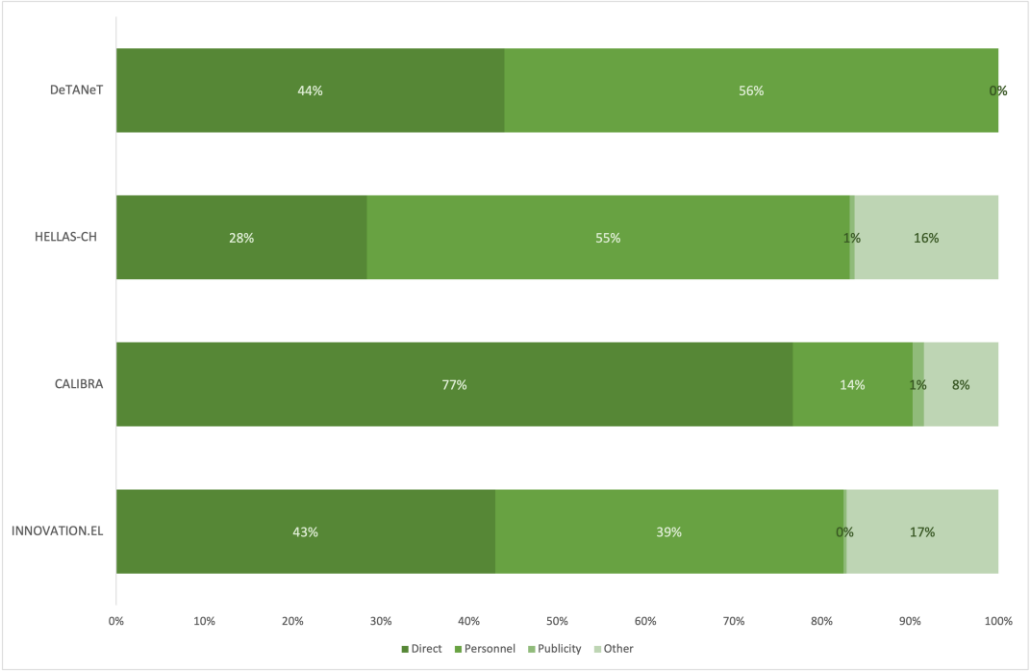

Figure 44. Distribution of budget by category of expenditure (Source: GSRI, calculations authors)

The budget distribution by category of expenditure for the four NRIs also highlights some notable differences, with CALIBRA allocating a much higher share of funding to direct costs (equipment and consumables) than the rest (77% compared to an average of 37% in the three other NRIs). This is because, even though the facility already had a considerable equipment, it needed a serious upgrade.

National RI	a) Number of researchers working in improved research centre facilities (FTE)	b) Number of young researchers (FTE)	Difference (a-b) (FTE)	Direct personnel expenses	Per researcher
CALIBRA	19.8	18.3	1.5	€ 409,535	€ 20,684
DeTANeT	45.55	39.61	5.94	€185,965	€ 4,082
HELLAS-CH	122.27	109.73	12.54	€ 2,090,533	€ 17,098
INNOVATION.EL	98.77	76.73	22.04	€ 1,502,875	€ 15,216

Figure 45. Human resource indicators – physical science and materials NRIs (Source: EPANEK-GSRI, calculations authors)

In the DeTANet case, the higher investment in personnel denotes its “absolute priority of hiring young researchers, due to the ageing staff working in the HEP community in Greece”. Overall, the four NRIs have recruited close to 41 FTE young researchers with the support of the project funding.

2.5.4. Service provision and user access policies

The way the RIs structure their service provision varies from one to another, as can be observed from their questionnaire replies and websites.

INNOVATION-EL has developed a catalogue of services (presented on their website) in three broad categories: use of facilities, R&D services, and research training. The available equipment and techniques in the facilities are organised to make their selection easier, and there are explanations and examples of each. At any of the browsing steps through the catalogue, it is possible to submit a query for the desired service. Outsourcing R&D-as-a-service is offered as a one-stop-shop solution for private companies, combining their expertise and capacities under a "strict Intellectual Property policy". Training and education services are being developed and deployed with courses and hands-on workshops around four main topics, making it possible to request special thematic sessions.

HELLAS-CH provides open access to FORTH and HMU facilities through a common proposal entry point. Selection is made after an evaluation of the proposals based on scientific and technological merit, determined by a committee of experts. Proprietary access is determined by agreement between the user and HELLAS-CH, and it is subject to an access fee to cover the operational costs. The access results may be confidential and lead to IP rights. The time available for this category is up to 30% of the total access time of external users. There is a third option – long-term access – which is intended for experiments with equipment and devices that require longer installation and assembly times. In such cases, the possibility is provided for the equipment to remain in the NRI for long periods. Apart from access to the facilities at the premises of the RI, there is the possibility to access mobile equipment, which is mainly addressed for in situ services related to the IPERION CH consortium.

CALIBRA operates as an open-access multi-user NRI for interdisciplinary research and applications, as well as education and training in the fields of materials analysis, human health, environmental monitoring and cultural heritage. User access is granted through the submission of research proposals to the ISTAC who meets twice a year to evaluate the proposals on their scientific merit. However, it was not possible to find any indication on how to submit proposals on their webpage.

DeTANet is focused on supporting HEP groups in Greece and bringing know-how from participating in CERN experimentation and instrument testing back to Greek companies. There is no standard procedure for this access which is based on the relationship established with the NRI members.

2.5.5. Results, impact and sustainability

Despite the relatively early development stage and, in some cases, because of their activity and capabilities before the NRI project, the NRIs reported quite significant results. This points towards the potential for a scaling of impacts over time if the various sustainability criteria are addressed. In general, the four NRIs have steered their investment towards equipment and staff giving them the potential to interact with Greek research institutions and the productive sector.

The NRI project has allowed **INNOVATION-EL** to upgrade its existing research infrastructures and purchase new equipment. It has been able to provide access to existing and new services offered by a network of research laboratories involved in the synthesis, characterisation and micro-nano fabrication of advanced nanomaterials and

devices/systems. The NRI has provided services to academic and industrial research communities, as well as innovation support to organisations and other relevant social actors. A noteworthy website and access platform (https://innovation-el.net/) has fielded many queries during the pilot period. Lastly, the NRI has carried out significant networking and dissemination activities to promote the NRI's research results.

CALIBRA has developed experimental set-ups at already existing facilities and installed two more scientific instruments: a cyclotron for PET radioisotope production; and an AMS accelerator for radiocarbon dating. The latter will be a unique facility in a country with a very rich cultural heritage as well as to support research projects focusing on environmental monitoring (air, soil, underwater). The NRI has established an open-access procedure to its instrumentation and has been able to create a critical mass of highly qualified scientists from different disciplines through the formation of a large user group around ion-beam based applications. It has led to the production of more than 60 high-quality papers using CALIBRA facilities, more than 20 Diploma, Master and PhD theses, and to strengthening the presence of the Greek researcher community in the European scientific landscape.

HELLAS-CH is an example of how the presence of a research infrastructure can contribute to the local economy, not only employing personnel from Crete or attracting users to the island, but also establishing new start-ups and SMEs (e.g. Biomimetic, https://www.biomimetic.gr). The NRI has also developed new methods in 'agrophotonics' (identification, origin, and quality control of agro-products) in collaboration with local companies that exploit them, biomedical methods and products (laser-based imaging techniques and devices, diagnostics, hadronic therapy) and methods and products for the cultural heritage and environment sectors.

A main objective of DeTANet is to support Greek companies when applying as suppliers to CERN contracts. One example is an aluminium company that has been producing precision pieces for one of the detectors at CERN and was assisted to do so by the NRI.

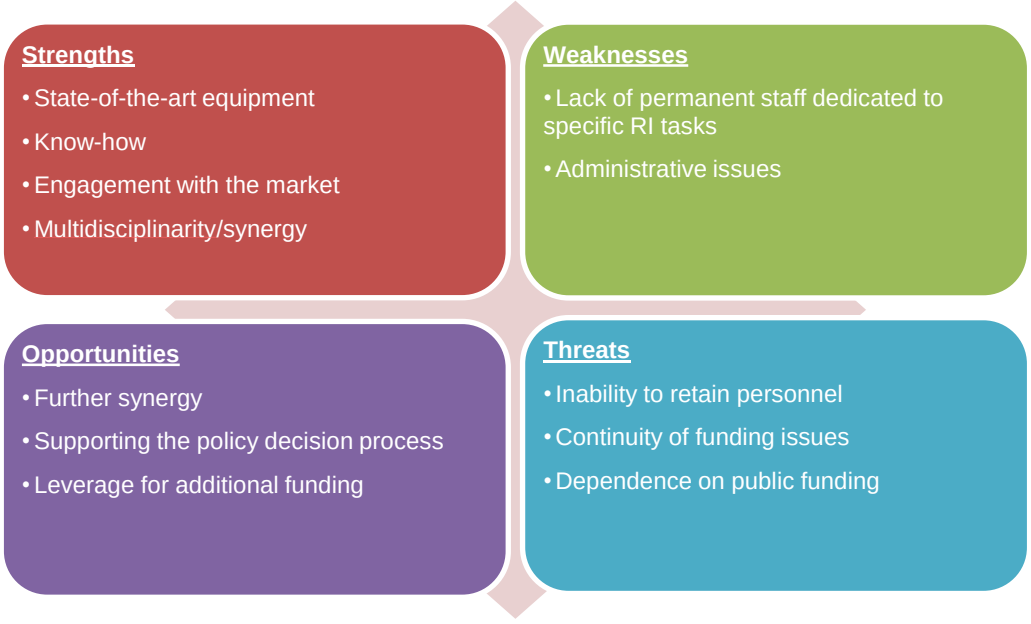

Figure 46. SWOT analysis of the physical sciences and materials NRIs

In terms of future sustainability, distributed NRIs underlined that – even though the governance model is considered to have been good enough to manage current operations – the absence of a single legal entity compromises the development of the NRI due to the difficulty to engage in contracting either in national or EU programmes or with the private sector. It also hinders the ability to manage the revenue generated through such activities sufficiently well enough to support the expansion of services and retain NRI staff. The issues related to the recruitment and retention of technical and management staff, viewed as a necessary condition for future development, are particularly challenging. The same applies to securing long-term funding to maintain infrastructure and upgrade existing equipment as and when needed.

2.6. Data and digital research infrastructures

The last group of NRIs covers a diverse set of priority areas (arts, humanities and language research, social sciences, transport and logistics) from a thematic perspective, but they have the common defining characteristic of being e-infrastructures that build on computing and cloud technologies as they provide digital services to researchers. Their activities foster open access to publications and enhance the application of 'FAIR'[81] data principles. The NRIs in this domain provide support to researchers, notably to social science and humanities (SSH), and build on the Greek RIS3 priorities on 'digital technologies' as well as 'tourism, culture and creative industries', and 'transport and supply chains'. Greek scientific specialisation in these fields is relatively strong with computer science, information systems, library and information systems, tourism studies, linguistics, and language and transportation fields all recording an h-index in 2018 above the Greek average[82].

The digital technologies sector in Greece has strengths including research excellence in software for health, energy, future networks and internet, etc. The sector attracts investment by multinational firms in 'centres of excellence' and a new generation of companies in microelectronics, the Internet of Things, cloud computing, robotics, big data etc. is emerging[83]. However, Greece's digital economy and society performance overall remains relatively poor, and it is close to the bottom of the DESI ranking[84]. In response, the 2020-2025 'Digital Transformation Bible', a new digital strategy led by the Greek Ministry of Digital Governance, identifies 455 specific projects (of which 145 are ongoing) for implementing the a 'Digital Greece' strategy. It includes the following strategic axes for the digital transformation of the Greek society and economy: (i) connectivity; (ii) digital skills; (iii) digital state; (iv) digital business; (v) digital innovation; and (vi) integration of digital technology in every sector of the economy[85]. A total of 40 start-ups out of 587 operate in the data analytics and big data sector in the Elevate Greece database[86].

Tourism is a key source of revenues for Greece. The direct contribution of tourism to the country's economic output is estimated at 7.7% of the total gross value added in 2019, which is the highest among EU Member States. Tourism accounts for 10.0% of total employment and travel/tourism accounted for 43.3% of total service exports in 2018. In this context, digitalisation and virtualisation of Greek cultural assets is viewed as a key means to increase the revenue generated through providing services such as 'virtual museums' and 3D site tours as well as upgrading the visitor experience to cultural and tourism sites.

[81] See: https://www.go-fair.org/fair-principles/
[82] Source: https://www.scimagojr.com/countryrank.php
[83] Source: RIS3 Strategy 2021-2027 Greece
[84] See: https://digital-strategy.ec.europa.eu/en/policies/desi
[85] See: https://digitalstrategy.gov.gr/
[86] See: https://elevategreece.gov.gr/startup-database/

Only three out of 587 start-ups in the Elevate Greece database operate in the art, cultural and creative industries field, suggesting there is potential for expansion of entrepreneurial innovation in this field.

According to the S3 2021-2027, the transport and logistics sector has recorded strong performance in terms of contributing to domestic gross value-added. Activities in the sector, such as shipping and water transport, have increasingly internationalised in recent years. The productivity of those employed in the logistics sector is high. At the same time, the road, rail and to some extent ports services could still further modernise and improve efficiency, with a lack of multimodal freight centres, weak spatial aggregation of companies, lack of qualified staff and low use of digital systems and technologies in the supply chain sector. In total, 14 start-ups operate in the logistics and transportation field and a further 11 in the mobility field, according to the Elevate Greece database.

While the possible range of Horizon 2020 topics relevant to this field is broad, Greek partners have played an active role in the projects selected under two main topics, namely the e-infrastructure and European Open Science Cloud (EOSC) calls. Two organisations (Athena and GRNET) have been highly active, accounting for 61% of the net EU contribution of EUR 33,748,129 awarded to Greek partners under these topics.

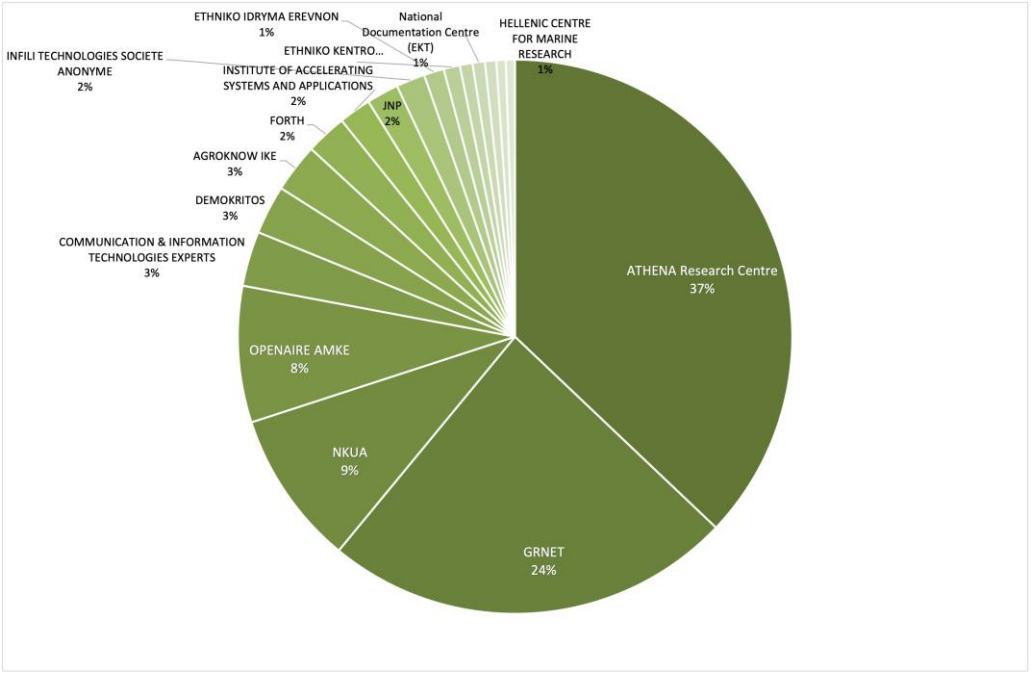

Figure 47. Greek beneficiaries of the e-infrastructure/EOSC calls of Horizon 2020 (net contributions) (Source: Horizon 2020 dashboard, data extracted 12 May 2022)

Unsurprisingly, the two dominant players in the Greek e-infrastructure Horizon 2020 funding (Athena RC and GRNET) are also leading in two out of four of the NRI data and digital infrastructures. The involvement and experience of Greek organisations in the development of the EOSC platform and open science platforms (OpenAIRE) suggests that there is a strong basis for the development of digital and data RIs in Greece.

Indeed, in line with the Open Science Agenda, the Greek Open Science Task Force[87], a bottom-up initiative which brought together the major open science stakeholders in the country, published a National Open Science Plan in June 2020. The plan proposed actions in six priority areas[88]: open access to scientific publications; research data management and sharing for research data to be open by default; research software development and management for research software produced by publicly funded activities and R&D projects to be available under a licence that allows its further modification and redistribution; equipping the Greek R&D community with the necessary qualifications, digital skills, incentives and reward mechanisms for the adoption of open science; open Science through NRIs and Digital Services for Research for enhancement of national RIs and service providers by providing a single access; integration/alignment with the EOSC.

Part of the plan has been transposed in the Digital Strategy of the Ministry of Digital Governance; while the funding for NRIs in the data and digital field also contributes to the plan's aims. In February 2022, as a follow-up to the taskforce, the Hellenic Open Science Initiative (HOSI)[89] was launched with 13 R&I organisations to implement Open Science policies in Greece and support the national representation and contribution to the EOSC in a coordinated and participatory fashion. Moreover, GRNET is coordinating the National Initiatives for Open Science in Europe (NI4OS Europe[90]) which seeks to reinforce contributions to the EOSC service portfolio and EOSC governance in 15 countries in south-eastern Europe (including Greece).

2.6.1. Strategic focus of the Greek NRIs in the data and digital field

In this domain, four NRIs are actively providing services to Greek researchers, and to a lesser extent other types of users, with one cross-cutting digital/e-infrastructure (HELIX) and three thematic digital infrastructures. The budget for the four NRIs varied from just over a million euros to EUR 4 million. The least-advanced NRI project of the four is HELIX which had only spent two-thirds of its budget by end 2021.

National Research Infrastructure	NRI full title	No. of partners	Approved budget (€)	Actual expenditure (€)	Budget execution
APOLLONIS	National Infrastructure for Digital Arts, Humanities and Language Research and Innovation	11	4,000,000	4,000,000	100%
ENIRISST	Intelligent Research Infrastructure for Shipping, Supply chain, Transport and Logistics	11	2,974,891	2,413,206	81.1%
HELIX	National Digital	3	3,859,823	2,569,891	66.6%

[87] See: https://hellenicdataservice.gr/news/actions/view/523
[88] See: https://zenodo.org/record/3908953#.YtaJs8FBxH1
[89] See: https://www.athenarc.gr/en/news/-hellenic-open-science-initiative
[90] See: https://ni4os.eu

National Research Infrastructure	NRI full title	No. of partners	Approved budget (€)	Actual expenditure (€)	Budget execution
	Infrastructures for Research				
SoDaNet	CESSDA_GR - The Greek RI for social sciences	7	1,066,340	1,066,340	100.0%
Total		32	11,901,054	10,049,437	87%*

Figure 48. Data and digital research infrastructures – key figures (Source: GSRI, calculations authors, *average budget execution)

The stated missions of the four NRIs are summarised below:

- APOLLONIS[91]: consolidate and operate an environment of services, resources, training and support, which enables the integrated access and use of designated collections of digital resources for research, educational and creative purposes, as well as the enrichment of resources and the production of new ones.

- ENIRISST[92]: a scientific e-infrastructure that supports seamless access, use, reuse, and trust of data and services regarding shipping, logistics and transport.

- HELIX: structured in three sub-projects: 1) Hellenic Networks Compute and Storage, aimed at further developing the national network for computational research (GRNET[93]); 2) Hellenic Data Service[94] aimed at supporting data-intensive research, handling the data management, analysis, sharing, and reuse needs of Greek scientists, researchers and innovators in a cross-disciplinary, scalable, and low-cost manner (Athena RC); and 3) Hellenic Federated Testbed[95] aiming to develop a wide-scale experimental facility by federating existing Future Internet research facilities in Greece (University of Thessaly).

- SoDaNet-CESSDA[96]: an open academic knowledge infrastructure, available to the research and academic community, policy makers, journalists, and any other potential user interested in social research.

Considering the potential contribution of the four NRIs to the three main RI-PATHS impact pathways, the figure below summarises the existing or potential impacts.

NRI	Enabling science	Problem-solving	Science and society

[91] See: https://apollonis-infrastructure.gr/
[92] See: https://www.enirisst.gr/
[93] See: https://grnet.gr/en/
[94] See: https://hellenicdataservice.gr
[95] See: http://helnet.eu/
[96] See: www.sodanet.gr

NRI	Enabling science	Problem-solving	Science and society
APOLLONIS	Development and consolidation of the services of the two infrastructures, within a framework of interoperability and mutual support. Access to large collections of digital data and resources, as well as innovative services and tools for processing them, supporting SSH in various research fields.	Targeted actions (outreach activities) for an active approach to engaging with business and the creative industries.	-Supporting the formation of a national community around the digital humanities topic. -Ensuring Greek participation in the respective ESFRI infrastructures.
ENIRISST	Collect, process and provide researchers and users with information and tools on national and international, passenger and freight transport including sea, air, inland and intermodal transport.	-Support key economic activities and SMEs active in the areas of the RI. -Support stakeholders (academic community, researchers, infrastructure operators, private and public companies, policy makers) in their research, investment plans and policy making.	Create new and enhance existing networks that will ensure the flow of knowledge and information on shipping, supply chain.
HELIX	-Enhancing cloud computing resources for researchers. -Support the full lifecycle of scientific data management, processing, sharing and reuse. -The creation of a wide-scale experimental facility by federating existing Future Internet research facilities in Greece.	-Improved potential for developing data science as a service (e.g. domain specific communities, governments, NGOs, industry). -Possible future industrial data platform and industrial customers. -Development of new 5G and internet services with industrial partners.	-HELIX is part of the effort to develop an open science agenda in Greece. -Training and tools (e.g. HELIX Lab) for scientific community related to data-driven science. -Improved open access to publications and data for broader set of users; including potentially citizen scientists.
SoDaNet	-Consolidation and improvement of Greek social science data repositories ensuring dissemination and support for deposit of research data by	Cooperation with businesses using social science data (e.g. opinion polling firms, media, policy consultants, etc.). -Impact on evidence-	-Enhanced data-sharing culture within national social science communities. -Improved open access for citizens to data on key societal topics (e.g.

NRI	Enabling science	Problem-solving	Science and society
	researchers. -Training and education of students (MSc and PhD) and researchers in data collection, analysis, metadata management, etc. leading to improved high quality research data in line with FAIR principles.	based policy making by using datasets (e.g. migration, income and living condition. opinion polling data, etc.) in public policy design and evaluation, etc.	see infographics collection on SoDaNet website). -Coordinating Greek participation in the corresponding ESFRI infrastructure, thereby capitalising on knowledge gained from international networks.

Figure 49. Data and digital research infrastructures – declared aims by type of impact pathway (Source: authors based on project documentation and survey responses)

All four NRIs have focused their efforts on the enabling science impact pathway during this phase of funding by further reinforcement and development of research data repositories and services along with actions to train and educate researchers in data management and analysis. The potential impact of the NRIs on, notably, socio-economic policy making processes is significant but still nascent at this stage with some business or industrial partnerships already existing or planned. The potential for supporting transdisciplinary research (e.g. the use of social science data in, for example, medical or epidemiological research and applications) is evident. The broader impact of the NRIs on science and society as part of the open science agenda (including citizen science and access to data on societal challenges, e.g. migration) is likely to be important in the medium term.

2.6.2. Governance and operational management

The governance arrangements of the data and digital NRIs are strongly influenced by the experience and models of the equivalent ESFRI-level RIs, notably in the case of APOLLONIS and SoDaNet which are part of the CLARIN/DARIAH and CESSDA ESFRI 'landmarks', but also for ENIRISST which also modelled itself on the CESSDA ERIC example.

NRI	Lead partner	Governance framework
APOLLONIS	Athena Research Centre	Cooperation agreement (2016) – providing for a joint coordinating committee including the coordinators of the two constituent RIs (CLARIN:EL and DARIAH-GR). Joint committee meets on an annual basis. Partners of the two constituent RIs meet on an annual or semestrial basis.
ENIRISST	University of the Aegean	A cooperation agreement signed in April 2018 provides the framework for the NRI development. The governance structure of the project, and NRI when fully operational, consists of a board, a quality council; a technical board; scientific advisory committee; and ambassadors. A general assembly of WP/Task leaders convenes monthly for the duration of the project implementation for coordination and monitoring.

NRI	Lead partner	Governance framework
HELIX	GRNET S.A.	Absence of a single governance structure. NRI project is managed as three sub-projects by the three partners.
SoDaNet	EKKE	SoDaNet governance is based on a cooperation agreement (MOU, signed in 2015), in line with the principles of ERIC collaboration. The management structures include a scientific committee, a steering committee and an advisory board. The scientific committee has representatives from all academic partners at meets at least twice a year. The steering committee (three persons) ensures the operational implementation of the decision.

Figure 50. Data and digital research infrastructures – governance frameworks (Source: authors based on project documentation and survey responses)

Aside from HELIX, the data and digital NRIs have put in place well-structured and robust governance structures that are likely to provide a good basis for future development. They remain, however, based on consortium agreements and future development may benefit from a shift to a single legal entity. Working across many organisations creates difficulties due to different procedures, notably concerning public procurement. Similarly, applications to European funding programmes are complicated as they involve many Greek partners which is not generally possible.

Without necessarily shifting to a single legal entity, APOLLONIS seeks to benefit from the experience of NRIs in European countries that bring together CLARIN and DARIAH[97] to further align the two infrastructures in Greece. Further improvements in the governance structure are expected based on recommendations of a study produced by the APOLLONIS NRI team. In contrast, ENIRISST noted that they would favour the creation of a single legal entity with a VAT registration to facilitate participation in EU programmes and involvement in other research activities and services. SoDaNet pointed to international examples of inter-university not-for-profit consortium such as the Australian Consortium for Social and Political Research Incorporated (ACSPRI)[98]. ACSPRI is a not-for-profit organisation, formed in 1976, to facilitate access to Australian and overseas sources of computer-readable social science data. It runs regular training programmes in social research methods and research technology and operates a survey research centre.

In the case of HELIX, the issue of a 'merger' into a single legal entity appears complex and costly, as interviewees noted that all three organisations have very different funding and governance models, e.g. GRNET cannot accept private funding.

2.6.3. NRI funding, staffing and operations

In terms of the funding allocation (see Figure 64), the four NRIs mobilise a diverse number of participants with the HELIX project funding three partners, while ENIRISST has 11 partners at the other end of the spectrum. The funding is concentrated on the lead partner ranging from 60% for HELIX to 48% for APOLLONIS, 44% for SODANET and 36.5% for ENIRISST.

[97] Notably CLARIAH-DE (https://www.clariah.de/en/) and CLARIAH-NL (https://www.clariah.nl/).
[98] See: https://www.acspri.org.au

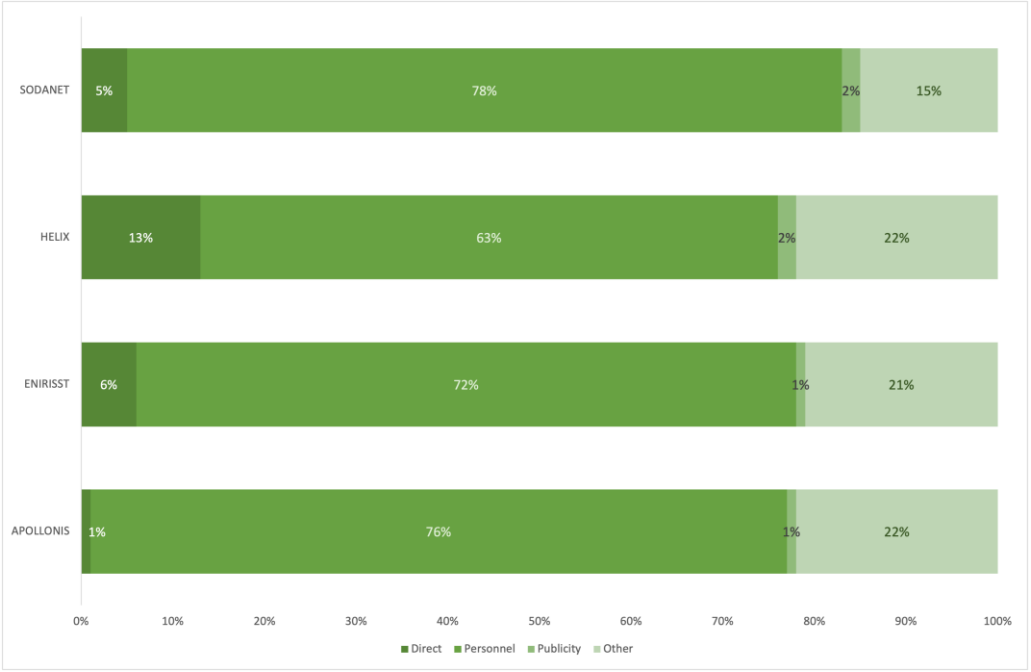

Figure 51. Distribution of budget by category of expenditure – data and digital research infrastructures (Source: GSRI, calculations authors)

The median funding ranges from 85,000 in the case of SODANET to 862,773 for HELIX which has the most unequal distribution of funding (but across only three partners). The NRIs with a larger number of partners tend to spread funding relatively thinly with several partners receiving below EUR 100k over the lifetime of the NRI project; this is assumed to be for staff time given the distribution of funding by category.

Indeed, the distribution of funding by main category underlines the human resource intensive nature of the data and digital NRIs, with almost no to limited investment in equipment ('direct costs). On average all four NRIs spend about a fifth of their budget on other costs, underlining the importance of community building in this category of NRI.

Despite the relatively significant proportion of funding allocated to staff, limited data has been provided, in the survey responses, by the three NRIs (HELIX did not respond) concerning the profile of staff employed using the funding. However, the data provided by EPANEK suggests a significant mobilisation of expertise and particularly young researchers (almost all the HELIX staff are in this category).

APOLLONIS noted, in its survey response, that the creation of the NRI has provided an attractive environment for highly skilled scientific and technical personnel, generating 85 new job posts. The NRI has built on the skills and experience of its interdisciplinary team, ensuring effectiveness and efficiency in a field that requires highly specialised training. ENIRISST also employs a significant number of highly skilled researchers, 65% of whom are new, at different career stages (early stage, recognised researchers, established researchers, etc.).

National RI	a) Number of researchers working in improved research centre facilities (FTE)	b) Number of young researchers (FTE)	Difference (a-b) (FTE)	Direct personnel expenses	Per researcher
APOLLONIS	95.46	85.3	10.16	€2,980,793	€31,226
ENIRISST	70.97	52.35	18.62	€1,642,969	€23,150
HELIX	49.89	48.48	1.41	€1,564,765	€31,364
SoDaNet	32.66	25.06	7.6	€806,200	€24,685

Figure 52. Human resource indicators – data and digital NRIs (Source: EPANEK-GSRI, calculations authors)

SoDaNet noted that different funding sources play a different role. European funding provides them with resources to gain knowledge and technical expertise, hire temporary highly trained staff, as well as to exchange with European research data communities. On the other hand, national funding is critical to ensure RI sustainability as well as to train and retain highly skilled staff within the RI and the country.

However, the long intervals between national project funding opportunities jeopardise the retention of trained personnel. All three projects (that responded to the survey) noted the difficulties faced in retaining young researchers who, due to low salaries and uncertainty about long-term funding, are attracted to work as researchers abroad or to move into the business/private sector. Similarly, the NRIs report significant difficulties in attracting (senior) researchers (back) from abroad due to language requirements and salary levels.

2.6.4. Service provision and user access policies

By their nature, the four NRIs are focused on providing a range of services, resources (metadata, digital repositories, multimedia, etc.) and training to targeted users. The three thematic NRIs have all developed (or further developed) the resources and services targeting specific communities of researchers (and other users).

NRI	Digital resources	Tools	Training/education
APOLLONIS	Access to the CLARIN:EL catalogue (over 3.7 trillion words); DYAS Humanities Thesaurus, resource registries for humanities, pilot '1940s thematic platform' metadata of digital collections and documents.	Over 50 tools and services are provided including data mapping, thesaurus management, metadata and object management, etc.	Summer schools on digital humanities and language technology, webinars, datathons, etc.
ENIRISST	Six thematic data platforms for collection, processing and sharing	More than 35 services across the platforms: for	Research training hub developed.

NRI	Digital resources	Tools	Training/education
	data covering shipping and marine environment, maritime heritage, passenger transport, inland and multimodal freight, etc.	example the shipping and financial markets platform has a decision support tool for shipping firms, banks, investors, etc. The passenger platform includes multimodal travel information tool, etc.	
HELIX	-Data catalogue and repository infrastructure – providing data discovery, use and publication on a horizontal (multidisciplinary) basis. -Providing scalable data processing services for very large and heterogeneous scientific data. -Open access publications harvested from OpenAIRE.	-Data management (uploading, harvesting, etc.) and metadata services. -Value added services for publications under development (link data with publications, etc.). -HELIX lab provides Jupyter computational notebooks for scientific computing as a hosted service.	Open access training and support.
SoDaNet	-Data catalogue covering eight different categories of data. -Data deposit services (metadata appraisal, publication, etc.). -Online applications for creating charts, statistics and maps. -Social terms dictionary. -Infographics collection.	-Support for developing data management plans. -Online survey services (open source Limesurvey tool). -Support for repository implementation using Dataverse.	e-courses, seminars, workshops, student internships.

Figure 53. Resources and services provided by the data and digital NRIs (Source: compiled by authors from NRI questionnaires and presentations)

The development level of the data repositories, software and training services varies with the two longer standing NRIs linked to the ESFRI RIs more developed, while ENIRISST is applying use cases to develop the thematic platforms further during 2022. HELIX is working on a long-term development roadmap. The 2018-2019 period was used to develop the technical foundations and core services; while they aim to further scale services and reach more scientific communities before operating on a full production basis from 2025.

The NRIs have developed training services. In the case of APOLLONIS and SoDaNet this involves an effort to train and educate the researchers from their scientific fields in digital

tools, techniques and methods as well as FAIR data management practices. The training offered can draw on the resources and expertise of the corresponding ESFRI projects. For example, SoDaNet has provided training and consulting to MSc and PhD students to design and conduct quantitative (web) surveys. APOLLONIS trains young scientists by making use of CLARIN:EL resources and services in several university courses, for instance, on computational linguistics, translation studies and digital humanities. ENIRISST has created a research-training hub as over 50 new researchers are involved in the infrastructure, and the aim is to establish a large network of researchers in the related fields. HELIX noted that over 1000 users have been trained in 40+ seminars, along with 100+ data librarians ('train the trainers').

The responses to the survey question concerning the share of operational time allocated to academics and the research sector are somewhat at odds with other evidence. Both APOLLONIS and SoDaNet indicated that half the operational time of their digital infrastructure is used by non-academics, while in their narrative responses they underline that they focus on users from the scientific sector. On the other hand, ENIRISST indicated 100% use by the academic/research sector, despite a reported effort to interact with business and public authority users.

APOLLONIS noted that during the funding period, the number of users of the NRI has increased by 714%. As of January 2022, the NRI reported 800 certified users, making use of resources and services requiring authentication, and about 120,000 visitors using the NRIs services and resources, while more than 5,500 researchers, students and professionals have participated in the NRI's educational and dissemination activities.

HELIX Data has 1500 plus registered users and 249 datasets; while HELIX Lab has 400 plus users. HELIX is already providing services to the Hellenic Academic Libraries Link (HEAL-LINK[99]) which has 43 members (all universities and research centres). HEAL-Link is actively working to train members on research data management and operate a research data repository integrated within the HELIX ecosystem. HELIX is also supporting the National Network for Climate Change (CLIMPACT[100]) with the integration, harmonisation, and optimisation of climate services and data from relevant Greek national infrastructures.

ENIRISST has initiated collaboration and signed MOUs with public authorities (11 local and regional authorities) and organisations for sharing data and models related to transport and shipping, and with industrial partners (12 letters of intent) in the fields covered by the NRI.

SoDaNet registered users have access to the Sodanet_GR Data Catalogue, where they can search and download survey and cubes data and metadata, create online maps and undertake online small-scale statistical analysis; as well as the e-learning courses hosted on the Sodanet_GR e-learning platform accompanied by self-assessment tests. As of January 2022, the NRI reported 4,675 visitors making use of various digital resources and services of which 400 users requiring authentication for specific datasets/resources. Additionally, during 2020-2021, dissemination and educational activities were delivered to social sciences departments at Greek universities as well as at the European level via data networks and RIs. An estimated 1,500 people attended including researchers/academic staff, students, social scientists, journal publishers, data professionals, and trainers.

Overall, the four NRIs have established a good foundation for future service provision to users. In certain cases, there remains further development work to be done and investment

[99] See: https://www.heal-link.gr/en/home-2/
[100] See: https://climpact.gr/main/

required to shift to a full 'production' phase (e.g. by HELIX and ENIRRIST). The development of additional software and computing services, data platforms, etc. is conditioned upon access to sufficient finance and avoiding funding gaps that limit the potential to provide services (an issue highlighted by all four NRIs).

2.6.5. Results, impact and sustainability

The four NRIs have made satisfactory progress in developing services given the funding available during the current period. The data platforms and services available (or in development) are highly relevant for Greek scientific communities and support the process of shifting to open science practices that respect FAIR data principles. The major outcome to date has been in the 'enabling science' impact pathway with the development or further enhancement of data and publication catalogues, data repositories, digital tools, and training and education to boost expertise in data management among Greek scientists (and other relevant users such as public administrations, etc).

The investment in the NRIs has reinforced the active Greek participation in ESFRI RIs (CESSDA, DARIAH, CLARIN) and given 'seed funding' for the alignment of Greek research data and publication repositories and related software services with open science practices. Users underlined the value of the services provided. For instance, SoDaNet is considered as a very helpful open-access resource for students and teaching and for researchers it provides a framework for collaboration and useful tools such as mapping services (spatial and temporal data) and support services to review uploaded data.

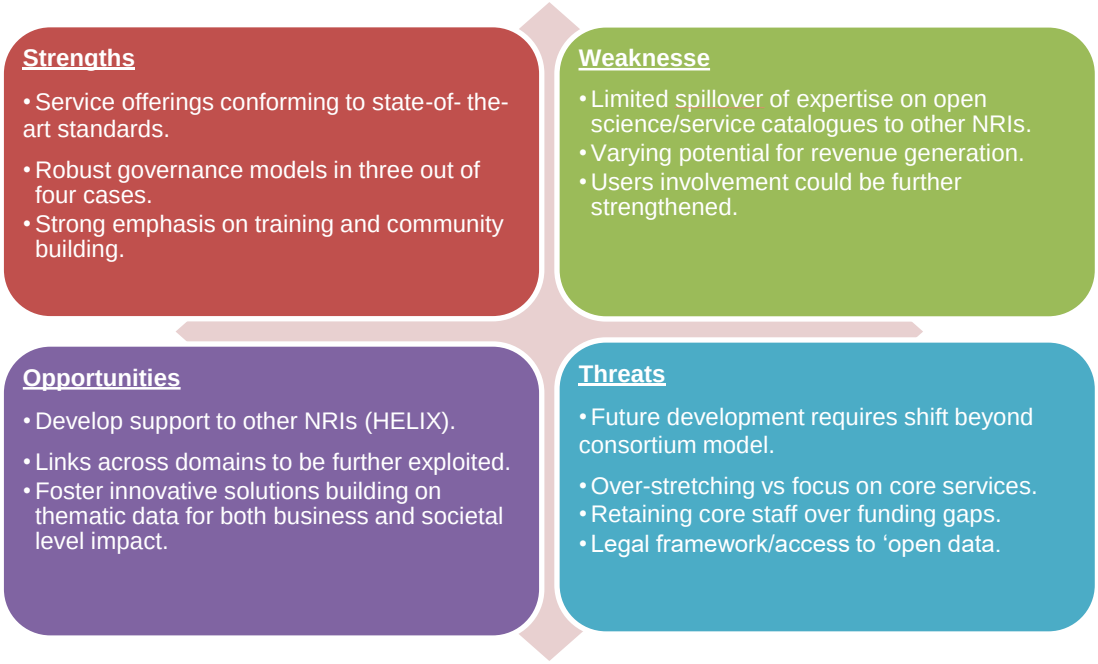

Figure 54. SWOT analysis of the data and digital NRIs

That said, given the experience of several of the major Greek organisations (GRNET, OpenAIRE, Athena) in the development of the EOSC portal (marketplace), there remains unexploited potential to harmonise user access, service catalogues and research data management support services for all national research infrastructures through the HELIX Data service.

There is potential for reaching beyond the research community: all four NRIs identifying opportunities for business partnerships or platforms and cooperating with and supporting public-sector actors on policy issues (migration, health, mobility, cultural policies etc.). APOLLONIS noted the potential to deepen cooperation with the galleries, libraries, archives, and museums (GLAM) sector, for example, to support digitalisation and curation of Greek socio-cultural heritage. There was positive feedback from business and other users on the improvement of access to data which they underlined is crucially combined with access to expertise in the NRIs on methods and tools for analysing data. The thematic NRIs also pointed to the potential for enhanced cooperation for data exchanges with and between NRIs and researchers in other fields (e.g. medical, agri-food, etc.).

In terms of sustainability and future 'operating models', the four NRIs are faced by the challenge of maintaining staff and investing further in the development of their service in the absence of a clear funding framework (hence relying on funding on a project-by-project basis). HELIX representatives noted that the GRNET Okeanos-Knossos cloud computing[101] for researchers and high-performance computing (ARIS)[102] infrastructures for large-scale scientific applications have received significant additional support through the Digital Transformation Bible (DTB) – the framework for implementing Greece's digital transformation strategy. However, the lack of follow-on funding for the Hellenic Data Service, which provides horizontal services, would compromise open-science development and participation in EOSC.

Non-grant-based sources of funding (fees for services, etc.) are also being explored. For instance, SoDaNet noted that while services are currently free for everyone, the introduction of a service charge for non-partners is a possibility; as is charging fees for seminars and training (e.g. to public administrations). Similarly, ENIRISST foresees paid access to tailor-made services and consulting and training services generating fees. APOLLONIS identified criteria to be met if they are to generate 'external revenue' including access to HPC resources, implementation of APIs and establishment of service-level agreements. In the case of HELIX, the option of developing industrial data platforms that provide low-cost processing infrastructures and data-science-as-a-service as well as training are planned in the next phase.

[101] See: https://grnet.gr/en/services/computing-and-storage-services/okeanos/
[102] See: https://grnet.gr/en/services/computing-and-storage-services/hpc/

3. Overall conclusions

The strategic objectives and guiding principles of the 2014 National Research Infrastructures Roadmap (see page 14 of the roadmap), which were translated into criteria for the selection and funding of the NRIs under the EPANEK Operational Programme, provide a framework against which the effectiveness of the NRI implementation can be appraised. In short, these principles were:

- Creation of, and then capitalising on, critical mass in areas of excellence related to national strategic priorities;
- Adoption of a coherent participation model in European and global RI initiatives;
- Implementation of RIs based on multi-annual investment plans with due attention to sustainability principles, coordinated procurement to avoid redundancies, optimised synergies, and the opening of RIs to users by adopting open-access models;
- Nurturing strong and continuous collaboration between academia/research and industry;
- Fostering sustainability through well-structured and operational governance models;
- Support RIs in the framework of regional support policies to take account of regional dimensions to national investments;
- A coordinated policy framework for e-infrastructures as enablers for research and knowledge-intensive businesses.

To summarise the overall policy and the (thematic) portfolio(s) of 28 NRIs, the PSF experts developed a 'theory of change' applying to the NRI programme and based on the relevant documentation (EPANEK OP[103], national RI roadmaps[104], the NRI call criteria, etc.) and the interviews carried out with national policy makers.

The intervention logic underpinning the NRI programme is defined with respect to four main expected impacts derived from the objectives set out in the above-mentioned programming documents.

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[103] According to the EPANEK OP, the NRIs were to be strengthened to:
Ensure the high level of Greek research activity mainly in priority areas and integration into European and global networks, scientifically and technologically support national policies for safety, the environment, health and other critical priority areas,
Create an open and collaborative environment that increases the demand for research and innovation from the business world,
Be attractive for Greek and global companies to purchase know-how and scientific services,
Contribute to the European Research Area (e.g. with research infrastructures primarily linked to ESFRI or other joint European initiatives or networks).

[104] According to the 2014 Roadmap, the NRIs were expected to:
Create an attractive environment for highly skilled scientific, technical and administrative personnel and facilitate the access of Greek research teams to global research infrastructures,
Act as enablers of regional development with long-term socio-economic benefits for the host regions through the creation of jobs, training and specialisation of human resources,
Foster an entrepreneurial climate favourable to industrial investment on research and innovation, with a direct impact across society (e.g. through spin-offs, new market opportunities related to procurement/equipment supplies and new, innovative products and services).

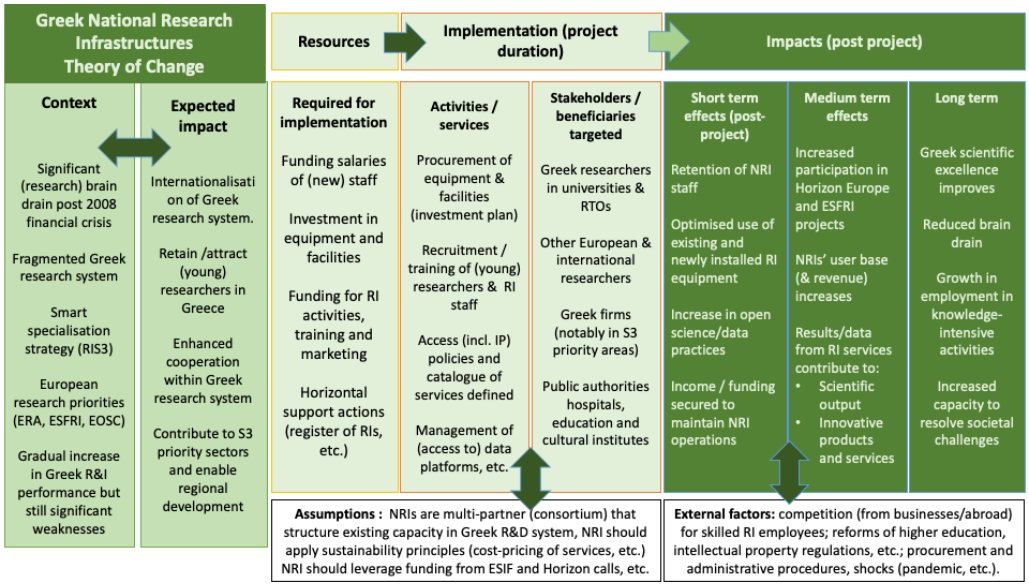

Figure 55. Greek NRI policy's theory of change (Source: PSF Panel own elaboration)

In the following sub-sections, several cross-cutting conclusions are drawn on the effectiveness of the NRI policy framework and the implementation of the programme. The PSF expert panel has also summarised the findings for each of the expected impacts.

3.1. Conclusions on the programme implementation and institutional framework

The PSF panel concludes that the NRI policy has provided a significant contribution to the structuring of Greek research and innovation capabilities in line with the national S3 priorities and ambitions. While it remains too early to judge the full impact, there has been good progress in implementing the activities and promising progress towards the short-term effects (as listed in Figure 55) during the 2014-2020 period. The NRI projects have been implemented broadly on schedule (despite the Covid pandemic) with an average rate of budget execution of 94% by end 2021 and some projects being extended into 2022 for justifiable operational reasons. The management of the disbursement of NRI funding by the EPANEK MA has been efficient with no significant issues raised by NRI coordinators aside from the difficulties faced with procurement of scientific equipment and supplies due to application of procurement rules better fitted to larger or more standard investment projects.

There are, nevertheless, several areas where improvements can be made at the strategic policy level and the coordination of programme implementation:

- The NRI Roadmap, multi-annual plan and selection of NRIs based on a set of objective criteria was a necessary, if not sufficient, condition for an effective use of public funds. The selection process, while implemented in an objective manner, led to the available funds being awarded to 28 NRIs, with in most cases a significantly lower than requested budget being awarded (the average budget being in the order of EUR 3.2 million). This reduction was raised by many of the NRI coordinators as limiting their ability to develop the NRI in the way initially planned. The preparatory nature of the first round of funding (which supported the establishment of the NRIs rather than their full operation) and the intention by the GSRI to fund projects covering the full range of S3 priorities justified this

approach. However, the funding of 28 NRI projects (which in turn distributed funding internally, including some minor partners) reduced the overall effectiveness of the NRI investment.

- The selection process led to several 'arranged marriages' of proposed RIs which have proved difficult to operationalise and are unlikely to be sustainable beyond the current projects. In other cases, there are grounds for consolidation of RIs operating in related or overlapping fields that should happen through a competitive selection process in the next funding round rather than by the merger of submitted proposals.

- While the majority of NRI teams exhibit a good understanding of the RI concept and the main principles that frame the intervention, the 'theory of change' which would enable a 'strategic' monitoring and assessment of impact is not explicit to all stakeholders and, hence, the indicators used to track performance are often not aligned with the function of a RI or the lifecycle stage (e.g. an emphasis when presenting results, by many NRIs, on their own staff scientific publications as opposed to reporting on the number of users citing use of the RI, e.g. peer-reviewed articles published as a direct result of research with or within the RI by users). Given the current lifecycle stage of the NRIs (preparatory to early operations), the panel expected more attention to be given to monitoring the progress in developing core services and activities for users and their uptake, and on the NRIs' human resource development (for which it proved difficult for the panel to obtain detailed information). This also hints at a still weak culture of service provision as a core mission for these NRIs – measures to reinforce this culture would be beneficial to allow the NRIs to develop in line with expectations and at the international level.

- The coherence and synergies with other national and regional funding programmes proved difficult to map and assess for the panel. As noted in the Background Report, EPANEK was the principal source of funding for the NRIs, in line with their status as 'singular' or unique RIs of national importance. Several NRIs reported additional funding from regional operational programmes or from other national sources such as HFRI (ELIDEK) or the Ministry of Digital Governance. However, the synergies with other national and regional funding programmes were not steered in a strategic manner (e.g. cross-departmental/ministerial coordination) and NRIs sourced additional funding on an ad hoc project basis (national or European) or from own institutional funding.

- The roadmap and NRI strategy foresaw several horizontal support measures (see Background Report for details) that were to be put in place including a 'register' of research infrastructures, revision of the national RI roadmap and actions to provide assistance or foster the development of common procedures and tools by the NRIs. The PSF panel considers that a more pro-active management of the portfolio of NRIs (by the GSRI) would have been beneficial, and that the non-implementation of the planned support measures is regrettable. Opportunities to foster learning, exchange (good) practice/processes and 'community building', both thematic and inter-disciplinary, by bringing together NRI coordinators and participants) have been missed.

- Moreover, the absence of the planned 'register' means that there is not a consolidated national inventory (portal) of research equipment, scientific instruments, core facilities hosted by NRIs and other research centres. This undermines the capacity for both users to access equipment/facilities and for the national authorities to take informed decisions on future investments. This latter point is linked to the issue of the strategic steering of investments in RIs from different national and regional programmes/funds. A national inventory would enable both the GSRI and other national authorities to prioritise investments in the NRIs; while distinguishing between (lower value) investments in

equipment and facilities of regional or individual organisation importance that can be funded by other budgetary resources. This register would also facilitate the setting up of a service-booking system, for the management of the NRIs' resources (equipment, staff, service access), eventually providing a centralised access system.

- A related factor of policy coordination that lessened the effectiveness of the current period investment concerns digital or e-infrastructures/research data infrastructures. The 2014 Roadmap rightly underlined the importance of a "an emerging umbrella e-infrastructure" – with virtual consolidation of resources and competences of distinct organisations. Despite the documented expertise and capacities of Greek organisations in this field, there has been insufficient attention paid to the development of federated solutions for research data and support for open science. The 28 NRIs would have benefited from support for developing research data platforms that nurture the full lifecycle of scientific data management, processing, sharing and reuse; as well as advice on the development of online service catalogues, access policies, etc.

- At this stage, the long-term sustainability of the majority of NRIs is far from guaranteed, due to a variety of factors but notably the legal entity question, gaps in funding undermining staff retention and operations, lack of funding for equipment maintenance and renewal, etc. The PSF panel considers that the sustainability potential (progress in creating a core RI management team, sophistication of access policies, identification of the user base and own revenue generation potential, governance models, links to ESFRI RIs, etc.) varies significantly across the 28 NRIs, with certain projects further away from developing into fully-fledged NRIs, and some even unlikely to do so.

The figure below uses a traffic light approach to summarise the panel's conclusions on the current implementation and development status of the 28 NRIs. They are summarised according to six criteria, as follows.

- Maturity of governance structure and management procedures. Ranking:
  - Green: Complete and well-functioning governance structure and dedicated central management team;
  - Orange: Governance structure in place but coordination and collaboration processes require strengthening and a reinforced management team;
  - Red: Incomplete governance set up and/or poorly functioning collaboration between partners.
- Quality of user access policy. Ranking:
  - Green: Centralised and functional (online, auditable) access to a single catalogue of services, user training/support services in place;
  - Orange: No centralised access procedure (or contact by email only), catalogue of services per node/site, user training/support provided but on ad hoc basis;
  - Red: User access procedures and catalogue of services not yet available (still being defined), user training/support processes need to be developed.

- Strategic outlook of the NRI, defined as the extent to which an NRI provides exceptional and unique facilities/equipment/collection and gathers a critical mass of expertise needed for top-class research and technology development. Ranking:
  - Green: Unique and strong infrastructure with strong partners and users and excellent alignment with national strategy;
  - Orange: Unique features exist and the NRI aligns with strategic goals, but strategic outlook could be improved by consolidation or stronger collaboration at the national level;
  - Red: The uniqueness of the infrastructure and strategic importance should be re-examined.
- European collaboration, defined as the extent to which an NRI has strong ties with European counterparts and potential to attract users and/or funds from Europe. Ranking:
  - Green: Established membership in European RIs (or similar networks) and significant funding secured from European or other international sources;
  - Orange: Good basis for developing European presence and cooperation; European/international funding secured to date is minor (tens of thousands per project) but further opportunities exist;
  - Red: Limited ties with European RI projects and/or limited or unexploited European funding opportunities.
- Impact on research excellence (including education/training and attraction of researchers). Ranking:
  - Green: NRI already providing services to researchers and likely to have high impact on research excellence;
  - Orange: Identifiable potential impact on research excellence but further efforts required to ensure broader scale of impact;
  - Red: Low to modest current and potential future impact on research excellence.
- Impact on innovation (on one or more S3 priorities). Ranking:
  - Green: NRI is providing services to business or other non-science users and has good potential for a future broad impact on business innovation and/or an innovative contribution to meeting societal challenges in one or more S3 priority areas;
  - Orange: Some examples of support for innovation but further efforts required to ensure broader business/societal engagement and impact;
  - Red: Low or unproven existing or potential impact on innovation.

Thematic field	National RI	Governance and management structures	Quality of user access policy	Strategic positioning of the NRI	European collaboration	Impact on research excellence	Impact on innovation (S3 priorities)
Agri-food	Food Innovation RI	Red	Orange	Red	Orange	Orange	Orange
Agri-food	OMIC ENGINE	Orange	Green	Green	Orange	Green	Orange
Agri-food	PLANT-UP	Orange	Orange	Orange	Orange	Green	Orange
Agri-food	FoodOmicsGR	Orange	Orange	Orange	Green	Green	Orange
Data & Digital	APOLLONIS	Green	Green	Green	Green	Green	Orange
Data & Digital	ENIRISST	Green	Orange	Green	Orange	Orange	Orange
Data & Digital	HELIX	Red	Orange	Green	Green	Green	Orange
Data & Digital	SoDaNet	Green	Green	Green	Green	Green	Orange
Energy	PROMETHEUS	Red	Red	Orange	Red	Orange	Orange
Energy	FuVEP	Green	Orange	Orange	Green	Green	Green
Environment	INVALOR	Orange	Orange	Green	Red	Orange	Orange
Environment	PANACEA	Orange	Orange	Green	Green	Green	Green

Thematic field	National RI	Governance and management structures	Quality of user access policy	Strategic positioning of the NRI	European collaboration	Impact on research excellence	Impact on innovation (S3 priorities)
Environment	CMBR	Orange	Orange	Green	Green	Green	Orange
Environment	HIMIOFOTS	Orange	Orange	Green	Orange	Green	Green
Environment	HELPOS	Green	Green	Green	Green	Green	Orange
Environment	RePHIL	Red	Orange	Green	Red	Green	Green
Health	INSPIRED	Red	Green	Orange	Orange	Orange	Orange
Health	ELIXIR-GR	Green	Green	Green	Green	Green	Orange
Health	INFRAFRONTIER-GR	Green	Green	Green	Green	Green	Orange
Health	BIOIMAGING GR	Green	Green	Green	Orange	Green	Orange
Health	OPENSCREEN GR	Orange	Orange	Orange	Orange	Red	Orange
Health	pMEDGR	Red	Green	Orange	Red	Orange	Orange
Health	BBMRI GR	Orange	Red	Green	Orange	Orange	Orange
Health	EATRIS GR	Red	Orange	Orange	Orange	Orange	Orange
Physics & materials	HELLAS-CH	Green	Green	Green	Green	Green	Orange

Thematic field	National RI	Governance and management structures	Quality of user access policy	Strategic positioning of the NRI	European collaboration	Impact on research excellence	Impact on innovation (S3 priorities)
Physics & materials	INNOVATION.EL	Orange	Green	Orange	Green	Green	Green
Physics & materials	DeTANeT	Red	Red	Orange	Orange	Orange	Orange
Physics & materials	CALIBRA	Green	Orange	Green	Green	Orange	Orange

Figure 56. Traffic light summary assessment of the progress of the 28 NRI projects

3.2. Contribution to the internationalisation of the Greek R&I system

The NRI policy framework placed significant emphasis on the potential for the investments in research infrastructures to enhance Greece's position in the ERA and notably the involvement in and cooperation with ESFRI infrastructures or international RI initiatives and networks. This aim was translated in the criteria for NRI selection by including a criterion on international networking and visibility of the NRI as well as criteria covering access policy to be extended to international users.

As discussed in Section 1, Greek official participation to ESFRI infrastructures concerns close to half of the ESFRI RIs of the 2021 Roadmap, and slightly more if additional participation in preparatory projects is considered. The NRI programme has not influenced this participation in a direct manner since a main barrier to participation in ESFRI (and other international RIs), according to the NRI coordinators interviewed, is that membership fees for ERIC-type organisations are not an eligible expenditure under the ERDF rules. The GSRI provides a letter of support to Greek organisations wishing to participate in ESFRI/international infrastructures. However, the organisations are expected to source funding of membership costs from own resources or project budgets.

In some cases, the participation is long-standing, e.g. Greek participation in CERN (and the ESFRI infrastructure HL-LHC) and the NRI project (in this case DeTaNet) serves to extend the cooperation into a new phase of development. Similarly, in the fields of social sciences, SoDaNet and APOLLONIS NRIs are building on close to a decade of cooperation in the framework of their respective ESFRI RIs (CESSDA, CLARIN, DARIAH). Similarly, the health related NRIs have a strong alignment with the relevant European infrastructures operating as national nodes, except for pMedGR in the field of precision medicines, which has no clear European counterpart. Some of the environmental NRIs are equally active members of European monitoring networks (ESFRI RIs such as EPOS and EMSO) such as for seismic activity and the marine environment but are not present in others (although Greece has recently applied to join the ICOS RI on carbon monitoring).

The partners involved in the NSR HELIX are active players in the development of the EOSC including the portal and service catalogue at European and south-east European levels, as well as the fact that the legal entity of the European level OpenAIRE scholarly communication infrastructure is Greek based. The ENIRISST partners consider there is potential to scale their experience given the absence of a European-level RI in the transport and logistics data field. Other NRIs are positioned in industrial research networks such as FuVEP, which is a member of the European Automotive Research Partners Association and is coordinating European projects on emissions standards; while partners in the PROMETHEUS NRI are members of the Hydrogen Europe research partnership. In the agri-food field, the picture is more varied with only involvement in MetroFood, although cooperation with other relevant ESFRI RIs is being explored. In this field, PLANT-UP has no clear European counterpart but considers there is a strong basis for Greek participation (or even leadership) in a future European partnership. Industrial research partnerships, e.g. in synthetic biology or food tech, through MOUs are also pursued.

Overall, the European and international engagement of NRIs, and more broadly their international visibility, remains variable. The PSF panel finds that:

- There is an absence of a clear strategic prioritisation of Greek participation in ESFRI and other international RIs. The current laissez-faire policy (letter of support, no funding) means that there is a proliferation of activities by individual organisations to take part in relevant European and international RIs and partnerships without these organisations

necessarily having the means to ensure they can meet the longer-term commitments. Membership fees are paid out of individual organisations budgets and/or from project budgets. The issue of prioritising Greek participation in ESFRI is not an issue solely for the GSRI. The academic and research organisations, which are partners in the NRIs, also need to prioritise their participation in ESFRI according to their own strategies, priorities and funding capabilities. A process for arriving at a consensus on national priorities for ESFRI requires an appropriate consultation of all the Greek R&I system players and is addressed in the recommendations in this Review.

- Currently, the NRI status does not directly provide Greek participants with any additional 'credibility' in their efforts to engage with European partners. There has been no coordinated initiative to promote the Greek NRI network at European level (joint branding, single access point website, etc.) that would support individual efforts of NRIs to position themselves in the European landscape.

- NRIs that have been nodes of ESFRI 'landmarks' for some years are clearly more advanced in the development of governance procedures and capacity to deliver services. Similarly, participation in ESFRI projects provides significant insights for earlier stage NRI, helping them to develop service catalogues, set up governance arrangements, etc.

- The absence of a single legal entity for the NRIs restricts the potential for involvement in European RIs, the signature of MOUs with international partners and the positioning of Greek partners in European scientific and industrial research partnerships. Various ad hoc solutions have been found with one or more of the NRI partners representing the NRI, however this is not an ideal or sustainable solution.

3.3. Impact on attracting and retaining researchers in Greece

As underlined in the programming documents and by interviewees, the NRIs were expected to have a significantly positive impact on retaining and attracting human resources (such as returning Greek scientists who went abroad for studies or post-graduate work). This objective remains highly relevant as Greece had the largest brain drain in Europe (based on the share of researchers having left their country of origin and the share of foreigners working in the country) during the period 2009-2019[105]. The same study finds that Greece also has a relatively weak capacity to attract incoming researchers, a low rate of return mobility (the extent to which countries can counterbalance brain drain by attracting their own researchers back to the country) and a relatively low rate of retention (average number of years per researcher in the country of destination) of researchers attracted.

The NRIS were expected to create "an attractive environment for knowledge-intensive activities and new employment for highly skilled scientists and engineers" (selection criteria call 2) and should be "led by internationally recognised researchers at the prime of their careers, have competent technical and administrative support staff, and attract researchers from all over the world for experiments, measurements and collaborations" (EPANEK).

The data from the EPANEK on the ERDF common indicators for recruiting young researchers and researchers working in improved research facilities suggest that the 28

[105] European Commission, Directorate-General for Research and Innovation, Knowledge ecosystems in the new ERA: Talent circulation and intersectoral mobility; update of intersectoral mobility schemes, Hoed, M.(editor), Nausedaite, R.(editor), Melin, G.(editor), Publications Office of the European Union, 2022, https://data.europa.eu/doi/10.2777/620810

NRIs have recruited over 1527 young researchers, or on average 54.5 per NRI (full-time equivalent) and, in total, employ 1781 (FTE) researchers, 63.5 on average per NRI. The number (FTE) of (young) researchers employed varies considerably from 122 (110) for HELLAS-CH to only 11 (10.4) for EATRIS.GR, reflecting both the available funding and the 'operating model' of the NRIs. In some cases, the NRIs targeted recruitment to address ageing staff profiles of researchers in specific fields (e.g. high energy physics).

Hence, in broad terms, the policy objective of investing in the NRIs to create an attractive environment for (young) skilled scientists and engineers can be considered to have been achieved. However, the NRI coordinators responses to the survey and the interviews carried out by the PSF panel suggest that this positive outcome does not guarantee a long-term impact for the Greek R&I system.

Firstly, as was underlined by the EPANEK managing authorities, the ability of the NRIs to recruit qualified personnel is undermined by relatively low salaries for employees of universities and research centres hosting NRIs and by the recruitment procedure. This is in line with the findings of the 2022 study on talent circulation[106] and the factors influencing brain drain, which highlights the main issues in the Greek research system were related to lack of open, transparent, clear and merit-based recruitment procedures, lack of transparency and objective evaluations and appraisals for career progression, and insufficient remuneration. More positively, the study did not find that access to infrastructures and equipment or research project funding was a factor encouraging brain drain in Greece.

Secondly, the unstable employment conditions of researchers and other RI staff (due to short-term contracts linked to project funding) mean that, in the event of a gap in funding, the NRI will be unable to continue to employ them. The short-term nature of contracts and limited career perspectives was the most negative factor identified by the NRIs in the response to the survey (86% of NRIs selected this option as a main challenge in recruiting/retaining staff); while gaps in funding was the second most identified challenge. The findings confirmed the absence of a longer-term funding perspective for staff as a main factor undermining the likely impact of the investment.

Thirdly, the PSF panel had difficulties in assessing the NRIs' staff profiles (due to lack of detailed information) with strong indications that many of the 'researchers' reported as operating NRI equipment for users were in fact doctoral students. This is neither sustainable nor appropriate as they should be pursuing their doctoral research not operating NRI services. Moreover, the call for NRI projects required that applicants should recruit as least ten post-doctoral researchers. However, the NRIs reported to the panel that they were not able to recruit the required managerial and technical staff to operate and develop the facilities. Most coordinators underlined that to sustain NRI development beyond the preparatory phase, the next funding round should enable the recruitment of dedicated personnel to operate and maintain equipment and a core management team covering key functions (director, finance, business development, marketing and public relations, etc.).

Overall, the recruitment by the NRIs of a significant number of researchers (partially funded in many cases) places a strain on the NRIs' capacity to sustain this employment; while the NRIs have not, as a rule, been able to recruit the core staff and RI management teams that should be operating the facilities and ensuring provision of services to researchers, businesses and other users. This points to a certain 'mission drift' with the NRI employees

[106] European Commission (2022). Ibid.

operating as ‘research teams’ working on research projects rather than as providers of research services to users.

3.4. Impact on enhanced cooperation within the Greek research system

A main aim of the NRI initiative was to ensure that past public (national and European funds) investments (in both facilities and human resources) in research facilities and e-infrastructures in Greece was capitalised on by reducing the fragmentation of related scientific resources and equipment distributed across the Greek universities and research centres. The 2014 Roadmap underlined the need for “a culture of sharing expensive scientific equipment and e-infrastructures” and “to shape a Greek R&D ecosystem around nuclei of excellence with considerable capacity and the need for conducting applied research in a competitive, state-of-the-art, internationalised environment”.

The PSF panel reviewed the governance and management structures of the 28 NRIs and concludes as follows:

- In terms of governance models, almost all NRIs operate based on consortium agreements, which are varied in terms of both sophistication (e.g. a variable use of international or industry/user advisory boards) and ambition. As noted above, the NRIs that are most aligned/connected with ESFRI or other European level RIs tend to have more robust and (approaching) ‘state-of-the-art’ governance models.

- The distributed RI model adopted by the vast majority of NRIs has been important in reinforcing the credibility of ‘smaller’ and ‘regional’ university/research centre teams participating in NRIs with respect to (business) users and to providing all users with a better overview of available equipment and expertise nation-wide (and not just in their immediate vicinity). This has enabled progress towards the objective of enhanced utilisation of existing scientific equipment and infrastructure as well as optimising new investments within the distributed RI (avoiding duplications, fostering critical mass).

- A small minority of the NRI project consortia are not functioning as cohesive partnerships. These tend to be cases where the decision to merge projects during the selection phase was ‘imposed’ but also concern projects where the NRI functions more as a consortium of researchers working on distinct ‘projects’ rather than providing services to users.

The consortium model has, in the main, sufficed during the preparatory phase, but will be sub-optimal for the long-term sustainability of the NRIs. Further efforts are required to ensure a transition from consortium-based projects to fully fledged NRIs operating as single legal entities with a single set of policies towards access, IP, financial management, HR issues and so on. There are at least three arguments in favour of creating a single legal entity for each NRI:

- As noted above, the capacity for the NRIs to position themselves strategically in EU-level RIs or projects is reduced or compromised by the lack of a single legal entity.

- From a user perspective, particularly businesses, the advantage of access to a ‘distributed set’ of equipment and services is considerably reduced by the requirement to access (and pay) for services via the individual partners of each NRI.

- The core staff of the NRI should be ideally ‘independent’ of the institutions hosting the equipment and providing services, enabling them to manage the NRI in a neutral

fashion with respect to all partner institutions, but also to guide users to the most appropriate researcher/technical expert able to respond to their needs.

3.5. Contribution to S3 priority areas and regional development

The NRI programme has contributed to a structuring of research (and to a lesser extent innovation) capacity, in important domains for Greek scientific and economic specialisations and future socio-economic development. The panel does not have the remit or resources to assess whether there are gaps in NRI coverage, with respect to the national R&I priorities, particularly as some apparent gaps might in fact be filled by research centres or institutes funded through other mechanisms.

The extent to which NRIs have developed effective strategies for identifying and engaging with their (existing and prospective) user base varies. Similarly, there is a variable geometry in the sophistication of service catalogues, development of service level agreements (SLAs), costing and pricing practices and access policies (by type of service, by site). Indeed, many NRIs do not yet have in place a single centralised point of access for users. As the NRI survey confirmed, the focus of the NRIs is currently on serving the needs of researchers from the NRI partners and from other universities. About half of the NRIs consider start-ups, SMEs and large companies, along with researchers, as the most important user groups. However, the NRIs self-assessment of the 'maturity' of their capacity to support business innovation and regional development was that it can be improved.

It is too early to assess the full impact in terms of enabling scientific excellence, supporting business innovation or addressing societal challenges. However, the assessment of the 28 NRIs (see sections 2.1 to 2.6) identified promising examples of all three types of impacts.

Enabling science

- A substantial improvement in access for researchers to state-of-the-art equipment, facilities, data and services has been achieved. Despite the need for further development of access policies for users, the NRIs have begun to provide access to equipment, facilities and data platforms with related services and software for researchers. NRIs have tested pilot actions to promote access and have taken inspiration from the EU-level transnational access processes. At the same time, the data on usage remains limited and responses to survey questions on users suggest that more could be done to track users by category and type of service provided. Moreover, both the survey results and the interviews suggest that research data management practices require further development in line with FAIR and open science principles.

- Most NRIs report an increase in scientific output, although this requires further verification since in many cases the investment in NRI equipment and facilities is too recent to have yet fed through into an increase in journal articles. The panel's assumption is that much of the reported publications have been in the pipeline for the researchers involved in the NRI project rather than being directly attributable, at this stage, to the NRI project. The issue of appropriate indicators of scientific output will be addressed further in the recommendation sections below.

- In line with the priority to help tackle the brain drain of researchers, skills enhancement of (young) researchers via training and capacity building actions has been a focus of activities for the majority of NRIs, with promising results reported. Almost 90% of NRIs provide training services (according to survey responses), although the nature of the reported services varies from ad hoc workshops to more structured training courses

aimed at users. In the future, there is a rationale for certain training courses to be delivered at a cross-NRI level, e.g. in research data management, data analytics, etc.

- The NRI investment has enabled several the NRIs to deepen their engagement with or develop new cooperation with European (ESFRI RIs) and international partners helping to enhance the visibility of Greek research excellence capabilities and expertise.

Problem-solving and fostering innovation

- There remains significant scope for increasing the use of NRI services, and thereby their impact, by businesses and other user groups (public sector, NGOs). Income generation to date from non-grant-based sources has been very limited (in part due to State Aid rules on income generation and recovery[107]) with only four NRIs reporting own revenue from services in response to the survey.

- There is proven interest from business (survey results and interviews) to access the NRIs' equipment and expertise. However, the actual use remains limited and NRIs need to further reinforce their (human) resources and the expertise required for effective business engagement (including IP management policies, etc.). Examples of NRIs working with spin-offs and established businesses provide encouraging pointers for the future. There is also a potential to develop industrial research data platforms.

Shaping science and society interactions

- There is a good potential for the NRIs to contribute in the future to supporting citizens' understanding of science (on topics such as food authenticity, link between health and food, the importance of preserving Greek biodiversity, etc.) as well as enhancing the access of all (citizens, businesses, public authorities, media, etc.) to data and digital resources resulting from the activities of the NRIs on environmental monitoring, historical and cultural collections, transport and logistics tracking, etc.

- There has been an effort by the NRIs to develop and broaden 'communities of practice' in their field of activity within Greece, starting with the researchers from the NRI partners but extending to other researchers and users of the NRI. Examples include work done to develop a synthetic biology plan and community as well as NRIs working to promote topics such as personalised medicine.

- The bottom-up collaboration by the main Greek research centres and universities involved in the NRIs in promoting an open science agenda is one example of efforts that are being made to promote changes to research practices. While the open science agenda is well promoted, there remains a need for further steps to embed FAIR data and open access into publication processes. The NRIs can help reinforce this trend by aligning their data management policies with European-level best practices.

[107] See Article 26 of the Commission Regulation (EU) No 651/2014 of 17 June 2014 declaring certain categories of aid compatible with the internal market in application of Articles 107 and 108 of the Treaty. ELI: http://data.europa.eu/eli/reg/2014/651/2021-08-01 Specifically: "Where a research infrastructure receives public funding for both economic and non-economic activities, Member States shall put in place a monitoring and claw-back mechanism in order to ensure that the applicable aid intensity is not exceeded as a result of an increase in the share of economic activities compared to the situation envisaged at the time of awarding the aid."

4. Recommendations for the future development and sustainability of the Greek NRIs

The Panel's recommendations are formulated with a view to ensuring that investment in the creation of NRIs during the 2014-2020 phase is optimised in the 2021-2027 period, and that the NRIs are put on a footing of long-term sustainability that fosters scientific excellence while contributing to meeting socio-economic and societal challenges. The recommendations are made in the context of the adoption of the new Operational Programme for Competitiveness in June 2022[108]. The OP Competitiveness 2021-2027 plans a further round of support for NRIs (expected to be of the same order of magnitude as in the 2014-2020 period). In addition, under the Recovery and Resilience Facility (RRF)[109] there is support planned for upgrading research centres supervised by the GSRI (including centres involved in the NRIs) as well as additional investment in basic and applied research, including for applied research for precision medicine, an unmanned systems R&D centre, and an applied R&D institute on artificial intelligence and data processing; as well as financial support for participation in European partnerships (namely Euro-HPC).

Recommendations on the national strategic policy framework for NRIs	Recommendations for enhancing NRI operational effectiveness
1. Adjust selection criteria for future funding of NRIs to foster transdisciplinary co-operation and the consolidation of the NRI landscape and ensuring that the NRIs mission is aligned with core aim of enabling user access. 2. Put in place a medium-term funding framework, including a performance-based element; that encourages NRIs to further develop their business case and favours sustainability. 3. Update the national RI strategy and roadmap, including policy guidelines on open science and digital and data infrastructures, and ensure a continuous dialogue on and monitoring of the RI landscape (strengths/gaps/needs). 4. Adopt a set of key performance indicators that reflect the specific role of the RIs in the national R&I system. 5. Support co-operation of the NRIs with ESFRI and EU RIs as the benefits for the NRIs are significant with respect to the organisation of access services, cost models, uptake of EU funding, etc.	1. Establish a NRI coordination and technical assistance unit to provide support services and training to NRI staff. 2. NRIs should adopt a legal form that guarantees an effective financial and operational management. 3. NRIs should have a dedicated core staff responsible for the overall strategic and operational management including transparent access policies. 4. Enhance open science and FAIR data management capacities of the NRIs 5. NRIs should reinforce their capacity to engage with and deliver services to industry and societal user

Box 4. Overview of the PSF panel recommendations

These recommendations build on and signpost the reader towards international best practices and guidelines (from the European Commission, OECD, etc.) on the management and operation of RIs. Several boxed examples are provided to illustrate.

[108] See: http://www.antagonistikotita.gr/epanek_en/events.asp?cs=21
[109] See: https://greece20.gov.gr/en/

4.1. Strategic (policy) recommendations

The recommendations concerning the strategic policy framework for the NRIs are designed to provide a schedule of actions to be taken over the coming five years (2023-2027) with a view to further developing and reinforcing the sustainability of the portfolio of Greek NRIs.

4.1.1. Adjust selection criteria for future funding of NRIs to foster transdisciplinary cooperation and consolidation of the NRI landscape

The PSF panel recommends a continuation of public funding for a portfolio of NRIs in Greece. Assuming a total budget of approximately EUR 100 million for NRIs under the new OP Competitiveness, the panel further recommends that no more than 20 NRIs should be funded during the current programming period and that funding is awarded for a five-year period with an interim performance review, based on self-monitoring report, and a peer review of each individual NRI and an evaluation of the NRI policy, as a whole, at the end of the five years.

This would imply an average budget of EUR 5 million for the 20 NRIs over a five-year period (e.g. 2023-2027). However, the panel considers that some NRIs may require higher or lower budgets (e.g. depending on the type and focus of NRIs and the need for (re)investment in facilities and equipment) and expect NRIs to justify their future funding needs, as well as identifying additional sources of revenue they expect to leverage.

As there is likely to be a gap between the past and future NRI funding awards (from last quarter 2022 and during 2023), we invite the GSRI to explore options for short-term bridging funding for operational costs (staff, established services) for the existing NRIs.

The NRIs funded in the new period should be selected based on a competitive call that encourages transdisciplinary cooperation and appropriate consolidation of facilities and resources. The call should encourage the existing NRIs to identify opportunities for mergers and rationalisation, as well as leaving open the possibility for new NRIs to be formed in fields relevant for the 2021-2027 national S3 priorities or other national strategies.

The panel has identified several cases where there is greater potential for inter- and trans-disciplinary cooperation (food and health, 'omics,' environment and health, etc.) as well as the need for cross-cutting cooperation (e.g. research data platforms). NRIs should be encouraged to pre-identify such opportunities for interconnections with other NRIs.

Accordingly, the selection criteria for the next round of NRI funding should encourage 'consolidation' of and enhanced cooperation between the existing NRIs, while leaving space for (a small number of) new NRIs to emerge.

Further, the panel proposes a set of criteria that updates and develops those used during the selection of the existing 28 NRIs, taking account of the lessons from this review and the lifecycle stage of the NRIs.

NRI governance and management (20 points)

- Credibility of the legal structure adopted/proposed (single legal entity, consortium) and possibility to centralise access, financial management, procurement, etc.;
- Structure and expertise of proposed NRI management team (including technical staff

managing facilities and equipment);

- Governance structure and strategic planning process (role of international advisory board, inter-disciplinary plans, involvement of users in guiding NRI strategy, etc.);

- Feasibility and quality of the NRI financial and investment plan covering a five-year period including estimates of capacity of partners to co-finance certain costs, plans to leverage additional public funding or generate (commercial) revenue, expected capacity and occupancy rate, and costs charged to users.

NRI operation and services (30 points)

- Importance of the proposed NRI project for science in the national context, this aspect will be evaluated in light of the updated national roadmap and developments in the relevant research field(s), but also in relation to possible alternatives nationally (In other words, does the proposal lead to a nationally unique/leading infrastructure?);

- Clearly defined set of services available to different types of users (scientific, business, government, etc.);

- Estimated number of users (internal to consortium partners, external by type) and outline strategy to attract new users;

- Clear access policy (who can do what and when); including a procedure for submitting and evaluating access requests (based on excellence or broad access policy);

- Capacity/limits for users outside the applying consortium, broken down into types of users (scientific, industrial, etc.);

- Cost and pricing policies (cost/price of access, for different services, by user type);

- IT capacity and infrastructure including inclusion of IT costs in the budget and guarantees for the cloud/HPC capacity required (e.g. from GRNET);

- A data management strategy defining how they will implement FAIR (Findable, Accessible, Interoperable and Reusable) data management principles (e.g. data stewards, repositories) and ensure interoperability with other NRIs and with ESFRI RIs;

- Ethics and gender equality plans.

Internationalisation strategy (20 points)

- Importance of the proposed NRI for science in a European or international context and the uniqueness of the proposal (in relation to possible 'competitors' abroad);

- To what extent does the proposal lead to an internationally unique/leading infrastructure and strengthening of the Greek position;

- Degree of alignment with the long-term strategy of the international research field (Horizon Europe, ESFRI, Sustainable Development Goals, etc.).

NRI potential impact for national priorities and users (30 points):

- Potential impact of the RI services on scientific users in the field targeted (by main type of service, including training) and notably on improving Greek scientific excellence;
- Potential impact on other scientific fields (from cross-disciplinary and collaborative activities);
- Potential impact of generated data via exploitation (data platforms, etc.) and reuse;
- Potential impact on business users, notably with respect to specific target business users in defined S3 priority sectors);
- Potential impact on other users (public sector, education, citizen science and public awareness).

Box 5. Proposed criteria for the selection of NRIs for funding 2021-2027

In line with the recommendation on a clearer strategy for European engagement, the GSRI may wish to differentiate between two categories of NRIs when awarding funding:

- NRIs that mainly focus on providing services to Greek researchers and users;
- Greek NRIs with a European (ERIC membership, etc.) dimension and/or of international relevance that serve both Greek and transnational users.

The latter category may require access to funding support for European engagement, but over time may also be expected to generate increased revenue flows from participating in transnational access schemes and European RIs or attracting international users.

In line with international practice (see Section 1), funding for research equipment installed in universities or research centres that serves 'localised' needs should not be eligible under the NRI programme. Such infrastructure should be funded either out of institutional resources or via 'medium-scale' type grant scheme operating at national level, or via regional operational programmes. The landscape analysis and register of RI resources (see recommendations above) should include such institutional or medium-scale equipment to provide a comprehensive mapping of resources and avoid duplication of investment.

The GSRI should ensure that the evaluation of NRI proposals is carried out with the assistance of an international panel of experts, with experience in the priority thematic fields and/or managing large-scale or national level RIs. To this end, proposals should be submitted in English. A two-step procedure may be envisaged to filter out consortiums that do not meet the main principles and avoid duplication or overlap in competing NRI. This could involve:

- a pre-selection based on a peer evaluation of the scientific case for the NRI (contribution to excellent science and uniqueness of the proposed NRI), followed by
- the submission of a full proposal for those passing the first stage which would be assessed based on the full set of proposed criteria.

The two-stage process would enable the GSRI, based on the recommendations of the peers, to sift out the proposed NRI that fail to pass the 'uniqueness' principle and/or to allow them to combine forces before submitting a full proposal, thereby ensuring a strategic prioritisation of the pre-selected NRIs.

4.1.2. Develop a medium-term, performance-based funding framework for NRIs

The long-term sustainability of the NRIs requires a revision of the funding model to:

- Offer NRIs, at least, a five-year period of funding enabling them to plan investments and development of services in an effective manner. The level of funding and type of eligible expenditure provided to NRIs could be differentiated by type of NRI (as in the Dutch and Flemish models) and/or depending on their lifecycle stage: well-established (mature) NRIs moving into an operational growth phase and/or requiring further upgrading, NRIs that have a potential for growth but that need to complete their preparatory phase, etc.

- Provide government funding to NRIs that includes sufficient cost coverage (investment and operating costs) and ensures continuity of operations and staffing without interruption (e.g. from one funding period to the next). In return, a requirement could be made for participating organisations to cover a share of costs (as is the case in the Netherlands) or the share of operating costs covered could be reduced over time.

- Add a performance-based element to the funding that incentivises NRIs to develop and implement a business case for obtaining additional income from other public programmes (national, regional and European) and generating revenue from service provision to users (businesses, public sector bodies, etc.). A share of the agreed funding would be dependent on the NRI meeting or exceeding agreed performance targets.

- Enlarge the type of costs eligible for support to better reflect the nature of NRI operations and match expected outcomes (e.g. business or international engagement).

Dutch Large-Scale Research Infrastructures (LSRI) funding model[110]

The Dutch Research Council (NWO) runs several schemes aimed at developing RI aimed at investments of varying scale and importance.

- Investment Grant NWO Medium scheme encourages Dutch universities, research institutes and scientific libraries to invest in innovative scientific equipment or data collections of national or international importance. It is intended for the purchase of equipment and the establishment, linking, and enrichment of data collections. The NWO-funded share has an upper limit of EUR 500,000 and a lower limit of EUR 110,000. The obligatory co-funding is at least 25% of the costs of the total investment.

- The Research Infrastructure National Consortia scheme funds applications submitted by one (or more) institution(s). However, the goal is to develop a nationally supported RI with the involvement of and access to a broad range of relevant researchers in the Netherlands. It is a starter fund for the RI not a subsidy for research and results exploitation. Applying institutions pay 25% of the set-up cost. In 2021, NWO invested

[110] See: Dutch case: https://www.nwo.nl/en/calls/large-scale-research-infrastructure-lsri-national-roadmap-consortia-2021

EUR 20 million in seven projects. Calls are organised every two years.

- The third scheme supports LSRIs used to conduct research and promote innovation in respective fields. Where relevant, the infrastructure can also be used for other purposes than research, for example education or public services. LSRIs can be single-sited or distributed.

The distributed LSRIs must:

- provide one central access point for researchers and external organisations, even if the infrastructure is spread across multiple locations,
- have one management board responsible for the entire infrastructure, and
- have a legal structure.

The size of the LSRI, in terms of total capital investment and running costs for five years, amounts to at least EUR 10 million (NWO share). The applying consortium must contribute at least 25% of the total project budget (NWO-contribution + own contribution). Funding can be requested for a period up to ten years. Within the total investment, a distinction is made between capital investments and running costs. The following cost categories are eligible: investments, IT costs, Dutch membership costs of an international research facility or an international research project, material costs, and personnel costs. The running costs pertain exclusively to the costs needed to make the infrastructure operational and accessible. In other words, they do not include the costs for the research programme.

Czech Large Research Infrastructures (LRI)

To ensure sustainability, the Czech LRI programme provides funding via the State budget mainly for operational costs and co-supported by ERDF funds for investment. The funding of operational costs covers:

- Personal costs – management, researchers and technicians operating the large research infrastructure;
- Operating costs – materials, energy, services (sub-contracts), international mobility, overheads (flat rate/full-cost), etc.;
- Membership fees – participation in international research infrastructure networks and legal frameworks (ERIC, etc.).

The basic interventions of the Czech Operational Programme Johannes Amos Comenius (OP JAC)[111] include in the R&D part (Priority 1):

- strengthening strategic and smart RDI policy management competencies and supporting innovation ecosystems at national and regional level;
- strengthening the internationalisation and development of the institutional environment

[111] https://opjak.cz/en/

of research organisations, strengthening excellent research teams;

- strengthening the cooperation between research organisations and the application sphere, strengthening the applicability of RDI results, and strengthening the orientation of research in research organisations towards areas with a high potential for applicability in practice;

- strengthening the key infrastructure needed for excellent research[112].

The Flemish funding framework for research infrastructure (Belgium)

Flanders has three different scales of intervention in favour of RIs:

- Medium-scale research infrastructure: defined as research infrastructure with a total financing cost of at least EUR 150,000 and at most EUR 1,000,000 (including VAT). This programme is managed in cooperation with the knowledge centres.

- Large-scale research infrastructure: defined as those with a total financing cost of at least EUR 1,000,000 (including the non-refundable portion of VAT). This programme foresees the establishment (acquisition or development) of large-scale research facilities.

- International research infrastructure (IRI) programme: supports the Flemish participation in and/or funding of international investment initiatives carried out at large-scale international or supranational facilities to which the Flemish government contributes and/or whose strategic importance for Flanders can be demonstrated. Within this programme long-term sustainability is guaranteed. Renewal of the contract is foreseen if the output of the past period and the workplan for the future period are evaluated to be of high quality.

The Flemish government (via FWO) funds infrastructure, upgrades, operational costs, personnel (technical staff, scientific), coordination costs (facility management and co-ordination) and access costs.

The IRI subsidy finances equipment, personnel, institutional, operational and logistic costs:

- Equipment: costs for research investments, notably costs for the acquisition or building and connection of (components) of the IRI, and for substantial upgrades, including the non-recoverable portion of VAT;

- Personnel costs for the development, construction or building of the IRI. This also includes personnel costs for upgrading the IRI and costs for operating or maintenance personnel once the infrastructure is up and running;

- Operational costs such as maintenance costs throughout the depreciation period, notably costs arising out of maintenance contracts or upgrades of the international

[112] A significant part will be support for developing the infrastructure equipment of so-called large research infrastructures that are open by their operators to all potential users on the principle of open access and are thus an important basis for R&D&I in CZ as well as drivers of regional development.

research infrastructure and equipment repair costs, coordination costs arising out of the multilateral nature including coordination costs to establish partnerships between international projects, institutional costs such as contributions and commitments entered into under international cooperation agreements and being a condition precedent for participation, and logistic costs that are necessary to carry out research at international research facilities, such as the accommodation of researchers.

The ESFRI (or other types of European or inter-governmental RIs) membership fee is paid by the Belgian Federal Science Policy Agency (BELSPO).

Box 6: Examples of national RI funding models (Source: authors based on cited references and websites)

Moreover, national rules governing public procurement[113] for scientific research organisations should be reviewed and updated to take better account of the need for sufficient flexibility for NRIs (and other research performing organisations) to procure equipment, services, and consumables in a timely manner in response to the needs of researchers conducting experiments, which may not be predictable in advance. A review of practices in other EU Member States' research funding agencies may also inform future changes to the Greek procedures. Nordic countries, France and Latvia are the best positioned and could be used as inspiration to create a more flexible framework in Greece for research-related procurements.

[113] According to the Single Market Scoreboard Greece's performance on public procurement in 2020 was unsatisfactory overall. See: https://single-market-scoreboard.ec.europa.eu/policy_areas/public-procurement_en

4.1.3. Undertake an RI landscape study and update the national RI roadmap

The Greek authorities (GSRI in consultation with other relevant ministries and agencies) should update the national research infrastructure strategy and roadmap to provide a strategic and longer-term (e.g. 2030) framework for investment. In an ideal world, the roadmap and process would follow a sequential process starting from consultation on the priorities from a scientific excellence but also socio-economic perspective (building on the consultation already undertaken for the first cycle of the RIS3 'entrepreneurial discovery process'), a landscape analysis, selection of proposed NRIs, and then implementation (funding, monitoring, evaluation) as set out in the diagram below[114].

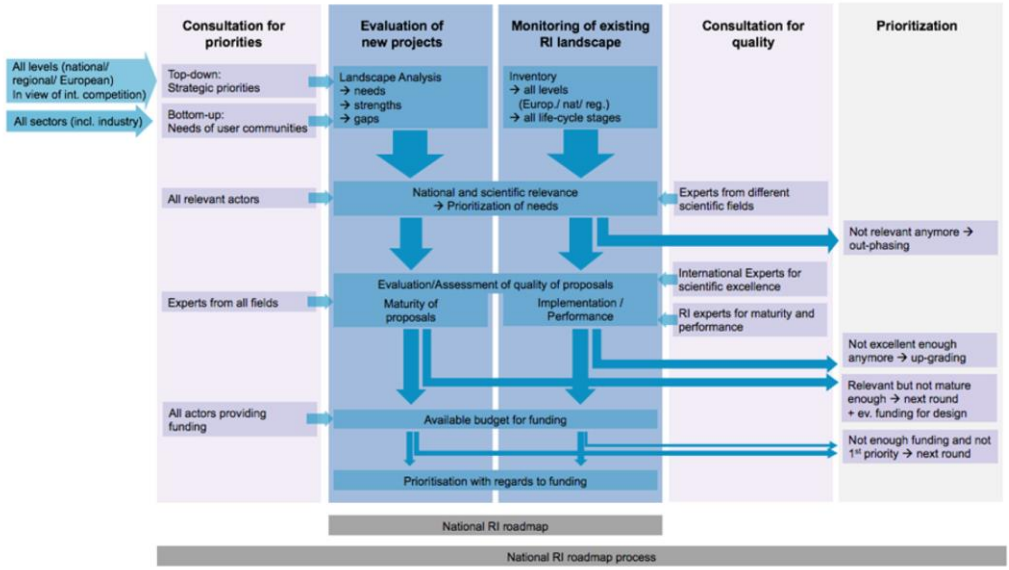

Figure 57. Best practice framework for national RI road map process (Source: InRoad (2018))

We have already highlighted in the previous recommendation the need to avoid an extended gap in funding for the NRIs and the national priorities defined by the previous and new S3 strategy have not radically changed. Moreover, as reviews of RI roadmap processes have highlighted[115], many countries adopt variants on this process that have proved effective. The following steps in the process are therefore recommended:

- The call for expression of interests and for full proposals for NRIs should constitute the basis for an initial selection of RIs to be included in an updated roadmap. As part of the application process, the universities and research centre included in the proposed NRI consortia should be invited to provide an updated list of facilities, equipment, resources (collections, etc.) and services as a first step in a landscape analysis.

- As early as possible, and no later than the second half of 2023, a comprehensive landscape analysis should be launched that provides a detailed mapping of RIs of different scale (regional, national, national of European/international importance) and

[114] See: Ruecker et al. (2018). Best practices and common trends of national research infrastructure roadmapping procedures, Monitoring and Evaluation mechanisms including recommendations. InRoad Deliverable 3.4 (https://doi.org/10.5281/zenodo.2349868

[115] See the country analysis and policy report at https://www.inroad.eu/

funded from other sources (RRF, Regional OPs, existing large facilities in research entities supported by the regular budget etc.) per thematic priority field. The landscape analysis should include an assessment of the potential for enhanced cooperation between RIs operating in different thematic fields[116].

- The landscape analysis then informs both the longer-term RIs planning (e.g. proposals for future investment in identified needs or gaps) and provides data needed for the development of a NRI registry. The registry serves both for planning future investments (by RIs and the funding bodies) as well as providing the basis for developing an online national catalogue of equipment and service.

A useful list of guiding questions for selecting and managing a portfolio of national RIs has been proposed in an OECD policy paper summed up below.

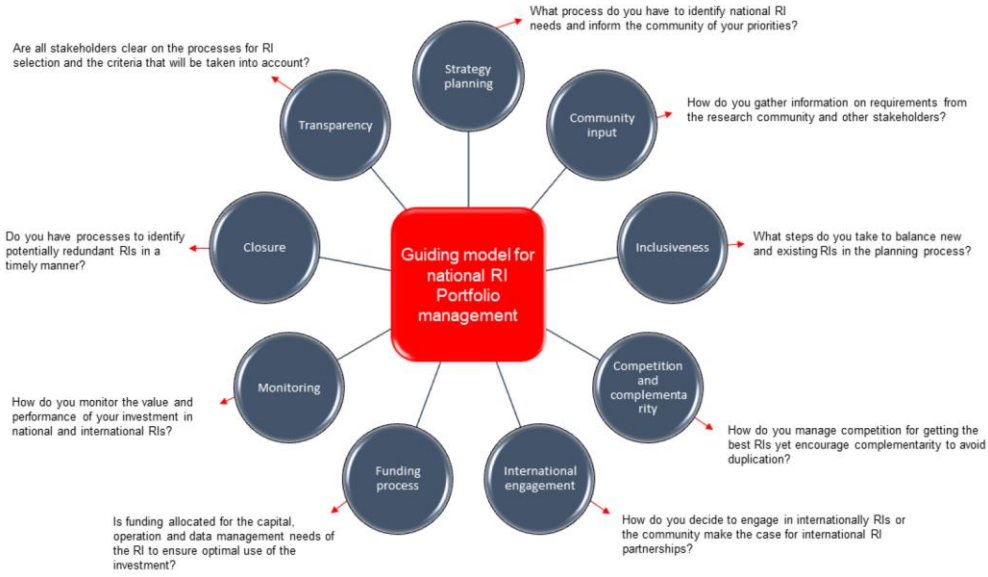

Figure 58. Key questions guiding the management of a portfolio of national RIs (Source: OECD (2020))

4.1.4. Align the NRIs with ESFRI RIs and promote NRIs at international level

The strategic position of Greek NRIs in European R&I partnerships, intergovernmental RIs (CERN, etc.) and ESFRI projects/landmarks should be further enhanced (in conjunction with recommendations in the updated national RI roadmap). This requires additional financial means (membership fees and for recruitment of qualified human resources) enabling active participation in the relevant European/international RIs. As noted above, most EU countries do provide funding as part of the operational budget for such costs.

The panel is aware that the Greek national budget for funding participation in ERICs or intergovernmental RIs is limited, and that ERDF funding may not be used to pay membership fees for ERICs. At the same time, according to the GSRI, the funding allocated

[116] See, for example, section 2 of the 2021 ESFRI landscape analysis: https://roadmap2021.esfri.eu/landscape-analysis/

to RIs under the new OP Competitiveness will also be used to co-finance successful Greek projects under Horizon Europe.

The limited 'own budgetary' resources reinforces the need for a strategic framework for Greek participation in European/international RIs. The selection criteria for NRIs allied to the landscape analysis and the updating of the roadmap should provide a basis for a consensus on the Greek priorities.

The NRIs should be required to develop, as part of their strategic business plan, an internationalisation strategy which would provide further evidence for selecting those NRIs to be considered Greek 'flagships' on a European level. The NRIs should be invited to make explicit the expected return from membership (e.g. opportunities to access additional European funding, expanding user base, etc.). The European/international connections of the NRI may also generate benefits for Greek businesses, as providers of technologies and services to European and international RIs (indeed this was already highlighted in the case of DETANET). Such an assessment of the 'return on investment' will help justify a national budget for membership fees or international engagement activities by the NRIs.

4.1.5. Adopt a set of key performance indicators that reflect the specific role of RIs in the national R&I system

The brief for this Review called for "recommendations for indicators to be used for monitoring and evaluating the National RIs, including international benchmarking". During the period reviewed, the monitoring of the NRI project implementation was supervised by the EPANEK management authority, which concerned both financial control and certification, support from staff experience with research project management, and on-site verifications by external experts.

However, the only KPIs applied by all NRI were the ERDF common indicators concerning researchers. The GSRI collaborated with the EPANEK MA on the supervision of the NRI projects, but there was no evidence of a harmonised process or broader set of KPIs applied to monitoring the development of the NRIs. Indeed, the PSF panel's questionnaire was welcomed by NRIs as a first opportunity to conduct a 'self-assessment'.

The panel recommends the establishment of a monitoring and evaluation framework that serves a dual purpose:

- the management of the NRI portfolio at a strategic policy level, including reporting to the government on the contribution of the NRI to national priorities; and

- a tool to steer the development of the NRIs in the ideal direction, where new (with respect to current framework) and relevant indicators are introduced and monitored; and as an operational management tool for NRIs to assess their own progress.

At the same time, the monitoring and evaluation framework should avoid adding a burden of reporting to the NRIs and be formed by a mix of qualitative methods and selected KPIs that reflect progress toward meeting the goals set by the NRI for their own performance and sustainability and their contribution to national policy objectives.

Accordingly, it is recommended that:

- As part of the application process, the NRI should be requested to select a number of KPIs (from an agreed long-list) that best help them track their performance and progress

towards the objectives they set (e.g. proportion internal/external users, public research/commercial users, income generated from services to users, number of scientific papers from users citing the use of the RI, additional public funding including regional national and EU grants, centralised access system, catalogue of services, links with EU RIs, etc.) and set their own targets;

- NRIs should provide an annual update on their selected KPIs to the GSRI as part of an annual progress review procedure and complete a self-assessment progress form;

- All NRIs should be required to appoint an external advisory board (most have done so already) and this advisory board should provide a mid-term and final assessment of the NRI using an agreed assessment form (which could be inspired by the PSF panel's original questionnaire) to be submitted to the GSRI;

- A mid-term evaluation of the NRIs progress should be conducted by an external evaluation committee (a chairperson, rapporteur and at least three experts per thematic field) using the annual KPI data, self-assessment and NRI external advisory board assessments as well as conducting panel meetings with NRI management;

- A final impact evaluation should be conducted at the end of the five-year period which would adopt the same process as for the interim evaluation complemented by a broader impact assessment with a focus on the contribution of the NRIs to the S3 priority sectors as well as other national priorities (e.g. climate crisis, energy transition, resilience etc.).

In terms of indicators, these should draw on, adapting as required, the frameworks developed in other countries (see Czech example in box below), the ESFRI[117] RI KPI monitoring framework, and the RI-PATHS methodology for socio-economic impact indicators. The ESFRI KPIs have been applied by several of the NRIs, such as OMIC-Engine which has developed a good set of KPIs and targets that can serve as an example for other NRIs.

- Number of user requests for access
- Number of users served
- Number of Master students using the RI
- Number of PhD students using the RI
- Number of user R&D results
- Number of user publications
- Number of operator R&D results
- Number of operator publications
- Number of publicly available data sets

[117] See: https://www.esfri.eu/latest-esfri-news/report-esfri-working-group-monitoring-ris-performance

- Number of commercial users
- Income from commercial users
- Income from non-commercial activities

Box 7: Example of key performance indicators for NRIs (Czech Republic case)

As outlined in the ESFRI guidance, it is important to track not only quantitative KPIs but also to identify and monitor qualitative KPIs. For instance, under the ESFRI KPI category enabling scientific excellence, a quantitative KPI such as the 'Number of publications based on the research performed using facilities/resources of the RI' can be complemented by impact cases which provide a narrative explanation of the added value of the RIs contribution to science (and similarly on businesses or societal challenges, etc.).

4.2. Recommendations on the future operational models for NRIs

4.2.1. Establish a NRI coordination technical assistance unit

A dedicated national-level NRI technical assistance unit (TAU) should be established (within GSRI or via a procurement contract) and adequately resourced (staff, operational budget). It would have the mission to manage the portfolio of NRIs, including developing a 'brand identity' for the NRIs, support for the design and roll-out of access policies and operating standards, service protocols, development and promotion of a one-stop-shop catalogue/register of NRIs services and facilities, etc.

In Spain, the Deputy General Directorate for Large Scientific and Technical Infrastructures (Ministry of Science and Innovation) is the responsible unit for strategic planning, coordination, monitoring and representation of the – equivalent to Greek NRI – Unique Scientific and Technical Infrastructures[118] (ICTS, Infraestructuras Científico-Técnicas Singulares, in Spanish).

The unit is also responsible for managing investment programmes co-funded by European funds for the ICTS. It coordinates the international representation of Spanish NRI at ministerial level.

The unit elaborates and updates the so-called Map of Unique Scientific and Technical Infrastructures[119] where the granted infrastructures are included. Being part of the Map brings visible brand recognition (ICTS are allowed to use the logo) and regular access to dedicated funds for developing their individual strategic plans. By means of the Map, the State and the regional governments coordinate policies and funding for ICTS development. On the unit webpage there is a map-based catalogue118 of RIs with access information and links to each RI access point.

Box 8: Coordination structure for the Spanish ICTS research infrastructures (Source: authors based on references cited)

[118] See https://www.ciencia.gob.es/en/Organismos-y-Centros/Infraestructuras-Cientificas-y-Tecnicas-Singulares-ICTS.html
[119] See https://www.ciencia.gob.es/dam/jcr:118a1517-94b7-4e09-9a01-ce488d741af2/

Moreover, the professional development of the NRI staff (management, technicians, researchers) could be fostered via a dedicated training programme organised centrally by the NRI TAU (in addition to the thematic or transdisciplinary or NRI-level training organised by the NRIs themselves aimed at their own staff and users).

For the development and updating of the 'catalogue/register' of NRI services, the landscape analysis (see strategic recommendations above) should provide input for the development of an online portal of research infrastructures and equipment that constitutes a catalogue of services. In the Dutch case, the same process was used to develop an online platform presenting the LRIs[120]. A more ambitious model would involve developing a catalogue building on and aligning with the technologies and methods adopted by the EOSC portal catalogue and CatRIS[121] catalogues (to which Greek experts from Athena contributed extensively). This would enable Greek NRI services to be promoted internationally as well via the EOSC catalogue.

The NRI TAU would be responsible for managing and monitoring the KPIs and collecting periodic data of NRI performance to feed into the mid-term peer reviews and final evaluations of the NRIs.

4.2.2. Foster the transition from a consortium to single legal entity model for NRIs

The issue of shifting from a consortium model to a single legal entity was raised by many NRI coordinators as a pre-condition for the future development of the NRIs. While the single legal entity model may not fit all NRIs and some partner institutions may hesitate to join such an entity, the consortium-based approach does have a certain number of limitations, as described previously. In the current model, the funding allocated to an NRI consortium is distributed as individual grants to each partner, with 'research committees' of universities each adopting different approaches to management costs, procurement, recruitment, invoicing users, etc. As noted above, the lack of a single legal entity also complicates relations with users, the development of an RI management team independent of specific partners, and participation in EU projects, etc.

In the Greek legal system, the option to adopt a not-for-profit structure exists and has been used in the past. An example in the science field is OpenAIRE, a non-profit partnership (AMKE) incorporated under the provisions of Greek Law (Articles 741 onwards of the Greek Civil Code and Law No 4072/2012) which is composed of members from across Europe[122].

[120] See: https://onderzoeksfaciliteiten.nl/
[121] See: https://www.portal.catris.eu/home
[122] See: https://www.openaire.eu/members

Various models of legal entities exist when it comes to national RIs, such as the European XFEL GmbH (Germany), the Diamond Light Source Ltd (UK), IMEC and other Flemish strategic research centres (constituted by inter-university consortia). In the Netherlands, RIs are often formed as a charitable foundation, which provides tax advantages.

In most of these cases, the 'shareholders' are the partner organisations who appoint a board. This structure can be applied in either an all-encompassing way, with the not-for-profit organisation owning the RI equipment and employing the staff, or it can be used in a very lightweight way, with the organisation having few assets of its own but entering into agreements over the supply of staff, services and equipment as in-kind contributions from its partners.

Box 9: Legal structures of national RIs

All NRIs that receive additional funding should be required to either create a single legal entity (or be in the process of creating one at the time of submission for funding) or to explain how they will operate as a consortium while ensuring a single central point of user access and financial management (procurement, accounting and invoicing system), as well as how they will manage participation to European programmes and ESFRI RIs.

4.2.3. All NRIs should have a dedicated management team

All NRIs funded during 2021-2027 should have in place dedicated management teams that ensure the overall management and development of the NRI and the effective operation of all non-scientific services (procurement, marketing of RI services, finance, HR, IP, etc.). The management and technical team should be separate from (and additional to) the scientific research/teaching staff of the partner organisations. The funding provided to NRIs for staff should not be used for standard research activities, which can be funded out of other EU/national project budgets or institutional funding, but rather for staff dedicated to managing and providing NRI services, from managers and technicians to academic, industrial, etc. users.

The exact composition of the management and technical staff will depend on the structure and mission of individual NRIs but would normally constitute at a minimum:

- NRI managing director
- Technology/Facilities Manager
- Financial officer
- Facilities/equipment operator(s) (technicians)
- Data scientist(s)/analyst(s)
- Industrial liaison officer (with expertise in intellectual property and technology transfer)

The exact number of staff and their status (full-time, part-time) will depend on the scale and user demand for each NRI, as well as the financial resources mobilised. However, the managing director and the facilities manager should ideally be full-time positions. The managing director's function is critical as he/she will be the public face of the NRI and responsible for communicating the mission, activities and results of the NRI with partners and funders. He/she would also be the interface between the management team and the

NRI supervisory board, etc. The managing director may be supported by and work with a management board (e.g. a representative of each 'node') and a scientific director.

Ideally, all staff should be hired by the single legal entity or seconded from partner organisations. As a sign of commitment to the NRI development and sustainability, the partners could co-fund a share of the salary base (e.g. of the managing director).

As noted above, the staff of funded NRIs should be provided with standardised training packages on key skills and knowledge required to deliver services and manage an RI, via the NRI TAU, as well as through internal staff development procedures (that should be set out in their proposal for funding.

4.2.4. Strengthen capacity to engage with and deliver services to industry and societal users

The NRIs should further develop their services for businesses or other non-scientific users (e.g. public sector, NGOs, etc.) and allocate sufficient resources to outreach activities (identification and interact with user groups, etc.) and the development of business services priced at rates ensuring full cost recovery (including depreciation costs of equipment).

European level studies and projects provide a good evidence base and guidance for developing the industrial and societal functions of the NRIs. A 2018 ESFRI report[123] noted that RIs are major drivers of industrial innovation: in their construction and major upgrade phases (design, engineering, commissioning) as sources of (pre-)commercial procurements and purchasers of new high-tech components, instruments and related services; in their operation phases, as facilities serving industrial R&I, offering opportunities to remove technological barriers leading to further innovation and to generate knowledge transfer.

To develop an innovation-orientated approach, the NRIs should reinforce their organisational capacities and expertise. For instance, the ENVRIPLUS project[124] proposed a useful set of eight criteria for assessing RI innovation-preparedness that could be applied to the NRIs:

1. Organisation: Does the RI have an innovation and industry liaison organisational structure with a central innovation-services hub to educate, drive and guide RI innovation preparedness and work plans together with at least one industry-liaison expert in each RI facility or node?

2. Staff: Does the RI have at least one industry-communications expert with both scientific and commercial PR skills available to lend support to activities of the industry-liaison staff?

3. Strategy: Does the RI produce an annual innovation and industry liaison strategy as a part of or in addition to its business plan?

4. Access: Does the RI website feature an interactive entry point for industry providing one-stop-shop access to services, news and information on activities and opportunities for collaboration?

[123] See: https://www.esfri.eu/latest-esfri-news/esfri-scripta-volume-iii-now-published-innovation-oriented-cooperation-research
[124] See: https://www.envriplus.eu/deliverables/ - D18.5 – RI innovation and industry liaison preparedness roadmap

5. Governance: Does the RI maintain an active industry advisory committee made up of multidisciplinary, gender-balanced representatives of the key relevant industry and technology sectors?

6. Use cases: Doe the RI publish online success stories and use cases describing fruitful partnerships and projects with companies, particularly with SMEs?

7. Capacity building: Does the RI run regular training workshops on focused innovation topics for RI Staff, open also to private-sector engineers and managers?

8. Outreach: Does the RI publish an online programme of industry-partnering workshops and brokerage events?

Moreover, as the 2018 ESFRI report on innovation-oriented cooperation among RIs points out, there are different models for charging services to industry:

- Excellence-driven collaborative research: free access for pre-competitive research; institutions/industry may contribute (in kind) in return for a share of novel IPR; not-for-profit rates in the framework of specific agreements (e.g. joint work on key technologies relevant for a cluster/sector); public-private partnership for access in the framework of research programmes;

- Proprietary research: full actual cost charged to users (notably industry).

The NRIs should seek to further develop the services and pricing models for different types of services (e.g. analytical services, contract R&D, industrial data platforms, etc.) aimed at industrial (business) users, both those located in Greece and abroad.

4.2.5. Enhance open science and FAIR research data management capacities of the NRIs

The NRIs have advanced at variable speeds towards applying open science (e.g. FAIR data) principle and building up research data management capacities. Data management policy capacity was generally scored lower in the survey and many NRIs do not appear to have put in place the adequate policies or resources.

The Greek Open Science Plan, elaborated in a bottom-up manner by the main academic and public research institutions, provides an excellent basis and serves as a guideline for further action at both national policy level and at the level. NRIs should be required to elaborate their data policy outlining how they store data, harmonise meta-data and provide services such as data stewards, etc. It is important that NRI or thematic research data platforms (groups of NRIs) should be interoperable at the national and European level.

From a digital research perspective, the NRI HELIX has established the basis for service provision to thematic research fields, but due to limited resources has not been able to roll out fully the services and software to support other NRIs. Along with the investment in cloud computing and HPC planned via funding from the Ministry of Digital Governance, the software and data analytical services provided by HELIX Data Service will require further investment to become a cross-cutting platform supporting other NRI development, including thematic data platforms. This is in line with the European Commission’s promotion of better coordination and interconnection between thematic RIs and horizontal digital RIs.

The landscape mapping recommended as part of the updating of the national RI roadmap should address the extent to which there is a need for the further development of services to thematic groups NRIs. As was mentioned in several interviews, further work should be done to link and enable access to national open government data with data and research services provided by the NRIs.

ANNEXES

ANNEX 1: AGENDAS OF THE PSF PANEL MISSIONS

1st COUNTRY VISIT TO GREECE

28th March – 1st April 2022

Agenda

Time and location	TUESDAY, 29th March, Thessaloniki
09.00 – 11.00 AUTH - Department of Mechanical Engineering	**FuVEP: Centre of Excellence for Future Vehicle Environmental Performance** 1. Leonidas Ntziachristos, Professor, Aristotle University of Thessaloniki, AUTH 2. Grigorios Koltsakis, Professor, AUTH 3. Ananias Tomboulides, Professor, AUTH 4. Dimitrios Karonis, Professor, National Technical University of Athens, (NTUA) 5. Antonios Tourlidakis, Professor, University of Western Macedonia, (UoWM) 6. Savas Geivanidis, Associate Professor, International Hellenic University (IHU) 7. Dimitrios Kolokotronis, Teaching & Technical Staff, AUTH & UoWM 8. Dimitrios Katsaounis, PhD, senior researcher, AUTH 9. Mihalis Metaxas, Consultant, Innovatia Systems + short welcome by: Efstratios Stylianidis, professor, vice Rector for Research, AUTH **Expert Panel:** Alasdair Reid, Angel Muñoz Martín and Susana Elena Pérez **Hellenic Ministry of Development and Investments:** Louiza Papamikrouli
11.00 – 11.30	Transit to Thermi
11.30 -13.30 AUTH - Centre for Interdisciplinary Research and Innovation (Balkan Centre- Thermi)	**FoodOmicsGR: A consortium for comprehensive molecular characterisation of food products** 1. Georgios Theodoridis, Professor of Analytical Chemistry, Department of Chemistry, Aristotle University Thessaloniki, Biomic_AUTh, FoodOmics Coordinator 2. Georgios Arsenos, Professor of Animal Husbandry, School of Veterinary Sciences, Aristotle University Thessaloniki 3. Alexandros Triantafyllidis, Professor of Animal Genetics, Biology School, Aristotle University Thessaloniki 4. Stavros Kalogiannis, Associate Professor of Metabolism Biochemistry at the Department of Nutritional Sciences & Dietetics of the International Hellenic University Thessaloniki 5. Nikolaos Thomaidis, Professor Analytical Chemistry, Department of Chemistry, National and Kapodistrian University of Athens.

	Expert Panel: Alasdair Reid, Angel Muñoz Martín and Susana Elena Pérez **Hellenic Ministry of Development and Investments:** Louiza Papamikrouli
13.30 – 14.15	Break
14.15 -14.30	Transit to CERTH
14.30 – 16.30	**PROMETHEUS: A Research Infrastructure for the Integrated Energy Chain** 1. Spyros Voutetakis (CERTH) Research Director, Director of CPERI 2. George Karagiannakis (CERTH), Principal Researcher 3. Dimitrios Zarvalis (CERTH), Researcher 4. Villy Zacharopoulou (CERTH), Researcher, PhD 5. Eleni Papaioannou (CERTH), Researcher PhD 6. Elias Papanikolaou (NCSR Demokritos" - virtuallly) Research Director **Expert Panel:** Alasdair Reid, Angel Muñoz Martín and Susana Elena Pérez **Hellenic Ministry of Development and Investments:** Louiza Papamikrouli

Time and location	TUESDAY, 29th March, Heraklion / Crete
09.00 – 10.15 University of Crete / Department of Chemistry	**PANACEA: Panhellenic infrastructure for atmospheric composition and climate change** 1. Prof. Nikos Michalopoulos, University of Crete, Coordinator (*physical presence*) 2. Prof. Maria Kanakidou, University of Crete, Deputy Coordinator (*physical presence*) 3. Evangelia Tzitzikalaki, University of Crete, Scientific Project Management (*physical presence*) 4. Dr. Evangelos Gerasopoulos, National Observatory of Athens, Subproject Coordinator (*via Zoom*) 5. Vassilios Amiridis, National Observatory of Athens, Deputy Subproject Coordinator (*via Zoom*) 6. Dimitrios Balis, Aristotle University of Thessaloniki, Subproject Coordinator (*via Zoom*) 7. Konstantinos Eleutheriadis, National Centre for Scientific Research "Demokritos", Subproject Coordinator (*via Zoom*) 8. Prof. Alexandros Papayannis, National Technical University of Athens, Physical Sciences (NTUA), Subproject Coordinator (*via Zoom*) 9. Prof. Spyros Pandis, FORTH – Institute of Chemical Engineering Sciences, Subproject Coordinator (*via Zoom*) **Expert Panel:** Ilaria Nardello and Tassos Perrakis **Hellenic Ministry of Development and Investments:** Antonios Gypakis
10.30 – 10.45 University of Crete	**INNOVATION.EL: National Infrastructure in Nanotechnology, Advanced Materials and Micro/Nanoelectronics** Prof. Spyros Anastasiadis (main partner) (Director IESL/FoRTH, Prof. in

	University of Crete) **Expert Panel:** Ilaria Nardello and Tassos Perrakis **Hellenic Ministry of Development and Investments:** Antonios Gypakis
11.00 – 12.15 Foundation for Research and Technology Hellas / Institute of Molecular Biology and Biotechnology	**BIOIMAGING-GR: A Greek Research Infrastructure for Visualizing and Monitoring Fundamental Biological Processes** 1. Dr. Ioannis Talianidis, Research Director, Institute of Molecular Biology and Biotechnology, FORTH. 2. Professor Christos Delidakis, Collaborating Professor, Institute of Molecular Biology and Biotechnology, FORTH. 3. Dr. Anastasios Pavlopoulos, Researcher, Institute of Molecular Biology and Biotechnology, FORTH. 4. Dr. George Tserevelakis, Postdoctoral Fellow, Institute of Electronic Structure and Laser, FORTH. 5. Dr. Emmanouil Vergis, Institute of Electronic Structure and Laser, FORTH. 6. Mrs. Angeliki Pasparaki, Institute of Molecular Biology and Biotechnology, FORTH. **Expert Panel:** Ilaria Nardello and Tassos Perrakis **Hellenic Ministry of Development and Investments:** Antonios Gypakis
12.15 – 12.30	Break
12.30 – 13.45 Foundation for Research and Technology Hellas / Institute of Electronic Structure and Laser	**HELLAS-CH: Synergy ELI - LASERLAB Europe, HiPER & IPERION-CH.gr** 1. Prof. Demetrios Anglos (IPERIon CH.gr coordinator; Professor, University of Crete; Collaborating Faculty at IESL-FORTH) 2. Prof. Spiros Anastasiadis (Director IESL-FORTH; Professor, University of Crete) 3. Prof. Michael Tatarakis (Director, Institute of Plasma Physics and Lasers; Professor, Hellenic Mediterranean University) 4. Dr. Paraskevas Tzallas (Research Director, IESL-FORTH) 5. Prof. Stelios Tzortzakis (Professor, University of Crete; Collaborating Faculty at IESL-FORTH) **Expert Panel:** Ilaria Nardello and Tassos Perrakis **Hellenic Ministry of Development and Investments:** Antonios Gypakis
13.45 – 14.15	Transport to the Hellenic Centre for Marine Research (HCMR) by car
14.15 – 15.15	Break
15.15 – 16.30	**CMBR: Centre for the study and sustainable exploitation of Marine Biological Resources** 1. Dr. Antonios Magoulas, Research Director, RI coordinator, HCMR 2. Dr. Panagiotis Kasapidis, Manager, HCMR 3. Dr. Giorgos Kotoulas, Responsible for the bioprospecting JRA, HCMR 4. Dr. Paraskevi (Vivi) Pitta, Head of facility (mesocosms), HCMR 5. Prof. Michael Pavlidis (or Giorgos Koumoundouros), Head of facility, University of Crete

	6. Assoc. Prof. Kriton Kalantidis, Head of facility, University of Crete - FoRTH **Expert Panel:** Ilaria Nardello and Tassos Perrakis **Hellenic Ministry of Development and Investments:** Antonios Gypakis

Time and Location	WEDNESDAY, 30th March, Athens
09.00 – 10.00 Room 412 GSRI	**INFRAFRONTIER-PHENOTYPOS: The Greek Research Infrastructure for Molecular and Behavioural Phenotyping of biological model organisms for chronic degenerative diseases** 1. Prof. George Kollias, RI Coordinator, BSRC Fleming, Associated Researcher, Medical School, University of Athens 2. Dr. Dimitris Kontoyiannis, RI Co-coordinator, BSRC Fleming, Associated Researcher 3. Dr. Iannis Talianidis, IMBB - FORTH, Director 4. Dr. Piyi Papadaki, BSRC Fleming, Project Manager **Expert Panel:** Tassos Perrakis, Michele Oleo and John Womersley **European Commission:** Vladimir Manolov
09.00 – 10.00 Room 230 GSRI	**APOLLONIS: National Infrastructure for Digital Arts, Humanities and Language Research and Innovation** 1. Prof. Panos Constantopoulos, Department of Informatics, Athens University of Economics and Business & Head, Digital Curation Unit, IMIS/Athena Research Centre Coordinator, APOLLONIS 2. Dr. Stelios Piperidis, Senior researcher and Head, Natural Language Processing and Language Infrastructures Department, ILSP/Athena Research Centre, Coordinator, CLARIN:EL 3. Dr. Paris Potiropoulos, Senior Researcher, Hellenic Folklore Research Centre - Academy of Athens Coordinator, DARIAH-GR **Expert Panel:** Susana Elena-Perez and Isabel Bolliger
09.00 – 10.00 Room 1 EYD	**REPHIL: Hellenic Research Fleet / reconstruction of the research vessel PHILIA** 1. Dr. Athanassios Machias (HCMR, Research Director, coordinator of the project) 2. Prof. Emanuel Samouilides (NTUA) 3. Dr. Konstantinos Tsagarakis (HCMR, Main Researcher) 4. Dr. George Katsaounis (NTUA) **Expert Panel:** Ilaria Nardello and Jan Hrusak
09.00 – 10.00 Room 2 EYD	**PLANTUP: Upgrading the Plant Capital** 1. Assoc. Prof. Maria Halabalaki, Department of Pharmacy, National and Kapodistrian University of Athens 2. Dr. Christina Varveri, Director of Research, Head of the Laboratory of Virology, Scient. Directorate of Phytopathology, Benaki Phytopathological Institute

	3. Prof. Ioannis Trougakos, Department of Biology, National and Kapodistrian University of Athens 4. Assis. Prof. Konstantinos Aliferis, Faculty of Crop Science, Agricultural University of Athens **Expert Panel:** Alasdair Reid and Angel Muñoz
10.00 – 10.15	**Break**
10.15-11.15 Room 412 GSRI	**OPENSCREEN-GR: An Open-Access Research Infrastructure of Chemical Biology and TargetBased Screening Technologies for Human and Animal Health, Agriculture and the Environment** 1. Dr. Dimitris Kletsas, Institute of Biosciences and Applications, National Centre for Scientific Research "Demokritos", Co-ordinator 2. Dr. Theodora Calogeropoulou, Institute of Chemical Biology, National Hellenic Research Foundation, partner 3. Dr. Constantin Tamvakopoulos, Biomecical Research Foundation Academy of Athens, partner 4. Prof. Elias Eliopoulos, Agricultural University of Athens, partner **Expert Panel:** Tassos Perrakis, Michele Oleo, John Womersley
10.15-11.15 Room 230 GSRI	**HELIX: National Digital Infrastructures for Research** 1. Angelos Trakos, Project Manager, Grnet 2. Dimitris Mitropoulos, Director of Network Operation Center, Grnet 3. Ioannis Ioannidis General, Director of Athena RC, Athena Research Center 4. Donatos Stavropoulos, Research Scientist, University of Thessaly **Expert Panel:** Susana Elena-Perez and Isabel Bolliger **European Commission:** Vladimir Manolov
10.15-11.15 Room 1 EYD	**HELPOS: Hellenic Plate Observing System** 1. Dr. George Drakatos, emeritus Research Director of N.O.A. (Institute of Geodynamics), Deputy Coordinator of the HELPOS Project 2. Prof. Anastasia Kiratzi, Coordinator of the Aristotle University of Thessaloniki (AUTh) Partnership, Representative (elected) of AUTh-DG in the Steering Committee after project completion (effective Jan 1, 2022) 3. Dr. Christos Evangelidis, Manager of NOA National Seismic Network and Head of National EIDA Node, Chair of ORFEUS EIDA Management Board **Expert Panel:** Ilaria Nardello and Jan Hrusak
10.15-11.15 Room 2 EYD	**OMIC-ENGINE: Synthetic Biology: from omics technologies to genomic engineering** 1. Prof. Kostas Matthiopoulos, University of Thessaly, Coordinator of RI 2. Prof. Fragiskos Kolisis, National Technical University of Athens, Director of RI 3. Assoc. Prof. Maria Grigoriou, Democritus University of Thrace, Coordinator Hub DUTH

	4. Prof. Georgios Spyroulias, University of Patras, Hub PP Coordinator. **Expert Panel:** Alasdair Reid and Angel Muñoz
11.15 – 11.30	**Break**
11.30-12.30 Room 412 GSRI	**ELIXIR-GR: Managing and Analyzing Biological Data** 1. Babis Savakis, ELIXIR-GR Project Co-ordinator, University of Crete and BSRC 'Alexander Fleming' 2. Martin Reczko, Head of the Greek ELIXIR Node, BSRC 'Alexander Fleming' 3. Maria Klapa, Node Technical Co-ordinator, FoRTH- Institute of Chemical Engineering Sciences (ICE-HT) 4. Thanasis Vergoulis, Node Compute Co-ordinator, GRNET **Expert Panel:** Tassos Perrakis, Michele Oleo and John Womersley
11.30-12.30 Room 230 GSRI	**SoDaNet_CESSDA_GR: the Greek RI for social sciences** 1. Dr. Dimitra Kondyli, Research Director, Institute of Social Research-National Centre for Social Research (EKKE), Scientific coordinator of SoDaNet_Gr 2. Prof. Ioannis Kallas, Professor of Methodology and Informatics techniques in social sciences (retired since 12/2021), University of Aegean, Chair of SoDaNet Steering Committe, 3. Prof. Christos Papatheodorou, Professor of Social Policy and Vice Rector for Finance, Planing & Development, Panteion University of Social and Political Sciences. 4. Prof. Dimitri A. Sotiropoulos, Professor of Political Science, National and Kapodistrian University of Athens **Expert Panel:** Susana Elena-Perez and Isabel Bolliger
11.30-12.30 Room 1 EYD	**HIMIOFoTS: Hellenic Integrated Marine and Inland Water Observing Forecasting and Offshore Technology System** 1. Leonidas Perivoliotis, HCMR, Coordinator HIMIOFoTS 2. Nikolaos Mamasis, NTUA, Coordinator Openhi.net 3. George Petihakis, HCMR, EMSO-ERIC representative 4. Gerasimos Korres, HCMR, Euro-Argo representative **Expert Panel:** Ilaria Nardello and Jan Hrusak
11.30-12.30 Room 2 EYD	**Food Innovation RI: Research Infrastructure on Food Bioprocessing Development and Innovation Exploitation** 1. Prof. Athanasios Koutinas, Professor Emeritus of Food Biotechnology, Deputy Coordinator, Department of Chemistry, University of Patras 2. Prof. Vaios Karathanos, Professor of Physical Food Chemistry, Harokopion University of Athens (HUA) 3. Assis. Prof. Theofania Tsironi, Assistant Professor in Food packaging, Agricultural University of Athens (AUA) 4. Assis. Prof. Panagiotis Kandylis, Assistant Professor in Food Science and

	Enology, Aristotle University of Thessaloniki (AUTH) **Expert Panel: Alasdair** Alasdair Reid and Angel Muñoz **European Commission:** Vladimir Manolov
12:30 – 12:45	**Break**
12.45-13.45 Room 412 GSRI	**INSPIRED: The National Research Infrastructures on Integrated Structural Biology, Drug Screening Efforts and Drug target functional characterization** 1. Dr Evangelia Chrysina, National Hellenic Research Foundation (NHRF), Institute of Chemical Biology, Senior Researcher, Coordinator of INSPIRED-RIs 2. Dr Georgios Spyroulias, University of Patras (UPAT), Department of Pharmacy, Professor, Partner of INSPIRED-RIs 3. Dr Maria Klapa, Foundation for Research and Technology (FORTH), Institute of Chemical Engineering Sciences (ICE-HT), Senior Researcher, Partner of INSPIRED-RIs 4. Dr Yannis Ioannidis, ATHENA Research Centre (ATHENA-RC), Professor, Partner of INSPIRED-RIs **Expert Panel:** Tassos Perrakis, Michele Oleo and John Womersley
12.45-13.45 Room 230 GSRI	**Detector Development and Technologies for High Energy Physics** 1. Prof. Konstantinos. Fountas, RI coordinator, University of Ioannina 2. Prof. Dimitrios Sampsonidis, Aristotle University of Thessaloniki 3. Dr. Dimitrios Loukas, Institute of Particle and Nuclear Physics, National Centre for Scientific Research “Demokritos” 4. Prof. Theodoros Alexopoulos, National Technical University of Athens **Expert Panel:** Alasdair Reid, Angel Muñoz and Isabel Bolliger
12.45-13.45 Room 1 EYD	**INVALOR: Research Infrastructure for Waste Valorization and Sustainable Management of Resources** 1. Prof. Ioannis Kookos, Department of Chemical Engineering, University of Patras 2. Assis. Prof. Sotirios Karavoltsos, Department of Chemistry, National and Kapodistrian University of Athens 3. Prof. Serkos Haroutounian, Agricultural University of Athens 4. Prof. Konstantinos Komnitsas, School Mineral Resources Engineering, Technical University Crete **Expert Panel**: Ilaria Nardello, Jan Hrusak and Susana Elena-Perez **European Commission:** Vladimir Manolov
13.45-14.30	**Lunch break**

14.30-15.30 Room 412 GSRI	**pMED: The Greek Research Infrastructure for Personalised Medicine** 1. Prof. George Kollias, RI Co-coordinator, Medical School. University of Athens, BSRC Fleming, Associated Researcher 2. Dr. George Panayotou, BSRC Fleming, President and Acting Director 3. Dr. Pantelis Hatzis, Medical School, University of Athens, Collaborating Researcher 4. Dr. Piyi Papadaki, Medical School of Athens, Project Manager **Expert Panel:** Tassos Perrakis, Michele Oleo, John Womersley and Jan Hrusak
14.30-15.30 Room 230 GSRI	**EN.I.R.I.S.S.T.: Intelligent Research Infrastructure for Shipping, Supply chain, Transport and Logistics** 1. Polydoropoulou Amalia, Professor, Co-ordinator and Scientific Responsible of E.N.I.R.I.S.S.T, Department of Shipping, Trade and Transport, University of the Aegean 2. Lyridis Dimitrios, Associate Professor, Department of Naval Architecture and Marine Engineering, National Technical University of Athens 3. Giannakopoulos Georgios, Researcher, SKEL Lab - NCSR Demokritos 4. Zervakis Vassilis, Professor, Department of Marine Sciences, University of the Aegean **Expert Panel:** Alasdair Reid and Susana Elena.Perez
14.30-15.30 Room 1 EYD	**INNOVATION.EL: National Infrastructure in Nanotechnology, Advanced Materials and Micro/Nanoelectronics** 1. Dr. Vassilis Kilikoglou, INN - National Centre for Scientific Research “Demokritos”, RI coordinator 2. Prof. Spiros Anastasiadis, Director IESL-FORTH; Professor, University of Crete 3. Prof. Philomela Komninou, ElMicLab, Aristotle University of Thessaloniki 4. Dr. Efstratios Kamitsos, TPCI - National Hellenic Research Foundation **Expert Panel:** Angel Muñoz, Isabel Bolliger and Ilaria Nardello **European Commission:** Vladimir Manolov
15.30-15.45	**Break**
15.45-16.45 Room 412 GSRI	**EATRIS-GR: Infrastructure for preclinical and early-phase clinical development of drugs, therapeutics and biomedical devices** 1. Dr. Constantin Tamvakopoulos, Deputy Coordinator, Research Director, Center for Clinical, Experimental Surgery and Translational Research Pharmacology-Pharmacotechnology, Biomedical Research Foundation, Academy of Athens 2. Dr. Maria I. Klapa, Principal Researcher, Head, Metabolic Engineering and Systems Biology Laboratory, Institute of Chemical Engineering Sciences (ICE-HT) Foundation for Research and Technology, Hellas (FORTH)

	3. Prof. Konstantinos Avgoustakis, Laboratory of Pharmaceutical Technology, Department of Pharmacy, School of Health Sciences, University of Patras 4. Dr. Alexandros N. Pintzas, Director of the Institute of Chemical Biology, National Hellenic Research Foundation (NHRF) **Expert Panel:** Alasdair Reid, Michele Oleo, John Womersley and Jan Hrusak **European Commission:** Vladimir Manolov
15.45-16.45 Room 230 GSRI	**CALIBRA: Cluster of Accelerator Laboratories** 1. Dr. Sotirios Harissopulos, Director of Research at the Institute of Nuclear and Particle Physics (INPP) of the National Centre for Scientific Research "Demokritos", RI coordinator 2. Dr. Anastasios Lagoyannis, National Centre for Scientific Research "Demokritos", RI deputy coordinator 3. Prof. Rosa Vlastou, Department of Physics, School of Applied Sciences, National Technical University of Athens, RI General Assembly Chair **Expert Panel:** Tassos Perrakis, Angel Muñoz, Isabel Bolliger, Illaria Nardello and Susana Elena-Pérez

Time and Location	THURSDAY, 31st March
10.00 – 10.30	**Prof. Athanasios Kyriazis, Secretary General for Research and Innovation** **Expert Panel:** John Womersley, Alasdair Reid and Susana Elena-Perez **European Commission:** Vladimir Manolov
10.45 – 11.45 Room 412 GSRI	**BBMRI-GR: Strategic expansion of the Greek Biobanking Infrastructure** 1. Dimitris Thanos, Coordinator, President of the Scientific Board, Biomedical Research Foundation 2. George Kollios, Partner, Professor of Medicine, School of Medicine, Democritus University of Thrace 3. Manolis Tsiknakis, Partner, Professor of Informatics, Foundation of Research and Technology Hellas 4. Vaso Tzelepi, Partner, Assoc. Professor of Pathology, School of Medicine, University of Patras **Expert Panel:** Alasdair Reid, Michele Oleo and John Womersley **European Commission:** Vladimir Manolov
10.45 – 11.45 Room 1 EYD	**Business users** 1. Stamatakis Emmanuel (PROMETHEUS) 2. Goustouridis Dimitrios (INNOVATION EL), 3. Kontos Nikos (PANACEA) 4. Kechagias Nikos (HELLAS CH) 5. Papanastasiou Dimitris (PANACEA)

	Expert Panel: Jan Hrusak, Susana Elena Perez and Ilaria Nardello
10.45 – 11.45 Room 2 EYD	**Scientific users** 1. Karpozilos Kostis (APPOLONIS/ DARIAH GR) **Expert Panel:** Isabel Bollinguer, Tassos Perrakis and Angel Muñoz
11.45 – 12.45 Room 412 GSRI	**Business users** 1. Karousis Nikos (INSPIRED & P-MED) 2. Moulos Panagiotis (ELIXIR-GR) 3. Stavropoulos George (OPEN SCREEN GR) **Expert Panel:** Tassos Perrakis, Michelle Oleo and John Womersley
11.45 – 12.45 Room 230 GSRI	**Scientific users** 1. Karathanos Vaios (PLANT UP) 2. Argyropoulou Aikaterini (Plant UP) **Expert Panel:** Susana Elena Perez and Angel Munoz
11.45 – 12.45 Room 1 EYD	**Business users** 1. Hatzopoulos George (FuVEP) 2. Pachnos Michalis (FuVEP), 3. Hontzopoulos Elias (HELLAS CH), 4. Pappas Nikos (CMBR)*, 5. Kourouklis Yannis (FuVEP) **Expert Panel:** Jan Hrusak and Ilaria Nardello **European Commission:** Vladimir Manolov
11.45 – 12.45 Room 2 EYD	**Business users** 1. Kakouti Georgia (APPOLONIS/ DARIAH GR) **Expert Panel:** Alasdair Reid and Isabel Bolliger
12.45 – 13.45 Room 412 GSRI	**Business users** 1. l Papadimitriou Vasso ((FOOD INNOVATION & FoodOmics), 2. Foteini Salta ((FOOD INNOVATION & FoodOmics), 3. Skolikis Dimitirs (PLANT UP), 4. Makras Eleftherios (FOOD INNOVATION) **Expert Panel**: Susana Elena-Perez, Jan Hrusak and Michelle Oleo

12.45 – 13.45 Room 2 EYD	**Scientific users** 1. Prof. Maravelakis Petros (SoDaNet_Gr) 2. Grigoriou Dimitra (APOLLONIS DARIAH GR) 3. Karapidakis Sarantos (APOLLONIS CLARIN EL) **Expert Panel**: Alasdair Reid, Isabel Bolliger, John Womersley and Tassos Perrakis **European Commission:** Vladimir Manolov
13.45 – 14.30	**Lunch break**
14.30 – 15.30 Room 412 GSRI	**Scientific users** 1. Papadatou Ioanna (P-MED) 2. Stathopoulos Panos (INFRAFRONTIER/PHENOTYPOS) 3. Chrysina Evangelia (ELIXIR GR) 4. Zoumpoulakis Panagiotis (INSPIRED) **Expert Panel:** Tassos Perrakis, Michelle Oleo and John Womersley
14.30 – 15.30 Room 2 EYD	**Scientific users** 1. Topakas Evangelos (CMBR) **Expert Panel:** Jan Hrusak, Angel Muñoz and Ilaria Nardello
15.00 – 16.00 Room 1 EYD	**Business users** 1. Papargyris Antonios (SoDaNet_Gr) 2. 3 Markopoulos Ioannis (all) 3. Brindezi Hara (ENRISST) 4. Dr. Mamaloukas – Frangoulis Vasileios (ENRISST) 5. Berbili Ioanna (ENRISST) **Expert Panel:** Alasdair Reid, Susana Elena-Perez and Isabel Bolliger **European Commission:** Vladimir Manolov
Time and Location	FRIDAY, 1st April
9.30-10.00 4 th Floor, Deputy Minister of Development and Investments	**Dr. Christos Dimas, Deputy Minister of Development and Investments** **Expert Panel**: John Womersley, Alasdair Reid and Susana Elena-Perez **European Commission**: Vladimir Manolov **GSRI**: Dr. Agni Spilioti, Dr. Antonios Gypakis

10.00-10.30 Room 829	**Mr. Georgios Zervos, Special Secretary for ERDF** **Expert Panel:** John Womersley, Alasdair Reid and Susana Elena-Perez **European Commission:** Vladimir Manolov GSRI: Dr. Agni Spilioti, Dr. Antonios Gypakis MA OP EPAnEK: Efthimios Koutroukis
10.30-10.45	**Break**
10.45-11.45 Room 305B	**Special Strategy, Planning and Evaluation Service (EYSSA)** 1. Maria Kostopoulou, Deputy Director of EYSSA 2. Michail Gkoumas, Officer 3. Stavroula Pelekasi, Officer 4. Petros Stavrou, Officer **Expert Panel:** John Womersley, Alasdair Reid, Susana Elena-Perez, Tassos Perrakis, Michele Oleo, Isabel Bollinger, Jan Hrusak, Ilaria Nardello and Angel Muñoz **European Commission:** Vladimir Manolov
11.45-12.45 Room 305B	**Managing Authority of the Operational Programme "Competitiveness, Entrepreneurship & Innovation" (EPAnEK)** 1. Efthimios Koutroukis, Head of Unit B1 - Monitoring of the implementation of Projects, EPAnEK 2. Sofia Liappa, Unit A1 - Programming and Evaluation, EPAnEK 3. Eleni Papadopoulou, Unit B1 - Monitoring of the implementation of Projects, EPAnEK 4. Helen Zongou, Unit A2 - Evaluation and Inclusion of Operations 5. Dr. Emmanuel Kalogeris **Expert Panel:** John Womersley, Alasdair Reid, Susana Elena-Perez, Tassos Perrakis, Michele Oleo, Isabel Bollinger, Jan Hrusak, Ilaria Nradello and Angel Muñoz **European Commission:** Vladimir Manolov
12.45-13.45 **Room 305B**	**General Secretariat for Research and Innovation (GSRI)** 1. Dr. Agni Spilioti, Head of the Policy Planning for Research and Innovation Directorate, GSRI 2. Dr. Antonios Gypakis, Head of the Policy Planning Department, GSRI 3. Louiza Papamikrouli, scientific officer, Policy Planning Department, GSRI **Expert Panel:** John Womersley, Alasdair Reid, Susana Elena-Perez, Tassos Perrakis, Michele Oleo, Isabel Bollinger, Jan Hrusak, Ilaria Nardello and Angel Muñoz **European Commission:** Vladimir Manolov

13:45 – 14:45	**Lunch break**
14:45 -15:45	**Wrap-up session** **GSRI:** Dr. Agni Spilioti, Dr. Antonios Gypakis and Louiza Papamikrouli **Expert Panel:** John Womersley, Alasdair Reid, Susana Elena-Perez, Tassos Perrakis, Michele Oleo, Isabel Bollinger, Jan Hrusak, Ilaria Nardello and Angel Muñoz **European Commission:** Vladimir Manolov
15:45 – 17:00	**Break**
17:00-17:30 **Room 417**	**Mr. Dimitrios Skalkos, Secretary General for Public Investments and NSRF** **Expert Panel:** Alasdair Reid and Susana Elena-Perez **European Commission:** Vladimir Manolov **GSRI:** Dr. Agni Spilioti, Dr. Antonios Gypaki

2nd COUNTRY VISIT TO GREECE

1st – 3rd June 2022

Agenda

DAY 1: Wednesday, 1ST JUNE 2022, 9:30 – 16:00	
Working Session with the Greek authorities **Hellenic Ministry of Development and Investments, Athens**	
9:30 - 9:40	**Opening and welcoming** Dr. Antonios Gypakis (Head of the Policy Planning Department, GSRI)
9:40 - 9:50	**Round table of participants**
9:50 - 10:15	**Presentation of main conclusions and recommendations of draft PSF Final Report** Alasdair Reid (Rapporteur of the Expert Panel)
10:15 - 11:30	**Working session: discussion** **Expert Panel**: John Womersley, Alasdair Reid, Susana Elena-Perez, Tassos Perrakis, Michele Oleo, Jan Hrusak, Ilaria Nardello, Angel Muñoz and George Strogylopoulos. **European Commission:** Vladimir Manolov **GSRI**: Dr. Agni Spilioti, Dr. Antonios Gypakis, Louiza Papamikrouli **EPANEK:** Dr. Ageliki Fetsi, Efthimios Koutroukis, Sofia Liappa, Eleni Papadopoulou, Helen Zongou, Dr. Emmanuel Kalogeris **EYSSA:** Maria Kostopoulou, Michail Gkoumas, Stavroula Pelekasi
11:30 - 11:45	**Coffee break**
11:45 - 12:00	**Transit time (Alasdair, John, Susana and Vladimir)**
12:00 - 12:30	**Prof. Athanasios Kyriazis, Secretary General for Research and Innovation** **&** **Mr. Michael Dritsas, Head of Cabinet of the Deputy Minister of Development and Investments Dr. Christos Dimas** **Expert Panel:** John Womersley, Alasdair Reid and Susana Elena-Perez

	European Commission: Vladimir Manolov **GSRI:** Dr. Agni Spilioti and Dr. Antonios Gypakis
13:00 - 14:00	**Lunch break**
14:00 - 16:00	**Working session: discussion** **Presentation of the Belgium and Czech experiences with RIs (**Michele Oleo and Jan Hrusak, National peers) **Expert Panel**: John Womersley, Alasdair Reid, Susana Elena-Perez, Tassos Perrakis, Michele Oleo, Jan Hrusak, Ilaria Nardello, Angel Muñoz and George Strogylopoulos. **European Commission:** Vladimir Manolov **GSRI**: Dr. Agni Spilioti, Dr. Antonios Gypakis, Louiza Papamikrouli **EPANEK:** Dr. Ageliki Fetsi, Efthimios Koutroukis, Sofia Liappa, Eleni Papadopoulou, Helen Zongou, Dr. Emmanuel Kalogeris **EYSSA:** Maria Kostopoulou, Michail Gkoumas, Stavroula Pelekasi

DAY 2: Thursday 2nd JUNE 2022, 9:00 – 17:00

Working Sessions with the NRIs (Parallel sessions)

Location: Hellenic Ministry of Development and Investments, Athens

9:00 - 11:00
Room 711
	Discussion session with NRIs working on agri-food
	• **Presentation of preliminary conclusions and policy options** (Alasdair Reid, Expert panel)
	• **Group discussion:**
	  ○ Challenges and bottlenecks
	  ○ Possible actions and future approach
	Participants:
	• Ass. Prof. Maria HALABALAKI, on behalf of the Coordinator of PLANTUP: Upgrading the Plant Capital
	• Prof. Georgios THEODORIDIS, Coordinator of FoodOmicsGR
	• Prof. Emer. Athanasios KOUTINAS, Deputy Coordinator of Food Innovation RI
	• Prof. Constantinos MATHIOPOULOS, Coordinator of OMIC-ENGINE
	Expert panel: Alasdair Reid, Angel Muñoz, Tassos Perrakis and Michele Oleo
	European Commission: Vladimir Manolov

9:00 - 11:00
Room 305B
	Discussion session with NRIs working on environment and sustainable development
	• **Presentation of preliminary conclusions and policy options** (Ilaria Nardello, Expert panel)
	• **Group discussion:**
	  ○ Challenges and bottlenecks
	  ○ Possible actions and future approach
	Participants:
	• Dr. Athanassios MACHIAS, Coordinator of PHILIA
	• Dr. Georgios DRAKATOS, Coordinator of HELPOS
	• Dr. Leonidas PERIVOLIOTIS, Coordinator of HIMIOFoTS
	• Assoc. Prof. Apostolos KOUTINAS, on behalf of the Coordinator of INVALOR
	• Dr. Panagiotis KASAPIDIS on behalf of the Coordinator of CMBR
	• Prof. Maria Kanakidou, on behalf of the Coordinator of PANACEA
	Expert panel: Ilaria Nardello, John Womersley, Susana Elena-Pérez and Jan Hrusak

11:00 - 11:30	**Coffee break**

11:30 - 13:30
Room 711
	Discussion session with NRIs working on energy
	• *Presentation of preliminary conclusions and policy options (Angel Muñoz, Expert panel)*
	• *Group discussion:*
	  ○ *Challenges and bottlenecks*
	  ○ *Possible actions and future approach*
	Participants:
	• *Prof. Zisis SAMARAS, Coordinator of FuVEP*
	• *Dr. Eleni PAPAIOANNOU on behalf of the Coordinator of PROMETHEUS*
	Expert panel: Alasdair Reid, Angel Muñoz and Michele Oleo
	European Commission: Vladimir Manolov

11:30 - 13:30
Room 305B
	Discussion session with NRIs working on health and pharmaceuticals
	• *Presentation of preliminary conclusions and policy options (Tassos Perrakis, Expert panel)*
	• *Group discussion:*
	  ○ *Challenges and bottlenecks*
	  ○ *Possible actions and future approach*
	Participants:
	• *Prof. Dimitris KONTOGIANNIS, on behalf of the Coordinator of INFRAFRONTIER-PHENOTYPOS*
	• *Evangelia CHRYSSINA, Coordinator of INSPIRED*

	• *Dimitrios KLETSAS, Coordinator of OPENSCREEN-GR* • *Charalambos SAVAKIS, Coordinator of ELIXIR-GR* • *Dr. Piyi PAPADAKI, on behalf of the coordinator of pMED* • *Dr. Ioannis ZACHARAKIS, on behalf of the Coordinator of BIOIMAGING-GR* • *Dr. Sissy KOLYVA, on behalf of the Coordinator of BBMRI-GR* • *Dr. Constantin TAMVAKOPOULOS, Coordinator EATRIS GR* *Expert panel: Illaria Nardello, John Womersley, Susana Elena-Pérez, Tassos Perrakis and Jan Hrusak*
13:30 - 14:30	**Lunch break**

14:30 - 16:30
 	
Room 711
	Discussion session with NRIs working on social & cultural innovation, data and digital research infrastructures
	• *Presentation of preliminary conclusions and policy options*
	(Alasdair Reid, Expert panel)
	• *Group discussion:*
	  ○ *Challenges and bottlenecks*
	  ○ *Possible actions and future approach*
	Participants:
	• *Panagiotis KONSTANTOPOULOS, Coordinator of APOLLONIS*
	• *Natalia MANOLA, on behalf of the Coordinator of HELIX*
	• *Dimitra KONDYLI, Coordinator of SoDaNet_CESSDA_GR*
	• *Prof. Amalia POLYDOROPOUOU, Coordinator of EN.I.R.I.S.S.T.*
	Expert panel: Alasdair Reid, Susana Elena-Pérez and Michele Oleo

14:30 - 16:30
 	
Room 305B
	Discussion session with NRIs working on physical sciences and materials
	• *Presentation of preliminary conclusions and policy options (Angel Muñoz, Expert panel)*
	• *Group discussion:*
	  ○ *Challenges and bottlenecks*
	  ○ *Possible actions and future approach*
	Participants:
	• *Dr. Vassilios KILIKOGLOU, Coordinator of INNOVATION.EL*
	• *Dr. Sotirios CHARISSOPOULOS, Coordinator of CALIBRA*
	• *Prof. Demetrios ANGLOS, on behalf of the Coordinator of HELLAS-CH*
	• *Prof. Constantinos FOUNDAS, Coordinator of Detector Development and Technologies for High Energy Physics*
	Expert panel: Angel Muñoz, John Womersley, Tassos Perrakis, Illaria Nardello and Jan Hrusak
	European Commission: Vladimir Manolov

16:30 - 17:00 **Room 305B**	*Wrap up session* *Expert panel: John Womersley, Alasdair Reid, Susana Elena-Perez, Tassos Perrakis, Michele Oleo, Jan Hrusak, Ilaria Nradello and Angel Muñoz* *European Commission: Vladimir Manolov*

DAY 3: Friday, 3rd JUNE 2022, 9:00 – 13:00	
Working Sessions with policy makers	
9:00 - 9:30	**Sotirios Diamantopoulos**, Legal Adviser to the Secretary General for Research and Innovation **Expert Panel**: John Womersley, Alasdair Reid, Susana Elena-Perez, Tassos Perrakis, Michele Oleo, Jan Hrusak, Ilaria Nardello and Angel Muñoz **European Commission:** Vladimir Manolov **GSRI**: Dr. Agni Spilioti, Dr. Antonios Gypakis and Louiza Papamikrouli
10:00 - 10:30	**Mr. Georgios Zervos, Special Secretary of ERDF** **Expert Panel**: John Womersley, Alasdair Reid, Susana Elena-Perez **European Commission:** Vladimir Manolov **GSRI**: Dr. Agni Spilioti and Dr. Antonios Gypakis
11:00 - 11:30	**Mrs. Elina Mavrona,** Adviser to the Secretary General for Public Investments and NSRF **Expert Panel**: John Womersley, Alasdair Reid, Susana Elena-Perez, Tassos Perrakis, Michele Oleo, Jan Hrusak, Ilaria Nardello and Angel Muñoz **European Commission:** Vladimir Manolov **GSRI**: Dr. Agni Spilioti, Dr. Antonios Gypakis and Louiza Papamikrouli
11:30 - 12:00	**Coffee Break**
12:00 - 13:00 **Room 305B**	**Wrap up session** • Key messages • Final Report next steps • Dissemination event in September **Expert Panel**: John Womersley, Alasdair Reid, Susana Elena-Perez, Tassos Perrakis, Michele Oleo, Jan Hrusak, Ilaria Nardello and Angel Muñoz

	European Commission: Vladimir Manolov **GSRI**: Dr. Agni Spilioti, Dr. Antonios Gypakis and Louiza Papamikrouli

ANNEX 2: PARTICIPATION BY GREECE IN ESFRI LANDMARKS & PROJECTS

Domain	Member	Observer	Prospective member		No Greek participation	
ESFRI RI name	Landmark	Landmark	Landmark	Project	Landmark	Project
DATA, COMPUTING AND DIGITAL RESEARCH IFRASTRUCTURES						
EBRAINS				1		
PRACE	1					
SLICES				1		
SoBigData++						1
ENERGY			1		2	2
ECCSEL ERIC					1	
EU-SOLARIS			1			
IFMIF-DONES						1
JHR					1	
MARINERG-i						1
ENVIRONMENT						
ACTRIS			1			
DANUBIUS-RI				1		
DiSSCo				1		
EISCAT_3D					1	
eLTER RI				1		
EMSO ERIC	1					
EPOS ERIC	1					

Domain	Member	Observer	Prospective member		No Greek participation	
ESFRI RI name	Landmark	Landmark	Landmark	Project	Landmark	Project
EURO-ARGO ERIC	1					
IAGOS					1	
ICOS ERIC					1	
LifeWatch ERIC	1					
HEALTH AND FOOD						
AnaEE					1	
BBMRI ERIC	1					
EATRIS ERIC					1	
ECRIN ERIC					1	
EIRENE RI				1		
ELIXIR	1					
EMBRC ERIC	1					
EMPHASIS						1
ERINHA					1	
EU-IBISBA				1		
EU-OPENSCREEN ERIC					1	
Euro-BioImaging ERIC					1	
INFRAFRONTIER	1					
INSTRUCT ERIC		1				
METROFOOD-RI				1		

Domain	Member	Observer	Prospective member		No Greek participation	
ESFRI RI name	Landmark	Landmark	Landmark	Project	Landmark	Project
MIRRI					1	
PHYSICAL SCIENCES & ENGINEERING						
CTA					1	
ELI ERIC					1	
ELT					1	
EMFL					1	
ESRF EBS					1	
EST						1
ET						1
EuPRAXIA						1
European Spallation Source ERIC					1	
European XFEL					1	
FAIR					1	
HL-LHC	1					
ILL					1	
KM3NeT 2.0				1		
SKAO					1	
SPIRAL2					1	
SOCIAL AND CULTURAL INNOVATION						
CESSDA ERIC	1					
CLARIN ERIC	1					

Domain	Member	Observer	Prospective member		No Greek participation	
ESFRI RI name	Landmark	Landmark	Landmark	Project	Landmark	Project
DARIAH ERIC	1					
E-RIHS				1		
EHRI						1
ESS ERIC					1	
GGP						1
GUIDE						1
OPERAS				1		
RESILIENCE				1		
SHARE ERIC	1					
Total	14	1	2	12	24	10

Source: https://roadmap2021.esfri.eu/projects-and-landmarks/browse-the-catalogue/?countries=EL

ANNEX 3: GREEK PARTICIPANTS IN THE HORIZON 2020 THEMATIC PRIORITY ‘RESEARCH INFRASTRUCTURES’

Organisation	H2020 Net EU Contribution
ATHINA-EREVNITIKO KENTRO KAINOTOMIAS STIS TECHNOLOGIES TIS PLIROFORIAS, TON EPIKOINONION KAI TIS GNOSIS	€14,105,286
NATIONAL INFRASTRUCTURES FOR RESEARCH AND TECHNOLOGY	€11,648,869
IDRYMA TECHNOLOGIAS KAI EREVNAS	€ 8,414,703
HELLENIC CENTRE FOR MARINE RESEARCH	€ 7,036,621
ETHNIKO KAI KAPODISTRIAKO PANEPISTIMIO ATHINON	€ 3,835,260
ETHNIKO ASTEROSKOPEIO ATHINON	€ 3,149,435
OPENAIRE	€ 2,737,586
NATIONAL CENTRE FOR SCIENTIFIC RESEARCH ‘DEMOKRITOS’	€ 1,769,520
INSTITUTE OF COMMUNICATION AND COMPUTER SYSTEMS	€ 1,762,641
ARISTOTELIO PANEPISTIMIO THESSALONIKIS	€ 1,710,629
ETHNIKO KENTRO EREVNAS KAI TECHNOLOGIKIS ANAPTYXIS	€ 1,582,475
PANEPISTIMIO THESSALIAS	€ 1,283,563
JNP STRATIGIKI KAI EPICHIRISIAKI SYMVOULEFTIKI IKE	€ 1,248,490
AGROKNOW IKE	€ 1,156,188
ETHNIKO IDRYMA EREVNON	€ 1,108,792
COMMUNICATION & INFORMATION TECHNOLOGIES EXPERTS ANONYMOS ETAIREIA SYMVOULEFTIKON KAI ANAPTYXIAKON YPIRESION	€ 1,059,625
NATIONAL TECHNICAL UNIVERSITY OF ATHENS – NTUA	€ 952,372
INSTITUTE OF ACCELERATING SYSTEMS AND APPLICATIONS	€ 740,313
CENTRE FOR RENEWABLE ENERGY SOURCES AND SAVING FONDATION	€ 630,854
PANEPISTIMIO PATRON	€ 563,875

Organisation	H2020 Net EU Contribution
INFILI TECHNOLOGIES SOCIETE ANONYME	€ 558,000
DIACHEIRISTIS ELLINIKOU DIKTYOU DIANOMIS ELEKTRIKIS ENERGEIAS AE	€ 557,876
ELLINIKO MESOGEIAKO PANEPISTIMIO	€ 542,500
POLYTECHNEIO KRITIS	€ 481,445
IDRYMA ORMYLIA	€ 475,083
ETHNIKO KENTRO TEKMIRIOSIS KAI ILEKTRONIKOU PERIECHOMENOU	€ 460,483
BIOMEDICAL SCIENCES RESEARCH CENTER ALEXANDER FLEMING	€ 410,724
VILABS OE	€ 306,250
IDRYMA IATROVIOLOGIKON EREUNON AKADEMIAS ATHINON	€ 276,120
COSMOTE KINITES TILEPIKOINONIES AE	€ 272,500
ACADEMY OF ATHENS	€ 241,250
DIMOKRITIO PANEPISTIMIO THRAKIS	€ 230,724
OLOKLIROMENA PLIROFORIAKA SISTIMATAAE	€ 219,000
PANTEIO PANEPISTIMIO KOINONIKON KAIPOLITIKON EPISTIMON	€ 187,838
ELLINOGERMANIKI AGOGI SCHOLI PANAGEA SAVVA AE	€ 102,688
EVROPAIKO INSTITOUTO DIKAIOU EPISTIMIS KAI TECHNOLOGIAS	€ 102,665
BIOMEDCODE ELLAS ANONIMI ETERIA EPISTIMONIKIS KAI TEXNOLOGIKIS EREVNAS KAI EMBORIKIS EKMETALLEFSIS EPHARMOGON IATRIKIS	€91,125
HELLENIC PASTEUR INSTITUTE	€82,531
ELLINIKI ARCHI GEOLOGIKON KAI METALLEFTIKON EREVNON	€66,060
THE JEWISH MUSEUM OF GREECE	€60,106
INTERNATIONAL CENTER FOR RESEARCH ON THE ENVIRONMENT AND THE ECONOMY	€60,000
VOLOS ACADEMY FOR THEOLOGICALSTUDIES	€58,476

Organisation	H2020 Net EU Contribution
INSTITOUTO GEOLOGIKON KAI METALLEFTIKON EREVNON	€47,608
ETHNIKO KENTRO KOINONIKON EREVNON	€38,813
Independent Authority for Public Revenue (IAPR)	€22,625
GEOPONIKO PANEPISTIMION ATHINON	€15,625
PANEPISTIMIO KRITIS	€12,931
MEDITERRANEAN AGRONOMIC INSTITUTE OF CHANIA	€9,375
PANEPISTIMIO IOANNINON	€9,375
HELLENIC HEALTH FOUNDATION	€9,375
ETHNIKOS ORGANISMOS PAROCHIS YPIRESION YGIAS	€5,500
ORGANISMOS FYSIKOU PERIVALLONTOS KAI KLIMATIKIS ALLAGIS	€ -
GENIKI GRAMMATIA EREVNAS KAI KAINOTOMIAS	€ -
ATHENS UNIVERSITY OF ECONOMICS AND BUSINESS - RESEARCH CENTER	€ -
Total	€72,511,764

Source: Horizon 2020 Dashboard

ANNEX 4: FUNDING BY PARTNER ORGANISATION AND NRI BY THEMATIC FIELD

Organisation	Food Innovation	FoodOmics.Gr	OMIC-ENGINE	Plant-Up	Total
University of Patras	€1,403,200		€600,000	€558,000	€2,561,200
National and Kapodistrian University of Athens		€649,459	€90,000	€497,000	€2,236,459
University of Thessaly			€1,870,000		€1,870,000
Aristotle University of Thessaloniki		€887,364	€50,000	€489,375	€1,396,739
Democritus University of Thrace	€496,800		€480,000		€976,800
Benaki Phytopathological Institute				€830,000	€830,000
University of Crete		€596,319		€200,000	€796,319
Agricultural University of Athens	€ 300,000	€256,933	€40,000	€131,250	€728,183
University of Ioannina	€300,000	€251,523	€120,000	€30,000	€701,523
National Technical University of Athens			€680,000		€680,000
Harokopio University of Athens	€250,000				€250,000
Ionian University	€250,000				€250,000
Mediterranean Agronomical Institute of Chania				€160,000	€160,000
Biomedical Research Foundation (Academy of Athens)		€138,454			€138,454
International Hellenic University		€129,120			€129,120

Organisation	Food Innovation	FoodOmics.Gr	OMIC-ENGINE	Plant-Up	Total
University of the Aegean		€89,826			€89,826
National Hellenic Research Foundation			€70,000		€70,000
Total	€3,000,000	€2,998,998	€4,000,000	€2,865,625	€13,864,623

Figure 59. Funding by partner and NRI – agri-food field (Source GSRI, calculations authors)

Organisation	FuVEP	Prometheus	Total
Aristotle University of Thessaloniki	€2,936,566		€2,936,566
National Technical University of Athens	€425,707		€425,707
University of Western Macedonia	€300,319		€300,319
Centre for Research and Technology Hellas - CERTH		€2,877,633	€2,877,633
National Centre of Scientific Research ‘Demokritos’		€802,630	€802,630
Total	€3,662,591	€3,680,263	€7,342,854

Figure 60. Funding by partner and NRI – energy field (Source GSRI, calculations authors)

Organisation/NRI	BBMRI-GR	BIOIMAGING-GR	EATRIS-GR	ELIXIR-GR	Infrafrontier-GR	INSPIRED	OPENSCREEN-GR	pMED-GR	Total
Biomedical Sciences Research Centre 'Alexander Fleming'		252515		522863	2950000			650000	4375377
National Kapodistrian University of Athens	5000	180000		6000	250000	225000		3150000	3816000
Foundation of Research and Technology – Hellas	67210	1570878	91396.5	196863	400000	246500			2572847
University of Patras	30000	286955	25000	128113		1557445			2027512
Academy of Athens	245000	289991	248000	33500	200000		282100	200000	1498591
National Centre for Scientific Research «Demokritos»		211250				220000	899600		1330850
GRNET S.A. – National Infrastructures for Research and				1227000					1227000

Organisation/NRI	BBMRI-GR	BIOIMAGING-GR	EATRIS-GR	ELIXIR-GR	Infrafrontier-GR	INSPIRED	OPENSCREEN-GR	pMED-GR	Total
Technology									
Democritus University of Thrace	40000	330000	33500	198625	200000	127500	229100		1158725
University of Thessaly				992638		140000			1132638
Aristotle University of Thessaloniki							1027606		1027606
National Hellenic Research Foundation		170508	40000	6175		540875	237500		995058
Hellenic Pasteur Institute		267779	62000	199000		150000			678779
University of Ioannina	30000			26625		171500	266884		495009
University of Crete	30000	260982		9000		140000			439982
Hellenic Centre for Marine Research		179142		167625					346768
"Athena" Research Center				95000		140000			235000

Organisation/NRI	BBMRI-GR	BIOIMAGING-GR	EATRIS-GR	ELIXIR-GR	Infrafrontier-GR	INSPIRED	OPENSCREEN-GR	pMED-GR	Total
Centre for Research & Technology Hellas	50000			182075					232075
Agricultural University of Athens						100000	82300		182300
National Technical University of Athens						60000			60000
Grand Total	497210	4000000	499896.5	3991100	4000000	3818820	3025090	4000000	23832116

Figure 61. Share of funding by partner and NRI – health and pharmaceuticals (Source GSRI, calculations authors)

NRI	CMBR	HELPOS	HIMIOFoTS	INVALOR	PANACEA	RePHIL	Total
Hellenic Centre for Marine Research	2,620,418	30,000	2,794,943		55,000	2,722,793	8,223,154
National Observatory of Athens		1,725,936	210,000		580,000		2,515,936
University of Patras		280,250		1,735,000	55,000		2,070,250
Aristotle University of Thessaloniki		939,812		274,713	710,000		1,924,525
University of Crete	450,000				1,410,000		1,860,000
National and Kapodistrian University of Athens	300,000	359,996	140,000	190,000	55,000		1,044,996
National Technical University of Athens		110,120	575,000		350,000	410,213	1,445,333
Technical University of Crete	153,800			700,000	55,000		908,800

NRI	CMBR	HELPOS	HIMIOFoTS	INVALOR	PANACEA	RePHIL	Total
Foundation of Research and Technology	308,000			120,000	239,950		667,950
University of the Aegean	100,003		207,032		55,000		362,035
Hellenic Mediterranean University	67,780	249,920					317,700
Democritus University of Thrace				180,000	55,000		235,000
University of Ioannina			30,000		55,000		85,000
Agricultural University of Athens				700,000			700,000
National Centre for Scientific Research					270,000		270,000
Earthquake Planning and Protection		269,810					269,810
Academy of Athens					55,000		55,000

NRI	CMBR	HELPOS	HIMIOFoTS	INVALOR	PANACEA	RePHIL	Total
Harokopio University of Athens			35,000				35,000

Figure 62. Funding by partner and NRI – environment and sustainable development Source GSRI, calculations authors

Organisation	CALIBRA	DeTANet	HELLAS-CH	INNOVATION.EL	TOTAL
National Centre for Scientific Research 'Demokritos' (NCSRD)	€3,422,200	€125,963		€1,475,000	€5,023,163
Foundation for Research and Technology – Hellas (FORTH)			€2,300,433	€1,400,000	€3,700,433
Hellenic Mediterranean University (HMU)			€532,583		€532,583
National Hellenic Research Foundation (NHRF)			€94,000	€400,000	€494,000
Aristotle University of Thessaloniki (AUTH)		€89,748		€325,000	€414,748
National and Kapodistrian University of Athens (NKUA)		€284,289	€94,000		€378,289
University of Ioannina (UOI)			€213,000	€125,000	€338,000
National Technical University of Athens (NTUA)			€144,000	€150,000	€294,000
Democritus University of Thrace (DUOT)			€173,000		€173,000
Ormylia Foundation (OF)			€155,000		€155,000

Organisation	CALIBRA	DeTANet	HELLAS-CH	INNOVATION.EL	TOTAL
National Quality Infrastructure System (NQUIS)				€125,000	€125,000
University of Patras (UOP)			€120,000		€120,000
Technical University of Crete (TUOC)			€74,000		€74,000
Biomedical Research Foundation Academy of Athens (BRFAA)			€48,500		€48,500
Hellenic Pasteur Institute (HPI)			€48,500		€48,500
TOTAL	€3,422,200	€500,000	€3,997,016	€4,000,000	€11,919,216

Figure 63. Funding by partner and NRI – physical sciences and materials (Source GSRI, calculations authors)

Organisation	HELIX	APOLLONIS	ENIRISST	SODANET	Total
Athena R&I Centre	€862,773	€1,918,726			€2,781,499
GRNET	€2,013,750	€97,774			€2,111,524
University of the Aegean		€90,000	€1,086,594	€201,800	€1,378,394
University of Thessaly	€500,000		€213,813		€713,813
Academy of Athens		€665,500			€665,500
National Technical University of Athens		€203,000	€414,850		€617,850
Aristotle University of Thessaloniki		€150,000	€440,657		€590,657
National Centre for Social Research				€464,900	€464,900
NCSR Demokritos		€240,000	€98,625		€338,625
National and Kapodistrian University of Athens		€249,000		€85,000	€334,000
FORTH		€297,000			€297,000
Democritus University of Thrace			€185,720	€63,000	€248,720
University of the Peloponnese			€136,250	€79,640	€215,890
University of Piraeus			€121,027		€121,027

Organisation	HELIX	APOLLONIS	ENIRISST	SODANET	Total
Hellenic Centre for Marine Research			€98,625		€98,625
Panteion University				€97,000	€97,000
University of West Attica			€93,492		€93,492
Centre of Planning and Economic Research			€85,238		€85,238
University of Crete				€75,000	€75,000
School of Fine Arts		€50,000			€50,000
Ionian University		€40,000			€40,000
Total	€3,376,523	€4,001,000	€2,974,891	€1,066,340	€11,418,753

Figure 64. Funding by partner and NRI – data and digital research infrastructures (Source: GSRI, calculations authors)

ANNEX 5: ERDF COMMON INDICATORS (24 AND 25) FOR HUMAN RESOURCES IN NRIS

National RI	a) Number of researchers working in improved research centre facilities (FTE)	b) Number of young researchers (FTE)	Difference (a-b) (FTE)	Direct personnel expenses	Per researcher
APOLLONIS	95.46	85.3	10.16	€2,980,792.72	€31,225.57
BBMRI GR	17.75	16.25	1.5	€278,126.07	€15,669.07
BIOIMAGING GR	74.32	64.66	9.66	€1,317,106.13	€17,722.10
CALIBRA	19.8	18.3	1.5	€409,535.00	€20,683.59
CMBR	83.38	68.38	15	€1,717,648.38	€20,600.24
DeTANeT	45.55	39.61	5.94	€185,965.00	€ 4,082.66
EATRIS GR	11.2	10.43	0.77	€231,577.94	€20,676.60
ELIXIR-GR	85.96	82.19	3.77	€2,137,005.01	€24,860.46
ENIRISST	70.97	52.35	18.62	€1,642,968.83	€23,150.19
Food Innovation RI	83.33	78.01	5.32	€1,739,168.87	€20,870.86
FOODOMICS- GR	48.03	40.5	7.53	€863,187.96	€17,971.85
FuVEP	27.26	19.75	7.51	€636,431.16	€23,346.70

National RI	a) Number of researchers working in improved research centre facilities (FTE)	b) Number of young researchers (FTE)	Difference (a-b) (FTE)	Direct personnel expenses	Per researcher
HELIX	49.89	48.48	1.41	€1,564,764.79	€31,364.30
HELLAS-CH	122.27	109.73	12.54	€2,090,532.94	€17,097.68
HELPOS	63.17	48.85	14.32	€1,599,149.22	€25,315.01
HIMIOFoTs	78.37	57.08	21.29	€1,660,567.26	€21,188.81
INFRAFRONTIER-GR	84.43	73.58	10.85	€1,987,116.45	€23,535.67
INNOVATION.EL	98.77	76.73	22.04	€1,502,874.97	€15,215.91
INSPIRED	98.02	77.2	20.82	€1,625,556.67	€16,583.93
INVALOR	108.4	102.83	5.57	€2,738,273.82	€25,260.83
OMIC ENGINE	74.14	72.02	2.12	€1,515,183.25	€20,436.79
OPENSCREEN GR	56.66	40.18	16.48	€1,001,165.63	€17,669.71
PANACEA	92.12	89.29	2.83	€1,653,137.94	€17,945.48
RePHIL	20.23	17.21	3.02	€641,657.81	€31,718.13
PLANT-UP	69.92	52.66	17.26	€1,309,659.87	€18,730.83

National RI	a) Number of researchers working in improved research centre facilities (FTE)	b) Number of young researchers (FTE)	Difference (a-b) (FTE)	Direct personnel expenses	Per researcher
pMEDGR	38.79	32.42	6.37	€850,558.00	€21,927.25
PROMETHEUS	29.73	28.33	1.4	€846,215.00	€28,463.34
SoDaNet	32.66	25.06	7.6	€806,200.30	€24,684.64
TOTAL (average per researcher)	1780.58	1527.38	253.2	€37,532,126.99	€21,357.08

Source: EPANEK management authority

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The Horizon Europe Policy Support Facility (PSF) has been set up by the Directorate-General for Research & Innovation (DG RTD) of the European Commission. It supports Member States and countries associated to Horizon Europe in reforming their national research and innovation (R&I) systems.

The country review of the Greek national research infrastructures (NRIs) was carried out between December 2021 and September 2022 by a panel of five independent experts and three national peers. The report provides recommendations to increase the contribution of the NRIs to the Greek R&I system and their socio-economic impact, followed by a set of cross-cutting conclusions and the 10 strategic and operational recommendations.

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