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Technological status and capabilities of existing ICT Research Infrastructures

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Executive summary

Digital Infrastructures and the future Internet including 5G and beyond technologies are the main enabling factors contributing to the digital transformation of our society. The COVID-19 crisis has demonstrated the vital role of digital infrastructures and showed they should be reinforced. Their design, deployment and operation are critical, calling for a scientific instrument to support the research in this domain for computer science and infrastructure researchers, as well as for data driven scientific applications involving interdisciplinary aspects.

This report summarizes the analysis of the current technological status and capabilities of existing ICT Research Infrastructures in Europe as it stands for the beginning of 2021. The analysis has been performed by the authors and reflects the knowledge gathered and processed by the authors using public documentation (e.g., available on the projects' websites) and through personal communication between sources of information in particular Member States.

This report does not intend to replace and override documentation prepared by larger communities and organizations (e.g., the European Commission, ESFRI or e-IRG). Instead, this report complements existing efforts made so far with a primary focus on ICT technologies related to SLICES and with new information received from Member States, not necessarily already included in above mentioned state-of-the-art reports.

This report has been prepared by SLICES-DS Partners with support and advice from the following organisations: Poznan Supercomputing and Networking Center (Poland), Sorbonne University (France), INRIA (France), MTA Sztaki (Hungary), Technical University of Munich (Germany), UPV/EHU (Spain), UC3M (Spain), UCLAN (Cyprus), Université Du Luxembourg (Luxembourg), SIMULA (Norway), CNR (Italy), Mandat International (Switzerland), KTH (Sweden), University of Gent (Belgium) and RNP (Brazil).

The document is intended at ESFRI stakeholders, policy makers, researchers and RI managers.

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Introduction

Digital communication and computer infrastructures are the most complex and largest system created by mankind. They can be illustrated though various forms such as the Internet or the 5G cellular networks. Their convergence accelerates and will materialize into a sophisticated digital system based on different technologies ranging from Data Centres to IoT, highly virtualized and programmable. A complementary set of scientific domains has contributed to the design and management of these systems. It is well recognized, as a best practice in many scientific disciplines that thought experiments can contribute to the discovery process. It is unfortunate that for years, it was believed that in order to research computer science and electrical engineering, commercial infrastructures (like Amazon Web Services, Microsoft Azure, Google Cloud, others) or small-scale custom lab testbeds were sufficient. However, repeatable research and experimentation requires a full control of the environment together with the ability to reach large scales and reproduce the observed results, and consequently create scientific data repositories complying with the FAIR data management principles.

SLICES ambitions to provide a European wide test-platform, providing advanced compute, storage and network components, interconnected by high-speed dedicated high-speed links. SLICES aspires to evolve to the preferred collaborative instrument for researchers at the European level, to explore and research new frontiers of the existing protocols and practices in Digital Sciences. SLICES will allow researchers and industry stakeholders to question scientific challenges regarding the future technologies and services. Existing platforms have fulfilled an important need for the associated research community (e.g., networking design, wireless network experimentation in real settings, Cloud computing. They have been instrumental to better understand the need, identify the important components, propose a reference architecture and APIs, qualify the experimenter's experience, and discuss the sustainability models. They shall positively influence the methodology to be followed for preparing the next phase of SLICES.

The current infrastructures to support digital sciences are tiny, very fragmented, often not equipped with the appropriate tools for monitoring, management, and control. They are very focused, targeting a single community and they remain transient as not sustainable in the way they are deployed and organised. They are dealing with physical infrastructures, IoT devices, wireless components, cognitive radio, MIMO, data centres, clouds, and others. Rarely, this diverse set of resources can be associated to address the end-to-end scenario.

Many testbeds have been therefore deployed, eventually used and often closed. This situation was one of the arguments for developing the federation of testbed approach as for NSF GENI and EU FIRE. Some of the outcome is illustrated by the Fed4Fire project, the OneLab facility or the 5TONIC20 laboratory to name some. Most of the SLICES members have been participating in such federations of testbeds.

Although this is a noteworthy achievement, these facilities still lack of a broader value, a sustainable solution as an independent organization and adopting the best practices and solid policies encountered in RI. Likewise, the current infrastructures are not necessarily open and scalable. In addition, an open data management plan should be deployed in order to archive the results and experiments results and make them available for instance for benchmarking purposes.

This report concentrates on existing efforts in Member States in building Research Infrastructures and e-Infrastructures for researchers, scientists and industry. Before going into details, it is important to clarify the use of the terms in the context of this report.

The term "Research Infrastructure" can be interpreted in many ways. For the purposes of this report the definition provided by the European Commission has been adapted[1]:

"Research Infrastructures are facilities that provide resources and services for research communities to conduct research and foster innovation. They can be used beyond research e.g. for education or public services and they may be single-sited, distributed, or virtual. They include:

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

[1] https://ec.europa.eu/info/research-and-innovation/strategy/european-research-infrastructures_en

On the other hand, in this report we distinguish also the term "e-Infrastructure". According to the European Commission[2] the definition of the term is as follows:

"e-Infrastructures provide digital-based services and tools for data- and computing-intensive research in virtual and collaborative environments. They foster the emergence of Open Science, i.e., new working methods based on the shared use of digital tools and resources across different disciplines and technology domains as well as sharing of results and an open way of working together."

In brief, e-Infrastructures provide operational services for individuals and projects (e.g. Research Infrastructures) in order to equip end users (e.g., researchers or scientists) with more sophisticated and complex research environments and facilitate the collaboration among research communities by sharing resources, analysis tools and data.

To build a database of RIs and e-Infrastructures in Europe for this report all members of SLICES (including those partners who are not involved in SLICES-DS) have been challenged with a simple 1-page long survey. The results of the survey are presented in this deliverable.

In total, we have received 12 answers from Member States about Research Infrastructures, while 11 answers about e-Infrastructures. Additionally, selected four "umbrella projects" have been described, as key SLICES-related e-Infrastructures operating at the European level. The following figure presents the geographical coverage of this study, split into Research Infrastructures (Figure 1) and e-Infrastructures (Figure 2).

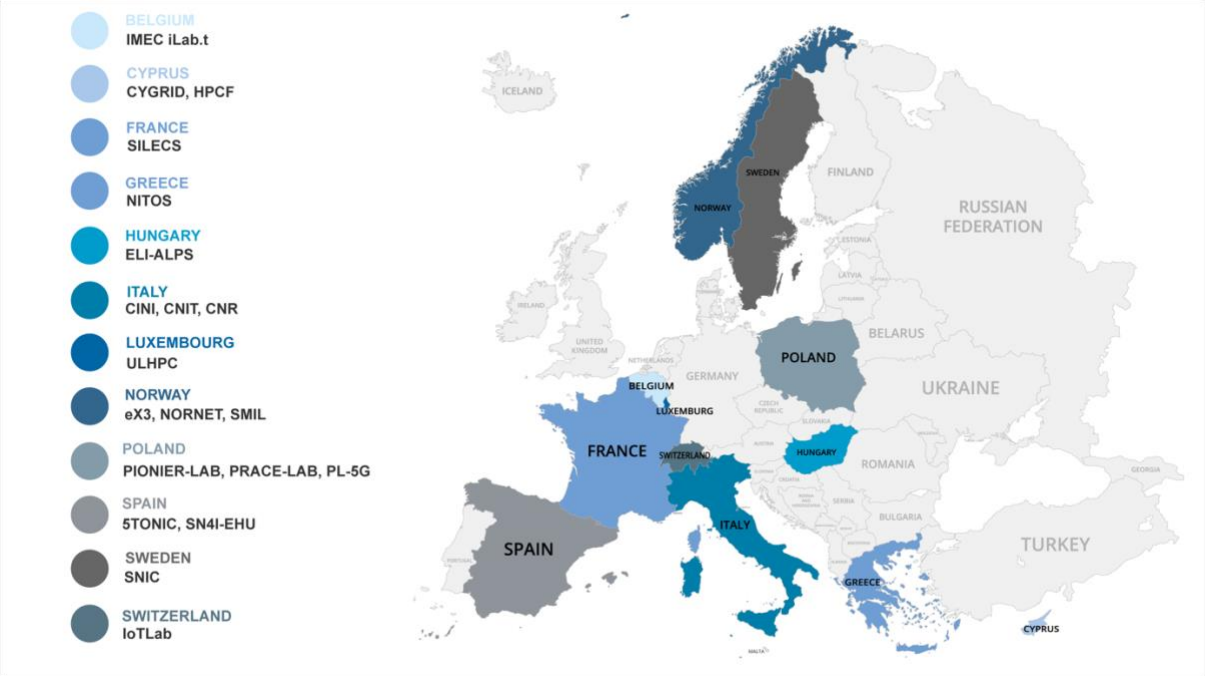


Figure 1 Geographical coverage of the survey - Research Infrastructures

[2] https://ec.europa.eu/digital-single-market/en/e-infrastructures

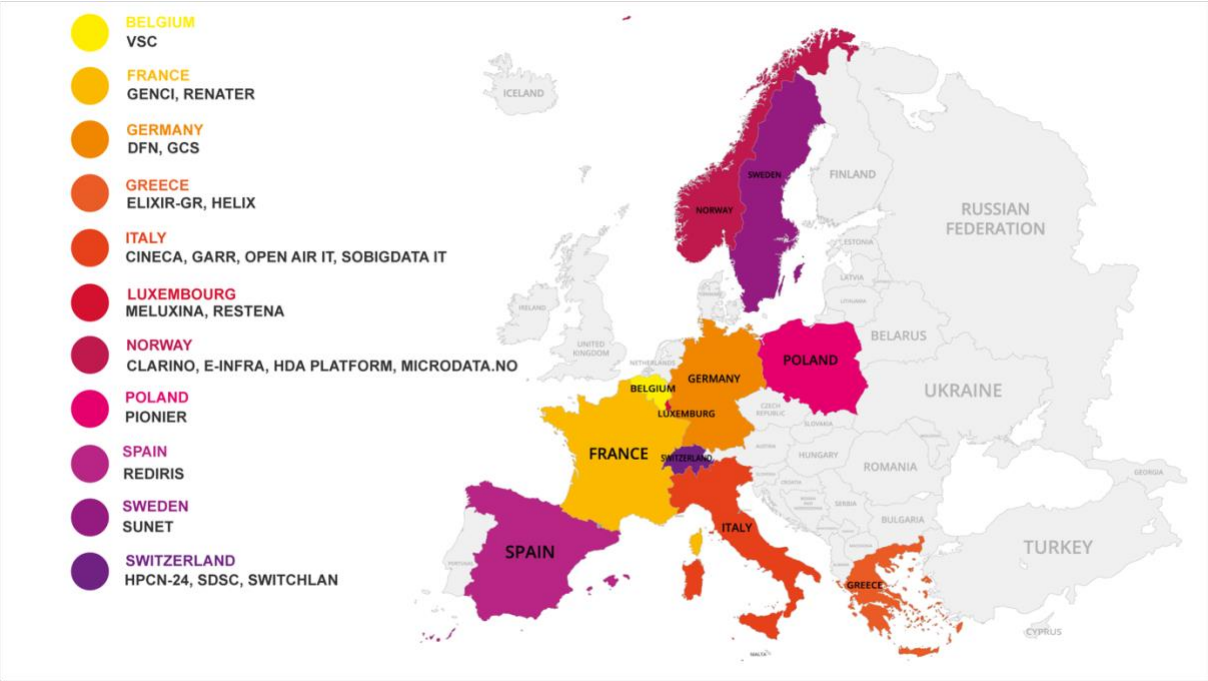


Figure 2 Geographical coverage of the survey - e-Infrastructures

The structure of the document is as follows. In Section 2, we present the summary of information about National Roadmaps of Research Infrastructures in Member States. Section 3 describes the methodology used in this analysis. In Section 4, we present the European landscape of ICT facilities, with a primary focus on Research Infrastructures and e-Infrastructures operated in Member States. This section includes also information about relevant to SLICES e-Infrastructures operating at the European level (e.g., PRACE, GÉANT, etc.) and national infrastructures from other regions. Finally, the conclusions and next steps are described in Section 5.

Methodology

To prepare a landscape of ICT Research Infrastructures the authors released a survey to representatives of SLICES in particular Member States. The survey has been prepared in a format to allow quick answers to the following questions:

1. What is the type of the infrastructure (Research Infrastructure or e-Infrastructure)?
2. What is the organization model?
3. What is the overall description of the infrastructure?
4. Is the project part of the National Roadmap of Research Infrastructures?
5. What is the governance model or partnership applied?
6. What is the timeline of the infrastructure?
7. What is the service offer?
8. Which communities are addressed with services?
9. What is the access type (physical or virtual)?
10. What is the geographical coverage of services offered?
11. Where more information is available (e.g. the URL of the website)?

The data collected from the survey are presented in Section 4.

Moreover, along with the questions about the infrastructure, survey asks additional questions about implementation of National Roadmaps of Research Infrastructures in Member States. The results of this analysis is presented in Section 3.

In order to compare the current situation in Europe and other regions, the analysis of Research Infrastructures has been extended to infrastructures available in South/North America and Asia, what has been summarized in Section 4. Since the main focus of this report is on research facilities, information about e-Infrastructures in other regions is intentionally omitted, although the authors are aware of mature and advanced e-Infrastructures running in respective countries. Information about these research infrastructures has been collected from publicly available documents, including project websites.

The survey was carried out in the period November 2020 - February 2021.

National Roadmaps of Research Infrastructures in Member States

The European Commission and ESFRI encourage Member States to develop national roadmaps for research infrastructures (RIs)[3]. National roadmaps in Member States are being developed to reflect national importance for local research communities. Typically, RIs included in the roadmap have a long utilization period (e.g. at least ten years) and have open policies for accessing resources and services by researchers and scientists.

The ESFRI initiative is continuously collecting information about national roadmaps developed by Member States and Associated Countries. The up-to-date list is available online https://www.esfri.eu/national-roadmaps. The table below summarizes efforts made by Member States supporting SLICES. It is worth mentioning, that most of the Research Infrastructures listed in this report are available on national roadmaps in corresponding Member States.

Country		Roadmap	Info	Status
	Belgium	Flanders - EN[4]	Flemish participation in international RIs published in 2020, Belgian roadmap under preparation	Active
	Cyprus		Roadmap under preparation[5]	Active
	Finland	FI | EN[6]	Roadmap update published in 2014	Active
	France	FR | EN[7]	Roadmap published in 2008, updated in 2012, 2016, and 2018	Active
	Germany	DE[8]	Roadmap updated in 2019	Active

[3] https://www.esfri.eu/national-roadmaps

[4] https://www.ewi-vlaanderen.be/sites/default/files/bestanden/large_scale_research_infrastructure_in_flanders_-_flemish_participation_in_international_research_infrastructures_2020.pdf

[5] Editorial note: National 'European Research Area' (ERA) Roadmap for Cyprus 2016 - 2020 is available: https://www.research.org.cy/wp-content/uploads/EthnikosOdikosXartisEXE.pdf

[6] http://www.aka.fi/globalassets/awanhat/documents/firi/tutkimusinfrastruktuurien_strategia_ja_tiekartta_2014_en.pdf

[7] http://cache.media.enseignementsup-recherche.gouv.fr/file/Infrastructures_de_recherche/16/4/infrastructures_UK_web_615164.pdf

[8] https://www.bmbf.de/de/roadmap-fuer-forschungsinfrastrukturen-541.html

Country		Roadmap	Info	Status
	Greece	GR | EN[9]	Roadmap updated in 2014	Active
	Hungary	EN | HU[10]	Roadmap published in 2018	Active
	Italy	IT[11]	Roadmap published in 2011, updated in 2017	Active
	Luxembourg		No roadmap available	Inactive
	Norway	EN | NO[12]	Roadmap published in 2012. Updated in 2016	Active
	Poland	EN[13]	Updated Roadmap published in 2020	Active
	Spain	EN | ES[14]	Roadmap updated in 2013	Active
	Sweden	EN | SV[15]	Roadmap published in 2011, updated in 2015 and 2018	Active

[9] https://ec.europa.eu/research/infrastructures/pdf/roadmaps/greece_national_roadmap.pdf#view=fit&pagemode=none

[10] http://nkfih.gov.hu/national-research-infrastructure-roadmap

[11] http://www.ponrec.it/ponri/notizie/2017/pnir/

[12] http://www.forskningsradet.no/prognett-infrastruktur/Norwegian_Roadmap_for_Research_Infrastructure/1253976312605

[13] https://www.gov.pl/web/science/polish-roadmap-for-research-infrastructures

[14] https://ec.europa.eu/research/infrastructures/pdf/roadmaps/spain_national_roadmap.pdf#view=fit&pagemode=none

[15] https://www.vr.se/download/18.312b62c9166b295ec241390/1541065048121/Guide-to-research-infrastructures_VR_2018.pdf

Country		Roadmap	Info	Status
	Switzerland	EN[16]	Roadmap published in 2019	Active
	The Netherlands	EN[17]	First Roadmap published in 2008. Updated in 2013 and in 2016	Active

[16] https://urldefense.proofpoint.com/v2/url?u=https-3A__www.sbfi.admin.ch_dam_sbfi_en_dokumente_2019_04_roadmap-2D21-2D24.pdf.download.pdf_roadmap-5F2019-5Fe.pdf&d=DwMGaQ&c=8NwulVB6ucrjuSGiwL_ckQ&r=9K-Kc96EmQLMSsTkCznYKJAxWGhaEh9UvO0gcxPJNTI&m=Tb8cSeE1hqG8OsayO7XhZthpSNLwT1yQXQPhnNHU-dQ&s=y3fO7yGjpmW_17g9lw7LSLzAOuFx5bI_9JIdMYFpcZA&e=

[17] http://www.nwo.nl/en/news-and-events/news/2016/33-research-facilities-and-clusters-top-priority-for-dutch-science.html

European landscape of ICT facilities

4.1 Research Infrastructures

1.1.1 National Research Infrastructures in Europe

1.1.1.1 Belgium

Name of the infrastructure	Imec iLab.t testbeds
Type of the infrastructure	Research infrastructure
Organization model	Distributed
Short description of the infrastructure	Imec iLab.t provides the following infrastructure and testbeds (https://idlab.technology/infrastructure/): Virtual Wall (550+ bare metal server), GPULab (150+ GPUs in a job based environment), w-iLab.t (200+ nodes for wireless and IoT research), Officelab (40+ nodes for wireless and IoT research in an office environment), CityLab (100+ wireless and IoT nodes in the city of Antwerp), Industrial IoT Lab for IoT and robot research in an industrial environment
Is the project part of National Roadmap of RI?	NO
Governance model/Partnership	Imec IDLab research group
Timeline	Available today (https://doc.ilabt.imec.be)
Target communities	ICT researchers, Cross-domain researchers (from other disciplines, e.g., agriculture, sociology, medicine, etc.), SMEs and start-ups, Industry, education
Service offer	Open and free for research goals. Bilateral contracts possible for consulting support or better than best-effort support.
Access type)	Mostly virtual. Some physical (e.g. specific wireless research, industrial IoT, typically in project or bilateral setting)
Geographical coverage	Regional (2 sites in Flanders)
URL of the website	https://doc.ilabt.imec.be and https://idlab.technology/infrastructure/

1.1.1.2 Cyprus

Name of the infrastructure	CyGrid
Type of the infrastructure	Research Infrastructure
Organization model	distributed
Short description of the infrastructure	CyGrid was established in 2002 in the University of Cyprus with the main goals to establish a Cypriot presence in international Grid infrastructures. Additionally, it aims to develop local know-how and expertise on the development and operation of Grid technologies and to promote the uptake of Grid technologies in Cyprus, the interconnection of existing and future resources, and the deployment of new applications and to support research in Grid and Global Computing. The infrastructure consists of two (2) clusters with 90 CPUs, Gb Ethernet (Micronet copper switch), 2.1 PB Storage Server (FiberChannel), Resource Broker and Information Index for EGEESEE Federation, Network Connectivity: Through CyNet to Geant (155 MBps to Athens) and to EMISPHER Satellite Network. CyGrid activities include: Deployment and management of local grid cluster, connected with the CrossGrid testbed, and providing computational and storage services. Management of the CyGrid Certification Authority (CyCA), which issues Grid users with certificates for accessing the Grid. Presentations and tutorials on accessing the Grid and installing the CrossGrid and DataGrid middleware. Coordination of efforts to expand the Grid infrastructure in Cyprus and to promote the use of the Grid by the cypriot academic and research communities.
Is the project part of National Roadmap of RI?	YES
Governance model/Partnership	University of Cyprus
Timeline	
Target communities	Grid Computing community
Service offer	Grid computing, high-performance computing, information services
Access type)	Virtual and Physical
Geographical coverage	National
URL of the website	http://grid.ucy.ac.cy/index.php?id=8

Name of the infrastructure	High Performance Computing Facility (HPCF)
Type of the infrastructure	Research Infrastructure
Organization model	Single-sited
Short description of the infrastructure	The mission of the High Performance Computing Facility is to provide compute and data resources to the research community of Cyprus and the Eastern Mediterranean region, and to establish itself as the national supercomputing facility of Cyprus. Cy-Tera is an innovative hybrid machine, which is the first supercomputer in Cyprus, and the biggest open access supercomputer in the Middle East. The Cy-Tera production machine is an IBM Hybrid CPU/GPU cluster consisting of 98 twelve-core compute nodes and 18 dual-GPI compute nodes with a peak performance of ~30Terraflop/s, supporting an excess oof 600 software packages. The total storage capacity is 2 Petabytes. User support and help-desk services to facilitate access to the machine are provided by dedicated operations personnel. A section of the facility serves the needs of government agencies (e.g., the Cyprus Meteorology Department). The facility is a regional supercomputing eco-system and is part of European Super-computer infrastructures (PRACE).
Is the project part of National Roadmap of RI?	YES
Governance model/Partnership	The Cyprus Institute's governance structure includes the CREF Board of Trustees, the CREF Executive Committee and its President. The Scientific Advisory Council and the Scientific Expert Panels have advisory roles. CyI's senior authority rests with the internationally acclaimed CREF Board of Trustees that is responsible for guiding and assessing the effective implementation of the Institute's vision and mission. The Board is currently comprised of leading personalities of the international academic, political and business world. The Board is supported by the Scientific Advisory Council that provides advice and recommendations on strategic research matters and priorities. The strategic decisions taken by the Board of Trustees regarding the development of CyI necessitate follow up actions which are pursued by the Executive Committee. The Executive Committee provides guidance to the management of the Institute for furthering its progress on all levels. In order to exercise scientific overview and steering for its Research Centers the CyI President relies on the specialized advice of the Scientific Expert Panels (one for each of the three Research Centers). A key strategic theme for CyI is its large network of local, regional and international partnerships, which include universities, research institutes and other institutions relevant to its thematic areas. The CyI research centers have been developed in partnership with centres of excellence in their respective fields: EEWRC with MiT; CaSToRC with the University of Illinois; and STARC with C2RMF. In addition, CyI has formed major collaborations with the Max Planck Society, the Jülich Supercomputing Center, CNRS, ENEA, CNR, ETH Zürich, Bibliotheca Alexandrina, Imperial College, Tel Aviv University, Skoltech and many others.
Timeline	
Target communities	Research community of Cyprus and the Eastern Mediterranean region

Service offer	High Performance Computing, Data processing and Analytics
Access type)	Virtual and Physical
Geographical coverage	Regional/National
URL of the website	https://www.cyi.ac.cy/

1.1.1.3 France

Name of the infrastructure	SILECS, Super Infrastructure for Large-scale Experimental Computer Science
Type of the infrastructure	Research infrastructure
Organization model	Distributed
Short description of the infrastructure	SILECS aims at designing and building a large infrastructure for experimental research on various aspects of networking and distributed computing, from small connected objects to the large data centres of tomorrow. It will enable end-to-end experimentation with software and applications at all levels of the software layers, from event capture (sensors, actuators) to data processing and storage, radio transmission management and dynamic deployment of edge computing services. Built in part from the FIT and Grid'5000 infrastructures, based on the expertise developed in the implementation of these platforms, this infrastructure connected by the Renater network will enable experiments at all levels, from hardware to each layer of the software stack for a range of different technologies.
Is the project part of National Roadmap of RI?	YES
Governance model/Partnership	Groupement d'Intérêt Scientifique
Timeline	2018-2020: Planning 2020-2022: Construction and set up 2022-2030: operation
Target communities	ICT researchers, Cross-domain researchers (from other disciplines, e.g., agriculture, sociology, medicine, etc.), SMEs and start-ups, Industry
Service offer	SILECS is a large infrastructure for experimental research on various aspects of distributed computing and networking, from small wireless objects to large data centers of tomorrow. It enables end-to-end reproducible experimental research on the entire data chain (from its capture to its processing, through its wired and/or wireless transmission) and it supports an open data approach. SILECS provides a large pallet of heterogeneous devices fully programmable, everywhere in the network, from end devices to cloud servers going through Internet routers with software and applications at all levels of the software layers. It enables to experiment, prototype and test wireless communications (cellular, IoT, wifi, etc) in different environments and topologies, including anechoic rooms, indoor and outdoor deployments. SILECS also includes advanced experimentation tools and facilities for HPC and distributed computing and it provides an interface to Cloud infrastructures like Cloudlab and Edgenet. Researchers can experiment with a fully customized software stack thanks to bare-metal deployment features, and can isolate their experiment at the networking layer. SILECS also provides advanced monitoring and measurement features for trace collection of networking and power consumption as well as full

	traceability of infrastructure and software changes on the testbed. Open and free, SILECS provides an environment and tools for accessing it, regardless of geographic location, via web interfaces or via ssh access., as well as measurement means for collecting data from experiences.
Access type)	Virtual and physical
Geographical coverage	National
URL of the website	https://www.silecs.net/

1.1.1.4 Greece

Name of the infrastructure	NITOS
Type of the infrastructure	Research Infrastructure
Organization model	distributed
Short description of the infrastructure	NITOS Facility is an integrated facility with heterogeneous testbeds that focuses on supporting experimentation-based research in the area of wired and wireless networks. NITOS is remotely accessible and open to the research community 24/7. It is used from hundreds of experimenters and is federated with several infrastructures all over the world and it is also part of the OneLab federation. The main experimental components of NITOS are: 1) a wireless experimentation testbed, which consists of 100 powerful nodes that feature multiple wireless technologies 2) a wireless city-scale sensor network in Volos city 3) a Software Defined Radio testbed 4) a Software Defined Networking testbed 5) a mmWave testbed 6) a Cloud infrastructure
Is the project part of National Roadmap of RI?	YES (as part of HELIX/HELNET action)
Governance model/Partnership	University of Thessaly (UTH)
Timeline	Available today
Target communities	Digital Sciences researchers, education
Service offer	Wireless and Wired Networking, Distributed computing, Big Data, Cloud Computing, Edge Computing, Educational activities
Access type)	Virtual and physical
Geographical coverage	Regional
URL of the website	https://nitlab.inf.uth.gr/NITlab/

1.1.1.5 Hungary

Name of the infrastructure	ELI-ALPS
Type of the infrastructure	Research Infrastructure
Organization model	Distributed
Short description of the infrastructure	The ELI programme is implemented in three sites. The Attosecond Light Pulse Source (ELI-ALPS) research institute (Szeged Hungary) hosts experiment on extremely short processes unfolding in atoms and molecules; the ELI-beamline (Czech Republic) focuses on generating short-pulse X-rays and on particle acceleration; and the ELI-NP (Romania) examines fundamental nuclear questions with ultra-powerful optical and gamma pulses. The attosecond research facility in Szeged provides a suitable environment for the laboratory-scale development of special high-energy laser systems to industrial partners but the laser generation process in itself can bring innovation and economic benefits in many areas.
Is the project part of National Roadmap of RI?	YES
Governance model/Partnership	The Project is managed by ELI-HU Non-Profit Ltd. in collaboration with Univwersity of Szeged
Timeline	Gradual commissioning from late 2017
Target communities	Basic research in physics, chemistry, material science and biomedical sciences. Applied research for industrial application purposes
Service offer	• To produce and transmit few-cycle light pulses onto target objects • Observation of elemental ultra-fast processes in molecules and atoms • Studying the collective excitation dynamics of solids and various linked systems • Extreme ultraviolet and x-ray pulses for material science and biomedical sciences experiments • Joint application of the attosecond toolset and the standard structural imaging techniques • Visualizing ultrafast structural dynamics at the sub-fs and nm scales • Analysis of relativistic light-matter interactions in time
Access type)	Virtual and physical
Geographical coverage	European and International
URL of the website	https://www.eli-alps. hu/

1.1.1.6 Italy

Name of the infrastructure	CINI-infrastructure
Type of the infrastructure	Research Infrastructure
Organization model	Distributed
Short description of the infrastructure	The CINI infrastructure is distributed among the several local sites constituting the Lab. In the following we provide a summary of what is located mainly in Messina (Mobile and Distributed Systems Lab) and in Bologna (Mobile Middleware Research Group). The CINI infrastructure in Bologna enables the experimentation and quantitative performance evaluation in fog/edge/cloud computing for large-scale deployment environments, with stringent constraints on reliability and latency. Therefore, it includes mobile IoT sensors and actuators, programmable AGVs, different types of wired/wireless connectivity technologies (also with Time Sensitive Networking solutions), a dedicated private 5G cell, as well as a set of edge nodes (also compliant with Multi-access Edge Computing - MEC) integrated in the cloud continuum with a local data centre (e.g., to support digital twins and AI-based networking). Specifically, the local data centre is a latest-generation cluster that includes: 1 Admin Node + 3 Control Nodes + 3 Compute & Storage Nodes, Switch Mellanox (18 ports 10/25 Gb + 4 ports 40/100 Gb), for a total of compute & storage of 120 cores @ 2.1 GHz, 576 GB RAM, 23 TB RAW Fast Data HDs, and 144 TB RAW Slow Data HDs. In addition, the infrastructure includes about 50 mobile nodes including 2 industrial and programmable AGVs, IoT devices (“regular” sensors and industrial sensors/actuators from a small manufacturing line with 3D printers, CNC centers, etc.), smartphones, Raspberry PIs, wearables, and gateway devices, supporting experiments on network slicing, time sensitive networking, and edge computing for Industrial Internet applications. The CINI infrastructure in Messina consists of a smart city testbed based on the Stack4Things (S4T) framework, that is an OpenStack-based opensource framework to deal with Cloud and IoT integration. Several smart cities services were installed (environmental monitoring, people counting, fleet management and more). Other similar S4T testbeds have been installed in the cities of Turin, Padua, Lecce, and Syracuse, but more cities will adopt the S4T framework in the near future according to several MoU recently signed with CINI. Dedicated open Hardware was also developed, named as the Arancino architecture, which integrates in one single device controller and processor and simplifies the data collection process (with edge computing) and the actuation processes. Several communication protocols can be used such as bluetooth, WiFi, Lora, Sigfox, 4/5G. The infrastructure includes a range of IoT devices (Arduinos, single-board computers and industrial sensors/actuators-hosting custom boards designed and produced by the academic spin-off company smartme.IO, etc.), 3D printers, smartphones, wearables, and gateway devices, supporting experiments on fog computing for Industrial Internet applications. A local cluster is also available that is a latest-generation cluster that includes: 1 Admin Node + 3 Control Nodes + 8 Compute & Storage Nodes, with multiple GbE connectivity options,

	for a total of compute & storage of 80 cores @ 2 GHz, 452 GB RAM, 30 TB mass storage.
Is the project part of National Roadmap of RI?	NO
Governance model/Partnership	CINI is a consortium involving 1,300+ professors of both Computer Science and Computer Engineering faculties, belonging to 39 public universities. Among the various activities, CINI supports the creation and development of national research Labs.
Timeline	
Target communities	ICT researchers and scientists
Service offer	Technologies and tools for testing IoT, edge/fog/cloud computing solutions, smart city applications.
Access type)	Virtual
Geographical coverage	National
URL of the website	n.a.

Name of the infrastructure	CNIT-infrastructure
Type of the infrastructure	Research Infrastructure
Organization model	Distributed
Short description of the infrastructure	The CNIT infrastructure is composed by two National CNIT Laboratories, namely the Smart and Secure Networks Lab (S2N) located in Genoa and Savona and the Wireless Communications Laboratory (WiLab) located in Bologna, Cesena and Ferrara. The S2N National Laboratory hosts an experimental infrastructure that provides: • complete support for the emulation of interconnections on both fixed and mobile high-speed networks, created on the basis of Software Defined Network (SDN) and Network Functions Virtualization (NFV) paradigms; • an integrated and virtualized computing environment capable of hosting both general-purpose and security applications. In particular, the platform consists of a physical networking infrastructure integrated with a powerful mini-datacenter (20 high-end servers providing more than 600 physical CPU cores, 1.7 TB of RAM and 100TB of high-speed SAS and SSD storage) capable of hosting network functions (VNFs and PNFs) and services of various kinds, including vertical applications also in MEC mode (Multi-access Edge Computing). The Wireless Communications Laboratory (WiLab) makes available the following testbed facilities: • Configurable end-to-end LoRaWAN network, with 25 programmable sensor devices and multiple LoRaWAN gateways connected to two Network Servers: one is developed by the headquarters and is fully configurable, the other is owned by A2ASmartCity with unlimited availability of use. • Configurable end-to-end NB-IOT network with programmable sensor devices. • Semi-anechoic chamber for e.m. compatibility and others for EMC measurements at 3 m up to 18 GHz for emission and radiated immunity tests. • End-to-end ultra-broadband localization network (UWB), a fully configurable indoor location network based on UWB technology. This includes a drone arena equipped with Vicon infrared and ultra-wideband positioning system for the validation of location technologies and systems operating on drones (UAV). • Lepida Regional network, the ICT network of the Public Administration including 100+ microwave links, 1000+ WiFi hot spots. • A testbed for vehicle-to-vehicle (V2V) e vehicle-to infrastructure (V2I) with ITS-G5 technology. The testbed is composed of two road side units (RSU) and two on-board

	units (OBU) of different vendors for interoperability test and communication tests.
Is the project part of National Roadmap of RI?	NO
Governance model/Partnership	CNIT (National, Inter-University Consortium for Telecommunications, www.cnit.it) is a non-profit consortium, established in 1995, bringing together 37 public Italian universities to perform research, innovation and education/training activities in the field of the Information and Communication Technology. The National Laboratories are CNIT resources available to all the Research Units, with the aim of developing very challenging experimental research activities at the national and international levels.
Timeline	
Target communities	ICT researchers and scientists
Service offer	Technologies and tools for testing SDN, NFV, MEC solutions, UWB-based localization systems, LoRaWaN-based sensing platforms,
Access type)	
Geographical coverage	National
URL of the website	n.a.

Name of the infrastructure	CNR-infrastructure
Type of the infrastructure	Research Infrastructure
Organization model	Distributed
Short description of the infrastructure	The CNR Infrastructure is composed of two different facilities, namely CNR-EDGE and CNR-AI. The CNR-EDGE facility is located in Pisa, and is developed and operated by the Institute for Informatics and Telematics, specifically in the Ubiquitous Internet Lab (UI). The main focus of the CNR-EDGE facility is to enable experiments in AI-based edge networking. It thus features several personal networking devices, IoT nodes, as well as a local data centre supporting edge AI-based networking solutions. Specifically, the local data centre is a latest-generation cluster for HPC that includes: 3 nodes with dual CPU Intel Xeon Platinum 8164 (total 104 cores), 512GB RAM, NVIDIA Tesla T4 16GB GPU, and 30 TB RAID-5 local disk array; 2 nodes (*) with dual CPU Intel Xeon Platinum 8276L (total 112 cores), 512 GB RAM, NVIDIA Tesla T4 16 GB GPU, and 30 TB RAID-5 local disk array; 1 node with dual CPU Intel Xeon E5-2640v4 (total 40 cores), 256 GB RAM, NVIDIA TITAN Xp GPU, and 8 TB RAID-5 local disk array; 1 node with quad CPU AMD Opteron 6282 SE (total 64 cores), 128 GB RAM, and 15 TB RAID-5 local disk array; all the nodes, except those marked with (*), are interconnected via a 10 Gigabit Ethernet switch and have access to a 42 TB NAS. This is used for testing AI-based network services for edge/fog environments. In addition, the infrastructure comprises about 30 personal mobile devices including smartphones, tablets, wearables, to support dedicated experiments using fog computing equipment. The infrastructure also includes (15) IoT devices including sensors and gateway devices, supporting experiments on WSN for Industrial Internet applications. The CNR-AI facility is an HPC cluster located in Naples, and is hosted by ICAR, the Institute for high performance computing and networking of the National Research Council (CNR). The HPC cluster has already installed a number of computing nodes that provide peak performance of about 800 Tflops, but there is plan for expanding it with 50 additional computing nodes with multiple cores and GPUs. With this planned upgrade we aim at offering 700.000 cores with a peak performance of about 3000 Tflops. The goal of this HPC infrastructure is to support the research community and the national industries and start-ups in developing new AI solutions and Big data analytics in a broad range of domains and applications, including autonomous driving, UAVs, 3D video analytics, industrial IoT, building automation, etc.
Is the project part of National Roadmap of RI?	NO (Italian National Roadmap of RI under finalization)
Governance model/Partnership	CNR-EDGE is developed and managed by the Institute for Informatics and Telematics (IIT) of CNR, specifically in the Ubiquitous Internet Lab (UI).

	CNR-AI will be managed by a Scientific Board representing eight CNR institutes working on AI, Big Data analytics and cloud computing technologies
Timeline	In operation since 2019
Target communities	ICT researchers and scientists Cross-domain communities
Service offer	Virtualization of edge-based resources for testing AI-based networking solutions, big data analytics, AI-enabled decision support systems, HPC services
Access type)	Virtual (under development)
Geographical coverage	National
URL of the website	n.a.

1.1.1.7 Luxembourg

Name of the infrastructure	ULHPC – High Performance Computing platform of the University of Luxembourg
Type of the infrastructure	Research Infrastructure
Organization model	Single-sited
Short description of the infrastructure	ULHPC- The platform provides computing and storage capacities to researchers in Luxembourg.
Is the project part of National Roadmap of RI?	NO
Governance model/Partnership	The ULHPC infrastructure is governed by the rectorate of the University of Luxembourg
Timeline	2007
Target communities	Researchers and scientists Cross-domain researchers (from other disciplines, e.g. biology, physics, medicine, etc.) SMEs and start-ups Industry
Service offer	- Computing capacities - Storage capacities - Hardware acceleration (GPU) - Development platform with built-in version control, issue tracking, code review, CI/CD - Tutorial/Support to users
Access type)	Virtual and physical
Geographical coverage	National
URL of the website	https://hpc.uni.lu/

1.1.1.8 Norway

Name of the infrastructure	Experimental Infrastructure for Exploration of Exascale Computing (eX3)
Type of the infrastructure	Research Infrastructure
Organization model	Single-sited
Short description of the infrastructure	The eX3 infrastructure facilitates experimental HPC research through providing an extremely heterogeneous computational cluster, showcasing a wide variety of technology components that are expected to be important for future supercomputers. The infrastructure is allows experiments and measurements that cannot be supported by a production-oriented HPC system.
Is the project part of National Roadmap of RI?	YES
Governance model/Partnership	Consortium of nine partners (five research, one national HPC management body, three companies)
Timeline	Granted for Dec 2017 – Nov 2022. Proposal for phase II (2022-2026) currently under review.
Target communities	Primarily HPC researchers. Second, advanced HPC users preparing for use of coming generations of supercomputers
Service offer	Early access to new technologies, computational resources, basic tech support
Access type)	Virtual and physical
Geographical coverage	National
URL of the website	https://www.ex3.simula.no/

Name of the infrastructure	NORNET
Type of the infrastructure	Research Infrastructure
Organization model	Distributed
Short description of the infrastructure	NorNet has two main components: NorNet Core and NorNet Edge. NorNet Core consists of more than tvelve programmable sites, each multi-homed to several network providers. NorNet Edge consists of several hundreds of smaller nodes that are connected to all mobile broadband providers in Norway. Together, these two components offer a unique platform for experimental networking research. NorNet is made available to the Norwegian and international networking research community.
Is the project part of National Roadmap of RI?	NO (it was for several years, now it is continued by Simula and used in several national and European research projects, partially funded by the Ministry of Transport and Communications)
Governance model/Partnership	Operated by Simula in collaboration with public and industrial stakeholders
Timeline	2012-
Target communities	Researchers in communication technology, public agencies and industrial actors
Service offer	Continuous measurements of broadband connections, experiments with network resilience, routing, etc.
Access type)	Virtual
Geographical coverage	National with extensions in some European countries through H2020-funded projects
URL of the website	www.nntb.no

Name of the infrastructure	The SimulaMet Interoperability lab (SMIL)
Type of the infrastructure	Research Infrastructure
Organization model	Single-sited
Short description of the infrastructure	• Benchmark and improve time-sensitive networking technologies for 5G networks between base stations and edge computing for 5G. • Study and improve mechanisms for network slicing to ensure successful co-use of 5G networks for critical applications. • Study how legacy computers can be used to realize Cloud Radio Access Networks by using software defined radio and lower cost of deployment by moving functionality from hardware to software. Of particular interest is real-time scheduling of Cloud RAN workloads in edge data centres. • Study new 5G and IoT applications enabled by edge computing using features such as low latency, high throughput and quality of service guarantees combined with edge computing capabilities available in 5G cellular networks. • Develop and improve self-driving networks for fast recovery with technologies such as SDN, P4 and Network Function Virtualization in combination with machine learning of large-scale data analytics of the entire networked system. • Understand and improve mechanisms required to establish Robust cellular networks for reliable infrastructure for new user groups which relies on dependable networks.
Is the project part of National Roadmap of RI?	NO, not yet. Currently it is a working pilot supporting a wide range of research projects at Simula. A proposal for public funding, which would include becoming part of the national roadmap, is currently under review.
Governance model/Partnership	Run by Simula
Timeline	2019 -
Target communities	Researchers in communication technology, industrial actors
Service offer	Experiments with 5G and IoT
Access type)	Virtual and physical
Geographical coverage	Regional
URL of the website	https://www.simulamet.no/simulamet-projects

1.1.1.9 Poland

Name of the infrastructure	PIONIER-LAB - National Platform for Integration of Research Infrastructures with Innovation Ecosystems
Type of the infrastructure	Research Infrastructure
Organization model	Distributed
Short description of the infrastructure	PIONIER-LAB is located on the Polish Road Map for Research Infrastructures. The Project assumes the construction of unique research laboratories based on the national fiber optic network PIONIER. The assumption of the Project is to make the platform available to entrepreneurs and other entities interested in conducting scientific research and development works based on the new, nationwide research infrastructure. The Project assumes closer cooperation of science with the economic sector and acceleration of innovation processes thanks to the direct participation of industry in the implementation of the Project's aims, as well as launching pre-incubators of entrepreneurship focused on the research infrastructure under construction.
Is the project part of National Roadmap of RI?	YES
Governance model/Partnership	The Project is managed by Poznan Supercomputing and Networking Center. The PIONIER-LAB Consortium is composed by 21 renowned Polish universities and research centers.
Timeline	2020-2023 (construction) 2024-2028 (min. 5 years of operation)
Target communities	ICT researchers and scientists Cross-domain researchers (from other disciplines, e.g. agriculture, sociology, medicine, etc.) Entrepreneurs SMEs and start-ups Industry
Service offer	The Project concentrates on the creation of eight closely related research laboratories, creating a shared cooperation space, the PIONIER-LAB research platform: 1. Laboratory of innovative network technologies 2. A distributed laboratory of time and frequency 3. Smart Campus as a Smart City Lab 4. Regional "Living" Innovation Laboratories inspired by ICT 5. Cloud Services Laboratory 6. Multi-Scale Simulation Laboratory 7. Laboratory of e-training services 8. Pre-incubation laboratory
Access type)	Virtual and physical
Geographical coverage	National
URL of the website	https://pionier-lab.pionier.net.pl

Name of the infrastructure	National Laboratory for Advanced 5G Research (PL-5G)
Type of the infrastructure	Research Infrastructure
Organization model	Distributed
Short description of the infrastructure	The aim of the PL-5G "National Laboratory for Advanced 5G Research" is to build a unique on a national scale research infrastructure for performing experiments of new techniques and solutions in the area of 5G network and services. 5G networks are designed for supporting users and devices mobility and, as a consequence, for assuring effective communication in society. The planned PL-5G research infrastructure is distributed. We plan that the main nodes will be located in leading research centers (consortium members), located at Warsaw University of Technology (WUT), Gdańsk University of Technology (GUT), Wrocław University of Science and Technology (WUST), AGH University of Science and Technology (AGH UST) from Krakow, Poznań Supercomputing and Networking Center (PSNC) from Poznań and the Communications Institute of the National Research Institute (NIT) from Warsaw.
Is the project part of National Roadmap of RI?	YES
Governance model/Partnership	The Project is managed by Warsaw University of Technology. The PL-5G Consortium is composed by 6 renowned Polish universities and research centers.
Timeline	2021-2023 (construction) 2024-2028 (min. 5 years of operation)
Target communities	ICT researchers and scientists Cross-domain researchers (from other disciplines, e.g. agriculture, sociology, medicine, etc.) Entrepreneurs SMEs and start-ups and Industry
Service offer	The discussed research infrastructure will follow the 5G architecture and will consist of three complementary laboratories: 1. 5G network laboratory - the laboratory will be built on the basis of solutions of 5G technologies (wireless and wired access networks, edge cloud computing, core network and central cloud computing) together with open programmable interfaces. 2. Laboratory of 5G simulators and measurement tools - it will provide simulators of 5G technology and measurement tools corresponding to the development and maintenance of the 5G network. 3. 5G environment laboratory - it will provide devices and software for creating network solutions, platforms and applications based on 5G technology (including integration with Internet of Things technologies).
Access type)	Virtual and Physical
Geographical coverage	Regional/National
URL of the website	Under construction

Name of the infrastructure	PRACE-LAB – Collaboration in the field of advanced computations in Europe
Type of the infrastructure	Research Infrastructure
Organization model	Distributed
Short description of the infrastructure	The main goal of the project is to increase the competitiveness of the scientific community and the economy, with particular emphasis on SMEs, on international markets. Thanks to the implementation of development works, it is planned to improve the position of the Polish ICT sector by supporting and strengthening the development of innovative solutions. The direct objective of the project is to build a widely available HPC (High Performance Computing) computing infrastructure consisting of high-performance computing servers, specialized processing units and flexible data management systems, and to provide scientific units and enterprises with services for research and development and activities based on this infrastructure. commercial. The implementation of the project is planned for 2019-2023 and will include the construction of specialized laboratories that guarantee the highest quality of services.
Is the project part of National Roadmap of RI?	YES
Governance model/Partnership	The Project is managed by Poznan Supercomputing and Networking Center. The PRACE-LAB Consortium is composed by 8 renowned Polish universities and research centers.
Timeline	2020-2023 (construction) 2024-2028 (min. 5 years of operation)
Target communities	ICT researchers and scientists Cross-domain researchers (from other disciplines, e.g. agriculture, sociology, medicine, etc.) Entrepreneurs SMEs and start-ups Industry
Service offer	The project creates six laboratories: 1. HPC and cloud computing 2. Access to processing infrastructure 3. Service management and monitoring 4. Data management services 5. Distributed data management 6. Security of PRACE-LAB infrastructure
Access type)	Virtual and physical
Geographical coverage	National
URL of the website	http://www.prace-lab.pl

1.1.1.10 Spain

Name of the infrastructure	5TONIC
Type of the infrastructure	Research Infrastructure
Organization model	Single-sited
Short description of the infrastructure	5TONIC was initiated by **Telefonica** and **IMDEA Networks Institute** with a clear vision to create an open research and innovation ecosystem laboratory in which industry and academia come together to boost technology and business innovative ventures. The laboratory promotes joint project development, joint entrepreneurial ventures, discussion fora, events and conference sites, all in an international environment of the highest impact. In other words, 5TONIC will serve to show the capabilities and interoperation of pre-commercial 5G equipment, services and applications, by leading global companies in the 5G arena. Apart from the initial members, 5TONIC welcomes new members to join and gain from the benefits of an advanced research and innovation laboratory, oriented to research, debate, field-testing and demonstration of all technologies and equipment to support 5G communications, services and applications. 5G networks are considered the gateway to the age of "intelligent everything" that awaits us. The development of 5G has thus become a landmark in the global competition for technological leadership. The 5TONIC Laboratory was created to promote joint project development, joint entrepreneurial ventures, discussion fora, events and a conference site, all in an international environment oriented to achieve the highest technological impact in this area. The main **5TONIC Research & Innovation Laboratory** site is located at IMDEA Networks Institute, a research institute on the forefront of technological innovation and with an extensive track record in European 5G Research Projects. IMDEA Networks is one of the main leaders at European level in the field of 5G networks.
Is the project part of National Roadmap of RI?	NO
Governance model/Partnership	Private-public enterprise/Managed by Steering board (Telefonica, Imdea Networks, Ericsson, Intel, Commscope, University Carlos III of Madrid, Cohere Technologies, Interdigital, Altran/Members affiliation
Timeline	2015 – No limit fixed
Target communities	Researchers, projects from members entities
Service offer	5G virtual software network area ; 5G wireless systems area; 5G demos and trials, 5G European projects; 5G events
Access type)	Virtual and physical
Geographical coverage	Regional
URL of the website	www.5tonic.org

Name of the infrastructure	SN4I-EHU
Type of the infrastructure	Research Infrastructure
Organization model	Single-sited
Short description of the infrastructure	The SN4I (Smart Networks for Industry) facility, is a 5G-enabled, NFV and SDN aware communication network that supports advanced Industry 4.0 applications deployed between the Faculty of Engineering in Bilbao, the RedIRIS Point of Presence in Leioa and the Aeronautics Advanced Manufacturing Research Centre (CFAA) in the Technological Park of Bizkaia in Zamudio. The SN4I infrastructure leverages NFV to provide a flexible way to deploy virtual services and SDN to allow the programming of network elements in order to interconnect these virtual services. After having deployed some use cases for NB-IoT and LTE/M it has recently been upgraded to support 5G within a National 5G Pilot and as a result of own investments. As a result, SN4I provides network, computing and storage slicing for the deployment of isolated concurrent services and experimentation. This deployment also allows to study the integration of NFV technologies with the Industrial Internet protocols and the coexistence with other networks like TSN (Time Sensitive Networks). Therefore, SN4I will complements traditional manufacturing research and activity in the Advanced Aeronautical field of manufacturing, with state of the art technologies like high bandwidth, low delay, on demand service creation, mission critical communications, SDN based security, etc. The integration of all these technologies with cutting-edge machine tools and manufacturing processes provides a mixed R+D+I centre in advanced and connected manufacturing technologies that represents state of the art 5G applications for Industry 4.0 and beyond.
Is the project part of National Roadmap of RI?	NO
Governance model/Partnership	SN4I which is deployed in part in the CFAA which is based on a private-public agreement promoted by the University of the Basque Country, the Basque Government, Provincial Council of Bizkaia, Business Development Basque Agency (SPRI Group) and the “Business Grouping for Development of Advanced Aerospace Manufacturing Techniques, EIG",
Timeline	2018 – No limit fixed
Target communities	Researchers from both manufacturing and IT sectors, projects from members entities.
Service offer	5G based deployment of virtualized services; 5G wireless systems area; 5G demos and trials.
Access type)	Virtual and physical
Geographical coverage	Regional
URL of the website	https://www.ehu.eus/en/web/cfaa/aplicaciones-industriales-de-5g

1.1.1.11 Sweden

Name of the infrastructure	Swedish National Infrastructure for Computing (SNIC)
Type of the infrastructure	Research Infrastructure
Organization model (single-sited/distributed)	Distributed
Short description of the infrastructure (max 800 characters with spaces)	The Swedish National Infrastructure for Computing (SNIC) is a national research infrastructure that makes available large scale high performance computing resources, storage capacity, and advanced user support, for Swedish researchers. SNIC is funded by the Swedish Research Council (VR-RFI) and the ten participating universities, Chalmers University of Technology, Gothenbug University, Karolinska Institutet, KTH Royal Institute of Technology, Linköping University, Lund University, SLU Swedish University of Agricultural Sciences, Stockholm University, Uppsala University and Umeå University.
Is the project part of National Roadmap of RI? (YES/NO)	YES
Governance model/Partnership	The SNIC General Assembly consists of representatives from all members of the SNIC consortium. SNIC is organizationally a part of Uppsala University. The General Assembly proposes members of the SNIC Board, who are then formally appointed by the Vice Chancellor of Uppsala University.
Timeline	
Target communities	Swedish researchers and scientists in need of computational and storage resources
Service offer	Computing and storage resources are offered for various computational workloads, from traditional cluster computing, through GPU support for AI/ML workloads, to HPE Cray EX supercomputers. A variety of service tiers are available depending on the computational needs.
Access type (virtual / physical / virtual and physical)	Virtual
Geographical coverage (Regional/National/European/International)	National
URL of the website	https://www.snic.se/

1.1.1.12 Switzerland

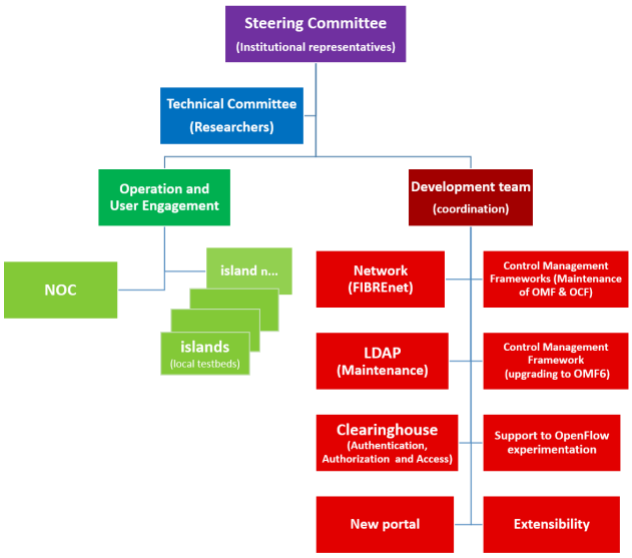
Name of the infrastructure	IoT Lab
Type of the infrastructure	Research Infrastructure
Organization model	Distributed
Short description of the infrastructure	IoT Lab is a testbed federation and the main server is hosted in Geneva. Other testbed servers are hosted in Novi Sad, Patras, Guildford and Geneva. Each testbed is a part of the IoT Lab testbed federation managed by Mandat International and the IoT Lab Association. The IoT Lab infrastructure permits to do research and experimentation in the different domains of the Internet of Things (IoT). A Cisco ESXi server is used in the IoT Lab platform: this server permits to host the virtual machines running the IoT Lab testbed federation and also the Mandat International IoT testbed. Furthermore, the server is used for the integration of IoT Lab in the Fed4FIRE+ testbed federation. An OpenStack cluster is also part of the infrastructure allowing further integrations and tests in the domain of IoT for internal usage.
Is the project part of National Roadmap of RI?	NO
Governance model/Partnership	Association
Timeline	Since 1st October 2013
Target communities	Researchers in IoT, crowd as the IoT Lab platform is providing crowdsourcing and crowdsensing tools.
Service offer	The IoT Lab infrastructure provides a Testbed as a Service for the researchers. It combines into a common platform crowdsourcing tools together with several testbeds on the Internet of Things. It provides a unique tool to ease all kinds of multidisciplinary research and experiments. It also facilitates reporting and sharing the most relevant results of the different research activities with the participants. The crowdsourcing tools are composed by the IoT Lab smartphone application enabling participants to join the IoT Lab community with the possibility to suggest, initiate and participate in research projects. It enables participants to accept privacy-friendly interactions with researchers, including crowdsensing on a voluntary basis and with a very strong personal data protection. This enables end-users to be at the core of the research cycle in order to better align the research with the real end-users needs and requirements. A LimeSurvery server is also a part of the crowdsourcing tools allowing the creation of surveys for the participants.
Access type)	Virtual access
Geographical coverage	European
URL of the website	https://iotlab.com/en (IoT Lab global services) https://www.iotlab.eu/ (IoT Lab platform)

1.1.2 National Research Infrastructures in other regions

This section presents several examples of RI available in other regions than Europe.

1.1.2.1 Brazil

Name of the infrastructure	Future Brazilian Environment for Experimentation (FIBRE)
Type of the infrastructure	Research Infrastructure
Organization model	Distributed
Short description of the infrastructure	The FIBRE testbed is as research facility constructed in the scope of a former project funded by the 2010 Brazil-EU Coordinated Call in ICT. It works as a large-scale Virtual Laboratory for students and researchers to test new applications and network architecture models. Currently, the FIBRE infrastructure consists of a federation of 11 local testbeds, also called “experimentation nodes” or simply “islands”. Each “island” has a set of network devices to support experiments in both fixed and wireless technologies. They are connected by an overlay network on the RNP (National network for higher education, research and innovation) backbone, comprised of two network separate layers: a control plane and an experiment plane. This network is named “FIBREnet”. The governance model allows each participating institution to have autonomy over their local resources, while they may use resources from other islands to setup network experiments. It is not necessary to host an experimental island to use the testbed. FIBRE is open to use by any researcher, professor or student from any institution.
Is the project part of National Roadmap of RI?	YES
Governance model/Partnership	The FIBRE Project ended in October 2014 (co-funded by the Brazilian government and the EU’s Seventh Framework Programme – FP7). In 2015 the Brazilian institutions took over FIBRE’s legacy infrastructure to start offering the testbed as a service. With the end of the EU-BR project, a new governance model, admission rules, policies, and service operation processes had to be defined. The diagram below depicts how the current governance model is structured.



The Steering Committee is the highest decision-making body and as such is responsible for advising on strategic and administrative issues. This committee is formed by one (1) representative from each institution providing computing resources to the testbed.

The Technical Committee guides the technical evolution of the testbed, generating recommendations and "roadmaps".

The Operation and User Engagement group is is charge of testbed maintenance and user support. It must ensure the good functioning of the testbed and promote dissemination activities.

The Development team has the duty to perform corrective and evolutionary maintenance of all software supported by the testbed. Currently, part of the team is working on upgrading FIBRE's CMF to OMF6.

Timeline	n.a.
Target communities	Brazilian researchers, scientists, professor and student in need of network and storage resources to test new applications and network architecture models.
Service offer	Provide a large-scale platform for promoting the Future Internet research in Brazil and region. Encourage educators to use the testbed for network classes to foster a new generation of researchers.
Access type)	Virtual access
Geographical coverage	National
URL of the website	https://www.fibre.org.br

Name of the infrastructure	Cloud ComputiNg EXperimental Testbed (CloudNEXT)
Type of the infrastructure	Research Infrastructure
Organization model	Distributed
Short description of the infrastructure	CloudNEXT is a testbed for the experimentation of new architectures, platforms and applications in cloud computing with direct accces to the harware of the infrastructure (baremetal). It has as objective to support experimentation when the use of virtual machines and containers are not appropriate, such as experiments where the hardware itself or the virtualization infrastructure are being investigated or when the virtualization itself interferes in the results of the investigation. CloudNEXT is composed of two different sites geographically distributed interconnected by the RNP's backbone. It provides to the experimenters the automated allocation of OpenStack computing clusters comprised of baremetal servers.
Is the project part of National Roadmap of RI?	NO
Governance model/Partnership	The infrastructure is operated by the Brazil's National Education and Research Network (RNP) and funded by the Ministry of Science, Technology and Innovation (MCTI).
Timeline	2018-2020 (construction) 2021-2023 (min. 3 years of operation)
Target communities	Researchers, SMEs, Industry
Service offer	Network resources, baremetal machines
Access type)	Physical and virtual access
Geographical coverage	Brazil
URL of the website	http://cloudlab-brasil.rnp.br/testbed

Additional information:

Since 2011 several experimentation environments with different scopes have emerged in Brazil, targeting at different research technologies, among them: FIBRE (Future Internet Brazilian Environment for Experimentation), the most important, based on SDN experimentation; FUTEBOL[18] (Federated Union of Telecommunications Research Facilities for an EU-Brazil Open Laboratory), for experimentation involving optical and wireless communications; CloudNEXT[19] (Cloud ComputiNg EXperimental Testbed), for experimentation on cloud computing using bare-metal resources; 5GINFIRE[20] , for experimentation in 5G networks based on NFV and cloud usage; FIWARE[21] Labs for IoT development; and finally NECOS[22], (Novel Enablers for Cloud Slicing), focused on the creation of slices that encompass different clouds with distributed resources. Many of these experimentation environments are research projects that are close to the end.

Given this scenario, we are beginning a new project, called Slicing Future Internet Infrastructures – SFI^2, which has the goal of providing a single multidomain and slice-based provisioning solution among these testbed infrastructures. SFI^2 aims to simplify the creation of complex networks with minimum configuration effort based on the intelligent orchestration of multi-domain slicing, offering Slice-as-a-Service (SlaaS) for future Internet developers.

[18] http://futebol.inf.ufrgs.br/

[19] http://cloudlab-brasil.rnp.br/testbed

[20] http://wiki.5ginfire.eu/5-ginfiretestbeds/ufu

[21] https://fiwarelab.rnp.br

[22] http://www.h2020-necos.eu/

1.1.2.2 Japan

Name of the infrastructure	Research Infrastructure for large-Scale Experiments (RISE)
Type of the infrastructure	Research Infrastructure
Organization model	Distributed
Short description of the infrastructure	RISE is a wide-area SDN testbed operated by NICT, which consists of SDN switches and computer nodes at more than 10 locations including overseas sites such as Seattle, Singapore, and Bangkok. RISE provides a wide-area SDN environment to a user which can be fully controlled by the user's controller. One of the major features of RISE is its flexibility in network topology. A RISE user can request the network topology of her slice without considering the underlying physical network configurations. Although the original objective of RISE was to accommodate wide-area SDN-related experiments on JGN, its technical coverage has been extended to IoT-related experiments with IoT gateways. The IoT gateways provide a simple interconnection mechanism between a RISE user slice and IoT devices, which decreases environmental setting-up costs of IoT-related experiments.
Is the project part of National Roadmap of RI?	n.a.
Governance model/Partnership	RISE is operated by National Institute of Information and Communications Technology (NICT)
Timeline	n.a.
Target communities	Researchers, SMEs, Industry
Service offer	Network nodes, compute nodes, SDN environment
Access type)	Physical and virtual access
Geographical coverage	Japan
URL of the website	n.a.

Name of the infrastructure	Japan-wide Orchestrated Smart/Sensor Environment (JOSE)
Type of the infrastructure	Research Infrastructure
Organization model	Distributed
Short description of the infrastructure	JOSE is an open testbed operated by NICT that can accommodate multiple Internet of Things (IoT) experiments consist of sensor networks, distributed storage/computation resources and network resources. There are 5 distributed data centers in Japan (Yokosuka, Kanazawa, Kyoto, Tokyo, Osaka) and more than 10,000 virtual machines (or containers) are available for the experiments on these data centers. The storage/computation/network resources are controlled and virtualized by SDN and SDI functions in a centralized manner. Each experimenter can deploy their processing modules on the distributed servers in the dedicated network slice. The experimenters can use the storage/computation resources physically located closer to the experimenter's sensor network as an edge-cloud facility. As one of the next steps of such testbed technologies, we are developing functions based on two-layered (Platform as a Service layer and Infrastructure as a Service layer) edge-cloud architecture for IoT edge computing experiments.
Is the project part of National Roadmap of RI?	n.a.
Governance model/Partnership	JOSE is operated by National Institute of Information and Communications Technology (NICT)
Timeline	n.a.
Target communities	Researchers, SMEs, Industry
Service offer	sensor networks, distributed storage/computation resources and network resources
Access type)	Physical and virtual access
Geographical coverage	Japan
URL of the website	https://testbed.nict.go.jp/jose/english/index.html

Name of the infrastructure	StarBED
Type of the infrastructure	Research Infrastructure
Organization model	Distributed
Short description of the infrastructure	StarBED is a general-purpose network emulation testbed operated by NICT based on 1000+ bare metal PC servers and network switches located in a single site (Ishikawa). Experimenters can install OSes and application software to the nodes and can configure their complex experimental topologies with VLANs. NICT has been developing a software suite named SpringOS for the operation of StarBED such as node power control, network configuration, and so forth. Experimenters can conduct not only wired network experiments but also wireless ones with NETorium that can emulate wireless communications such as WiFi and BLE on the wired networks of StarBED. Now, we are developing new mechanisms of wall-clock time coordination between emulation environments and software simulation environments to support experiments on StarBED in IoT technologies interacting with physical phenomena
Is the project part of National Roadmap of RI?	n.a.
Governance model/Partnership	StarBED is operated by National Institute of Information and Communications Technology (NICT)
Timeline	n.a.
Target communities	Researchers, SMEs, Industry
Service offer	Network emulation services
Access type)	Physical and virtual access
Geographical coverage	Japan
URL of the website	https://starbed.nict.go.jp/en/

1.1.2.3 South Korea

Name of the infrastructure	KREONET-S
Type of the infrastructure	Research Infrastructure
Organization model	Distributed
Short description of the infrastructure	KREONET-S is a new network project to drive softwarization of KREONET Infrastructure with network virtualization, automation, and intelligence technology development. It is deployed as an SDN-WAN in eight locations now in Korea (5), the US (2), and China (1), supporting various advanced R&E communities and users who want to experiment their innovative network technologies as well as to use KREONET-S for their very high-performance data transfer in the automated and intelligent manner using virtually dedicated networking environment. KREONET- S is growing to contribute primarily to the new areas of hyper-convergence and data-centric ICT based on IoT, cloud, big data, supercomputing, and data-intensive science.
Is the project part of National Roadmap of RI?	n.a.
Governance model/Partnership	n.a.
Timeline	n.a.
Target communities	Researchers, SMEs, Industry
Service offer	Three types of services: 1. Pure SDN services 2. SDN-IP services 3. Federated SDN services
Access type)	Physical and virtual access
Geographical coverage	Global
URL of the website	http://www.kreonet-s.net

Name of the infrastructure	SD-WAN International Testbed
Type of the infrastructure	Research Infrastructure
Organization model	Distributed
Short description of the infrastructure	This SD-WAN international testbed is based on a 100 Gbps path between Daejeon, South Korea and the StarLigt International National Communications Exchange Facility in Chicago. The SD WAN is based on highly programmable components using ONOS as a foundation.
Is the project part of National Roadmap of RI?	n.a.
Governance model/Partnership	SD-WAN is operated by Korea Institute of Science and Technology Information (KISTI)
Timeline	n.a.
Target communities	Researchers, SMEs, Industry
Service offer	Network services
Access type)	Physical and virtual access
Geographical coverage	Global
URL of the website	http://www.kreonet-s.net

1.1.2.4 United States of America

Name of the infrastructure	COSMOS
Type of the infrastructure	Research Infrastructure
Organization model	Distributed
Short description of the infrastructure	The COSMOS project is aimed at design, development, and deployment of a city-scale advanced wireless testbed in order to support real-world experimentation on next-generation wireless technologies and applications. The COSMOS architecture has a particular focus on ultra-high bandwidth and low latency wireless communication tightly coupled with edge cloud computing. The COSMOS testbed is being deployed in upper Manhattan and consists of 40-50 advanced software-defined radio nodes along with fiber-optic front-haul and back-haul networks and edge and core cloud computing infrastructure. Researchers are able to run experiments remotely on the COSMOS testbed by logging into a web-based portal which provides various facilities for experiment execution, measurements, and data collection. The COSMOS testbed will cover one square mile in West Harlem, with City College to the north, Columbia University's Morningside Heights campus to the south, the Hudson River to the west, and Apollo Theater to the east. This vibrant, densely populated neighborhood is seen as an ideal place to push the bandwidth and latency limits of 4G, and even fifth-generation wireless technology, or 5G, which carriers are starting to roll out in some cities now.
Is the project part of National Roadmap of RI?	n.a.
Governance model/Partnership	n.a.
Timeline	n.a.
Target communities	Researchers, SMEs, Industry
Service offer	High throughput and low latency wireless links, 4G/5G and beyond, Compute systems, Software Defined Radios, storage systems, GPU, FPGA, programmable network switches
Access type)	Physical and virtual access
Geographical coverage	United States of America
URL of the website	https://cosmos-lab.org/ https://advancedwireless.org/new-york-city/

Name of the infrastructure	POWDER-RENEW
Type of the infrastructure	Research Infrastructure
Organization model	Distributed
Short description of the infrastructure	The POWDER-RENEW project is a collaboration between the University of Utah, Rice University and Salt Lake City, with broad support from community, municipal and state leadership. The POWDER advanced wireless research platform will cover 2.3 square miles of the University of Utah campus, 1.2 square miles of downtown Salt Lake City, and a two-mile corridor in between, reaching a potential population of 40,000 people. Powder is an end-to-end platform for research on mobile wireless networks. It provides radios that are programmable down to the waveform, attached to a network that can be configured by the user, connected to a wide variety of compute, storage, and cloud resources. Researchers can use this platform to build their own wireless networks, using existing protocols or technologies (such as 4G and MIMO), up-and coming ones (such as 5G and massive MIMO), or new ones that they invent and build from the ground up. In this environment, they can experiment with novel networks, devices, and applications. Powder will be built over a 10 km² area of Salt Lake City, encompassing the downtown area, the University of Utah campus, and a residential neighborhood. This area includes a variety of terrain types, building sizes, and densities, making for a dynamic environment in which to perform real experiments. The RENEW project will develop world's first fully programmable and observable wireless radio network. With RENEW, wireless research and development community will be able to test diverse ideas and concepts, ranging from low-level hardware to all the way to novel applications. The project will support many firsts, like 1) Programmable wide-band radios, including 5G bands of 2.5 and 3.5 GHz, 2) Large-scale MIMO, including massive MIMO, 3) Novel PHY and network stacks, including 5G-like and WiFi-like protocol stacks, 4) Observable at all layers of the protocol stack, 5) Use of distributed computational resources throughout the infrastructure
Is the project part of National Roadmap of RI?	n.a.
Governance model/Partnership	n.a.
Timeline	n.a.
Target communities	Researchers, SMEs, Industry
Service offer	5G massive MIMO, Software Defined Radios, Compute systems, FPGA, programmable network switches
Access type)	Physical and virtual access
Geographical coverage	United States of America
URL of the website	https://advancedwireless.org/salt-lake-city/ https://powderwireless.net/ https://renew.rice.edu/

Name of the infrastructure	Chameleon
Type of the infrastructure	Research Infrastructure
Organization model	Distributed
Short description of the infrastructure	Chameleon is a deeply programmable large-scale research testbed supporting Computer Science experiments in areas ranging from systems and networking to cloud computing and machine learning. Chameleon resources support experiments re- quiring hundreds of nodes, large-scale storage system in many configurations, or a diversity of hardware systems including GPUs, FPGAs, advanced memory systems, and virtualizable network switches. To date, Chameleon has been used by 2,700+ users working on 450+ Computer Science research and education projects.
Is the project part of National Roadmap of RI?	n.a.
Governance model/Partnership	n.a.
Timeline	n.a.
Target communities	Researchers, SMEs, Industry
Service offer	Compute systems, storage systems, GPU, FPGA, network switches
Access type)	Physical and virtual access
Geographical coverage	United States of America
URL of the website	https://www.chameleoncloud.org

Name of the infrastructure	FABRIC
Type of the infrastructure	Research Infrastructure
Organization model	Distributed
Short description of the infrastructure	FABRIC is a unique national research infrastructure to enable cutting-edge and exploratory research at-scale in networking, cybersecurity, distributed computing and storage systems, machine learning, and science applications. It is an everywhere programmable nationwide instrument comprised of novel extensible network elements equipped with large amounts of compute and storage, interconnected by high speed, dedicated optical links. It will connect a number of specialized testbeds (5G/IoT PAWR, NSF Clouds) and high-performance computing facilities to create a rich fabric for a wide variety of experimental activities. Fabric has deployed nodes spanning the entire nation. FABRIC Across Borders (FAB) extends the network to nodes in Asia and Europe for expanded scientific impact.
Is the project part of National Roadmap of RI?	n.a.
Governance model/Partnership	n.a.
Timeline	n.a.
Target communities	Researchers, SMEs, Industry
Service offer	Compute systems, storage systems, GPU, network switches
Access type)	Physical and virtual access
Geographical coverage	United States of America
URL of the website	https://fabric-testbed.net/ https://whatisfabric.net/

Name of the infrastructure	AERPAW
Type of the infrastructure	Research Infrastructure
Organization model	Distributed
Short description of the infrastructure	Aerial Experimentation Research Platform for Advanced Wireless, or AERPAW is the nation's first aerial wireless experimentation platform spanning 5G technologies and beyond. AERPAW will enable cutting-edge research — with the potential to create transformative wireless advances for aerial systems. On the AERPAW platform, drones and 5G are integrated to be mutually beneficial. Drones are supporting 5G by providing increased coverage and connectivity; and 5G is supporting drones by providing improved signals and location data. On today's networks, fixed nodes enable 4G signals to connect to wireless devices. On the AERPAW platform, nodes will be mobile, with the ability to transmit and receive radio waves from user devices while moving on demand. For example, in the aftermath of a natural disaster such as a hurricane, existing cellular networks may be damaged. As a result, aerial base stations can position themselves to provide the best wireless coverage to victims and first responders who would otherwise have no cellular connectivity. Drones are not the only mobile nodes. Researchers will also be putting 5G equipment on cars, buses, golf carts, and rovers for vehicle-to-vehicle communications, which will support autonomous driving and accident reduction.
Is the project part of National Roadmap of RI?	n.a.
Governance model/Partnership	n.a.
Timeline	n.a.
Target communities	Researchers, SMEs, Industry
Service offer	5G and beyond, Drones, Mobility experiments, Programmable networks, Compute systems
Access type)	Physical and virtual access
Geographical coverage	United States of America
URL of the website	https://aerpaw.org/

Name of the infrastructure	CloudLab
Type of the infrastructure	Research Infrastructure
Organization model	Distributed
Short description of the infrastructure	CloudLab provides researchers with control and visibility all the way down to the bare metal. Provisioning an entire cloud inside of CloudLab takes only minutes. Most CloudLab resources provide hard isolation from other users, so it can support hundreds of simultaneous "slices", with each getting an artifact-free environment suitable for scientific experimentation with new cloud architectures. Run standard cloud software stacks such as OpenStack and Hadoop. Or, build your own from the ground up. CloudLab is built from the software technologies that make up Emulab and parts of GENI, so it provides a familiar, consistent interface for researchers.
Is the project part of National Roadmap of RI?	n.a.
Governance model/Partnership	n.a.
Timeline	n.a.
Target communities	Researchers, SMEs, Industry
Service offer	Compute systems, storage systems, GPU, network switches
Access type)	Physical and virtual access
Geographical coverage	United States of America
URL of the website	https://cloudlab.us/

Name of the infrastructure	BRIDGES/BRIDGES-II
Type of the infrastructure	Research Infrastructure
Organization model	Centralized
Short description of the infrastructure	Bridges-2 provides transformative capability for rapidly evolving, computation-intensive and data-intensive research, creating opportunities for collaboration and convergence research. It supports both traditional and non-traditional research communities and applications. Bridges-2 is integrating new technologies for converged, scalable HPC, machine learning and data; prioritizing researcher productivity and ease of use; and providing an extensible architecture for interoperation with complementary data-intensive projects, campus resources, and clouds. Bridges-2 is available at no cost for research and education, and at cost-recovery rates for other purposes. Bridges began early operations in February 2021. It is funded by a $10-million grant from the National Science Foundation.
Is the project part of National Roadmap of RI?	n.a.
Governance model/Partnership	n.a.
Timeline	n.a.
Target communities	Researchers, SMEs, Industry
Service offer	Compute systems, HPC, Supercomputer
Access type)	Physical and virtual access
Geographical coverage	United States of America
URL of the website	https://www.psc.edu/resources/bridges-2/

Name of the infrastructure	Global Research Platform (GRP)
Type of the infrastructure	Research Infrastructure
Organization model	Distributed
Short description of the infrastructure	The Global Research Platform (GRP) is an international scientific collaboration led by the International Center for Advanced Internet Research (iCAIR) at Northwestern University, the Electronic Visualization Laboratory (EVL) at the University of Illinois at Chicago, the Qualcomm Institute–Calit2 at UC San Diego, and its partners worldwide. This initiative aims to create one-of-a-kind advanced ubiquitous services that integrate resources around the globe at speeds of gigabits and terabits per second. GRP focuses on design, implementation, and operation strategies for next-generation distributed services and infrastructure to facilitate high-performance data gathering, analytics, transport, computing, and storage, at 100 Gbps or higher. GRP actively works with partners in North America, Asia, Europe, and South America to customize international fabrics and distributed cyberinfrastructure to support data-intensive scientific workflows.
Is the project part of National Roadmap of RI?	n.a.
Governance model/Partnership	n.a.
Timeline	n.a.
Target communities	Researchers, SMEs, Industry
Service offer	Compute systems, HPC, Supercomputer
Access type)	Physical and virtual access
Geographical coverage	United States of America
URL of the website	http://www.theglobalresearchplatform.net/

4.2 e-Infrastructures

4.2.1 National level

4.2.1.1 Belgium

Name of the infrastructure	Vlaams Supercomputer Centrum
Type of the infrastructure	E-infrastructure
Organization model	Distributed
Short description of the infrastructure	VSC is the Flanders' most highly integrated high-performance research computing environment, providing world-class services to government, industry, and researchers.
Is the project part of National Roadmap of RI?	YES
Governance model/Partnership	Multiple universities working together with 1 board, led by Research Fund – Flanders (FWO)
Timeline	Operational
Target communities	Supercomputing needs
Service offer	Free, but with admission process. Quota are assigned.
Access type)	Virtual
Geographical coverage	Regional (Flanders)
URL of the website	https://www.vscentrum.be

4.2.1.2 France

Name of the infrastructure	Grand Équipement National de Calcul Intensif (GENCI)
Type of the infrastructure	E-infrastructure
Organization model	Distributed
Short description of the infrastructure	GENCI, in charge of providing high-performance computing and processing data, has the mission, at national and European level, to promote the use of intensive computing associated with Artificial Intelligence for the benefit of french academic and industrial research communities
Is the project part of National Roadmap of RI?	YES
Governance model/Partnership	“civil company” (société civile)
Timeline	2007 -
Target communities	Researchers in need of computational resources and data storage.
Service offer	Access to supercomputers, wide range of user supports.
Access type)	Virtual
Geographical coverage	National and European
URL of the website	https://genci.fr/

Name of the infrastructure	RÉseau National de télécommunications pour la Technologie, l'Enseignement et la Recherche (Renater)
Type of the infrastructure	E-infrastructure
Organization model	Distributed
Short description of the infrastructure	Connecting knowledge, the French National Telecommunication Network for Technology, Education and Research, also known as RENATER, is the benchmark digital infrastructure serving the Education and Research community. It manages France's national electronic communications network for technology, education and research.
Is the project part of National Roadmap of RI?	YES
Governance model/Partnership	"Groupement d'Intérêt Public " (GIP)
Timeline	1993 -
Target communities	French Education and Research community at any point in France and internationally.
Service offer	It offers a base network infrastructure and innovative, high-quality, interoperable and mobile network services, provides security, interoperability, transparency and trust in data interchanges for the Education and Research community, and widens the range of services proposed in order to contribute to digital transformation for Education and Research stakeholders.
Access type)	Virtual
Geographical coverage	National
URL of the website	https://renater .fr/

4.2.1.3 Germany

Name of the infrastructure	GCS – Gauss Centre for Supercomputing
Type of the infrastructure	E-infrastructure
Organization model	Distributed
Short description of the infrastructure	The Gauss Centre for Supercomputing (GCS) is a German association consisting of three German supercomputing centers, the LRZ (Leibniz Supercomputing Centre located in Garching near Munich), the HLRS (High Performance Computing Center Stuttgart), and the JSC (Jülich Supercomputing Centre). These three centers operate Germany's largest and most powerful high-performance computing infrastructure.
Is the project part of National Roadmap of RI?	NO
Governance model/Partnership	The GCS is jointly funded by the federal ministry of research and education and the states where the supercomputing centers are located, Baden Württemberg, Bavaria and North Rhine-Westphalia. The GCS is member of PRACE (Partnership for Advanced Computing in Europe) an international association representing 25 member states, that operate supercomputing infrastructure in Europe.
Timeline	2007 -
Target communities	German and European Universities, research centers and industry partners
Service offer	HPC services, training and education.
Access type)	Virtual and Physical
Geographical coverage	International
URL of the website	https://www.gauss-centre.eu/

Name of the infrastructure	DFN – Deutsches Forschungsnetz (en. German Research Network)
Type of the infrastructure	E-infrastructure
Organization model	Distributed
Short description of the infrastructure	DFN – the German Research Network is a high-performance network created for academia and research. The DFN is operated by the DFN-Verein, an association supported by German universities and research institutes. The goals of the DFN-Verein are the continued development of its network, the DFN, and the provision of additional services for the German research community.
Is the project part of National Roadmap of RI?	NO
Governance model/Partnership	The DFN-Verein is composed by over 350 members, such as universities, research institutes and associated companies. The DFN-Verein owns and operates a nation-wide network infrastructure. The DFN-Verein closely collaborates with the European research network GÉANT, actively collaborating in the development of new services and technologies for next generation networks.
Timeline	1984 -
Target communities	German Universities, research centers and industry partners
Service offer	• Internet network services • interconnectivity between HPCs • support for regional networks • advanced services and tools (e.g. videoconferencing, identity provider, applications on demand, storage, clouds, etc.)
Access type)	Virtual and Physical
Geographical coverage	International
URL of the website	https://www.dfn.de/en/

4.2.1.4 Greece

Name of the infrastructure	ELIXIR-GR
Type of the infrastructure	E-infrastructure
Organization model	distributed
Short description of the infrastructure	ELIXIR-GR is the Greek National Node of the ESFRI European RI ELIXIR, a distributed infrastructure that enables the life science research community across Europe to share and store their research data as part of an organised network. Its goal is to 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. ELIXIR-GR offers a collection of unique tools and databases that focuses primarily on biomedical research and marine biology are provided and will be continually expanded. Training is offered to all stakeholders in the form of handson workshops and webbased training courses.
Is the project part of National Roadmap of RI?	YES
Governance model/Partnership	Aristotle University of Thessaloniki, Democritus University of Thrace, National Technical University of Athens (NTUA), University of Athens (UoA), University of Crete (UOC), University of Ioannina (UOI), University of Patras (UoP), University of Thessaly (UTH), Athena Research & Innovation Center (ATHENA), Biomedical Research Foundation of the Academy of Athens (BRFAA), Biomedical Sciences Research Center "Alexander Fleming" (FLEMING), Centre for Research & Technology, Hellas (CERTH), Foundation for Research and Technology Hellas (FORTH), Hellenic Center for Marine Research (HCMR), Hellenic Pasteur Institute (HPI), National Hellenic Research Foundation (NHRF), National Infrastructures for Research and Technology (GRNET)
Timeline	
Target communities	Biological, Biomedical and Bioinformation communities
Service offer	**Compute resources**. ELIXIR-GR aims to provide large-scale computing resources for data-intensive tasks needed to store, analyze and process big biological data, such as molecular sequence and bioimaging data. **Data resources.** ELIXIR-GR will store, safeguard and provide access to biological databanks for which the Greek R&D life science community has high levels of appropriate domain expertise. Standards/Interoperability. In compliance with the standards of ELIXIR-EUROPE, ELIXIR-GR will address requirements for unified programming access to databanks and services. **Training.** ELIXIR-GR will provide training for life scientists and other stakeholders in using the bioinformatic and biocomputing services available at ELIXIR and other international RIs.

	Tools. In collaboration with other ELIXIR Nodes and the ELIXIR Hub, ELIXIR-GR will offer a catalog of tools and services provided by the scientific community for biological data management and analysis.
Access type)	Virtual
Geographical coverage	National
URL of the website	https://www.elixir-greece.org/

Name of the infrastructure	HELIX
Type of the infrastructure	E-infrastructure
Organization model	distributed
Short description of the infrastructure	HELIX (funded by GSRT) is a convergence-building instrument for the coordination of research-oriented eInfrastructures in Greece. It is comprised of three independent and complementary entities – NNCRI, OpenAIRE-D and HELNET- that will respectively address the increasing horizontal “big computing” and “big data” needs of the Greek academic & research community and the emerging need for experimentally driven research. Overall, it will form a single national ecosystem within which it will provide research and advisory services, support training activities, and offer relevant expertise on the combination of high-end communications, high-performance and high-throughput distributed computing, elastic cloud resource provisioning, and scalable data processing & analysis. It will facilitate data sharing and access to global knowledge across different research disciplines, scientific teams, and institutions, thereby contributing to interdisciplinary research, formation of inter-institutional virtual research team within Greece, and participation of Greek research facilities in virtual integrated facilities (including private research networks) with global scope. It will instrument several ‘as a Service’ offerings where part of the management capabilities is handed over to researchers, thereby facilitating innovation on novel frameworks delivering advanced researcher-controlled capabilities.
Is the project part of National Roadmap of RI?	YES
Governance model/Partnership	National Infrastructures for Research and Technology (GRNET), Athena Research & Innovation Center (ATHENA), University of Thessaly (UTH), University of Patras (UoP), National Technical University of Athens (NTUA), University of Athens (UoA)
Timeline	
Target communities	Digital Sciences community
Service offer	high-performance and high-throughput distributed computing, elastic cloud resource provisioning, and scalable data processing & analysis.
Access type)	Virtual and Physical
Geographical coverage	National
URL of the website	http://helnet.eu/

4.2.1.5 Italy

Name of the infrastructure	GARR
Type of the infrastructure	E-infrastructure
Organization model	distributed
Short description of the infrastructure	GARR is the ultra-broadband network dedicated to the Italian research and education community. The fiber optic infrastructure is based on leading-edge telecommunication technologies and covers more than 15.000 km of backbone and access links. The capacity of single backbone links reaches 100Gbps, while access links can reach 40 Gbps. In addition to the network infrastructure, GARR operates a computing and storage infrastructure
Is the project part of National Roadmap of RI?	NO
Governance model/Partnership	GARR network is designed and managed by Consortium GARR, a non-profit association founded under the auspices of the Ministry of Education, University and Research
Timeline	In operation since 1991
Target communities	Researchers and scientists, academic institutions
Service offer	network & access, digital identity, wifi mobility.
Access type)	Virtual
Geographical coverage	National
URL of the website	https://www.garr.it/

Italy

e-Infrastructures

Name of the infrastructure	CINECA (PRACE Italian node)
Type of the infrastructure	E-infrastructure
Organization model	distributed
Short description of the infrastructure	Cineca is a non profit Consortium, made up of 67 Italian Universities and 13 Institutions. SCAI (SuperComputing Applications and Innovation) is the High-Performance Computing department of CINECA, the largest computing centre in Italy and one of the largest in Europe and a PRACE Tier-0 hosting site. SCAI provides high performance computing resources, data management and storage systems and tools and HPC services and expertise at large, aiming to develop and promote technical and scientific services related to high-performance computing for the Italian and European research community.
Is the project part of National Roadmap of RI?	NO
Governance model/Partnership	Non-profit consortium. Several Italian Research Institutions have special agreements for computing provision. Industrial applications can request an obtain an "on-demand" computing provision
Timeline	In operation since 1991
Target communities	Cross-domain researchers and scientists, industrial users
Service offer	HPC
Access type)	Virtual
Geographical coverage	National
URL of the website	https://www.hpc.cineca.it/

Italy

e-Infrastructures

Name of the infrastructure	SOBIGDATA Italian Node
Type of the infrastructure	E-infrastructure
Organization model	distributed
Short description of the infrastructure	SoBigData is a platform providing an integrated ecosystem for ethic-sensitive scientific discoveries and advanced applications of social data mining on the various dimensions of social life. SoBigData provides an e-infrastructure offering different tools and methods, as well as hosts specialized Virtual Research Environments
Is the project part of National Roadmap of RI?	NO
Governance model/Partnership	SoBigData consortium consists of 12 partners from 6 member countries of the European Union. Italy host of the 6 country nodes of the RI. The Italian node is composed of three organizations: CNR, University of Pisa, and Scuola IMT Lucca.
Timeline	In operation since 2015
Target communities	Cross-domain researchers and scientists
Service offer	Virtual Research Environments, catalogue of tools and methods, open data sets.
Access type)	Virtual
Geographical coverage	European
URL of the website	http://www.sobigdata.it/

Name of the infrastructure	OPENAIRE Italian Node
Type of the infrastructure	E-infrastructure
Organization model	distributed
Short description of the infrastructure	OpenAIRE is a participatory initiative that offers a suite of services and tools to develop and promote Open Science in Europe. CNR is responsible for the technical coordination of OpenAIRE and for the development of content management functionalities for the OpenAIRE System
Is the project part of National Roadmap of RI?	NO
Governance model/Partnership	The governance structure of OpenAIRE consists of three bodies: the General Assembly (decision making body), the Executive Board (steering) and the Management Office (daily activities). Furthermore a network of 34 European National Open Access Desks is active.
Timeline	In operation since 2008
Target communities	Cross-domain researchers and scientists
Service offer	publication repository, search engines of research artefacts (literature, data, and methods).
Access type)	Virtual
Geographical coverage	European
URL of the website	https://www.openaire.eu/cnr-isti

4.2.1.6 Luxembourg

Name of the infrastructure	RESTENA
Type of the infrastructure	E-infrastructure
Organization model	Single-sited
Short description of the infrastructure	The Restena Foundation interconnects and provides network and security services for research and education institutions in Luxembourg, as well as in the health, culture and national administration sectors. It also manages the .lu domain name registration infrastructure, the top level domain name for Luxembourg.
Is the project part of National Roadmap of RI?	NO
Governance model/Partnership	The Foundation brings together all types of research and teaching bodies and the Ministry of National Education and Vocational Training, the Ministry of Higher Education and Research, and the Ministry of Finance. The Foundation also coordinates Internet resources nationally.
Timeline	2000 -
Target communities	Universities Research centers Start-ups located on technology transfer campuses Regional authorities
Service offer	• Internet network services • DNS • NREN missions • support for regional networks • advanced services and tools (e.g. videoconferencing, identity provider, applications on demand, storage, clouds, etc.)
Access type)	Virtual
Geographical coverage	National
URL of the website	https://www.restena.lu

Name of the infrastructure	MELUXINA
Type of the infrastructure	E-infrastructure
Organization model	Single-sited
Short description of the infrastructure	MeluXina focuses on users' needs, according to their sector and to their size. Indeed, in line with its economic policy the Grand-Duchy ensures that the supercomputer will fit SMEs specific needs. Finally, MeluXina integrate the EuroHPC world-class supercomputers network. Access to the machine is done through EURO-HPC (35%) or through a pay-per-use approach at commercial pricing (65%)
Is the project part of National Roadmap of RI?	YES
Governance model/Partnership	Under the governance of the Luxembourg Ministry of State and the Luxembourg Ministry of Economy, LuxProvide S.A., as a 100% subsidiary of LuxConnect, is in charge of the acquisition, launch and operation of Luxembourg's high-performance computer MeluXina. The mission of LuxProvide, headquartered in Bissen (Luxembourg), is to facilitate access to the use of the computational capabilities of MeluXina by setting up a competence centre in collaboration with Luxinnovation and the University of Luxembourg providing dedicated support to companies in their high-performance computing projects. LuxProvide will ultimately employ up to 50 people.
Timeline	2021 -
Target communities	Universities Research centers Start-ups located on technology transfer campuses Regional authorities SMEs
Service offer	• Internet network services • HPC expertise • advanced services and tools (e.g. videoconferencing, identity provider, applications on demand, storage, clouds, etc.)
Access type)	Virtual
Geographical coverage	National
URL of the website	https://luxprovide.lu/

4.2.1.7 Norway

Name of the infrastructure	Common Language Resources and Technology Infrastructure Norway (CLARINO)
Type of the infrastructure	E-infrastructure
Organization model	Distributed
Short description of the infrastructure	CLARINO is the Norwegian infrastructure for language resources and technologies, which operates the Norwegian part of the pan-European CLARIN infrastructure. The aim is to make existing and future language resources easily accessible for researchers and to bring eScience to humanities disciplines. Any researcher can, through federated authentication, gain access to a vast body of language resources, including e.g. speech recordings, literary and historic archives, linguistic corpora, etc. In addition, CLARINO offers services for depositing, managing, citing, searching and processing language data.
Is the project part of National Roadmap of RI?	YES
Governance model/Partnership	Consortium of six research institutions
Timeline	2011-
Target communities	Researchers
Service offer	Data access and integration
Access type)	Virtual
Geographical coverage	National & European
URL of the website	https://clarin.w.uib.no/

NORWAY

e-Infrastructures

Name of the infrastructure	The Norwegian e-infrastructure for Research & Education (E-INFRA)
Type of the infrastructure	E-infrastructure
Organization model	Distributed
Short description of the infrastructure	This is an umbrella project covering all national, production-oriented supercomputers available for publicly funded research. It also includes large-scale, systems for long-term data storage.
Is the project part of National Roadmap of RI?	YES
Governance model/Partnership	Managed by Sigma2 - the national agency for supercomputing. The Sigma2 Board have representatives from the 4-5 largest universities in Norway.
Timeline	2015 -
Target communities	Primarily researchers in need of computational resources and data storage. Second, users from industry or public sector.
Service offer	Access to supercomputers, wide range of user supports
Access type)	Virtual
Geographical coverage	National
URL of the website	www.sigma2.no

Name of the infrastructure	The Norwegian Health Data Analysis Platform
Type of the infrastructure	E-infrastructure
Organization model	Distributed
Short description of the infrastructure	Unified access to a wide range of national health registers for research purposes. Norwegian health registers are generally regarded to have exceptionally high quality, in many cases going back to the 1950s and 60s with close to complete coverage. Thus, these data are in high demand also internationally.
Is the project part of National Roadmap of RI?	YES
Governance model/Partnership	Managed by the Directorate for e-Health.
Timeline	2017 -
Target communities	Researchers in need of high-quality health data
Service offer	Data access, advanced tools for data analysis (in progress)
Access type)	Virtual
Geographical coverage	National
URL of the website	www.helsedata.no/en

Name of the infrastructure	National Microdata Platform for Norwegian and International Research and Analysis (Microdata.no)
Type of the infrastructure	E-infrastructure
Organization model	Distributed
Short description of the infrastructure	Unified access to a wide range of national statistical registers for research purposes.
Is the project part of National Roadmap of RI?	YES
Governance model/Partnership	Managed by Statistics Norway
Timeline	2019-2023
Target communities	Researchers in need of high-quality societal data
Service offer	Data access, advanced tools for data analysis (in progress)
Access type)	Virtual
Geographical coverage	National
URL of the website	https://microdata.no/en/

4.2.1.8 Poland

Name of the infrastructure	PIONIER - Polish Optical Internet
Type of the infrastructure	E-infrastructure
Organization model	Distributed
Short description of the infrastructure	PIONIER - a nationwide broadband optical network represents a base for research and development in the area of information technology and telecommunications, computing science, applications and services for the Information Society. Built entirely from the KBN (Committee for Scientific Research) funds, currently connects 21 Academic Network Centers Centers of Metropolitan Area Networks (MAN) and 5 of the HPCs (High Performance Computing) using their own fiber connections.
Is the project part of National Roadmap of RI?	NO
Governance model/Partnership	The PIONIER Consortium is composed by 22 renowned Polish universities and research centers. PSNC is the owner of the nation-wide network infrastructure, while all Consortium Members are owners of the metropolitan network infrastructures and/or HPC centers. PSNC represents the PIONIER Consortium in the structures of the European research network GÉANT, actively collaborating in the development of new services and technologies for next generation networks.
Timeline	2003 -
Target communities	Universities Research centers Regional authorities Industry
Service offer	• Internet network services • interconnectivity between HPCs • support for regional networks • advanced services and tools (e.g. videoconferencing, identity provider, applications on demand, storage, clouds, etc.)
Access type)	Virtual
Geographical coverage	National
URL of the website	http://www.pionier.net.pl/online/en/

4.2.1.9 Spain

Name of the infrastructure	REDIRIS
Type of the infrastructure	E-infrastructure
Organization model	Distributed
Short description of the infrastructure	RedIRIS is the Spanish academic and research network that provides advanced communication services to the scientific community and national universities. It is funded by the Ministry of Science and Innovation and is included in the Ministry's map of Special Scientific and Technological Facilities (ICTS). It is managed by the Public Corporate Entity Red.es, which reports to the Ministry of Economic Affairs and Digital Transformation. RedIRIS has over 500 affiliated institutions, mainly universities and public research centres, which join this community by signing an affiliation agreement. RedIRIS-NOVA offers access to the worldwide research network over the pan-European network, a dark fibre network infrastructure with a point of presence in each country that interconnects the 33 national research networks. GÉANT is a hybrid network that supports circuit switching and packet switching services. It also provides access to research networks in other parts of the world, such as (USA), (Canada), (Latin America), (North Africa), (Eastern and Southern Africa), (South Africa), (Asia-Pacific), (Japan), and (China) and ERNET (India).
Is the project part of National Roadmap of RI?	YES
Governance model/Partnership	Managed by the public Corporate Entitiy Red.es (Ministery of Economics Affair and Digital Transformation). Affiliation of public and non-profit adacemic and research institutions
Timeline	1988 – No limit fixed
Target communities	Public and non-profit private universities; Public research bodies; Singual Installations for Science and Technology (ICTS); Non-profit technology and research centers and institutions that participate in projects in the National Plan R&D&i; Non-profit science and technology parks; Public and non-profit private primary and secondary schools. Other entities of special interest for the Spanish science and technology system.
Service offer	Connectivity, Private Networks, Security, Cloud, Digital Identity, Collaboration, Email Quality, Roaming, Data Transfer, Institutions Support, Dissemination and Dynamization
Access type)	Virtual and physical
Geographical coverage	National
URL of the website	www.rediris.es

4.2.1.10 Sweden

Name of the infrastructure	Swedish University Network (SUNET)
Type of the infrastructure	E-infrastructure
Organization model (single-sited/distributed)	Distributed
Short description of the infrastructure (max 800 characters with spaces)	SUNET operates, maintains and develops Sweden's university data network, and also offers a range of online services for research IT and education. The Swedish Research Council is responsible for Sunet. Since SUNET was established in the 1980s, the organisation has enabled Swedish researchers to access other national and international e-infrastructures and their associated resources and services. SUNET also provides services for various types of electronic cooperation, for example video conferences. The current implementation of SUNET is called SUNET-C and is based on redundant and varied connections of 10–100 Ge to the country's higher education institutions and many state-owned museums and other cultural organisations. SUNET-C is also connected to international networks, and in this way provides access for Swedish researchers to international collaboration. In addition to ordinary network access with routers, SUNET can provide point-to-point connections for transferring large data amounts straight between two points using a wavelength service. This service is becoming increasingly important for large e-science projects and infrastructures.
Is the project part of National Roadmap of RI? (YES/NO)	YES
Governance model/Partnership	Organisationally, SUNET has been part of the Swedish Research Council since 2001, and has a funding model that differs from all other Swedish infrastructures. The Swedish Research Council receives earmarked funding for SUNET's activities, and SUNET also has its own directive from the Ministry of Education and Research. SUNET represents Sweden in NORDUnet, which is a cooperation between the Nordic National Research and Education Networks (NREN), in Norway (UNINETT), Denmark (DeiC), Finland (Funet), Iceland (RHnet) and Sweden (SUNET).
Timeline	
Target communities	Swedish researchers and scientists
Service offer	Communication and networking
Access type (virtual / physical / virtual and physical)	Virtual
Geographical coverage (Regional/National/European/International)	National
URL of the website	https://www.sunet.se/

4.2.1.11 Switzerland

Name of the infrastructure	SWITCHlan
Type of the infrastructure	E-infrastructure
Organization model (single-sited/distributed)	Distributed
Short description of the infrastructure (max 800 characters with spaces)	SWITCH is a foundation of the Swiss universities, whose mission is to provide outstanding information and communication services (e-infrastructures) to research and education. The e-infrastructure of SWITCH consists of three principal parts, which complete with each other in an ideal way: SWITCHlan as the physical network layer, SWITCHengines as the infrastructure layer and SWITCHedu-ID (AAI) as the middleware layer. As such, SWITCH has moved towards an integration of networks, cloud infrastructure and ID/access services and continues to improve its functionality in order to present an integrated offering to the user.
Is the project part of National Roadmap of RI? (YES/NO)	YES
Governance model/Partnership	SWITCH's funding scheme is built on contributions of the community and of Swiss and European research funding bodies as well as SWITCH own equities. As the community fully pays for running services, new projects and innovations are supported by additional, national and international funds and own means.
Timeline	In operation since 2017
Target communities	Swiss researchers and scientists, academic institutions
Service offer	Information, communication and network services for research and education
Access type (virtual / physical / virtual and physical)	Virtual
Geographical coverage (Regional/National/European/International)	National
URL of the website	https://www.switch.ch/network/

Name of the infrastructure	Swiss Data Science Center (SDSC)
Type of the infrastructure	E-infrastructure
Organization model (single-sited/distributed)	Distributed
Short description of the infrastructure (max 800 characters with spaces)	The ETH Domain launched the Initiative for Data Science in Switzerland (IDSS) in 2015 to strengthen data science through education and research and the provision of infrastructure. Within this initiative, EPFL and ETH Zurich initiated the Swiss Data Science Center (SDSC) and now jointly lead and operate the Center in close collaboration with the research institutes of the ETH Domain. The Center's mission is to accelerate the adoption of data science and machine learning techniques within the academic community at large as well as in industry. The SDSC is composed of a multi-disciplinary team of data and computer scientists plus experts in selected domains, with offices in Lausanne and Zurich.
Is the project part of National Roadmap of RI? (YES/NO)	YES
Governance model/Partnership	Managed by EPFL (École polytechnique fédérale de Lausanne) and ETHZ (Eidgenössische Technische Hochschule Zürich). The main funding sources are ETH Domain. ETH Domain is composed by EPF Lausanne, ETHZ Zurich and 4 Swiss research institutes. More information about ETH Domain available here: https://ethz.ch/en/the-eth-zurich/organisation/eth-domain.html
Timeline	In operation since 2018
Target communities	EPFL and ETHZ researchers and scientists, academic community
Service offer	Information services
Access type (virtual / physical / virtual and physical)	Virtual
Geographical coverage (Regional/National/European/International)	National
URL of the website	https://datascience.ch/

Name of the infrastructure	HPCN-24
Type of the infrastructure	E-infrastructure
Organization model (single-sited/distributed)	Single-sited
Short description of the infrastructure (max 800 characters with spaces)	The Swiss National Supercomputing Centre (CSCS) in Lugano develops and operates an open access research infrastructure for extreme-scale scientific computing, which is also referred to as supercomputing. This research infrastructure is a User Lab, the resources of which are accessed openly and managed in a transparent, peer-review process. There are two tiers of allocations. Researchers from all over the world can apply for Tier 1 projects for requests of up to one million node-hours p.a., which are allocated by a panel of eminent, international scientists, and Tier 0 allocations for very large projects that require more than one million node-hours p.a. The launch of Tier 0 calls and subsequent proposal screening is managed by the Partnership for Advanced Computing in Europe (PRACE).
Is the project part of National Roadmap of RI? (YES/NO)	YES
Governance model/Partnership	The host institution is ETH Zurich. The main funding sources are ETH Board and ETH Zurich. As Switzerland is a member of PRACE AISBL represented by ETH Zurich, PRACE is also a source of funding. Indeed, ETH Zurich is a host member of PRACE.
Timeline	In implementation phase, to be in operation in 2023
Target communities	Researchers and scientists from all over the world, PRACE users
Service offer	High-Performance Computing and Networking (HPCN) service
Access type (virtual / physical / virtual and physical)	Virtual
Geographical coverage (Regional/National/European/International)	International
URL of the website	https://www.cscs.ch/

4.2.2 European level

4.2.2.1 EGI

Name of the infrastructure	EGI - Advanced Computing For Research
Type of the infrastructure	E-infrastructure
Organization model (single-sited/distributed)	Distributed
Short description of the infrastructure (max 800 characters with spaces)	EGI is the International Grid & Cloud Infrastructure for Research. EGI is a federation of over 350 resource centres set up to deliver integrated computing services to European researchers. EGI's distributed e-infrastructure links together 620,000 CPU cores across 340 providers, serving 200 research communities and about 40,000 researchers in Europe and worldwide.
Is the project part of National Roadmap of RI? (YES/NO)	n.a.
Governance model/Partnership	The EGI Foundation (also known as EGI.eu) coordinates the EGI infrastructure on behalf of the participants of the EGI Council. The EGI Foundation is not-for-profit and was established in Amsterdam in 2010 under Dutch law. The foundation is led by Tiziana Ferrari (Managing Director) and is governed by the EGI Council. Day-to-day operations are supervised by the Executive Board.
Timeline	2010 -
Target communities	Researchers, scientists, industry
Service offer	EGI delivers advanced computing services to support scientists, multinational projects and research infrastructures: • Compute • Storage and Data • Security • Training • Applications
Access type (virtual / physical / virtual and physical)	Virtual and physical
Geographical coverage (Regional/National/European/International)	International
URL of the website	https://www.egi.eu/

4.2.2.2 EUDAT

Name of the infrastructure	EUDAT
Type of the infrastructure	E-infrastructure
Organization model (single-sited/distributed)	Distributed
Short description of the infrastructure (max 800 characters with spaces)	EUDAT's vision is Data is shared and preserved across borders and disciplines. Achieving this vision means enabling data stewardship within and between European research communities through a Collaborative Data Infrastructure (CDI), a common model and service infrastructure for managing data spanning all European research data centres and community data repositories. European researchers and practitioners from any research discipline can preserve, find, access, and process data in a trusted environment, as part of the EUDAT Collaborative Data Infrastructure. EUDAT offers heterogeneous research data management services and storage resources, supporting multiple research communities as well as individuals, through a geographically distributed, resilient network distributed across 15 European nations and data is stored alongside some of Europe's most powerful supercomputers.
Is the project part of National Roadmap of RI? (YES/NO)	n.a.
Governance model/Partnership	The CDI Council is the highest authority of the EUDAT CDI and has responsibility for all-important decisions. It controls EUDAT's activities in scientific, technical and administrative matters. It approves workplan of activity and new members, adopts the budgets and reviews expenditure. The Council is assisted by the EUDAT CDI Board and the EUDAT CDI Secretariat.
Timeline	2012 -
Target communities	Solutions for communities, data providers, researchers, data managers
Service offer	SERVICE CATALOGUE: • Data Hosting, Registration & Management & Sharing • Data Management Planning • Data discovery • Data Access, Interface & Movement • Identity and Authorization
Access type (virtual / physical / virtual and physical)	Virtual and physical
Geographical coverage (Regional/National/European/International)	International
URL of the website	https://www.eudat.eu/

4.2.2.3 GÉANT

Name of the infrastructure	GÉANT
Type of the infrastructure	E-infrastructure
Organization model (single-sited/distributed)	Distributed
Short description of the infrastructure (max 800 characters with spaces)	GÉANT is a fundamental element of Europe's e-infrastructure, delivering the pan-European GÉANT network for scientific excellence, research, education and innovation. Through its integrated catalogue of connectivity, collaboration and identity services, GÉANT provides users with highly reliable, unconstrained access to computing, analysis, storage, applications and other resources, to ensure that Europe remains at the forefront of research. Through interconnections with its 39 national research and education network (NREN) partners, the GÉANT network is the largest and most advanced R&E network in the world, connecting over 50 million users at 10,000 institutions across Europe and supporting all scientific disciplines. The backbone network operates at speeds of up to 500Gbps and reaches over 100 national networks worldwide.
Is the project part of National Roadmap of RI? (YES/NO)	n.a.
Governance model/Partnership	GÉANT is owned by its core membership. This includes 36 National Members, which are European national research and education network (NREN) organisations, and one Representative Member - NORDUnet - which participates on behalf of five Nordic NRENs. National research and education network (NREN) organisations are specialised internet service providers dedicated to supporting the needs of the research and education communities within their own country.
Timeline	Following on from the first pan-European networks built by DANTE (TEN-34 and TEN-155), GÉANT was born on 1 November 2000. Since then it has continued to play a key role in transforming the way researchers collaborate. Born out of the telecoms liberalisation of the late 1990s, GÉANT enables the best minds across Europe and the world to work together on ground-breaking research activities that were previously not possible or were inefficient due to limited or unstable commercial networks. With fast evolving technology, services and capacity, GÉANT has long been the most advanced research network in the world.
Target communities	Researchers, scientists, industry
Service offer	GÉANT develops the services its members need to support researchers, educators and innovators - at national, European and international levels. Our portfolio of advanced services covers connectivity and network management, trust identity and security, real-time communications, storage and clouds and professional services.

	CONNECTIVITY & NETWORK MANAGEMENT Connectivity services support the NRENs in delivering world-class network facilities to the research and education community. **TRUST, IDENTITY & SECURITY** Securing access to services and providing federated identity systems to enable efficient collaboration. **CLOUD SERVICES** From large scale computing facilities to personalised storage, the cloud offers research and education immense opportunities. **REAL-TIME COMMUNICATIONS** Enabling communication and collaboration across the community. **PROFESSIONAL SERVICES** With 39 partners across Europe and a € multi-million budget, GÉANT has met the challenge of complex international project management.
Access type (virtual / physical / virtual and physical)	Virtual and physical
Geographical coverage (Regional/National/European/International)	International
URL of the website	https://www.geant.org

4.2.2.4 PRACE

Name of the infrastructure	PRACE - Partnership for advanced computing in Europe
Type of the infrastructure	E-infrastructure
Organization model (single-sited/distributed)	Distributed
Short description of the infrastructure (max 800 characters with spaces)	The mission of PRACE (Partnership for Advanced Computing in Europe) is to enable high-impact scientific discovery and engineering research and development across all disciplines to enhance European competitiveness for the benefit of society. PRACE seeks to realise this mission by offering world class computing and data management resources and services through a peer review process. PRACE also seeks to strengthen the European users of HPC in industry through various initiatives. PRACE has a strong interest in improving energy efficiency of computing systems and reducing their environmental impact.
Is the project part of National Roadmap of RI? (YES/NO)	n.a.
Governance model/Partnership	PRACE is established as an international not-for-profit association (aisbl) with its seat in Brussels. It has 26 member countries whose representative organisations create a pan-European supercomputing infrastructure, providing access to computing and data management resources and services for large-scale scientific and engineering applications at the highest performance level.
Timeline	2012 -
Target communities	Researchers, scientists, industry
Service offer	**PRACE HPC ACCESS** PRACE systems are available to scientists and researchers from academia and industry from around the world through the following forms of access: • **Preparatory Access** is intended for short-term access to resources, for code-enabling and porting, required to prepare proposals for Project Access and to demonstrate the scalability of codes. Applications for Preparatory Access are accepted at any time, with a cut-off date every 3 months. • **The PRACE SME HPC Adoption Programme in Europe** (SHAPE) provides support to SMEs to include HPC in their business model. • The **Distributed European Computing Initiative (DECI)** which is designed for projects requiring access to resources not currently available in the PI's own country and whose projects do not require resources on the very largest (Tier-0) European Supercomputers or very large computational allocations. • **Project Access** is intended for individual researchers and research groups including multi-national research groups and can be used for 1-year production runs, as well as for 2-year or 3-year (Multi-Year Access) production runs.

	PRACE TRAINING AND EDUCATION PRACE has an extensive education and training effort for effective use of the RI through seasonal schools, workshops and scientific and industrial seminars throughout Europe. Seasonal Schools target broad HPC audiences, whereas workshops are focused on particular technologies, tools or disciplines or research areas. Participation in PRACE Training Events is free of charge for both academia and industry. All trainings are announced on the PRACE Training Portal Education and training material and documents related to the RI are also available through the PRACE Training Portal. **PRACE HPC MARKET SURVEILLANCE** PRACE undertakes software and hardware technology initiatives with the goal of preparing for changes in technologies used in the Research Infrastructure and provide the proper tools, education and training for the user communities to adapt to those changes. One goal of these initiatives is to reduce the life-time cost of systems and their operations, in particular the energy consumption of systems and the environmental impact. The PRACE leadership systems form the apex of resources for large-scale computing and data management for scientific discovery, engineering research and development for the benefit of Europe and are well integrated into the European HPC ecosystem.
Access type (virtual / physical / virtual and physical)	Virtual and physical
Geographical coverage (Regional/National/European/International)	International
URL of the website	https://prace-ri.eu/

Conclusions

Research Infrastructures stand as key enablers for fast technology development and innovation for research communities and industry. Strengths and competitiveness of the European ICT market strongly depends on availability of beyond state-of-the-art facilities for carrying out visionary research and experimentations.

This report presents the European landscape of ICT facilities in the named Member States in technological areas relevant for SLICES. In the context of Research Infrastructures, the report demonstrates excellent coverage of technology available in ICT facilities in particular Member States, which benefits in a potential good use of local Research Infrastructures by researchers, scientists and industry. Similarly, the report provides information how the Member States provide operational services through e-Infrastructures.

Below we present a summary of results received through the survey.

We received responses from 13 Member States:

- Belgium
- Cyprus
- France
- Germany
- Greece
- Hungary
- Italy
- Luxembourg
- Norway
- Poland
- Spain
- Sweden
- Switzerland

Figure 3 Geographical coverage of the survey in Europe

We received 43 responses, while 20 concerned Research Infrastructures and 23 e-Infrastructures. 25 infrastructures out of total 43 responses (58%) have been included on National Roadmaps of Research Infrastructures. However, some of the infrastructures not included on National Roadmaps declare the submission is in progress and expect to be included to the list in upcoming period.

33 infrastructures declare Regional or National coverage, while 10 infrastructures declare European/global coverage and availability of their research services to communities (e.g. through on-going H2020 projects).

23 infrastructures offer their access to services and resources as virtual access only; 20 infrastructures offer both, virtual and physical access to resources and services.

The results completed through the survey show that although the deployment of ICT-based Research Infrastructures in Member States is progressing very well, Europe as a whole lacks joint efforts and coordination at the pan-European level. Efforts are distributed, individually coordinated by particular Member States and, in consequence, the effect of synergy between local/regional efforts is unachievable.

Similarly to e-Infrastructures, which provide operational services to cross-domain use cases and scenarios, yet well established at the pan-European level (e.g. examples of EGI, EUDAT, GÉANT or PRACE), the ICT-based Research Infrastructures need a governing body to orchestrate, integrate and operate cross-country research services for the scientific community and industry. In this context, SLICES can provide a strong liaison between European and national/regional programmes and act as an umbrella project for Member States' local initiatives and projects. As presented in this report, in there are many fragmented Research Infrastructures developed in Member States. SLICES will contribute to provide a large and integrated facility for research in networking and distributed computing.

The SLICES ambition is to provide a fully programmable and virtualized, remotely accessible, European-wide research infrastructure, providing advanced computing, storage and network components, interconnected by dedicated high-speed links. SLICES is aimed as the collaborative instrument of choice for EU researchers in Future Internet and distributed systems, to explore and push the boundaries of future DIs at the forefront of worldwide competition. SLICES will leverage on existing efforts in Member States and help them to bring their research services at the European level.

Last but not least, strong investments in Research Infrastructures around the world, with just a few examples of infrastructures from South and North America and Asia elaborated in Section 4, indicates that Europe, in order to maintain the leading role in development and deployment of key ICT technologies, needs a European-wide Research Infrastructure integrating and consolidating fragmented efforts from Member States.