THE GERMAN COUNCIL OF SCIENCE AND HUMANITIES (WISSENSCHAFTSRAT) PROVIDES ADVICE TO THE GERMAN FEDERAL GOVERNMENT AND THE STATE (*LÄNDER*) GOVERNMENTS ON THE STRUCTURE AND DEVELOPMENT OF HIGHER EDUCATION AND RESEARCH.

BACKGROUND INFORMATION Berlin 17 17 2017

Science-driven Evaluation of Large-scale Research Infrastructure Projects for the National Roadmap

WHAT ARE RESEARCH INFRASTRUCTURES?

Research infrastructures are instruments and resources essential to almost all scientific disciplines and research areas, as they enable research, academic teaching, the promotion of young researchers, and the transfer of technology and knowledge. The German Council of Science and Humanities distinguishes between four different types of research infrastructures:

_ **Instruments** and large-scale facilities, which may be geographically fixed or distributed over multiple locations, e. g. particle accelerators, telescopes or distributed imaging instruments;

_ **Resources** in the sense of information infrastructures, e. g. collections, archives, data surveys and collections in the social sciences (surveys and panel studies), as well as databases;

_ **Information technology infrastructures** (e-infrastructures), e. g. high-performance computers, supercomputers (Grids),

_ **Social research infrastructures** (e. g. centres for research and scientific encounter, Institutes for Advanced Studies).

WHY ARE RESEARCH INFRASTRUCTURES IMPORTANT?

The importance of research infrastructures for the capability of the scientific system has been increasing. They have become indispensable in almost all areas of science for dealing with challenging scientific research questions, for promoting young scientists, and for conducting internationally viable top-level research. They represent another cornerstone of the research system, besides the researchers themselves and the institutions.

Along with their scientific importance, challenges are also increasing in terms of financial, personnel, and organisational matters. Financial, because they become more and more resource-intensive; personnel, as qualified experts must be found for system operation; and organisational, because the degree of complexity of the institutions or the networks are demanding for appropriate governance models.

In the recent years, questions of data concept and data management have also attracted prominent attention as strategic core tasks of large-scale research infrastructures, particularly to ensure a secure, sustainable and efficient data provision and data use.

WHAT IS A ROADMAP FOR RESEARCH INFRASTRUCTURES AND WHICH ONES ALREADY EXIST?

Roadmaps, as the term is used here, present the need for research infrastructures of scientific communities and/or a country. In Germany, the National Roadmap Process is a strategic instrument for the prioritisation of investments in large-scale research infrastructures. The European Strategy Forum on Research Infrastructures (ESFRI) | [1], founded in 2002, significantly impacted the roadmap processes in European member states. Since the first ESFRI Roadmap for Research Infrastructures was published in 2006 and regular updates | [2] followed, many European states have started similar processes. The following Table 1 gives an overview of existing national roadmaps in Europe.

Table 1: National roadmaps for research infrastructures in Europe

Country	Publication of the roadmap(s) and updates*
Austria	2014
Belgium	Roadmap under preparation
Bulgaria	2010
Croatia	2014
Cyprus	Roadmap under preparation
Czech Republic	2010, 2015
Denmark	2011, 2015
Estonia	2010, 2014
Finland	2009, 2014
France	2008, 2012, 2016

| [1] See: http://ec.europa.eu/research/infrastructures/index_en.cfm?pg=esfri-background, last accessed 20/06/2017.

| [2] See: ESFRI: Strategy Report on Research Infrastructures. Roadmap 2016, Brussels, Belgium 2016. http://www.esfri.eu/roadmap-2016, last accessed: 20/06/2017. An ESFRI Roadmap 2018 is under preparation.

Country	Publication of the roadmap(s) and updates*
Germany	2013, 2018
Greece	2007, 2014
Hungary	Roadmap under preparation**
Iceland	Roadmap under preparation**
Ireland	2007
Italy	2011, 2017
Latvia	No roadmap
Lithuania	2011, 2015
Luxembourg	No roadmap
Malta	No roadmap**
Montenegro	2015
Netherlands	2008, 2012, 2016
Norway	2012, 2016
Poland	2014
Portugal	2014
Romania	2008, Update under preparation
Slovak Republic	No roadmap
Slovenia	2010, 2016
Spain	2007, 2010, 2014
Sweden	2006, 2007, 2011, 2012 , 2015, 2016
Switzerland	2015
Turkey	Roadmap under preparation
United Kingdom	2010, 2012

*Own Research and according to ESFRI, http://ec.europa.eu/research/infrastructures/index_en.cfm?pg=esfri-national-roadmaps, as of April 2017, last accessed 26/06/2017; This table does not claim to be exhaustive.

**Strategy papers are existing.

Also other non-European countries publically present their plans and needs for research infrastructures by publishing roadmaps. The United States was the first country worldwide developing a long-term and interdisciplinary prioritisation plan at governmental level, in 2003. |[3] Additionally, other non-European countries have initialised national roadmap processes, such as Australia, Brazil, China, or South Africa.

|[3] See: DOE, 2007: DOE Office of Science Publishes Update of Landmark Plan: "Facilities for the Future of Science: A Twenty-Year Outlook". 11.10.2007. https://energy.gov/articles/doe-office-science-publishes-update-landmark-plan-facilities-future-science-twenty-year, last accessed 29/06/2017.

WHAT IS THE FUNCTION OF A ROADMAP FOR RESEARCH INFRASTRUCTURES IN GERMANY?

Unlike the ESFRI Roadmap and some national roadmaps for research infrastructures of other states, the Roadmap for research infrastructures of the Federal Ministry of Education and Research (BMBF) is not merely a "wish list" of research infrastructures, whose realisation is desirable. With inclusion in the Roadmap the BMBF indicates its willingness in principle to fund the implementation of the project.

Disclosure of future German investments in such a Roadmap is important and necessary for Germany because:

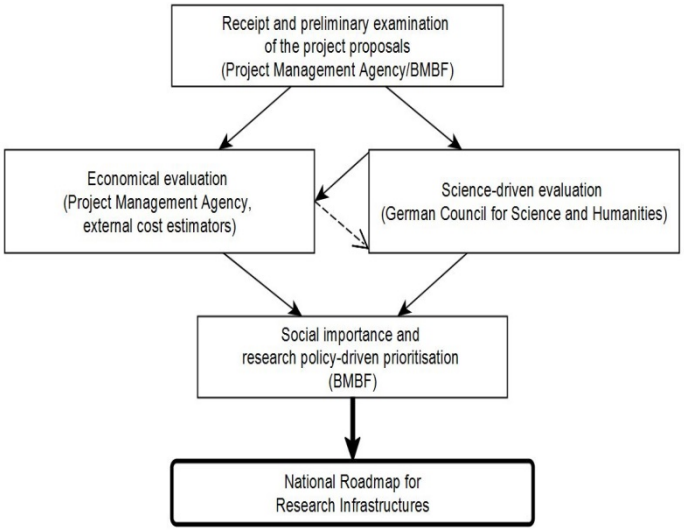
_ it contributes to a long-term investment strategy with respect to establishing research infrastructures in Germany,
_ it may contribute to a reduction of bad investments, and to an optimisation of resource deployment, with a view to creating a high-performance research system,
_ it has repercussions on the scientific communities and contributes to synergetic effects, hence providing a basis for networking and further cooperations with national and international partners,
_ it contributes to Germany's positioning in Europe and also globally, and
_ Germany is taking on a pioneering role through announcing its willingness in principle of funding with the inclusion in the Roadmap. Thus, Germany may further strengthen its influence on international developments of research infrastructures.

HOW IS THE CURRENT NATIONAL ROADMAP PROCESS FOR RESEARCH INFRASTRUCTURES ORGANISED?

After successfully carrying out a pilot phase from 2011 to 2013, the BMBF established a National Roadmap Process at the beginning of 2015 and launched a new round of proceedings.

In August 2015 an open call for submitting proposals was published. After a formal initial examination by the BMBF in the spring of 2016, the submitted proposals were subjected to a science-driven and parallel an economic evaluation. The science-driven evaluation was carried out by a mandated committee of the German Council of Science and Humanities and the economic evaluation by a project management agency of the BMBF. The results of both processes are the basis for the prioritisation of the BMBF, which decides on the inclusion of the research infrastructure in the National Roadmap by also taking into account its socio-political relevance. Figure 1 gives an overview of the entire process.

Figure 1: Relationship between involved parties in the National Roadmap Process



WHICH RESEARCH INFRASTRUCTURES WERE EVALUATED IN THE CURRENT GERMAN ROADMAP PROCESS?

Twelve proposals of comprehensive research infrastructures have been included into the process. They fulfil the following criteria: (1) they are of national strategic importance, (2) are characterized by a long lifespan, (3) the German share of investments requires more than EUR 50 million for establishment and construction during the first ten years, EUR 20 million for projects in the humanities and social sciences or educational research, respectively, (4) their access and hence their use is regulated via an evaluation of the scientific quality, and (5) the leading responsible institutions have declared their willingness to cover the operating costs. The twelve research infrastructures can be assigned to the following three research areas:

Research infrastructures in the field of Engineering and Natural Sciences

The area of research in Engineering and Natural Sciences is very heterogeneous, encompassing a wide variety of disciplines and fields. Disciplines such as physics, astronomy, chemistry, biology, and engineering sciences are contributing to this area of science. The objects of research are equally varied, ranging from the smallest building blocks of matter to the largest structures in the universe and fundamental forces.

The research infrastructure proposals evaluated in 2017 are assigned to materials research, astrophysics, and photonics:

_ Ernst Ruska-Centre 2.0 (ER-C 2.0)
_ European Solar Telescope (EST)
_ National Photonics Labs (NPL)

Research infrastructures in the field of Environmental and Earth System Sciences

Environmental and Earth System Sciences encompass a wide spectrum of scientific disciplines, such as geosciences, physics, chemistry, biology, and also the social and engineering sciences that contribute to research in this area. At the core of Environmental and Earth Systems research is the acquisition of knowledge about reciprocal processes in and between the Earth's spheres (biosphere, geosphere, atmosphere and hydrosphere) and the anthroposphere. The five proposals in this research area evaluated in 2017 are:

_ Aerosol, Clouds and Trace gases Research InfraStructure – German contribution (ACTRIS-D)
_ AtmoSat
_ German Center for Biodiversity Monitoring (BioM-D)
_ German Natural Science Collections Infrastructure (DCOLL)
_ Tandem-L (TDL)

Research infrastructures in the field of Biological and Medical Sciences:

Biological and Medical Sciences are concerned with living organisms and their structure, functions as well as relations with their environment. A wide range of scientific disciplines, such as physics, chemistry, and biology are contributing to this area. The focus of the research infrastructure proposals positioned in this area in the current Roadmap Process is on imaging and optical procedures in biomedicine:

_ German BioImaging Research Infrastructure (GerBI-RI)
_ Leibniz Center for Photonics in Infection Research (LPI)
_ National Biomedical Imaging Facility (NIF)
_ National Imaging Science Center (NISC)

Two of the research infrastructures submitted for the current Roadmap Process |[4] and the three chosen proposals of the pilot phase of the National Roadmap for research infrastructures in Germany |[5] are included on the ESFRI Roadmap 2016. Of the proposals actually being evaluated for the current Roadmap, two additional proposals are striving for inclusion in the ESFRI Roadmap or aspire to be attached with an ESFRI project, respectively. |[6]

WHO WAS INVOLVED IN THE SCIENCE-DRIVEN EVALUATION?

For the science-driven evaluation the German Council of Science and Humanities established a mandated committee consisting of 18 members. Six out of these were also members of the German Council of Science and Humanities. Five of the remaining external experts in the mandated committee work in Germany, whereas seven are institutionally located in Switzerland (2), the US (1), Austria (1), Great Britain (1), The Netherlands (1), and Finland (1).

Each research infrastructure proposal was assigned to one committee member who was close to the subject to function as rapporteur. Unlike the general procedure of joint consultancy of science and politics in the Council, the federal government and the federal states (*Länder*) were only represented as guests in the committee. As the committee was mandated, an approval of the evaluations by the German Council of Science and Humanities was not required.

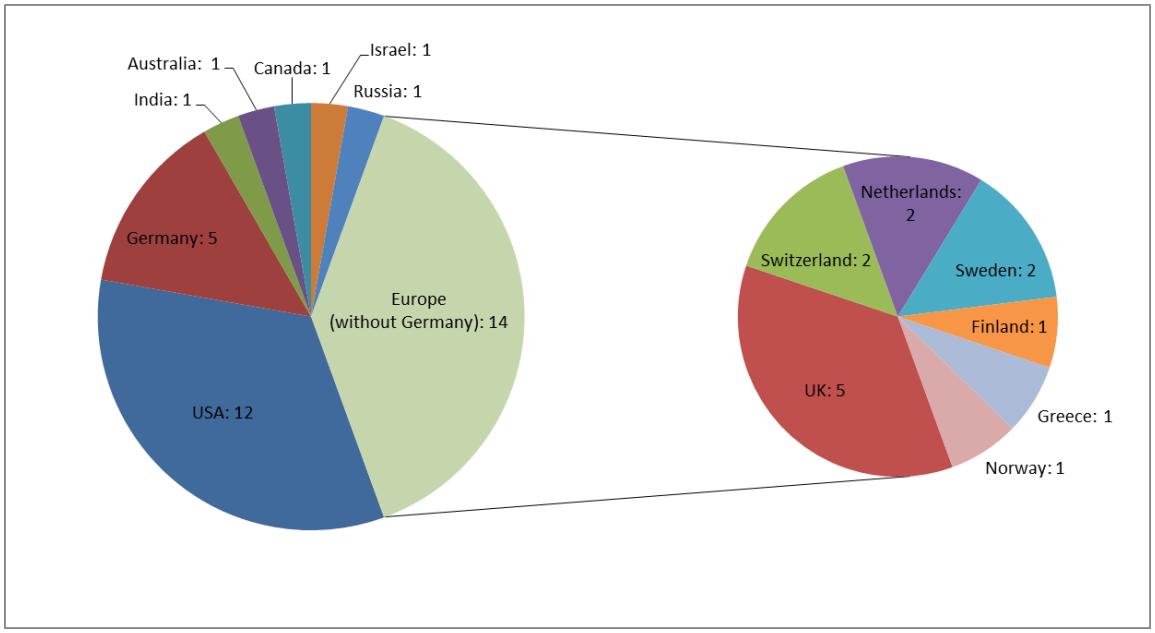
Furthermore, three reviewers were consulted for each research infrastructure proposal. Their countries of origin (with respect to the institutions) can be seen in the following Figure 2.

|4 European Solar Telescope (EST), Aerosol, Clouds and Trace gases Research Infrastructure – German Contribution (ACTRIS-D).

|5 Cherenkov-Telescope-Array (CTA), EU-Openscreen-Platform, In-service Aircraft for a Global Observing System (IAGOS). See: ESFRI (ed.,): Strategy Report on Research Infrastructures. Roadmap 2016, Brussels 2016.

|6 German Natural Science Collections Infrastructure (DCOLL), German BioImaging Research Infrastructure (GerBI-RI).

Figure 2: Countries of origin of the reviewers



HOW DID THE SCIENCE-DRIVEN EVALUATION PROCEED IN DETAIL?

Both, the individual evaluation and the comparative evaluation followed four evaluation dimensions:

_ **Scientific potential** (amongst others, strategic importance and relevance for the research field, necessity, support by the relevant scientific communities, the development of new research fields, existence of competing and complementary research infrastructures),

_ **Utilisation** (amongst others, the size and origin of user groups, regulation of the access to research infrastructures, capacity utilization, data concept),

_ **Feasibility** (amongst others, the technological requirements, institutional and personnel requirements of the hosting institution, risks),

_ **Relevance to Germany as location of science and research** (amongst others, relevance of the research infrastructure proposal to Germany's role and interests, impact on the visibility and attractiveness of German science, knowledge and technology transfer).

The procedure of the science-driven evaluation can be seen in following figure.

Figure 3: **Procedure of the science-driven evaluation**