Mid-Size Instrumentation in the Life Sciences:

III. Development of Research Infrastructures in Europe

Imprint

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Preface

ERA-Instruments is a European project bringing together funding agencies, ministries, charities and research performing organisations to aid in establishing centres for mid-size research instrumentation that meet the needs of the scientific community.

Workshops, meetings and further stakeholder consultation have led to a wealth of results and conclusions that we present as a series of publications under the heading of "Mid-Size Instrumentation in the Life Sciences". The focus of this third issue is on development of regional and decentralized facilities.

ERA-Instruments has surveyed and analysed the current situation of research instrumentation in the life sciences in the context of the ongoing and intensifying European discussion on research infrastructures. Mid-size facilities and networks of regional centres as they are typical for the life sciences are very different from the single-sited large scale facilities that are mostly known from the field of physics including astronomy. Much can be learned from existing large scale facilities, but there are also important differences that need to be recognized and addressed. The recommendations aim at highlighting the characteristics of research infrastructures in the life sciences taking into account the specific situation in Europe.

The paper is addressed to the EUROHORCs, science policy makers, funding organizations and any stakeholders involved in instrumentation for the life sciences.

Summary

Life science research is increasingly dependent on sophisticated instrumentation. Growing costs and complexity of operation have promoted the aggregation into centres and core facilities. In Europe this process is typically self-organized and the creation of centres depends in a self-regulatory manner on the scientific needs and institutional commitments. This bottom-up approach can be contrasted to the top-down installation of large scale facilities in other regions of the world, for instance in Canada, China and Japan. While telescopes, particle accelerators and research vessel are by their nature large scale facilities, research infrastructure for the life sciences can typically vary in the degree of centralisation. The extremely rapid and often unpredictable development of new technology for the life sciences asks for correspondingly fast adaption of existing research infrastructures. The bottom-up approach is probably more flexible in this regard, while the top-down installations allow for strategic planning, can emphasize professional management and provide higher visibility.

The European Strategy Forum on Research Infrastructures (ESFRI) has been instrumental in extending the discussion on research infrastructure to all scientific fields including the life sciences. The distributed nature of life science research infrastructures is explicitly acknowledged and reflected by the ESFRI projects in the biomedical section of the ESFRI roadmap that has also strongly influenced national roadmaps. However, the process for establishing them and the expected governance models seem to originate from a large scale facility perspective.

Existing facilities and centres vary widely in size and outreach. A discussion of life science requirements should take a comprehensive view and take into account all levels of distributed infrastructures: from networks of regional centres to the hub-and-spokes model with a strong centralized component. Networking of and optimizing access to existing instrumentation and expertise should be cost-efficient and, thus, attractive to funding organisations. New installations, e.g. from structural funds, should be integrated into existing networks wherever possible to facilitate training and exchange of experience. Sharing best-practice models for efficient operation and management of facilities on all levels will be beneficial to the scientists that make use of the research infrastructure. Crucial components for successfully establishing and operating RI facilities are – independent of size – qualified scientific and technical personnel, professional management and sufficient financial support.

The situation in Europe

The life sciences have undergone a major transition in the past few decades. The ingenious researcher working in his or her laboratory, maybe with a few helping hands, has been replaced by voluminous projects that tackle scientific questions with massive work force and highly sophisticated instrumentation. Especially fields like DNA sequencing, "-omics" approaches, structural biology and biomedical imaging not only rely, but depend increasingly on technological developments. The associated instrumentation has outgrown in size, numbers and prices the individual laboratory so that shared use and centralized operation in core facilities have begun.

National funding and research organisations in Europe have reacted to the resulting (financial) needs with a diversity of funding approaches that is typical for Europe – as a strength, but also a weakness. There have been very few top-down centrally organized (and funded) installations of major research infrastructures (RIs) for the life sciences. Rather, in a bottom-up manner, scientifically and technically successful groups or institutes have expanded their equipment while attracting collaborations and guests up to a point where the facility can offer access and/or service for a scientific community at large. Management of access and operation becomes an important issue and the financial model has to consider the shared use in contrast to scientific collaborations. This would be considered a research infrastructure. The scientific communities themselves are only beginning to get used to the situation that major instrumentation cannot always be owned and hosted in the own laboratory, but can be accessed and used in dedicated RIs that (hopefully) offer excellent scientific service and expertise.

Other countries such as Canada, China or Japan have adopted more strategic approaches[1] and the resulting facilities such as RIKEN in Yokohama or the Beijing Genomics Institute at Shenzhen are known world-wide. Large facilities with international visibility rarely grow from bottom-up initiatives, but require strategic planning and political will. The top-down installation of RIs allows for emphasising organisational aspects such as professional management or access policies from the very beginning. Efficient use of resources can be a potential benefit, but centralized organisation and administration bring also the risks of disproportionate overhead and lack of flexibility. Exclusive and guaranteed funding may initially provide an advantage but can in the long-run result in the loss of competitiveness. Hence a balance needs to be achieved between secured funding and open competition between RIs.

The fast pace of technological developments in the life sciences necessitates a correspondingly rapid adaption of RIs. The latter is a strength of the European bottom-up situation where a dynamic growth or reduction of facilities follows in a self-regulatory manner the needs of the scientists. On the other hand, professional management and stable funding come as specific challenges to self-made or growing RIs.

[1] *See also ERA-Instruments' study tours at http://www.era-instruments.eu/news/dates_archive.html*

How are new RIs established?

There are two fundamentally different ways for creating new RIs as indicated above. What usually comes to one's mind in the first place is the creation of single-sited large facilities such as ESRF, DESY or CERN where creation of the RI is strongly associated with construction works, large buildings and enormously expensive equipment. Research vessels and telescopes are further examples where the setting up of the RI is a scientific (and political) endeavour in itself. The location of new RIs is often a compromise between political, economical and scientific considerations, with variable weighing of these factors. Recent examples are ITER in Cadarache and the ESS in Lund. It is obvious that these RIs require long-term planning and will only be established with high-level political (and financial) support. A preparation and planning phase will usually be completed with a "Stop" or "Go" decision for the construction.

The building of the RI will take a number of years and first use, usually first measurements, mark the beginning of the operational phase. This top-down installation of new RIs is a conceptually very straightforward approach despite all the details and the long time that it takes. Governments and ministries can control and monitor the process closely, not least because they give the "Go" command and the legal and financial support to continue. The high visibility of large facilities to the general public makes it also attractive for politicians to support them. National roadmaps will naturally address such RI projects.

RIs in the life sciences

The European RI roadmap presented by ESFRI[2] is also assuming this top-down approach and the ESFRI projects are expected to undergo the same procedure of preparatory phase -> implementation phase -> operation phase with an – at least indicatory – budget defined well in advance of the preparatory phase. For the life sciences (as well as for environmental or social sciences) there are so far very few examples of large scale facilities with pan-European character. One exceptional case are the EMBL (European Molecular Biology Laboratories) that host RI facilities that are open to external users for scientific service. Some large scale facilities in the physics area, especially sources for synchrotron radiation and neutrons, are finding increasing applications in the life sciences. Examples include the ESRF, ESS, ELI and X-FEL, all from the ESFRI roadmap. These RIs need to increase their interaction with the life science communities and include them in their user base.

Most facilities for life science research are of local or regional relevance and they are the result of aggregating scientific instrumentation to core facilities. The decision to create such a core facility is normally made by the local university or universities and possibly other local research institutes. The strategic view is dominated by the local needs although funding might come also from national programmes. Examples are NMR and MRI centres, proteomics facilities, cytometry service units and so on. Core facilities are very suitable means for organizing resources and services inside a university or institute. A balance of user demands and financial capabilities will determine the size and range of services.

[2] *ESFRI on the webpages of the EC: http://ec.europa.eu/research/infrastructures/index_en.cfm?pg=esfri*

However, the increasing costs for instrumentation and the growing complexity in operation and data analysis does more and more prevent universities from offering all leading edge instrumentation and techniques in-house. Core facilities that are led by scientifically successful researchers attract additional external users and projects, but scientists that are willing to open their facilities to external guests will often find that the local financial support is limited to serving the local needs. Funding for additional capacity, especially personnel, is often a limiting factor for the transition from a local facility to an externally accessible RI. European framework programmes have promoted transnational access, e.g. by integrating projects, and have helped in establishing networks of facilities that as a whole constitute capable pan-European RIs. Although ESFRI has acknowledged and included in the ESFRI roadmap also distributed and virtual RIs in addition to the "classical" large scale single-sited facilities, it has applied the same underlying concept for all. The following will show that this scheme that originates from the large scale facilities is less applicable to many RIs in the life sciences.

There is no marked-out path along which an ambitious facility can evolve into an RI with a stable financial model. Institutional funding that allows large single-sited RIs to offer access and service to external users free of charge is difficult to obtain for smaller and often bottom-up created facilities. Obtaining resources for dedicated management is also typically a problem. User fees are therefore common practise in the life sciences. Smaller size has the additional disadvantage of lower visibility (a known fact) with concomitant difficulties in raising funds, especially from governments and ministries. An important advantage for the user is that bottom-up established mid-size facilities and small RIs tend to be highly competitive and user oriented. Therefore, policy makers and programme managers should try to find ways of supporting local or regional facilities that are ready to open their instrumentation and expertise for external users.

Structural funds

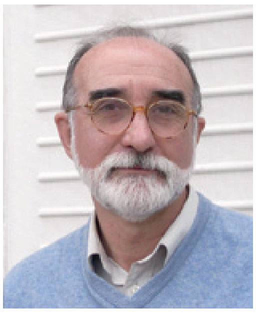
A relatively new development is that structural funds from the European Commission (EC) are also used for creating new research facilities. This allows especially new member states to build new RIs and participate in distributed RIs. Training and capacity building measures need to accompany this top-down approach and integration in a RI network with established RIs can be very beneficial. A major challenge in this approach is that structural funds give very limited support to these and other operational costs, which universities or other research institutions might find very hard to cover. Additional support is needed to make optimal use of the investments.

Management

Irrespective of their origin or the source of funding, there is a common challenge to all RIs, namely management. Various management issues arise during the life cycle of an RI from the starting, over the operational to the deconstruction phase. In particular, implementing appropriate management schemes during the establishment of a facility can be crucial for the future success. Dedicated RI funding organisations or programmes, such as the Canada Foundation for Innovation (CFI)[3] or NCRIS in Australia[4] emphasise the decisive role of management of RIs. In Europe, projects like RAMIRI[5] aim at training (prospective) managers of new large scale facilities. Elucidating and addressing the specific challenges of managing mid-size RI in the life sciences could be a worthwhile undertaking and both, local and shared facilities, could benefit from supporting actions on that subject.

[3] *See http://www.innovation.ca*
[4] *See http://ncris.innovation.gov.au*
[5] *See http://www.ramiri.eu*

Statement



Question:
What is the most pressing problem in managing RIs?

José L. Carrascosa, Chairman of the Scientific Advisory Board of ERA-Instruments and member of the ESFRI BMS-group:

"The increased complexity and sophistication of the equipment and the corresponding operation in RIs has demanded the progressive incorporation of well trained scientists and technicians into their operational and management schemes. The intrinsic scientific and technical interest of implementing cutting-edge methodologies, and the set up of complex, new frontier equipment has attracted new generations of top professionals who understand that these objectives are of comparable interest as those found in more academic environments.

Unfortunately, although the RIs are well aware of the need for properly organizing access, maintenance of the equipment, and good service practices, in most of the cases they do not plan at a similar level the development of the scientific and technical careers for the personal involved in providing the best possible access to that cutting-edge service. Thus, it is becoming more and more evident that these professionals feel in many cases that their important contributions are not sufficiently recognized. An important challenge in the proper organization for RIs in future must be to clearly define career perspectives for these top professionals. Otherwise, we risk that those best suited will withdraw due to the lack of scientific and technical incentives, thus compromising the best exploitation of the RIs investments."

RI roadmaps

Europe hosts a great diversity of research infrastructures. This high degree of diversity in RI and funding structures is certainly is a major characteristic of the European research system. Associated with diversity can be a higher degree of stability, as national priorities can complement each other. On the negative side, national funding in Europe is often scattered in the form of individual centres that lack coordinated placement or operation. In addition, only a few of them have the critical mass to enable an integrated approach to a scientific problem and to achieve international visibility.

The European Strategy Forum on Research Infrastructures (ESFRI) has, like no other initiative, set off and promoted the discussion and consideration of research infrastructure in Europe. The publication of the ESFRI roadmap and its updates has had an enormous impact on both scientific communities and policy makers. Although the initial focus was on large scale facilities that are required only by some scientific fields – many of them in the area of physics – ESFRI had already for the first roadmap broadened the scope to cover all scientific fields including the life sciences. The updates of the ESFRI roadmap have even emphasized those fields that have only recently begun the discussion on research infrastructures.

Almost half of the new ESFRI projects of the 2008 and 2010 updates are in the life sciences. It is a major achievement of ESFRI to have raised awareness on the political level for the importance of RI also in the life sciences. Additionally, distributed and virtual RIs have been brought to attention. The recent establishment of ERIC (European Research Infrastructure Consortium) as a legal framework for pan European RIs is a further step in bringing ESFRI projects to reality.[6] Notably, the first ESFRI project making use of this opportunity is not a large scale facility, but a virtual RI from the social sciences (SHARE).

In the wake of the ESFRI process many member states of the European Union have outlined or have begun to map out their RI needs and to prioritize their national and international engagements in form of roadmaps that often strongly refer to the ESFRI roadmap. While some countries have already heavily invested in RI and need to maintain and extent their engagements, others are still in the process of building up RI capacity. The considerable costs of establishing, running and maintaining RIs are limiting national developments and make prioritisation and cooperation mandatory.

[6] *See http://ec.europa.eu/research/infrastructures/index_en.cfm?pg=eric*

A comparison of national RI roadmaps reveals some variation in terms of procedure of establishing and aims. However, major similarities become evident. Firstly, national funding policies have a strong international orientation. Participation in international facilities is considered necessary as RIs become more and more expensive, while it remains fundamental to achieve or maintain high standards in research quality. Secondly, the importance of life science research is widely recognised. The RIs in the life sciences constitute a significant portion of the total RIs included in national roadmaps and often receive a considerable portion of the available funding.

Most roadmaps further recognise two necessary key factors for research infrastructures: operation costs and personnel. This view is confirmed by facility managers who consider purchase of equipment in many cases not as the major bottleneck for research infrastructures; rather costs for operation, maintenance and upgrades, and costs for personnel running equipment and increasingly for processing data, have become the limiting factors.

International cooperation is seen as essential to reach or maintain a competitive level in research. Although national roadmaps generally do not explore concrete options for cooperation and exchange of knowledge, they all clearly indicate that international research infrastructures are considered as important vehicles to realise these. In fact, they attract the most talented researchers from abroad and they encourage international cooperation. For the same reasons, hosting a facility is highly desirable, as this translates into brain gain for the hosting country in terms of attracting scientists and knowledge exchange via attracting cutting edge projects. In addition, RIs usually attract other R&D activities, in particular in the high-tech industry, favouring its cooperation with the scientific community and providing an impulse to the local and national economy.

For these reasons there is a strong incentive for all countries to host an international RI or in case of distributed facilities to host a node of an international RI. This usually also allows connecting national facilities to international networks in a specific research area. In particular the latter can be interpreted as a decentralization of infrastructures in Europe. This process is certainly a reality in the life sciences (including biomedical infrastructures) which mostly have distributed character. Cost issues, and also the need to create focus and mass, lead to coordinated efforts to optimise the distribution of equipment in Europe, thereby creating decentralized research infrastructures.

Statement

Question:
What makes a pan European RI?

Hervé Pero,
DG Research,
European Commission,
Brussels:

"Research Infrastructures (RIs) are facilities which support the work of researchers, serving scientists by gathering the observation data they need, treating this data and preserving it for future use (of a multidisciplinary nature whenever possible).

Many of the facilities of world-class excellence (or those which strive to go beyond the frontiers of science and technology) are outside the reach of individual Member States or national research communities. They should thus pool their resources across the borders to respond to researchers' needs.

Research Infrastructures of pan-European interest are those facilities which are the result of such pooling of resources, or which contribute, through their integration with others, to generate the required research services and outreach potential. They contribute to the attractivity of the European Research Area as well as to the leadership of Europe at international level. Their access is normally based on scientific excellence, evaluated through peer review. The access to their public databases should also be organized through the web.

National or regional RIs can also be recognized as being of pan-European interest if their own capacities and performances are of the nature of those described above. This is particularly the case for the so-called "distributed RIs". However, national or regional RIs are generally part of the second tier or third tier of the European eco-system of research infrastructures.

To help strengthening the consistency of the European research eco-system, the Council of the European Union, on the advice of ESFRI, has recommended the development of Regional Partner Facilities, which should be complementary to the development of large scale research infrastructures. Such regional facilities can very often benefit from the support of the Regional Funds."

Distributed RIs

In the ESFRI process life sciences have appeared exclusively with distributed RIs. Some large scale facilities such as ESRF or DESY are indeed dedicating significant fractions of the total measurement time to life science projects and they have build dedicated beam lines in some cases. But they were not built as RI for the life sciences and the majority of users do not come from this field. It is also obvious that there are many facilities in and for the life sciences that do not appear on the ESFRI roadmap, and correctly so, because they are not of European, but of regional or national relevance. On the other hand, networks of facilities as created by the EC integrating projects, e.g. EU-NMR[7] or the new PRIME-XS offer service and even travel grants to researchers from all of Europe and are not mentioned by ESFRI. Finally, there is still the individual equipment in the laboratories that consumes also considerable parts of the instrumentation funding. That all goes to say that the life sciences require research infrastructures on different levels and that a comprehensive picture cannot limit itself to the ESFRI projects or the ESFRI format that requires even for a distributed RI a hierarchical governance structure and does not accept decentralized networks of mid-size facilities.

For the scientist visiting a facility, the main point is to get access to leading edge instrumentation and to receive support in using it for his or her projects (including support in data analysis, if possible). Especially in the life sciences, RIs are often serving a wide research community and the specific and often multi-disciplinary expertise of the RI staff is instrumental for the success of the facility. The manager of the facility will also be mostly concerned with the local provision of those services. Networking of facilities is of clear benefit for exchange of expertise, for efficiently directing users to facilities and for establishing common scientific standards and protocols for sample preparation and data analysis and data archiving. This is all valid for any facility that is offering access to external users independently of the overarching governance structure. When considering single facilities the relevant criterion is the willingness and ability of a facility to be open for shared access.

Shared facilities in the life sciences are so far mostly funded in a decentralized manner by national or even regional funding schemes. Networking those local centres for more efficient operation and access is clearly desirable albeit still a major challenge. The decentralized character of these RIs might argue in many cases for a network structure without a central organisation or governance thus allowing the facilities to remain independent. The ESFRI projects in turn require also for distributed RIs a centralized structure with hierarchical governance and preferably centralized funding as for single-sited RIs. Policy makers and funders should recognize distributed facilities in both organisational forms as vital to the competitiveness of European life science research. Increased appreciation should emphasize the visibility also of this kind of research infrastructure.

[7] *See: http://www.eu-nmr.eu*

Statement

Question:
What are the shortcomings of current policies?

Dietmar Manstein, Member of the Scientific Advisory Board of ERA-Instruments and head of a light microscopy and an x-ray diffraction facility in Germany:

"Europe has an incredibly diverse and rich science base and outstanding research infrastructure. The activities of government-funded research organizations, charitable foundations, research universities, and initiatives coordinated by the European Commission have helped to shape research infrastructure in Europe with its outstanding centres of excellence. The multinational workforce at these centres is helping to disseminate state-of-the-art techniques and the ability to use complex instrumentation throughout the EU member states.

Although internationalization of research in other institutions is growing, the European Molecular Biology Laboratory (EMBL) remains the most relevant hub for knowledge transfer, infrastructure implementation and usage in areas such as advanced imaging techniques, proteomics, and synchrotron-based structural biology.

The challenges that we are facing in maintaining excellent RIs are defined in part by the need to improve university training, IT infrastructure, and funding for maintenance and repair costs. University teaching needs more recognition and more funds. Moreover, the reforms of the last decade led to an increased specialization of university curricula and graduates that lack a solid background in the natural sciences.

An adequate IT infrastructure providing the means for data analysis, storage, and long-term archiving is essential for the use of medium and large scale instrumentation. Even for instruments that generate a Terabyte of data every couple of hours, adequate IT infrastructure is frequently not considered as part of funding schemes. Finally, funding schemes need to give better consideration to the complexities of commissioning and maintaining advanced research instruments. Policies that exclude funding for extended warranties and service support are counterproductive."

Conclusions

The life sciences require a broad spectrum of research infrastructures, from the lab equipment to international large scale facilities. A recent development is the increasing use of mid-size facilities that allow access to leading edge instrumentation and that provide the expertise and experience for making the best use of the expensive equipment. Cutting edge research in these fields is more and more depending on the availability of the latest technologies. The importance of these facilities does not depend on whether they are stand-alone, part of a network or part of a European RI consortium, as long as they offer excellent scientific service and support.

Policy makers and funders should take an inclusive view to the issue of RI for the life sciences and should emphasize the visibility of distributed RIs, in form of networks or as ESFRI projects. A balance between different levels in size and organisation of RIs should be kept in order to be economically efficient and scientifically effective. In the life sciences networking and optimizing existing decentralised facilities seems more promising in this respect than installing new centralized RIs (maybe even from scratch) although the later is clearly a more visible measure and, thus, potentially more attractive to politicians. However, the goal should always be providing the best resources to scientists, not prestige and status.

Scientific research is an international endeavour. Many mid to large scale RIs cannot be supported by a single country. Hence international collaboration in establishing and running RI is increasing. A vision of a global research area should envisage international exchange allowing the best researchers to make use of the best research infrastructures world-wide.

Abbreviations

CERN	Organisation Européenne pour la Recherche Nucléaire
CFI	Canada Foundation for Innovation
DESY	Deutsches Elektronen Synchrotron
EC	European Commission
ELI	Extreme Light Infrastructure
EMBL	European Molecular Biology Laboratories
ERA	European Research Area
ERIC	European Research Infrastructure Consortium
ESFRI	European Strategy Forum on Research Infrastructures
ESRF	European Synchrotron Radiation Facility
ESS	European Spallation Source
ITER	International Thermonuclear Experimental Reactor
MRI	Magnetic Resonance Imaging
NCRIS	National Collaborative Research Infrastructure Strategy
NMR	Nuclear Magnetic Resonance
R&D	Research and Development
RAMIRI	Realising and Managing International Research Infrastructures
RI	Research Infrastructure
RIKEN	Rikagaku Kenkyùsho
SHARE	Survey of Health, Ageing and Retirement in Europe
XFEL	X-ray Free-Electron Laser

About ERA-Instruments

The programme

It has become increasingly obvious that concepts and strategies for research infrastructure (RI) funding should be harmonised and coordinated within the EU. ESFRI has determined requirements for European RI funding and has presented a roadmap. Growing attention is paid to life sciences that rely on RIs of a less centralised, but more networked dimension. There is a clear need for action in the interdisciplinary area between physics, chemistry, biology and medical sciences as cutting edge instrumentation becomes increasingly expensive and, yet, indispensable for world-class research.

However, promotion of research policies, apart from the ESFRI projects, has been restricted so far to national efforts without managing these actions with a European view. Funding and research organisations cannot afford to remain at the national stage with world-wide competition for the best scientists and the most promising projects. Frontier research is international since long and funding organisations have to follow scientists to the European level.

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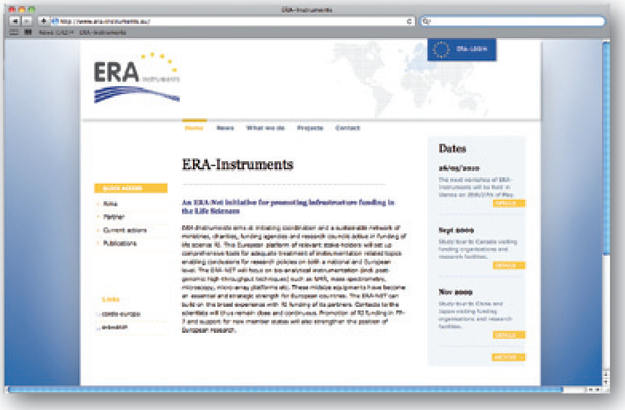
The ERA-Instruments website

www.era-instruments.eu



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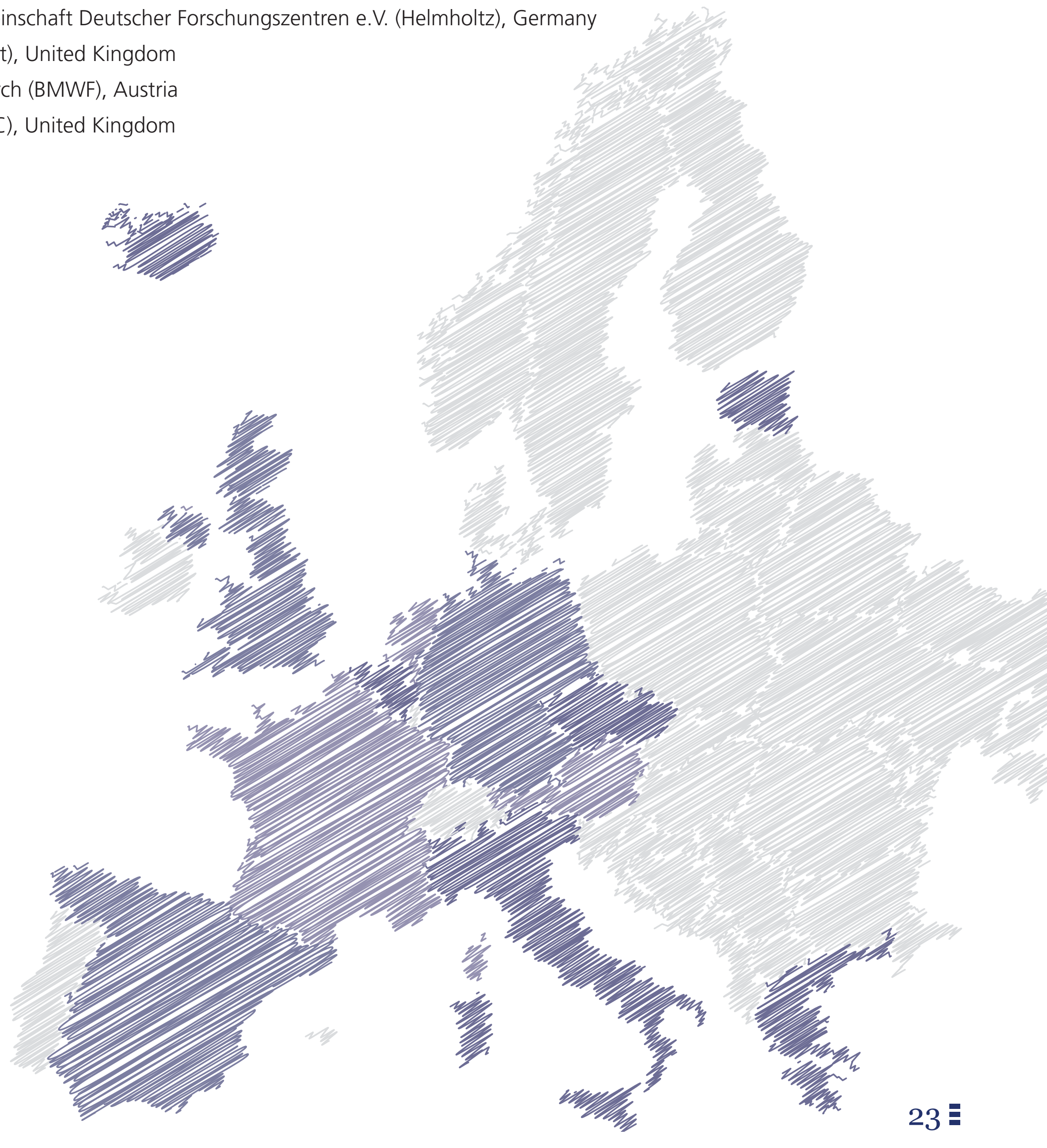

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SEVENTH FRAMEWORK
PROGRAMME