Recommendation by the
19th General Meeting
of the German Rectors'
Conference (HRK)
on 10 November 2015
in Kiel

How university management can guide the development of research data management. Orientation paths, options for action and scenarios

HRK German Rectors' Conference

The Voice of the Universities

Ahrstraße 39
53175 Bonn, Germany

Tel.: +49 (0) 228 887-0
Fax: +49 (0) 228 887-110

post@hrk.de
www.hrk.de

Table of contents:

Brief overview

Developments occurring as a result of digitisation, which is seeing very dynamic progress in every area, are having a significant influence on research processes. This is particularly noticeable in the topic of "research data management (RDM)" which will play a key role in many scientific activities in the future. Various kinds of activities have already been observed in this area: while researchers around the world are networking in the "Research Data Alliance"[1], the Alliance of Science Organisations in Germany, as part of the Priority Initiative "Digital Information", is urging the establishment of sustainable structures for RDM[2]. The Council for Scientific Information Infrastructures has also put this subject towards the top of its agenda[3]. Similarly, the federal government is addressing the subject as part of the "Digital Agenda", the "IT summit" and the German Internet Institute which is currently in planning[4]. In its "Guidelines on the Handling of Research Data", the DFG draws attention to the urgency of the tasks still to be tackled[5]. Among the federal states, Baden-Württemberg, for example, is committing to establishing and developing RDM under its e-science funding programme[6]. On an international level, the European Commission has made the subject an important funding priority within the "Horizon 2020" Framework Programme for Research and Technological Development[7]. Given the large number of stakeholder groups, the HRK sees an urgent need for coordination and agreement between the higher education institutions on the establishment of a structure for RDM which can be used by every federal state and is internationally compatible. The aim must be to involve every higher education institution as far as possible.

As early as in May 2014, the HRK had announced that management of research data was a key strategic challenge for university management[8]. There is consensus that the potential that digitisation offers research must be increased. The ability of researchers at every university, as far as possible, to access national and international developments in scientific communities must be guaranteed. However, abstract demands are of little help. In this recommendation, the many-layered developments and challenges are discussed in the form of practical directions for action from an organisational point of view. This will be the first time that university management has been provided with a concrete guideline for developing RDM at their own institutions and within alliances. It describes orientation paths, options for action and scenarios which, from the point of view of university management, arise when establishing and developing institutional RDM. The following describes the step-by-step process to be used ideally in a typical situation:

(1) Provide orientation: it is not only research data policies that should be agreed at the higher education institutions. Management should also specify frameworks for action or ask researchers to provide suitable specifications for themselves.
(2) Strengthen the data culture: university management should

describe the benefits to researchers of allowing open access to their data and create appropriate incentives.
(3) Develop a strategy: a review of the current status should include all stakeholder groups and operational levels at the higher education institution and take account of the alliances, cooperative arrangements and networks in which the higher education institution plays a part. When the strategy is drawn up, particular use should be made of the great potential of research data management for the strategic positioning of the higher education institution.
(4) Organise the implementation: University management must decide how the current structures and activities in various locations in the institution can be merged to form a well coordinated structure for the whole institution and which additional structures still need to be established. Plans should be based on a clear concept for governance. The need for communication in particular should not be underestimated here.
(5) Develop infrastructures: the requirements of the researchers are crucial in determining how research data infrastructures are established and developed. The inclusion and use of subject-related and overarching solutions are highly recommended. One particularly important aspect of the infrastructures is the development and provision of services at the higher education institution in question.
(6) Improve skills: The process should take account of options for modifications and updates. All the stakeholder groups at the university should develop their research data management skills. This applies to students, teachers and researchers in every phase of their academic career and to the staff in the central administration departments.

Key factors for success and management errors that can jeopardise that success are also discussed.
The "RDM scenarios" aim to distinguish between types of research activity (from an individual final thesis to cooperation with industry) and their various implications for RDM. Reference is made in each scenario to opportunities and risks that may be relevant from the point of view of university management.

Finally, the recommendation explicitly discusses the urgent requirement for a means whereby organisational structures can cooperate nationally and internationally on RDM. It also considers the high additional financial burden on the higher education institutions of setting up and operating the necessary infrastructure. The HRK is appealing to politicians in the federal government and in the federal state governments to assume a *coordinating role* in establishing an overarching infrastructure for RDM and to make the necessary *funding* available.
The funding should provide additional incentives for more cooperation between higher education institutions both within the federal states and across their borders. Firstly, the federal states should work together more intensively on joint initiatives and secondly, the opportunities for cooperation between the federal government and

the federal states in accordance with the new Article 91 b (Para 1) of the Basic Law should be exploited. The HRK also expects policy-makers to make a significant contribution to the coordination of roles and functions on a national level and thus create a reliable framework which will give all the stakeholder groups the planning certainty they need. Initiatives to create financially sound structures with the aim of securing personnel and services are therefore urgently required. Legal and fiscal obstacles which obstruct the reimbursement of services between universities, particularly where these universities are in different federal states or different countries, must be removed. Finally, the HRK calls on policy-makers in light of the great need for training in RDM to put in place a suitable training initiative with appropriate financial support[9].

1. Introduction

With the recommendation entitled "Management of research data – a key strategic challenge for university management" issued in May 2014[10], the management of higher education institutions in Germany underlined the growing importance of research data in the research process. Firstly, careful handling of openly accessible research data is a key prerequisite for excellent research. Secondly, university management regard research data management (RDM) as a key strategic challenge for higher education institutions and acknowledge their responsibility to make the institutional infrastructure that researchers at their institutions need for high-quality research data management available to them.

This document is based on the recommendation of May 2014 and describes options for action, orientation paths, and possible implementations which arise from the establishment or development of institutional RDM from the point of view of university management. The procedure that follows for the institutional implementation of RDM is a step-by-step, "ideal-typical" process which can take different forms depending on the university. In the later operation of the RDM system, working with all the components remains a long-term task. The description views the establishment and development of an RDM system as a stimulating and productive interaction between *top-down* and *bottom-up elements*: on the one hand, university management provides binding specifications, with guidelines and frameworks for action on the basis of the governance concept[11]; on the other, the researchers also shape the RDM to a large extent with their own very broad-based activities which are mostly anchored in the subject-specific communities, with their articulation of their requirements and with the development of implementation proposals[12]. Furthermore, with a view to creating an integral system for national RDM infrastructures, an important factor for success is that the higher education institutions do not plan measures for establishing and developing RDM in isolation. Instead, this should be carried out at an early stage in cooperation with other higher education institutions and research institutions to facilitate mutual compatibility.

2. Challenges for university management – "ideal-typical" step-by-step process

2.1. Providing orientation

- Research data policy

An important factor for success is that the university management – after internal discussion with all the stakeholder groups – starts by sending a clear, primarily internal, message that RDM will represent a key element of the university's ethos going forward. Publication of a "research data policy" in the form of strategic guidelines for RDM has often proven helpful in putting the subject of RDM at the top of the university agenda[13]. These guidelines can only become effective later on if they have been drawn up and agreed in advance in a participative process with the researchers at the higher education institution.

As a rule, a policy of this kind is made up of the following components:

- a definition of "research data";
- a joint commitment to handling the data openly (*data sharing*), pointing out that this is not only good scientific practice, but is also very important for the best use of research results and the quality of the research;
- the announcement (in the sense of an offer) by university management that it will provide researchers with reliable and efficiently usable structures for RDM;
- the designation of internal contact partners whom the researchers can contact with questions and by whom they are advised and supported;
- the announcement of skill-promoting measures (such as information events at lectures and seminars, training for doctoral candidates and standalone events to provide instruction on research methods).

- Framework for action

To underpin the implementation of these strategic guidelines and to firmly establish the necessary awareness of careful handling of open access research data in the institution, management should provide frameworks for action or ask the researchers to define the specifications themselves. These should describe their aims clearly and authoritatively and state the measures required to implement RDM in a series of steps. The catalogue of measures must be realistic in terms of its feasibility, where the schedule and the material aspects are concerned, particularly against the backdrop of the institution's available resources or financial options. The objective of the framework for action should be a set of regulations which offer researchers and information service staff at the institution an unambiguous code of conduct and clear guidance. On this basis, the stakeholder groups can be certain that their work on the RDM system will be safe, legal and reliable. These regulations will be included in the terms of use, statutes and project proposal rules for the provision and use of services that will eventually be established.

They should contain statements on the following topics:

- RDM steps: which rules (and, if applicable, standards) apply to creating, archiving, exchanging and publishing data? How can the interoperability with third-party data services be guaranteed?
- Legal conformity: who can claim copyright of the data? How will the stipulations of the funding bodies, data suppliers and repositories be implemented under the relevant contracts?
- Open access to data: what is permitted and what is not? What obligations are there to third parties? When should data not be disclosed (restrictions due to data privacy and patent protection)?
- Access and use: who has access privileges? What restrictions are there or should there be on use?
- Data backup and data storage: how must the providers of the IT infrastructure and associated services ensure data security and reliable storage of the data?
- Information that there should be comparable and transparent conditions (such as the same requirements for data preparation and the same opportunities to use it) for all the members of the alliances to which the institution's own researchers belong as well as a shared understanding of appropriate conduct in the group (*compliance*).
- Procedures for contracts with networks, platforms, repositories and journals which involve handing data over to third-parties: what are the minimum requirements of the higher education institution? Must contracts be submitted to university management? Who is liable if university management was not aware of the existence of a contract?
- Recommendation to the researchers to use open licences[14].

At this and at all further stages of the implementation phase, university management should be supported by a steering group made up of representatives of all the people and departments involved at the university. The group can ensure that information flows between the important stakeholder groups and improve the prospect of success of the measures by their involvement and integration early on in the process. After the implementation phase, the steering group should be replaced by a smaller, permanent body which will oversee the further development of the infrastructures and the demand management with the participation of the users.

2.2. Strengthening the data culture

An important prerequisite for successfully establishing institutional RDM is that university management is convinced by its relevance. It is also important that this conviction extends as far as possible through the higher education institution. It should be seen as good scientific practice that digital research results in particular are handled carefully and with a view to their reuse. This must also be firmly established as

an easily addressed topic of communication between colleagues in the daily research routine.
In order to avoid fundamental misunderstandings concerning *data sharing*, attention should be drawn to restrictions imposed on disclosing the data by data privacy or patent protection provisions[15]. Furthermore, access to particularly sensitive data or data which researchers feel deserves special protection should be arranged in accordance with requirements and need through a privileges management system. On the other hand, it should be emphasised that – even taking different stages of development in the subject communities into account – a gradual introduction of *data sharing* is possible (from releasing metadata only or disclosure only to project groups or within the university to *open access to data* for everyone). Above all, however, university management should point out the advantages for researchers who disclose their data: primarily the acquisition of scientific knowledge and a better reputation in the subject community, particularly on an international level. Furthermore, university management should create incentives which make RDM and the disclosure of their data even more attractive to researchers[16].

2.3. Developing a strategy

- A review of the current status

The first step to developing a strategy is a review of the current status. This might involve suitable internal surveys on the activities of researchers and their requirements. In this way, university management will acquire an overview of which stakeholder groups are addressing RDM at their own institution, how they use RDM and the context in which they operate. This will presumably also reveal deficits and challenges such as unintentionally allowing third parties privileges, transferring data to private cloud providers or proprietary technical solutions at faculty level.
A review of the current status should look at all the stakeholder groups and levels of activity at the university and the interfaces to national and international partners in particular: the researchers, the departments and faculties, the information services centres of the university (above all the library and the computer centre) and the key positions of responsibility (such as vice presidents with the relevant remit, the Chief Information Officer, legal experts, the research and communications department and the university archive). As researchers as a rule manage their research data primarily with partners outside of their own university and, indeed, in networks, the current status review should take account of which alliances, cooperative partnerships and networks the university participates in. Thirdly, the review of current status should examine the forms of financing (basic funding versus project funding, public versus private finance) which support the RDM activities.

- Particular potential of RDM for the university's strategic positioning

The next step is to think about how the planned creation or development of institutional RDM can support the higher education

institution's general strategy. For example, it should be asked which priorities of institutional RDM have already been revealed in the review of the current status (such as a concentration on certain subjects or on certain services from the library or the computer centre with an impact outside of the institution) and deserve to be further developed against the background of the general development wanted for the university. Strengthening the RDM system implies considerable opportunities and chances for the university to develop its strategic positioning and its profile, particularly where international competition is concerned: research results can be reused and utilised more easily and new axes of cooperation can be established with other universities. Particularly when a university decides to develop itself into a competence centre, for certain RDM services for example, it becomes more visible and more attractive. Smaller universities can obtain the necessary services through a partnership or a regional network.

2.4. Organising the implementation

- The structural challenge

Based on a definition of objectives, university management should set out how it wants to (further) develop the RDM at its own university in the coming years. A concept for implementation of this kind will not set out all the steps in advance, but describe alternatives which can be selected depending on the situation. The biggest challenge is in deciding how the institution's structures and activities that exist in various locations can be brought together to a well coordinated integrated institutional structure, i.e. a coherent collection of procedures, roles and shared resources, and which additional structures need to be created. At the same time, it is necessary to set out which structures and services the university does not want to retain or establish itself, so that relevant services (such as the use of computer capacity and storage, virtual research environments or the archiving of data) will have to be obtained from third parties.
Furthermore, it must be taken into account that the requirements will be very different from case to case and from subject to subject and will also depend on the type of higher education institution. That is why the establishment and development of infrastructures for RDM involve creating a generic service architecture consisting of a technical platform (hardware, software and access), tools and services as a flexible basis for specific solutions.
The components of traditional project management can be applied to implementing the service architecture. In particular, this includes identifying risks and setting out alternative scenarios, then defining the organisation of the process with assigned roles and responsibilities, describing milestones in the schedule and preparing a financing plan with costs and income. As cooperative projects with third parties and alliances play a significant role in RDM, it is necessary to describe not only roles and responsibilities within the university, but also strategic cooperation with external partners (such as other universities, subject networks, and discipline-specific and higher-level data centres).

- Governance

An important pre-condition for success is that the plans are based on a clear concept for governance which describes the role of university management in its interactions with others involved in the process. RDM can only be implemented successfully across a higher education institution if the management is allowed to exert a certain amount of influence on the process. To do this, it requires the scope of action referred to as "governance". As discussed in the HRK recommendation entitled "Higher education institutions in a digital age: rethinking information competency – redirecting processes" (November 2014), governance encompasses the following elements:
- influence through strategy developments and policies;
- management and steering through regulations and
- decisions on the basis of oversight and controlling.
(Controlling is expressly not to be understood here as "control", but rather as "steering and regulating".) At the same time, "the way in which internal university decision-making is organised" should "balance the need for internal management (governance) and also for self-organisation, in particular by the faculties or departments".[17]

- Communication

A crucial element in the success of the process is that university management presents a convincing argument in favour of its objectives both internally and externally (*advocacy*). It should make clear that professional and conscientious RDM as well as an open approach to handling data are essential components of good research. The researchers should be made aware of the ways in which they will benefit from a stronger commitment to RDM[18]. Examples of best practice can also provide them with important guidance. The objective of communication must be to convince every stakeholder group that the university will reliably create the infrastructures required for data management and that they will be permanently maintained. University management should emphatically communicate its objective through as many suitable channels as possible to its own university members, the scientific community in general and to policy-makers[19].

2.5. Developing infrastructures

- Infrastructures *for science*

The research process from the perspective of the researcher and the requirements that thus arise should be the decisive orientation factor in the creation and development of research data infrastructures (with "personnel/services", "tools" and "technology" as the three layers of the service architecture). The primary aim is to create a strong service infrastructure which integrates the service architecture into the researcher's individual working environment. Researchers should be provided with the support that they need at each point in the *data life cycle* – that is, from the creation and management of the data, through its analysis and publication to its use in teaching and new project ideas[20]. If institutional structures have become obsolete or inefficient from a research perspective, they should be restricted or

dismantled. It follows that new structures needed for research should be set up flexibly and quickly.
Beyond larger infrastructure requirements, university management should also examine the quality and sustainability of "distributed" infrastructure (at departmental level, for example). Further development in this respect can mean providing options for centralised forms of data storage (such as a university computer centre or library).

- Particular strengths of the higher education institutions in the overall system of information infrastructures

For financial reasons, it will only be possible for a university to provide all the infrastructure needed throughout the *data life cycle* in exceptional cases. Instead, certain reasonable priorities will be set. Higher education institutions in particular are predestined to offer certain services and options in the context of national and international information infrastructures: while responsibility for processing dynamic process data prior to publication (or without the intention to publish) lies with the researchers or mainly with subject-specific networks, the publication and archiving of research data is the task of institutions if no subject-specific provision is available (the "long-tail" problem). Particularly where archiving is concerned (including long-term archiving), universities can position themselves against other providers as suitable "places for research data". Compared to project-related networks, which as a rule are short-lived and can be associated with data security problems, or commercial providers (such as Amazon, Google, Dropbox or ResearchGate) who might limit or block access, the university repositories offer a much greater degree of reliability in terms of securing access to collections of data in the long term. Regarding the documentation of data in particular, university libraries can bring to the RDM system special indexing and archiving expertise which has been proven over a long period. Finally, compared to institutions conducting research on a large scale (particularly non-university research institutes), it is clear that universities not only have a special part to play in preparing and storing *big data*, but also in the use of *long-tail* data in particular. Large research institutions on the other hand seem to be concentrating increasingly on the production and (often heavily standardised) processing of *big data*[21].

- University management in the field of action between institutional structures and partners outside of the university

Planning for a university's own structures should always be preceded by an analysis of existing structures outside of the institution. These are often supraregional (infra)structures which have been developed for subjects or subject clusters in various ways. The use of such subject-related and overarching solutions is highly recommended. University management can encourage the researchers at its own institution to familiarise themselves with the existing structures for their subjects, to archive data in them and to participate in their

development (by agreeing on standards for citation and for metadata[22], for example, or by making best practice available). In particular, they can encourage the researchers at their institution to participate in the many and varied activities of the "Research Data Alliance", a global, *bottom-up* operated network for promoting the open exchange of data[23]. University management should form (possibly nationwide) alliances with other universities, for which they should agree shared arrangements[24]. Where possible, they should also work towards making the provisions of their own institution non-exclusive (i.e. not just for their own members), avoiding insular solutions, and instead offering a permanent welcome to research partners.
With this in mind, all the solutions established at universities should be designed to complement existing community solutions or as starting points with as much reach as possible in relation to them. The institutional solutions (such as the institution's repository of research data) should be linked directly to the national and international structures to improve opportunities for cooperation and to increase the visibility of the data stored at that institution.
Where the information infrastructures at the institution are concerned, it is important on the one hand to use and build on existing strengths and on the other to introduce new structures. The procedures between the library and the computer centre in particular should be integrated for RDM purposes.

- Ensuring the provision of services

A key aspect of the infrastructures is the provision of services. The researchers rely on many services which facilitate research data management for them over the whole data life cycle – producing, transporting, processing, describing, publishing, presenting and (long-term) archiving the data. The services offered by the university should be geared as far as possible towards helping researchers to find appropriate support at every point in the data life cycle and to avoid duplicating their work. The services should be integrated as closely as possible into the researchers' working and research environment[25].
Advice is also required on legal issues (relating to international cooperation or questions of liability, for example) and on administrative tasks (such as providing RDM-relevant details for the university's research information system, quality assurance and discussions of research proposals including improving their likelihood of success and the preparation of a data management plan).
If it is not possible for the institution's facilities to deliver the support requested, they should be able to refer researchers to competent providers outside of the university. The various parts of the university – faculties and departments, the library, computer centre, e-learning centre, research department, archive and legal advice department – should work together to devise regulations for the procedures and processes. Researchers should receive comprehensible information about who at the institution is responsible for which aspects of RDM. At larger universities, a central contact point for this purpose is helpful.

2.6. Improving competences

To arrive at a good institutional system of research data management, it is necessary to develop the competences of all the stakeholder groups at the university[26]. This applies first and foremost to students, teachers and researchers in every phase of their academic career. Appropriate modules or elements of modules should be integrated into all the degree programmes to improve the RDM-related information competency of students. The information services provided by the libraries and the computer centres should be oriented even more towards RDM issues than they have been up to now. This should also include teaching elements which are accorded full ECTS credits. While the options in the Bachelor's degree programme are more generic, the research-oriented teaching at Master's level should take more account of the subject-specific and individual requirements of the students. As well as students on Master's programmes and doctoral candidates, professors also need knowledge and skills so that they can handle their data correctly. Similarly, all those involved must receive sufficient instruction on legal and ethical questions. Fundamentally, each individual should decide to what extent they wish to take on data management themselves (such as programming databases, drawing up a data management plan or an electronic laboratory record) and receive the appropriate training to do so. To make this possible, university management should ensure that the researchers are advised accordingly and can take appropriate training courses. Furthermore, information competency for RDM can also be acquired within the university's own teaching schedule, while collaborating on actual issues with the science library on site or through communicating in networks.
Library, computer centre and e-learning centre staff and the research and legal department staff at the higher education institutions must extend their skills to include RDM to enable them to support the researchers in RDM. It is very important that new degree programmes are created which prepare for careers such as *"data librarian"* or *"data scientist"*. Initiatives of this kind already exist in the UK and the Netherlands[27].

2.7. Summary: what should be done and what should not be done

- Providing orientation

Do: Awaken responsibility * Agree and approve research data policy * Set out a framework for action.
Don't: Start the process too late or set it up to be purely software-driven * Issue overly strict or impracticable specifications.

- Strengthening the data culture and creating incentives

Do: Establish careful handling of digital research results and the awareness of their reuse as part of the research routine * Clearly explain the benefits of an open and sustainable data culture and

create appropriate incentives * Introduce measures to facilitate *data sharing* gradually.
Don't: Demand that measures to facilitate *data sharing* be put in place immediately.

- Developing a strategy

Do: Include all stakeholder groups in a review of the current status and be aware of any deficits * Use RDM activities to profile the university * Take account of different subject cultures.
Don't: Fail to take account of researchers' participation in networks and alliances in the review of current activities * Allow the fastest researcher to set the pace.

- Organising the implementation

Do: Base the plans on a clear governance concept * Ensure agreement between stakeholder groups in the higher education institution and third parties * Set out clearly what the higher education institution *cannot* provide. * Assign responsibility.
Don't: Specify a restricting framework for implementation * Underestimate the need for communication * Ignore external networking.

- Developing infrastructures

Do: Build on existing researcher activity * Put scientific requirements at the centre of all activities * Integrate services with the *data life cycle* in mind.
Don't: Create and develop infrastructures based on technology and tools only, without reference to staff and services * Retain obsolete or inefficient structures * Underestimate costs.

- Improving competences

Do: Gear information services more towards RDM than previously and provide support for RDM as early as the degree programme stage * Integrate RDM into degree programmes with ECTS credits (and possibly offer it as a general skill).
Don't: Ignore RDM at the degree programme stage * Allow skills profiles in central facilities (libraries or computer centres) to be updated without verification.

3. Research data management scenarios

Different types of research activities are described in the following. Each of them is associated with opportunities and risks which may be relevant from the point of view of university management. Depending on how a research project is designed, different requirements for archiving, infrastructure and services, forms of reuse, profiles of decision-makers and users (including the legal framework situation) emerge. The necessary consideration of cost and benefit follows from this.

3.1. Final dissertations and independent doctoral projects[28]

Data: Depending on the discipline, the quantity of data and its composition can be very heterogeneous. While RDM can be complex and expensive for doctoral degree projects, this is less the case for students' projects due to their duration.

Time axis: Formal terms are specified in the examination regulations. The terms for the actual concept development should also be applied to the research data that is used and created. The minimum retention period should be observed; however, it is possible for the final qualification to be disallowed during this period. For grants, a commitment of the funding higher education institution similar to that for employed doctoral candidates should be considered.

Type of reuse: Similar reuse conditions apply to grants as to other individual projects. Students' work is often completely open to reuse. It is mostly the responsibility of the teaching units to support reuse while there are no provisions applying across the university.

Relevance of the data: The value can range across a wide spectrum and is often only revealed later.

Institutions: The higher education institution.

Costs/resources: While individual costs are manageable, in total they can be substantial. The higher education institution is only responsible for the examination regulations. Third-party funding is not available as a rule.

Requirement for advice: High.

Problems: On the one hand, the authors are, generally speaking, fully responsible for maintaining the data. On the other, the higher education institutions can use examination regulations to define framework specifications which also extend to data management. Decision makers must often first be made aware of the necessity of RDM as its organisation is usually decentralised. There are no standards. It is difficult to monitor and control.

3.2. Individual projects which are not embedded in a larger organisational structure (such as projects funded by the DFG's normal procedures and projects receiving basic funding from the higher education institutions)

Data: Data volumes vary in size and heterogeneity.

Time axis: The data needs to be archived for an unspecified or varying length of time; however, there are formal terms based on the rules of good scientific practice.

Type of reuse: The data is usually completely open to reuse, as the projects only become known through publication (in some cases in the form of preprints, however) and therefore interest in reuse is often substantially delayed.

Relevance of the data: Similar situation as in 3.1. However, an estimation of the value should be part of the project description.

Institutions: The higher education institution is usually responsible for RDM. Funding organisations can specify additional conditions.

Costs/resources: Individual costs are generally manageable, but in total they can be substantial. The DFG has so far not made any additional resources available for the basic level of data management (archiving only). At the same time as submitting a project proposal, it is possible to apply for and have approved project-specific funding for the next stages of data management to serve the purpose of reuse of research data[29]. The flat-rate component of funding is earmarked for other purposes and does not cover all the overheads. The higher education institutions have up to now not taken much account of resources for RDM.

Requirement for advice: High, because as yet there is no comprehensive training in this area.

Problems: Generally speaking, decision makers must first be made aware of the necessity of RDM. There are very few standards and controlling structures for these projects. However, there are some subject-specific guidelines (biodiversity, education and social sciences) which put the requirements made of RDM into concrete terms and which help to establish evaluation benchmarks for RDM.

3.3. Projects in a highly networked international subject community (e.g. archaeological excavation data, studies in the social or economic sciences with large volumes of data; linguistics)

Data: The data volumes are often large to very large. The composition of the data is largely homogeneous within the project or even within the community.

Time axis: Can vary as the community specifies the scope. Can be extremely long (archaeology).

Type of reuse: Standard use is comparatively clear. However, there is not yet a long-term strategy for reuse in many communities.

Relevance of the data: Often high to very high.

Institutions: Centralised (sometimes internationally coordinated) courses exist or are being developed by non-university facilities or data centres.
Costs/resources: Very high; third-party funding possible but long-term perspective unclear.
Requirement for advice: Low, as a rule, as the structures have been defined and largely accepted.
Problems: Decisions taken beyond the local level.

3.4. Time-limited university alliances, often of a multidisciplinary or interdisciplinary composition (e.g. Transregio CRCs, the Excellence Project)
Data: The data volumes and the composition of the data are heterogeneous and depend on the discipline in question.
Time axis: Is increasingly dictated by a commitment to the third-party funding body. It is often only geared towards the project duration although there is often a longer-term requirement.
Type of reuse: Heterogeneous, but prompt reuse is expected as a rule. Long-term reuse is currently rare.
Relevance of the data: Varies, but depending on the discipline, can be very high due to the long duration of the projects and therefore to the volume of data.
Institutions: Conflicting options (jointly and locally? Joint supraregional solution? Distributed across subject communities?). The focus on a location is contrary to the significance that the project is desired to have within the community.
Costs/resources: Different from case to case; third-party funding only if applied for. Applications are possible (e.g. DFG's INF projects).
Requirement for advice: Can be very high, as new structures often have to be put in place.
Problems: There are not always plans; competition between locations can present the potential for conflict.

3.5. Collaborative research on an international level, highly networked from the beginning, often involving major instrumentation (such as in climate research, particle physics, bioinformatics and space research)
Data: The data volumes are generally very large. The data composition is homogeneous within the community. There are clear requirements for the metadata, etc.
Time axis: Long. Community specifies routines.
Type of reuse: Standard.
Relevance of the data: High to very high.

Institutions: There are work-sharing options on an international basis.
Costs/resources: Very high; third-party funding possible but long-term perspective unclear.
Requirement for advice: Low, as the framework conditions are prescribed and cannot be changed.
Problems: Decisions on the way forward are often taken beyond the local level; higher education institutions are as a rule one partner among several.

3.6. Cooperative ventures with industry (e.g. in engineering, organisational psychology, business administration or computer science)
Data: Data volumes are as a rule small to medium. Data composition varies.
Time axis: Short or medium-term (after agreement).
Type of reuse: Academic use and/or private business utilisation, must be negotiated.
Relevance of the data: Varies with the academic or economic situation.
Institutions: Higher education institution or commissioning entity (by agreement).
Costs/resources: Can be third-party funded under the contract.
Requirement for advice: Present (particularly where cooperation is with an SME); in addition to technical advice, legal advice is often needed.
Problems: The partner often has stringent data confidentiality (and also possibly data security) requirements. Reuse by academics can give rise to legal problems. Liability risks to the higher education institution must be excluded. It is difficult to monitor and control.

Summary:
Scenarios 3.1, 3.2, 3.4 and 3.6 will be discussed at higher education institution level or as "partner solutions". More national priorities and international alliances are gradually evolving for scenarios 3.3 and 3.5. Solutions which go beyond the federal state level seem helpful for all six scenarios. The possibility of a financial contribution by the federal government should always be taken into account by the federal states.

4. An appeal to policy-makers: sustainable establishment of infrastructures for research data management requires more coordination and new funding procedures.

For the future of Germany as a research location, it is very important that the sustainable establishment and development of scientific information infrastructures (particularly for RDM) are tackled without delay. Other countries such as the Netherlands, the UK and the USA have already progressed far ahead of us. To close this gap and

maintain Germany's attractiveness as a location for research, the German higher education institutions want to make their contribution to establishing scientific information infrastructures. However this requires both a *coordination initiative* to do justice to the multi-institutional and multiregional nature of the information infrastructures and enhancement and adaptation of the *funding procedures* to ensure that the infrastructures thus established are sustainable.
The HRK is therefore calling upon the policy-makers in the federal government and federal states to re-adjust public funding for the information infrastructures in two ways:

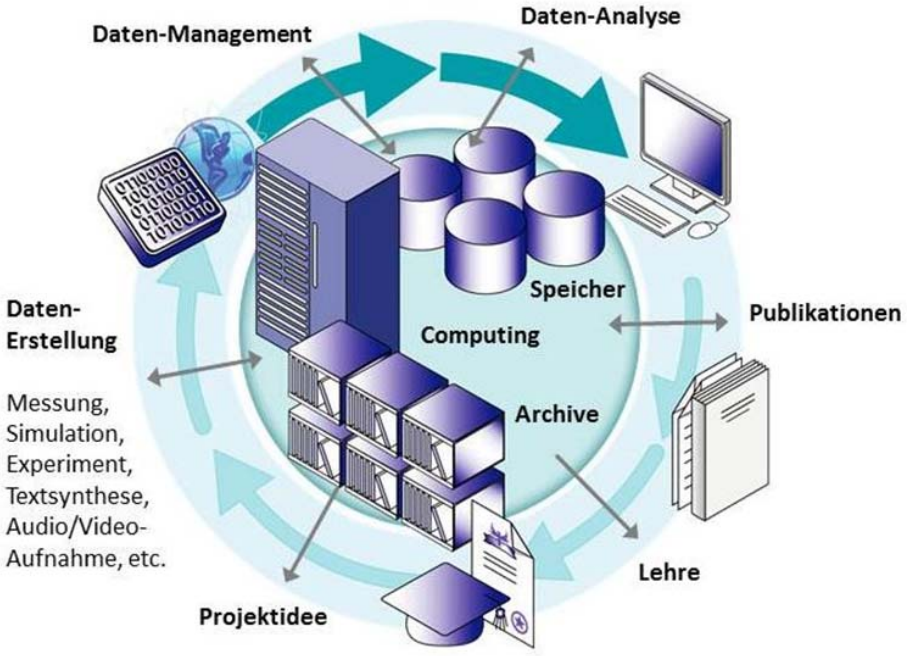
1. Information infrastructures need cooperation. Policy-makers must actively provide incentives to bring this about. If higher education institutions compete against higher education institutions, or against non-university research institutions, federal states against federal states or against the federal government to establish and develop information infrastructures, the result will be substantial losses in efficiency and resources. This situation would encourage the wrong decisions on the way forward to be made and it would be detrimental to the necessary establishment of well coordinated, compatible and widely distributed information infrastructures. Therefore, the higher education institutions should, more than has been the case in the past, cooperate with others in the same federal state and others across the country. The federal states should also work together in joint initiatives. The options for cooperation between the federal government and the federal states in accordance with the new Article 91 b (Para 1) of the Basic Law can be used to establish and develop information infrastructures. All the options it offers should be exploited. Joint initiatives are crucial to the development of a well coordinated, sufficiently differentiated integrated system of information infrastructures in Germany which is also compatible and competitive in an international arena. The HRK expects policy-makers to actively drive forward the coordination of roles and functions on a national level. This will create a reliable framework for all stakeholder groups, which allows them to spend financial resources with the necessary planning security and therefore with the prospect of long-term success. From the HRK's perspective, the Council for Scientific Information Infrastructures could be a suitable body to assume a coordinating role in close collaboration with the HRK and make appropriate suggestions.

2. The establishment and development of the necessary RDM structures opens up new perspectives for research. However, the measures and processes required for the infrastructure also give rise to new costs which the higher education institutions cannot meet from their (already meagre) basic funding. Most RDM activities are currently being financed through projects. However, the project form is only suitable for the establishment phases; it is counter to the idea of sustainability and regularly compromises the success of initiatives.

Without long-term secure funding, there is a serious risk that the structures financed via projects will fail once the end date has passed. Project funding does not achieve a sustainable outcome. Initiatives to create structures with financial support with the aim of securing personnel and services are therefore urgently required. Furthermore, the higher education institutions should be granted special governance options for the administration and spending of structural funding because this is the only way they can fulfil their strategic responsibility in an integrated system of national information infrastructures. Legal and fiscal obstacles which obstruct the reimbursement of services between universities, particularly where these universities are in different federal states, and also in an international context, must be removed.
Finally, the HRK calls on policy-makers in light of the great need for training in RDM to put in place a suitable training initiative with appropriate financial support.

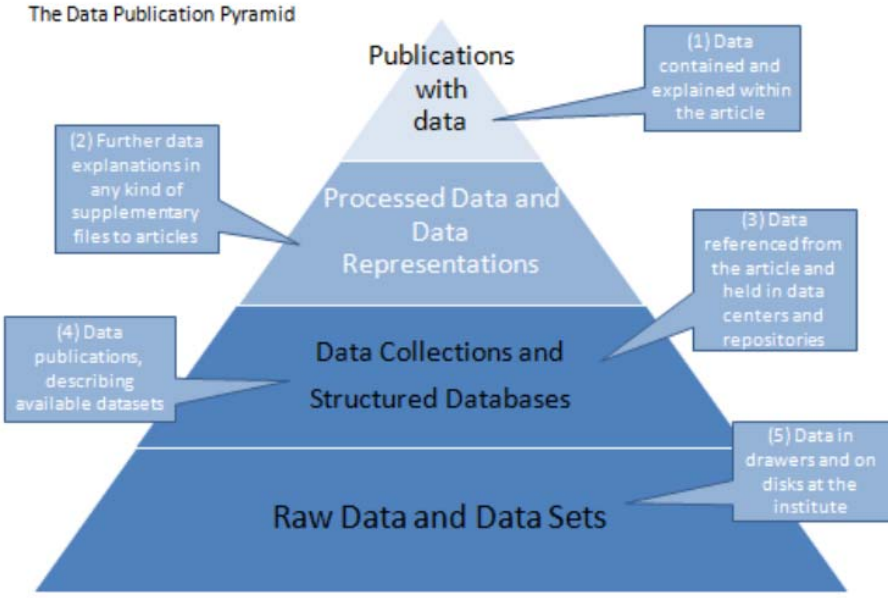
Appendix

Illustration: "Data Life Cycle"



Source: SCC @ KIT

Illustration: "ODE Data Publication Pyramid"



Source: Susan Reilly, Wouter Schallier, Sabine Schrimpf, Eefke Smit and Max Wilkinson, Report on Integration of Data and Publications, 2011, p. 6 (http://www.stm-assoc.org/2011_12_5_ODE_Report_On_Integration_of_Data_and_Publications.pdf)

---

[1] https://rd-alliance.org/

[2] http://gfzpublic.gfz-potsdam.de/pubman/item/escidoc:986900:3/component/escidoc:991888/Position_Paper_Research_Data_en.pdf

[3] http://www.rfii.de/en/category/documents/

[4] http://www.digitale-agenda.de (in German only)

[5] http://dfg.de/download/pdf/foerderung/antragstellung/forschungsdaten/guidelines_research_data.pdf

[6] https://mwk.baden-wuerttemberg.de/de/forschung/forschungslandschaft/e-science/ (in German only). The information infrastructures working group at the Niedersachsen Rectors' Conference is currently preparing a recommendation on RDM. In North Rhine-Westphalia, experts from higher education institution libraries and computer centres are working on a report on the current status of RDM.

[7] http://ec.europa.eu/programmes/horizon2020/

[8] http://www.hrk.de/uploads/tx_szconvention/HRK_Empfehlung_Forschungsdaten_13052014_EN.pdf

[9] This paper was produced by the HRK working group entitled "The future of digital information in teaching and research" under the supervision of Vice-President Prof. Dr. Andreas Bertram. The HRK would like to thank the following people for their commitment: The members of the working group: Prof. Dr. Petra Gehring, Dr. Ulrike

Gutheil, Dr. Wolfram Horstmann, Prof. Dr. Wilfried Juling, Dr. Antje Kellersohn, Prof. Dr. Joachim Schachtner, Prof. Dr. Peter Schirmbacher, Prof. Dr. Uwe Schwiegelshohn, Dr. Beate Tröger and Prof. Dr. Martin Ullrich. The experts who provided the working group with important information at a hearing: Prof. Dr. Martin Egelhaaf, Prof. Dr. Hannes Hartenstein, Dr. Katja Hartig, Najko Jahn, Prof. Dr. Wolfgang E. Nagel, Dr. Wolfram Neubauer, Prof. Dr. Heike Neuroth, Jeroen Rombouts, Dr. Wilma van Wezenbeek and Dr. Peter Wittenburg. Prof. Joachim Wambsganß for his helpful revision of the text. These members of staff at the University of Lüneburg for examples of good practice: Torsten Ahlers, Dr. Hasko von Bassi, Binh Long Duong, Prof. Dr. Alexander Freund, Andrea Japsen, Tim Kawalun, Prof. Dr. Joachim Wagner, Prof. Dr. Henrik von Wehrden and Anke Zerm. Dr. Ania López for information on research data policies. Editorial responsibility for the recommendation: Dr. Ulrich Meyer-Doerpinghaus (HRK Head Office).

[10] Management of research data – a key strategic challenge for university management, recommendation by the 16th General Meeting of the German Rectors' Conference (HRK) on 13 May 2014 http://www.hrk.de/uploads/tx_szconvention/HRK_Empfehlung_Forschungsdaten_13052014_EN.pdf

[11] See below on page 7 of this recommendation.

[12] See the relevant appeal by the DFG to the subject bodies, professional associations and communities in the new "Guidelines on the Handling of Research Data" (as note 5).

[13] See Management of research data – a key strategic challenge for university management (as note 9)
p. 4. In Germany, the universities of Bielefeld, Göttingen, and Heidelberg and the Humboldt University of Berlin have so far approved such principles. Cf. Ania López, Gemeinsamkeiten und Unterschiede verschiedener Policies und Diskussion [Common features and differences of various policies and discussion], 2014: http://www.forschungsdaten.org/images/0/01/Lopez-Policies-Workshop-20141002.pdf (only available in German). In the UK, numerous universities have already approved policies: http://www.dcc.ac.uk/resources/policy-and-legal/institutional-data-policies

[14] As stated in the recommendations by the Open Access working group of the Priority Initiative "Digital Information" run by the Alliance of Science Organisations in Germany: http://www.allianzinitiative.de/fileadmin/user_upload/redakteur/Appell_Offene_Lizenzen_2014.pdf (in German only)

[15] See in this respect the relevant wording in the LERU Roadmap for Research Data: "Not all data can be open. There may be funding constraints, where use of the data is governed by a pre-existing research agreement. The data may be confidential and as such there may be privacy issues which mean that the data cannot be open." (http://www.leru.org/files/publications/AP14_LERU_Roadmap_for_Research_data_final.pdf), p. 12.

[16] In this respect, also see the DFG's new "Guidelines on the Handling of Research Data", see above footnote 5, p. 2)

[17] HRK: "Higher education institutions in a digital age: rethinking information competency – redirecting processes", resolution of the 13th General Meeting of 20/11/2012 http://www.hrk.de/resolutions-publications/resolutions/resolution/convention/higher-education-institutions-in-a-digital-age-rethinking-information-competency-redirecting-pr/, p. 14 f.

[18] See p. 5 above in this recommendation.

[19] The LERU Roadmap for Research Data states: "Management plays a crucial role in driving cultural change within the institution, articulating and reinforcing its orientation towards open access, both through incentivisation and enforcement, and ensuring that the value of open data is recognised." (see endnote 14, p. 29)

[20] See the illustration of the Data Life Cycle on p. 16 of this recommendation.

[21] To distinguish between big data and long-tail data, see the presentation by Christine L. Borgman, "Big data and the long tail: Use and reuse of little data" (http://works.bepress.com/cgi/viewcontent.cgi?article=1294&context=borgman).

[22] Cf. the List of Metadata Standards at the Digital Curation Centres at the University of Edinburgh (http://www.dcc.ac.uk/resources/metadata-standards/list) or the recommendations for social and economic sciences in the paper "Auffinden, Zitieren, Dokumentieren [Find, cite, document]" http://auffinden-zitieren-dokumentieren.de/wp-content/uploads/2014/08/Forschungsdaten_Webansicht.pdf) (in German only)

[23] https://rd-alliance.org/ The RDA also offers workshops and training courses on RDM to any individuals or institutions with an interest. Contacts: Herman Stehouwer, responsible for support in RDA Europa (herman.stehouwer@rzg.mpg.de), and Peter Wittenburg, Head of RDA Europa (peter.wittenburg@rzg.mpg.de). They both work at the Max Planck Computing and Data Facility (MPCDF) in Garching.

[24] See HRK, Management of Research Data (end note 9) p. 4.

[25] See p. 8 of this paper above.

[26] On the following, the HRK as before: "Higher education institutions in a digital age" (see end note 16).

[27] http://www.uzh.ch/research/LERU_Roadmap_for_Research_data.pdf, p. 29.

[28] These are doctoral projects which are not carried out by a member of the higher education institution. As a rule they are financed with a grant.

[29] They include usage fees and expenditure which arise with the use of established data repositories.