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ABSTRACT

**Infrastructure for research data from
the field of *material and immaterial*
cultural heritage**

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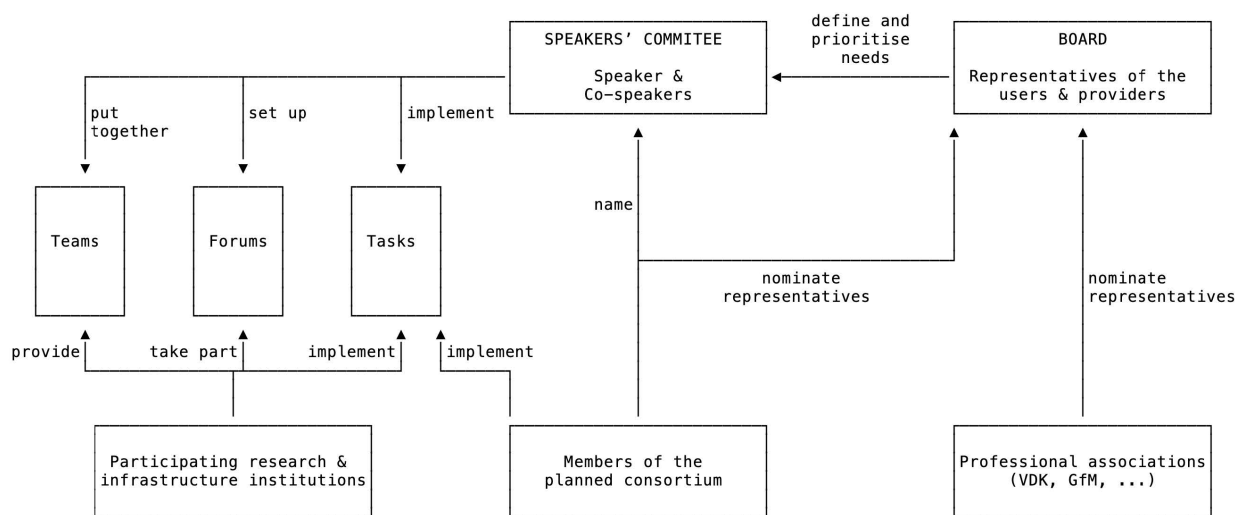
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Overview diagram

The governance of NFDI4Culture is orientated around the following criteria:

1. lean decision-making channels
2. transparent communication
3. innovative solutions
4. rapid alignment of strategy to criteria for success



The strategic decision-making organ is the board of NFDI4Culture. This board has the central task of prioritising needs and finding solutions for current and future scientific, organisational or strategic issues. The board comprises representatives of the users and providers in a 2:1 ratio. The consortium partners delegate the representatives of the providers. The representatives of the users are delegated and nominated for the board by the respective professional associations (currently the Verband deutscher Kunsthistoriker e.V., Gesellschaft für Musikforschung, Dachverband der Archäologie und Altertumswissenschaften, Gesellschaft für Medienwissenschaft for example).

As well as prioritising needs, the board monitors the implementation of the consortium's tasks. Goals and criteria for success are defined for the implementation of the tasks. The board is regularly informed of the implementation progress. The board can recommend to the speakers' committee (see below) that tasks be changed when goals are achieved, or be cancelled and new tasks added. Tasks are implemented by the respective competent consortium partners in close cooperation with the participating institutions. The board meets (at least) 1 x per quarter. It must always make majority decisions.

The speakers' committee is the operative body of NFDI4Culture. It administers the means and implements the consortium's tasks. The speakers' committee comprises the speaker of the consortium and the co-speakers of the consortium partners who are responsible for specific tasks. Each consortium partner names a co-speaker. The speaker represents the consortium in public, for example in the NFDI's consortium meeting. To implement long-term tasks, the speakers' committee is supported by an office which can be located across several sites.

For the consortium to implement the given tasks quickly and effectively and react to new challenges and problems and find innovative solutions, the speakers' committee can put together teams independently as well as upon recommendation of the board. These teams work innovatively and according to agile standards. They are always put together on a multidisciplinary basis. The participants are appointed in accordance with their professional expertise so that the teams comprise a range of expertise so a solution for the respective problem can be found. The teams are there to develop and refine ideas so that the board can decide on their practical implementation. General decision-making criteria are defined for this purpose. The speakers' committee installs the teams and has the task of removing obstacles so that the teams can work as well as possible and find prompt solutions within 2–6 months. The office can commission scrum masters or innovation coaches with this task. The teams can be put together from the circle of consortium partners, the participating institutions and external parties.

While the teams are always only used for a limited period, the speakers' committee can set up forums for specific and generic topics. These forums work on central and in part crosssectoral issues (creating standards, digitalisation, visualisation, etc.). They serve the exchange of information within the consortium but also its exchange with external partners.

The forums organise themselves and are open to anyone interested in the topic. On the basis of their expertise, the forums can provide the speakers' committee and the board with advice regarding the prioritisation and implementation of central tasks and the finding of innovative solutions. The consortium partners and participating institutions actively participate in the forums.

Key questions of the consortium

The aim of NFDI4Culture is to create a decentralised, research-related infrastructure for research data from the field of material and immaterial cultural heritage. The consortium offers digital resources, tools and services for the data-based research of primarily nontextual cultural assets, whose material and medial dimensions have an intrinsic value, which is not completely realised in a digital representation. Digital representations (digital reproductions) of cultural assets can themselves become immaterial cultural assets (e.g. if the material object is destroyed by war or disasters or because of the historicity of medial objects). They methodologically extend the possibilities of research. When researching material and immaterial cultural assets, procedural research data is created which is highly relevant to the participating disciplines. The cultural, medial and material diversity of the research items stands in contrast to a differentiated institutional as well as disciplinary research landscape. This can be seen in the wide range of disciplines participating in NFDI4Culture, extending from musicology, art history and archaeology to theatre, film and media sciences and to ethnology. Furthermore, the research data produced in the consortium is above all relevant for all other disciplines in the humanities and cultural sciences, sometimes even for the social sciences and natural sciences. In addition, there is a strong institutional differentiation of the research landscape, as it is primarily organised in numerous smaller units and individual researchers and also comprises alongside university institutes, art colleges, academies and non-university research institutes above all cultural heritage institutions, to which academic research has close contact. These are in particular galleries, libraries, archives and museums (GLAM).

NFDI4Culture deals with six key questions:

1. Question of **Digitisation**:

How can cooperation be improved between institutions so that scientific needs are transparently taken into consideration when cultural assets are digitised? How can the interoperability, reusability and sustainability of digitally reproduced cultural assets be guaranteed?

2. Question of **Standards and Processes**:

Which data standards, data management, quality assurance and data curation processes are suitable for research data on material and immaterial cultural assets? How can research lead to the further development of standards and processes so that they are more widely used by the disciplines?

3. Question of **Tools and Services**:

Which software tools and data services exist in line with the data life cycle for working with research data on material and immaterial cultural assets? Which tools and services still need to be developed and enhanced? How can an institutional and technical sustainability of tools and services be guaranteed?

4. Question of **Availability and Publication**:

Which solutions exist for the availability and publication of digital reproductions and procedural research data in line with FAIR principles? How can these solutions be further developed between the participating institutions so that they are available long-term to all users of NFDI4Culture?

5. Question of **Rights and Data Ethics**:

Which solutions exist to deal with a legal situation which is often complex (e.g. due to copyright, related rights, rights of use, exploitation rights, domiciliary rights, personal rights, protection of cultural assets, etc.) in relation to research data on material and immaterial cultural assets? Which ethical questions need to be taken into consideration? Which technical options are required to deal with the legal situation and how can they be implemented?

6. Question of **Expertise and Consultation**:

How can concepts for needs-based training, further education, teaching and learning as well as services for consultation and support be developed on the basis of the expertise represented within the consortium?

In order to answer these key issues, the consortium has divided into six central areas of responsibility where proposals and solutions are specifically developed for working with research data on material and immaterial cultural assets. Cross-cutting issues have been formed within these six tasks, such as concepts for the improvement of data literacy and code literacy in the participating disciplines as well as concepts for the transfer of the results to cultural policymaking, the cultural industry and society with an interest in cultural assets.

Known needs and current status of research data management in the relevant subject-specific relevance of the planned consortium

The needs of the users of NFDI4Culture and the status of the data management can be displayed on the basis of exemplary use cases and divided into six areas of responsibility.

1. Area of Responsibility:

Digitisation of Material and Immaterial Cultural Assets

Exemplary research perspective (use case):

In a heritage institution, a collection of cultural objects is to be digitised and the digital reproductions are to be made available on the web for research purposes.

In the 1990s, numerous research and heritage institutions had already begun using a rudimentary database for documentation purposes, however, only a few large institutions have extended this beyond a mere creation of inventories. In a few cases, digital reproductions have already been made available to research in the form of web-based information offerings and infrastructures (e.g. Museum für Kunst und Gewerbe in Hamburg, Städel Museum in Frankfurt, Heidelberg University Library). In some places, digitisation is currently being carried out in line with standards which are inadequate and using diverging technical know-how. Smaller institutions in particular lack the technical and practical knowledge required for implementation. Thus, only a fraction of our cultural heritage has until now been available to researchers in a digital form. In addition, digitisation campaigns are often not targeted enough to research needs. Therefore, on the digitisation level, there is already a great need for coordination between institutions for research-led digitisation processes in the areas of 2D-, 3D-, video- and audio-digitisation.

2. Area of Responsibility:

Data Standards, Data Quality and Data Curation

Exemplary research perspective (use case):

On the basis of digital reproductions, researchers from various disciplines would like to encode and annotate features of mediaeval glass paintings or music. Which standards can be applied?

A general interoperability of research data on material and immaterial cultural assets is not yet available in practice. Nevertheless, good approaches already exist in the form of standards. For example, the International Council of Museums has developed a reference model, the CIDOC-CRM, to accurately describe cultural assets. The IFLA-LRM provides an entity relationship model for the (bibliographic) description of various characteristics of intangible and tangible entities. The Music Encoding Initiative (MEI) is a relevant standard for the encoding of recorded music. Metadata can be exchanged between repositories using LIDO (lightweight information describing objects). The International Image Interoperability Framework (IIIF) provides standardised APIs which enable a comprehensive exchange of digital objects. Semantic Web Technologies enable an improved traceability of disseminated research data and qualified links between data repositories. Links indicate standard files and specialist vocabularies such as the authority file of the German National Library (GND), the Art and Architecture Thesaurus (AAT), the Thesaurus of Geographic Names (TGN) and also increasingly Wikidata. The use, further development and mutual interleaving of these as well as additional standards must be encouraged within institutions and among researchers. There is a great need for the development of transferable data management, quality assurance and curation processes.

3. Area of Responsibility:

Research Tools and Data Services

Exemplary research perspective (use case):

In order to investigate cultural processes during specific historical eras, researchers need the option of accessing and analysing as large a range as possible of relevant digital cultural assets.

There is a great need for shared evidence and federated search systems which enable simple access to and high-performance analysis on large databases of cultural assets. As digital reproductions and procedural data in this area are subject to highly differing rights, federated data services must be established within the framework of the consortium with which the data sovereignty of the conservation institutions can be safeguarded. Platforms for certain types of data already exist (e.g. prometheus -- the distributed image archive for research and teaching, the Répertoire International des Sources Musicales (RISM), the OA disciplinary repository media/rep/, in a broader sense the Europeana and the DDB [German Digital Library] as well). The efficient federated access to decentralised, heterogeneous data repositories requires open standardised metadata on the basis of open interfaces. However, in research the establishment rate for such systems still varies greatly. Thus, NFDI4Culture will promote the accessibility of research data and distributed archives as well as integrating algorithm and software-based research methods (e.g. AI, Computer Vision). In doing so, the consortium wishes to satisfy the great need for digital research tools and ensure synergies for a sustainable use of software tools e.g. as open source applications. Existing research centres such as the Zentrum Musik – Edition – Medien (ZenMEM), the Cologne Center for eHumanities (CCeH), the Digitale Akademie of the Academy of Sciences and Literature Mainz as well as the specialist information services will guarantee greater software sustainability.

4. Area of Responsibility:

Sustainable Provision and Publication of Data

Exemplary research perspective (use case):

Junior researchers would like to permanently publish citable research datasets and results from their studies in Open Access.

There is increasing demand in the humanities for offerings for the professionally supported, sustainable and uncomplicated Open Access publication of research data. In the field of generic solutions, publicly funded solutions such as Zenodo (CERN) have also established themselves alongside commercially operating platforms (e.g. Academia.edu). Solutions which enable research data and results to be published in line with academic standards (e.g. including DataCite or ORCID) and which ensure academic visibility in one's own community have until now been primarily developed by specialist information services, but are not yet common knowledge. Thus, at Heidelberg University Library (heiUP) and at the SLUB Dresden (musiconn.publish) solutions were developed which facilitate the digital workflow from the publication of research data to eBooks and online publications right up to a print edition. It is necessary to extend these solutions and take them to the wide range of participating specialist disciplines. For research data from research projects, disciplinary repositories should enable and make permanently available data publications which go beyond text and two-dimensional images, for example with (annotated) 3D formats.

5. Area of Responsibility:

Rights and Data Ethics

Exemplary research perspective (use case):

An institution wishes to provide research with digital reproductions and procedural data on artistic artefacts which are legally compliant, and to do so it needs a functioning rights management.

Research data on material and immaterial cultural assets is mainly subject – as are the cultural assets themselves – to a complex legal situation. When data is publicised, aspects of data ethics

must be considered, e.g. in the area of data on cultural assets originating from a colonial past or with regard to research data whose publication could lead to a loss of the actual objects (e.g. due to archaeological looting). A central task will be to offer advice in order to create legal certainty for the providers and users of digital offerings with regard to the existing legislation. Efficient authentication and access solutions must also be implemented, which on the one hand enable digital research and on the other guarantee legal certainty. Furthermore, the experiences and requirements of NFDI4Culture should be passed on to the legislators in order to advise them with regard to drafting science-friendly legislation.

6. Area of Responsibility:

Expertise, Consultation, Further Education and Qualification

Exemplary research perspective (use case):

Researchers would like to draft a digital research project which includes material or immaterial cultural assets and require advice and expertise in data management, in handling data and in software-based research methods.

Research data on material and immaterial cultural assets always only constitute a representation of the object and never the object itself. For this specific situation, the consortium needs to develop specific assessment criteria for reflective dealings in the sense of data literacy. As research processes are increasingly data-driven, it is of decisive significance for researchers to also learn to critically evaluate and reflect on algorithms and software tools in scientific and social contexts (code literacy). There is a great need for nationally available consultation and qualification services, which are competently set at all steps of an application or research process. NFDI4Culture will endeavour to reach a stronger embedding of data and code literacy in curricula in the sense of critical data studies and critical algorithm studies.

Summary of the planned research data infrastructure that is specifically intended to address the needs of research users in their respective work processes

In its six central areas of responsibility, the consortium will set up an infrastructure which is specifically targeted at the users' research needs. In NFDI4Culture, forums will be organised where existing data standards will be discussed in close dialogue between providers and users, and data management, quality assurance and data curation processes will be further developed and honed in line with scientific criteria and technical innovations as will the new research questions resulting from them. For the area of responsibility of the digitisation of material and immaterial cultural assets (1), needs-oriented competency centres will be set up between the applicants and the participating research and heritage institutions; they will pool particular expertise in relation to the specific technical digitisation processes (2D, 3D, reconstructions, music encoding, audio, video) and develop suitable format models and description standards for the digitisation of cultural assets. In respect to data standards, data quality, data management and data curation (2), the consortium will implement existing standards and quality assurance measures for the description and exchange of data on cultural assets. These standards are the prerequisite for the third area of responsibility (3) in which software-based tools are developed for the analysis of research data on cultural assets, commented interfaces are implemented and furnished with a differentiated and comprehensive rights management for their use. Regarding the provision and publication of digital reproductions and procedural research data (4) on material and immaterial cultural assets, existing offerings will be scaled and made public for the wider research community.

In addition, the consortium partners will standardise their publication services and provide users with disciplinary repositories for their data publications. In respect to rights and data ethics (5), the aim is to establish legal certainty for users. To do so, authentication and access solutions for research data will be implemented on a technical level alongside consultation services. Consultation, qualification and generation of feedback (6) is a crucial field of responsibility for the success of NFDI4Culture. Alongside consultation centres, needs-based training and further education offerings will be developed which are then imparted institutionally or commercially. In addition, a web-based helpdesk will be set up which offers concrete solutions and assistance for the problems and demands of researchers. It also facilitates direct access to the digital resources, services and tools of NFDI4Culture. The helpdesk is at the same time an instrument which generates application-related feedback from NFDI4Culture's decentralised offerings and collects it as requirements within the context of a professional management of ideas.

Description of data types and underlying data processing/data analysis methodologies

In principle, it is necessary to differentiate between (1) digital representations (reproductions) of cultural assets including their metadata and (2) procedural research data resulting from research processes. This results in the following division:

Digital Representations of Cultural Assets:

- all forms of 2D digital reproductions (two-dimensional photographs of material or immaterial cultural assets, e.g. photos of paintings, sculptures, sheet music, scores, but also recordings of performed works such as dances, etc.)
- 3D models of cultural assets created from 2D photographs by using photogrammetric processes (e.g. 3D models of objects from church treasures or art collections, but also musical instruments, etc.)
- 3D digital reproductions of cultural artefacts, rooms or buildings (photographs from laser, projection and/or structured light scanners, point clouds and colour information from texture cameras)
- all types of audio-visual data on material and immaterial cultural assets (music, film, video recordings etc.)

Procedural Research Data:

- graphic formats (raster formats and vector formats including their image metadata, e.g. Exif, XMP, etc.), vector formats for the digital depiction of notes
- digital reconstructions of cultural assets, computer-generated structures of objects or buildings on the basis of CAAD or rendering programmes, computer-based simulations of cultural spaces or artistic performances
- encoding and annotation formats (e.g. XML-based formats for encoding music or annotating images, time tags or shape annotations for videos, etc.)
- metadata and serialisations of semantic models (e.g. CIDOC-CRM, IFLA-LRM and other derivatives) for the description of material and immaterial cultural assets, exchange formats (e.g. IIIF, LIDO), authority data (e.g. GND, Getty vocabularies:AAT, TGN, ULAN)

Planned implementation of the FAIR principles and information about existing policies

NFDI4Culture is closely orientated to the guidelines of the Schwerpunktinitiative "Digitale Information" of the Alliance of Science Organisations in Germany. Research data on material and immaterial cultural assets, all (data) services based on it and software tools should be made available to researchers in a comprehensively usable form, preferably without legal, financial, technical or organisational barriers (see guidelines of the Schwerpunktinitiative 2018–2022, p. 4). The Arbeitskreis Digitale Kunstgeschichte [working group for digital art history] and the Fachgruppe Digitale Musikwissenschaft [panel for digital musicology] are involved in the consortium. In their disciplines, both bodies are addressing the drafting of guidelines for the open and reliable handling of research data. In addition, the FAIR principles are being applied in all of the consortium's six areas of responsibility:

- 1) **Digitisation:** Digital representations are traceable and are made available to research via federated evidence and search systems. Well-matched digitisation standards geared to the needs of the researchers will lead in future to an improved interoperability and reusability of digital cultural assets.
- 2) **Data Standards and Data Quality:** Providers and researchers will collaborate to achieve an agreement on open data standards, persistent identifiers, version and provenance management, interfaces, software and its documentation. This will improve the findability of the objects but also the accessibility, interoperability and reusability for research over the research data's entire life cycle.
- 3) **Tools and Data Services:** An agreement on standardised protocols for the exchange of research data increases the interoperability of the consortium's offerings on the data service level. Software is described with standardised metadata, versions and derivatives of the software are clearly identified using PIDs and are made permanently available together with their documentation. This increases the sustainability of software technology and at the same time the reusability of the tools.
- 4) **Provision and Publication:** Existing offerings for professionally supported, sustainable and uncomplicated research data publications will be greatly enlarged. This increases the accessibility but also the reusability of research results in the field of material and immaterial cultural assets.
- 5) **Rights and Data Ethics:** The accessibility and reusability of research data and software is safeguarded within the framework of the consortium by using open licences whenever possible and by clearly stating the holder of rights. At the same time, the consortium provides authentication and access solutions which facilitate digital research while guaranteeing legal certainty.
- 6) **Expertise and Consultation:** NFDI4Culture develops consultation and qualification services which convey to the specialist communities knowledge of the FAIR principles and the options for their practical implementation. A helpdesk offers users specific solutions to and assistance with problems and issues in all four FAIR areas.

Planned measures for user participation and involvement

NFDI4Culture evaluates researchers' needs and conceives itself as a technical, social and scientific platform for the users of research data on material and immaterial cultural assets. The users have a majority of votes in the board (see Governance) and play a prominent role in decision-making within NFDI4Culture. The board is the central organ of NFDI4Culture, where needs are established and the projects which are to be realised are prioritised. Furthermore, teams and forums are used to develop ideas for solutions to the needs and to hone these so that the board can decide on the realisation and possibly also on the funding of a tool or a service. Alongside this structure, a professional needs and ideas management is implemented by way of the helpdesk and the consultation centres. This constantly generates feedback and ascertains needs which are subsequently discussed in the board and prioritised.

Existing and intended degree of networking

NFDI4Culture currently already has a close exchange on an institutional and personal level with other consortium initiatives (e.g. with Text+, NFDI4Memory, NFDI4Objects). There is a high level of complementarity in the methodical approach and in the types of research data. The aim is to further extend cooperation with the consortiums referred to above in the course of the application process as well as in the future NFDI. This should create an offering for the humanities and cultural sciences as a whole, but which also extends beyond that to the entire German scientific system. On a national basis, NFDI4Culture is institutionally linked with numerous groups. To be named are the initiatives of the Leibniz- Roadmap such as KultSam und DCOLL, national infrastructure projects such as CLARIAH and the Deutsche Digitale Bibliothek (DDB), but also institutional associations such as the Union der Deutschen Akademien der Wissenschaften. There are also numerous international scientific cooperations. The Repertoire International des Sources Musicales (RISM) can be named as an example for the field of musicology with its working groups in 32 countries across the globe. In the field of art history, there are scientific connections to twelve European countries, the United States and Canada through the Corpus Vitrearum International, while the network PHAROS: The International consortium of Photo Archives organises on a joint platform the documentation centres in the various countries. Services such as the image archive Prometheus, the graphics portal or the image index link internationally distributed databases and provide their service worldwide. Alongside that, there are close institutional ties throughout Europe, e.g. through the European Federation of Academies of Sciences and Humanities (ALLEA). On the level of data standards, the participants in NFDI4Culture actively play a leading part in international standardisation bodies (e.g. in the Music Encoding Initiative/MEI, the CIDOC-CRM, the LIDO Working Group etc.).