SPP100+

SPP HUNDERT PLUS

RESEARCH DATA MANAGEMENT

HANDBOOK

A strategy for research data management in the priority program SPP100+

TECHNISCHE UNIVERSITÄT DRESDEN

MB.

GOAL

To enable efficient collaboration among subprojects from various universities and institutions, and to ensure research data is managed according to scientific best practices and professional standards.

VISION

Encourage cooperation, reproducibility, and openness of research data among the various projects. SPP100+ aims to improve the impact and quality of our research findings while encouraging interdisciplinary collaboration and information sharing by putting convenient data management procedures into place.

RESEARCH DATA MANAGEMENT

Research Data Management (RDM) ensures data integrity, accessibility, and usability by effectively organizing, storing, and documenting research data. In specialized programs like SPP100+, robust RDM is essential for managing complex data, facilitating collaboration, and ensuring compliance with ethical standards. It preserves valuable data, supports ongoing innovation, and enhances the overall success of research initiatives.

Introduction

Motivation

The Priority Program SPP 2388, "Hundred Plus—Extending the Service Life of Complex Structures through Intelligent Digitalization," funded by the German Research Foundation (DFG), necessitates the integration of Research Data Management (RDM) due to its collaborative nature across 19 subprojects organized into five core research clusters—Cluster A (Geometric-semantic models), Cluster B (Damage detection), Cluster C (Monitoring and simulation), Cluster D (Digital twin concepts), and Cluster E (Data-driven methods)—as well as the interdisciplinary platforms Cluster Nibelungenbrücke and Cluster OpenLab as illustrated in figure 1.

The central project in the Priority Program SPP 2388 ensures efficient research data management to facilitate smooth collaboration across clusters. Proper data compilation, maintenance, and sharing enhance interdisciplinary understanding and innovation, allowing insights from different clusters to inform, strengthen, and build upon one another.

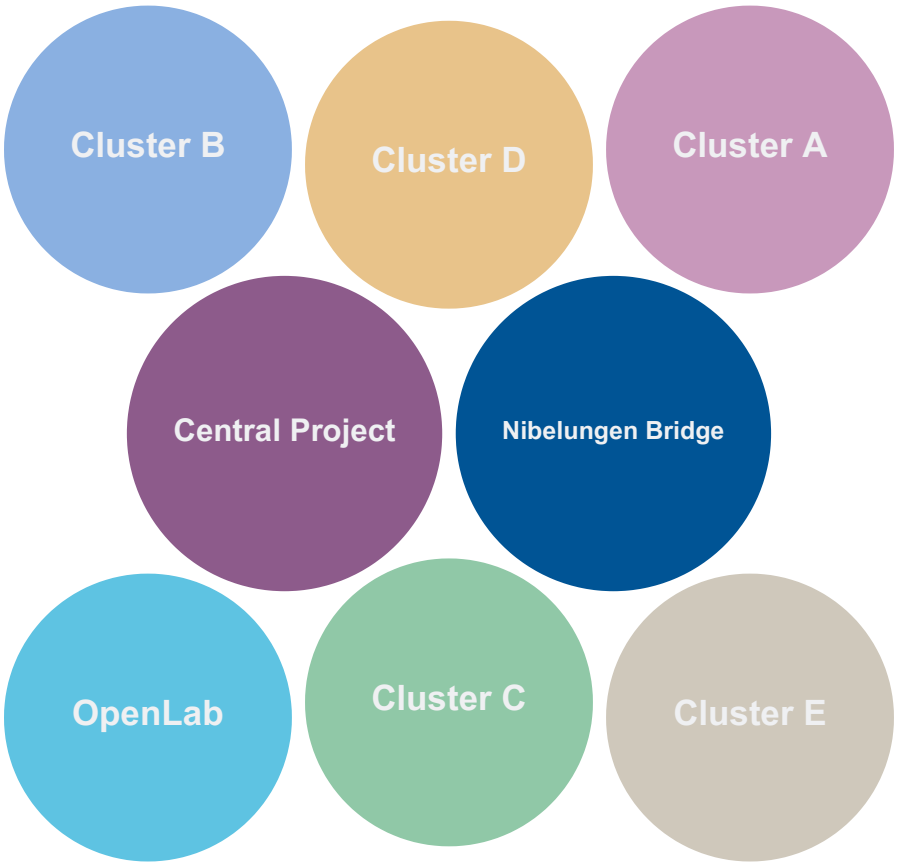

Figure 1: SPP100+ Clusters

Research Data Management represents a key role in the success of the SPP100+ program, enabling centralized data access and fostering synergy among diverse research efforts. To support this, a comprehensive RDM concept was initiated for the program. In this handbook, we present key aspects and processes that have been implemented to achieve our goals from 2022 to 2025.

Research Data Management Strategy for SPP100+

Research data management in SPP100+ begins with project planning as demonstrated in figure 2, where each subproject develops a Data Management Plan (DMP). This is a part of the planning process, where specific questions related to research data should be addressed and discussed within the project team. In the project phase where research data is generated, collected, or reused, the project establishes Research Data Management aspects. These include professional handling of research data, organizing and storing data, file structure, naming conventions, and other related elements.

During the project and at the project end, the central project actively supports the publication of research data by providing comprehensive guidelines on available open repositories for both publishing and long-term archiving.

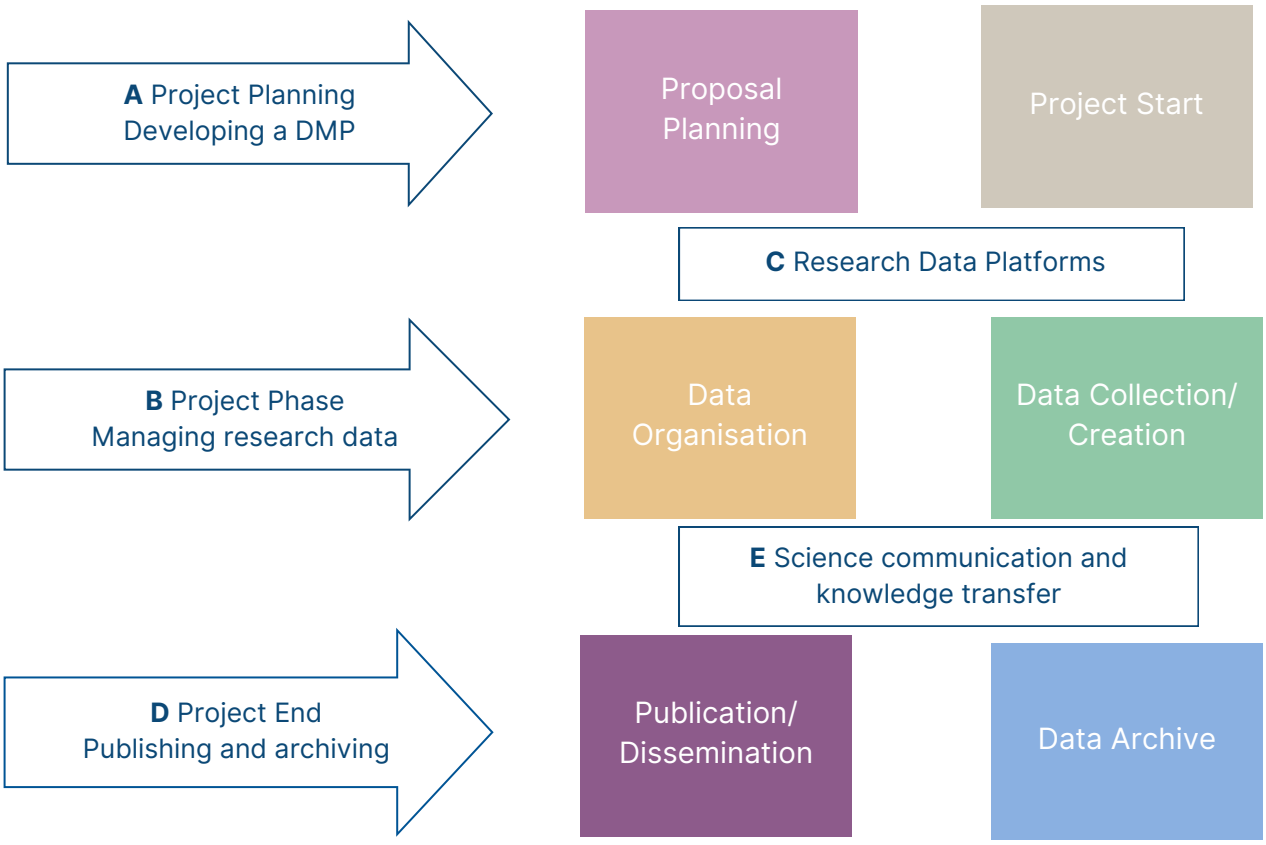

Figure 2: Research Data Management Concept

The subsequent sections A, B, C, D, and E present a detailed Research Data Management (RDM) framework as it applies to the three distinct phases of the project, with particular emphasis on the underlying principles, procedural implementations, and mechanisms designed to support the systematic organization, preservation, and dissemination of research data across all stages.

PLANNING RESEARCH DATA MANAGEMENT

RDM should be planned from the start of a project to ensure data integrity, accessibility, and usability. In programs like SPP100+, robust RDM supports complex data, collaboration, and compliance with ethical standards. Early integration streamlines data collection, ensures preservation, and enhances research efficiency, ultimately contributing to project success.

A. Project planning: Planning Research Data Management

A.1 Understanding DFG requirements

The DFG (German Research Foundation) checklist for handling research data provides a comprehensive framework for ensuring proper management, documentation, and long-term accessibility of research data. It outlines key considerations ranging from data generation and storage to legal compliance and data sharing. By following this checklist, researchers can enhance data quality, maintain data security throughout the project, and ensure that data remains usable and accessible for future research and collaboration.

A.1.1 Data Management and Security

The DFG checklist for handling research data provides a comprehensive approach to manage data throughout the entire research process. Researchers must clearly define how data is generated, reused, and processed, considering the types of data (e.g., image data, text data, or measurement data) and the expected data volume. It is vital that researchers document the data properly using standardized metadata, frameworks, and ontologies to ensure that the data is well organized and can be easily understood and used in the future. In addition, data quality must be maintained through strict quality control procedures, which can include checks for accuracy, completeness, and consistency. Securing the data during the project is essential, and researchers must identify appropriate storage solutions to protect sensitive information, ensuring that access is carefully controlled. Managing access rights and permissions is critical to prevent unauthorized use and maintain data security. Identifying the necessary digital tools and software required for processing, analysis, and sharing data ensures that the data is usable and integrable into different systems throughout the project's lifecycle.

A.1.2 Legal considerations and Long-Term Accessibility

Legal and ethical considerations are fundamental in the proper handling of research data. Researchers must be proactive in addressing issues such as copyright, data ownership, and usage rights, ensuring compliance with legal frameworks and institutional guidelines. It is important to anticipate any legal restrictions that may arise, particularly in terms of future publication, accessibility, or sharing of the data. This may include complying with data protection laws or adhering to specific licensing agreements. Furthermore, the checklist highlights the importance of planning for long-term data sharing and archiving, ensuring that data remains accessible for reuse by other researchers long after the project concludes. Criteria for selecting data for sharing need to be carefully defined to ensure that only high-quality and reusable datasets are made available to the research community. In addition, the roles and responsibilities for managing the data should be clearly allocated within the project team, with specific individuals accountable for different aspects of data management. Adequate resources—including time, budget, and skilled personnel—should be allocated to ensure that the data is curated properly, archived securely, and remains accessible for the long term, even after the completion of the project.

A.2 Data Management Plan

The management of research data across the Priority Program SPP 100+ is governed by a comprehensive framework that ensures data is properly organized, stored, and shared. A key component of this framework is the Data Management Plan (DMP), a structured document developed within the coordination project. The DMP serves as a template for managing research data and is intended for use by each subproject within the program to standardize data practices and ensure consistency throughout. A detailed version of the DMP can be found in the appendix. DMP specifically focuses on the data that is processed or generated during the research project and should be created at the project's initiation. This ensures a consistent and coherent approach to RDM practices from the beginning to the end of the project. In situations where certain information is initially unavailable, it is acceptable to provide estimations or propose tentative approaches. However, it is important to clearly indicate such information as provisional or preliminary. The DMP can be reviewed and modified as necessary during the project's course, with a recommended minimum review frequency of every six months. Any modifications made to the DMP should be thoroughly documented and communicated accordingly.

A.2.1 Project Overview and Data Details

A concise and clear DMP should begin with essential project information, such as the project name, team members, affiliated institutions, duration, and a brief project description. The DMP should outline the current processing status of the project and identify the individual responsible for managing the data. It should also include specific details about the research data generated and reused, covering data formats, types, volumes, methods of generation, tools used (instruments, software, etc.), and sources of reused data. Information about the publication of research data should be included, specifying the location, compliance with FAIR principles (Findable, Accessible, Interoperable, and Reusable), assigned licenses, and access restrictions.

A.2.2 Resources, Ethics, and Archiving

The DMP must define the resources and responsibilities within the project, specifying roles in RDM, access rights, and providing contact information for future data-related inquiries. Ethical and legal considerations should be addressed, including data protection, copyright, and security measures for sensitive data. The storage and backup strategy should be outlined, including the location of the data, backup intervals, and any access restrictions. Finally, the archiving process should be detailed, covering the formats, volume, and location of archived data, measures to ensure long-term data availability, and the metadata necessary for contextualizing the data. Legal and infrastructural requirements for archiving, along with associated costs, should also be specified.

A.3 Confidentiality Agreement

The Confidentiality Agreement is established to protect sensitive information and proprietary data associated with the SPP100+ research project. It defines the responsibilities of all participating researchers in preventing unauthorized disclosure and ensuring data security. By committing to these terms, researchers help maintain the project's integrity and protect confidential information.
The subproject leaders have established formal agreements with both the Institute of Concrete Structures at the Dresden University of Technology (TUD), which also represents the central project within SPP 100+, and LBM Worms.

A.3.1 Agreement with TUD

To ensure the integrity and confidentiality of project-related data, the subproject leaders have established a formal agreement with the Institute of Concrete Structures at the Dresden University of Technology (TUD), which also represents the central project within SPP 100+. This agreement protects sensitive information and upholds the highest data security standards throughout the project's lifecycle. It enforces strict confidentiality protocols, prohibiting unauthorized sharing with third parties and ensuring data is used exclusively for the 'SPP 2388 - Hundred Plus' project.

A.3.2 Agreement with LBM Worms

LBM (Landesbetrieb Mobilität) Worms is the regional mobility authority responsible for managing and maintaining transportation infrastructure in the Worms area, including roads, bridges, and other transportation-related structures. LBM Worms is also responsible for the Nibelungen Bridge, which is used as a reference bridge for the validation of research methods in SPP100+. The agreement enforces strict confidentiality protocols, prohibiting unauthorized sharing with third parties and ensuring that all data is used exclusively for the 'SPP 2388 - Hundred Plus' project. Additionally, research paper publications that use data from the validation bridge, Nibelungen Bridge Worms, must also reference LBM Worms. Publications containing details about the validation structure of the Nibelungen Bridge Worms require prior approval from LBM Worms before release. Additionally, sharing structural documents with third parties is prohibited without explicit agreement from LBM Worms. To ensure data security, all project staff and individuals with document access must sign confidentiality agreements. These measures protect sensitive information, uphold data integrity, and maintain the project's credibility.

WORKING WITH RESEARCH DATA

Working with research data involves careful management of metadata, data formats, and file organization. Metadata documentation provides essential context for datasets, ensuring they are easily understood and accessible. Standardizing data formats and using clear, consistent file naming conventions enhance data usability, discoverability, and collaboration

B. Project phase: Working with research data

B.1 Data Documentation

Metadata is essential for managing and utilizing research data effectively within the SPP100+. It provides a structured framework that details critical aspects of each dataset, including its origin, format, and usage guidelines. This comprehensive documentation not only ensures that data is accurately described and easily accessible but also aligns with the FAIR principles—Findable, Accessible, Interoperable, and Reusable. By clearly documenting datasets, metadata contributes to making data findable and accessible, as researchers can locate and retrieve data efficiently.
Furthermore, detailed metadata supports interoperability by providing context and standardizing descriptions, which facilitates the integration of data from various sources. Finally, by ensuring that datasets are well-documented and include usage guidelines, metadata enhances reusability, allowing other researchers to understand and apply the data effectively.
By maintaining high standards of metadata, the SPP100+ not only upholds the integrity and efficiency of its research but also supports collaborative efforts, ensures transparency, and safeguards the program's data assets.

B.1.1 Requirement-Customized Metadata

In the SPP100+, we have developed a customized set of metadata questions that every researcher must answer for each dataset they provide. This ensures that all research data shared within the program is accompanied by detailed and consistent documentation. By requiring researchers to address these specific metadata questions, we facilitate comprehensive data description, enhance data usability, and support effective collaboration and integration across various subprojects. This approach not only upholds high standards of data management but also promotes transparency and reproducibility within the SPP100+ research community.

B.1.2 Documentation and Upload Procedures

In the SPP100+, researchers are required to upload metadata text files to the program’s group drive (see Sec. C.1). These files provide detailed context and information necessary for effectively understanding and utilizing the data, ensuring that datasets are accurately described, categorized, and linked to related files. Looking forward, there is significant potential for this documented metadata to be further standardized, introducing more uniform guidelines for structure, terminology, and formatting. This would streamline data management processes, improve consistency, and increase the interoperability of datasets, ultimately enhancing cross-team collaboration and ensuring the long-term sustainability and impact of the research.

B.1.3 Metadata Template

The metadata template provides essential details for organizing and describing a dataset, including general information such as the dataset title, project, publisher, and contact details of the creators. It outlines the data's type, source, format, size, language, and collection date, along with geographic location and funding sources. The template also covers the software and methods used for data creation and processing, as well as any additional data handling. Furthermore, it includes sections for specifying data access rights, licensing, and any related files, ensuring transparency and proper documentation for sharing and interpreting the data. Figure 3 shows the content of the customized metadata template in SPP100+.

*Template-En.txt - Editor

Datei Bearbeiten Format Ansicht Hilfe

```
# METADATA TEXT FILE GENERATION

Metadata Generated By:** Name of the person filling out this metadata
Metadata Generation Time:** Date and time of document creation
Metadata Path:** This is automatically saved and does not need to be filled out

# GENERAL INFORMATION

Dataset Title:** A short and concise title displayed for submission.
Project:** The subproject <B01, A03>
Publisher:** Research institution (university) to which the submitter belongs
Contact Information of the Main Creator:** <Name, Institution, Address, Email>
Contact Information of Associated or Co-Creator:** <Name, Institution, Address, Email>

# DESCRIPTION OF THE DATA

Data Type:** Type or kind of data (e.g., photos, measurements, other)
Data Source:** The source from which the data originates
Format:** Data format
Size:** Data size
Language:** The language in which the data is written or associated
Content of the Research Dataset:** Description of the content and categorization of the research data type
Date of Data Collection/Generation (single date, period, approximate date):** <required format YYYY-MM-DD>
Geographical Location of Data Collection:** <Latitude, Longitude, City/Region, State, Country, if applicable>
Information on Funding Sources Supporting Data Collection:** Supporting or funding sources
Description of Additional Data Processing:** Explanation of any further processing of the original data.

# METHODOLOGICAL INFORMATION

Software Used:** Details on software used to create or process the data
Instrument or Software-related Information Required for Data Interpretation:** <Provide full name and version
of the software,as well as any necessary packages or libraries required to run scripts.>
Methods of Data Processing:** <Describe how the submitted data was generated from raw or collected data>
Description of Methods Used for Data Collection or Capture:** <Provide links or references to publications
or other documentation containing the experimental design or protocols used during data collection>

# INFORMATION ON SHARING/ACCESS

Data Usage Rights Holder:** Institution of the data submitter
Were the Data Derived from Another Source?** If yes, please specify the source(s):
Should Your Data Be Publicly Accessible and Available as Open Access?** <yes, no>
Licenses or Restrictions Placed on the Data:** If the research data is to be shared or published, the license
determines the third-party rights to use the data and any obligations that arise from using the data.
Links to Publications that Cite or Use the Data:**

# CONNECTION TO OTHER FILES
File List of Files Associated with This Dataset:** List related datasets or files that may be important when
related to this current dataset.
Relationship Between the Files, if Relevant:** Explanation of the relationship between the mentioned files.
```

Figure 3: Metadata Template

B.2 Data Format

As technology evolves, programs and file formats often change, making older files harder to access and interpret. This creates challenges for the long-term usability of digital data, requiring ongoing efforts to maintain accessibility. Table 1 lists some recommended file formats.

Table 1: Recommended File format

File type	Recommended	Not suitable for archiving
Text	• PDF/A (*.pdf, preferred subtypes 2b and 2u) • Plain Text (*.txt, *.asc, *.c, *.h, *.cpp, *.m, *.py, *.r etc.) coded as ASCII, UTF-8, or UTF-16 using byte order mark • XML (inclusive XSD/XSL/XHTML etc.; with included or accessible schema and character encode explicitly specified)	Word *.doc PowerPoint *.ppt
Spreadsheet or table	• Comma- or tab-delimited text files (*.csv)	Excel *.xls, *.xlsb (binary formats)
Raw data and workspace	• ASCII Text is suitable for long-term use, but the data import may be time-consuming. • S-Plus files (*.sdd) may be saved as text files. • Matlab *.mat files may be saved in HDF Format. Saving nontrivial ASCII Matlab *.mat files should be avoided because they are not readable with the Matlab load command. • Network Common Data Format or NetCDF (*.nc, *.cdf) • Hierarchical Data Format (HDF5) (*.h5, *.hdf5, *.he5)	Binary files such as the standard Matlab files *.mat or the R files *.RData
Raster image (bitmap)	• TIFF (*.tif) (uncompressed, preferentially TIFF 6.0, Part 1: baseline TIFF). TIFF is preferred as compared to PNG or JPEG2000. • Portable Network Graphics (*.png, uncompressed) • JPEG2000 (*.jp2, lossless compression) • Digital-Negative-Format (*.dng) to keep raw data of digital fotos in addition to a second copy in TIFF format	JPEG has lossy compression, please be aware of the issue of data loss with this compression format

Table 2: Further recommended File format

File type	Recommended	Not suitable for archiving
Vector graphics	• SVG without JavaScript binding (*.svg)	Graphics InDesign(*.indd), Illustrator(*.ait) EncapsulatedPostscript (*.eps) Photoshop (*.psd)
Geospatial data.Vector and rasterdata.	• ESRI Shapefile (essential – .shp, .shx, .dbf,optional – .prj, .sbx, .sbn). • Geo-referenced TIFF (.tif, .tfw). • CAD data (.dwg). • Tabular GIS attribute data.	Don't use formats lack georeferencing information (e.g., JPEG, PNG).
CAD	• AutoCAD Drawing (*.dwg) • Drawing Interchange Format, AutoCAD (*.dxf) • Extensible 3D, X3D (*.x3d, *.x3dv, *.x3db)	PDF is generally notideal for active CADwork.
Digital audio data	• WAV (*.wav) (uncompressed, pulse-codemodulated) • Free Lossless Audio Codec (FLAC) (.flac).	MPEG-1 Audio Layer 3(.mp3) has lossycompression, but iswidely adoptedDigital
Digital video data	• FFV1 codec (version 3 or later) in Matroska container (*.mkv) • MPEG-4 (.mp4). • OGG video (.ogv, .ogg). • motion JPEG 2000 (.mj2).	Windows Media Video(*.wmv)

B.3 File Organization and Naming

Effective organization of file folder structures for research data hinges on clarity, consistency, and ease of navigation. A well-structured hierarchy ensures that data remains accessible and manageable throughout the research process. The SPP100+ research guidelines highlight the importance of documenting this structure, specifically advising that a descriptive text file be included at the top level of each subproject subfolder. This file should detail the folder organization and contents, enhancing understanding and collaboration within the research group.

B.3.1 File Folder Structure

In the SPP100+ Group Drive (illustrated in sec. C.1), the goal of standardizing the first level of the subproject folder structure is to create a clear and consistent framework that promotes easy navigation and understanding of the subprojects. By establishing a uniform system, all participants can access and organize project materials in a structured way. As a guideline, it is recommended that the folder structure not exceed ten folders in width and three folders in depth to maintain simplicity and efficiency. To achieve this, the structure is suggested to be organized into four main directories.
The first directory is designated for LITERATURE related to the subproject, which will serve as a repository for relevant research, academic papers, references, and other scholarly materials that provide context and background for the project. The second folder is allocated for DOCUMENTATION, containing all reports, progress updates, meeting minutes, and other materials that detail the project's implementation, methodologies, and processes. The third and fourth folders are specifically reserved for RAW DATA and RESULTED DATA, respectively. This clear separation ensures that original data is kept intact in its unprocessed form, while derived outcomes, analyses, and conclusions are stored separately for easy access and review.

B.3.2 Naming convention

Naming conventions for research data in joint projects help maintain organization, clarity, and consistency. A defined scheme ensures easy identification and location of files, reducing confusion and errors. Consistent naming supports data integration, comparison, and version tracking and enhances collaboration, data sharing, and project efficiency. Both folder and file names should be concise, clear, and limited to a maximum of 50 characters. The recommended naming pattern is: date (YYYYMMDD) + short description (project dependent) + author (abbreviation), with underscores replacing spaces (e.g., 20210406_FileNaming_RDM_FL.doc). Different versions should be labeled as V01, V02, etc., and include the research software version if applicable. Additionally, a README file should be created at the first folder level to explain the naming conventions and folder structure, ensuring consistency and clarity within the SPP100+ Data Platform.

RESEARCH DATA PLATFORMS

Research data platforms are key to effective data management, storage, and accessibility. For the SPP100+ program, a strong data infrastructure is essential to ensure data integrity, support collaboration, and facilitate efficient research. This approach will optimize data handling and enhance the program’s overall success.

C. Research Data Platforms

C.1 Group Drive

As part of the research data infrastructure for SPP100+, Group Drive and a SharePoint are utilized. The SharePoint enables collaborative documentation and versioning of documents among subproject members and clusters, supporting efficient administration and coordination. For managing and sharing large volumes of research data, Group Drive is employed to handle data uploads and sharing within the program, supporting knowledge transfer and collaboration. Together, these tools will enhance the management and accessibility of research data across the program.

The Group Drive is organized to support the varied needs of the SPP100+, providing a centralized system for file storage and collaboration across all subprojects and clusters. Figure 4 demonstrate the used folders structure.

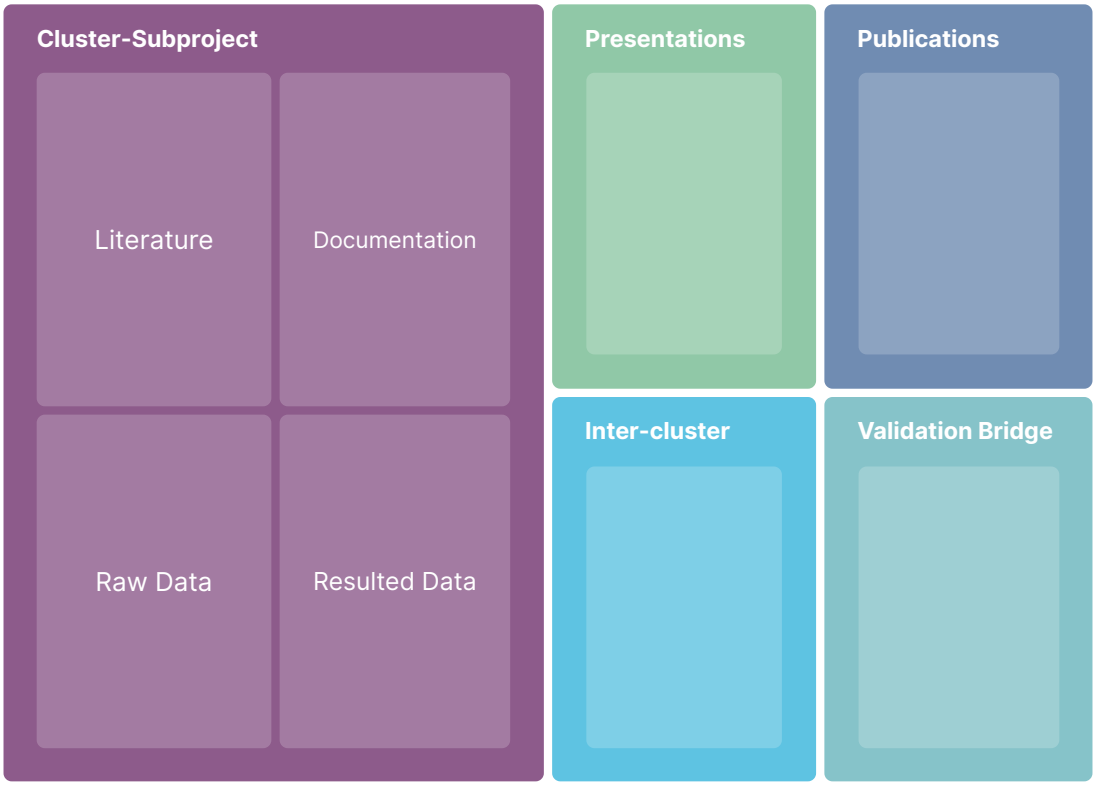

Figure 4: Group Drive - File Folder Structure

By implementing a clear and logical folder hierarchy, the drive ensures that all critical information is systematically categorized and readily accessible to all project participants. This structured approach not only facilitates seamless access to important documents and data but also enhances overall project efficiency by reducing time spent searching for files and improving communication among team members. The file folder structure is demonstrated in figure 4.

C.2 SharePoint

The SPP100+ SharePoint homepage is designed for optimal user experience by organizing key elements into clear sections that streamline access to essential resources and tools. It features the Tasks section for centralizing questionnaires and forms, the Discussion section for important documents related to SharePoint management, and the Workspace section for quick access to project files shown in figure 5.

Figure 5 illustrates the elements of the SharePoint homepage. The SPP100+ logo currently links to the official program website. The next step is to integrate links to the structural health monitoring data and the digital twin directly on the homepage.

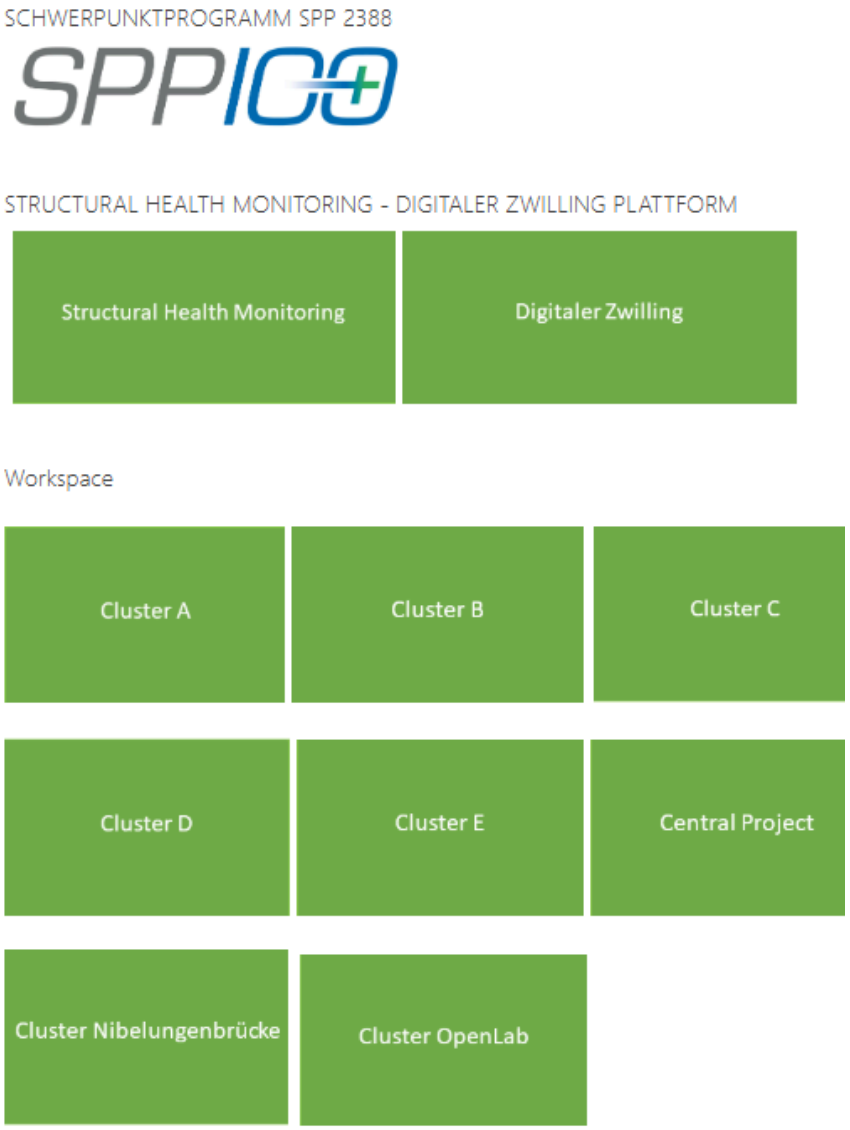

Figure 5: SharePoint Homepage

The workspace section in SharePoint is used for maintaining organized and easily accessible organizational resources, ensuring that essential materials such as protocol minutes, cluster meeting records, and joint publications are systematically stored. The structure enables subproject members to work together seamlessly, ensuring that relevant documents are easily retrievable and that collaboration on shared tasks is well-coordinated. Figure 6 presents the workspace for all clusters in SPP100+, and figure 7 shows how the workspace of cluster A, for example, is further structured to provide workspaces for the subprojects within the cluster and one folder for the exchange among the subprojects.

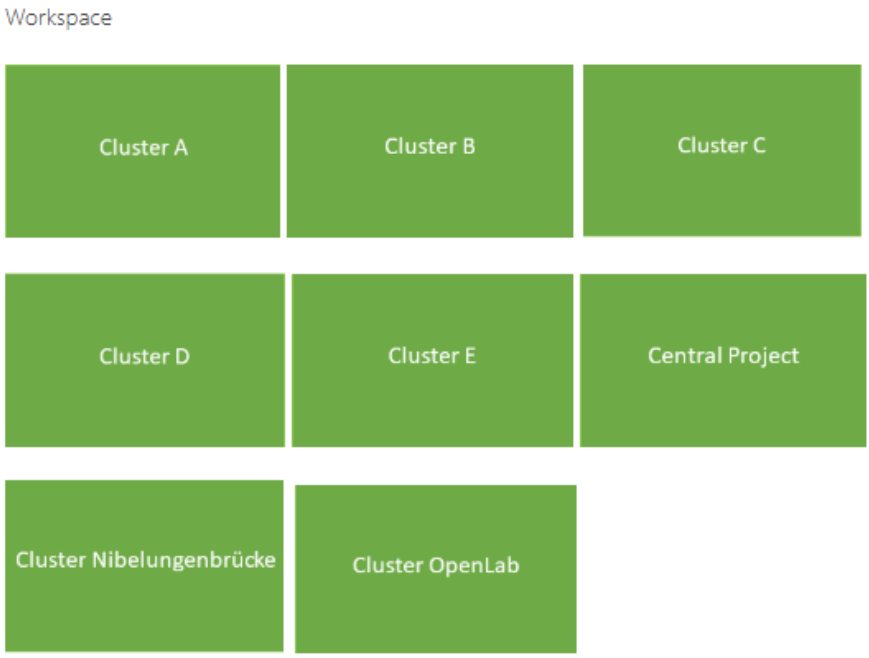

Figure 6: SPP100+ SharePoint Homepage-Workspace

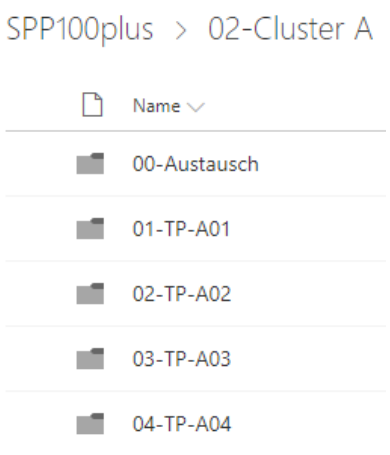

Figure 7: Cluster-A workspace

C.3. Access Permission Strategy

SPP100+ balances collaboration and security with four access levels in the group drive and SharePoint, as shown in figure 8. Subproject members work in dedicated spaces, while cluster members use shared research data. Researchers manage their own subprojects folders with read and write rights, while view-only access across other subprojects.

C.3.1 Global Read Permission

This permission allows all researchers across the SPP100+ to access and read the contents of designated folders. It ensures that valuable information is broadly visible to all participants, promoting transparency and shared knowledge within the program.

C.3.2 Global Write Permission

Beyond just reading, this permission enables all program members to contribute to and modify the content within the folders. It supports collaborative efforts by allowing users to add, update, or delete information, thus facilitating collective input and ongoing updates.

C.3.3 Cluster-wise Write Permission

This type of access is specific to members of particular clusters. It permits them to write and execute actions within folders designated for their cluster. While cluster members can manage and modify their own cluster's folders, this permission restricts write permission to folders belonging to other clusters, maintaining organized and secure data boundaries.

C.3.4 Subproject-wise Write Permission

This permission is reserved for members of individual subprojects. It allows them to make contributions and changes only within their specific subproject's folders. This focused access ensures that only authorized members can manage or alter content related to their particular subproject, promoting data integrity and control.

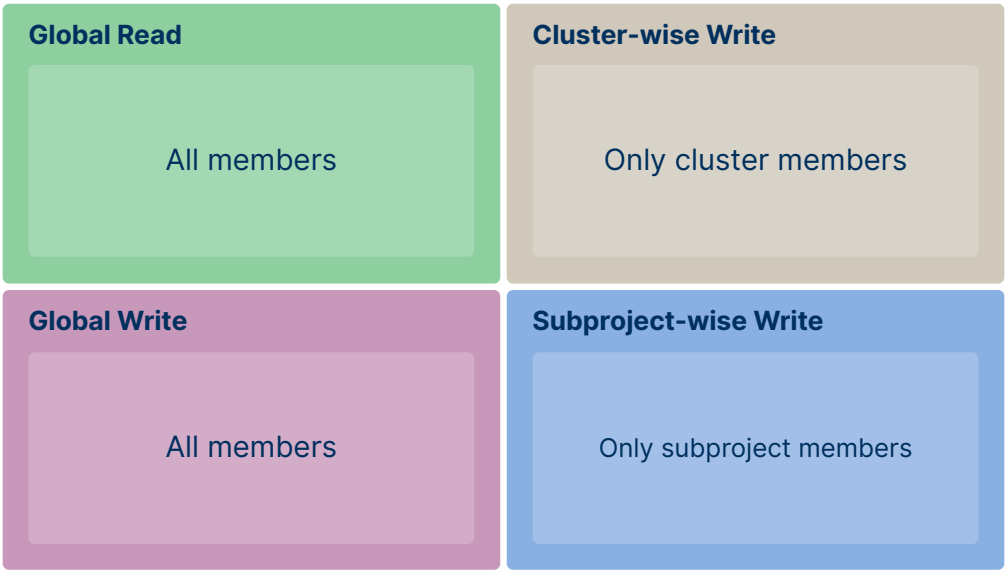

Figure 8: Permission types used in SPP100+

C.4 Metadata Process and Workflow

The metadata text file includes all necessary questions about the research data, which researchers would upload it in their respective subproject folders along with the research datasets (see section B.1.3). The SPP100+ Metadata template has been provided to all researchers for this purpose.

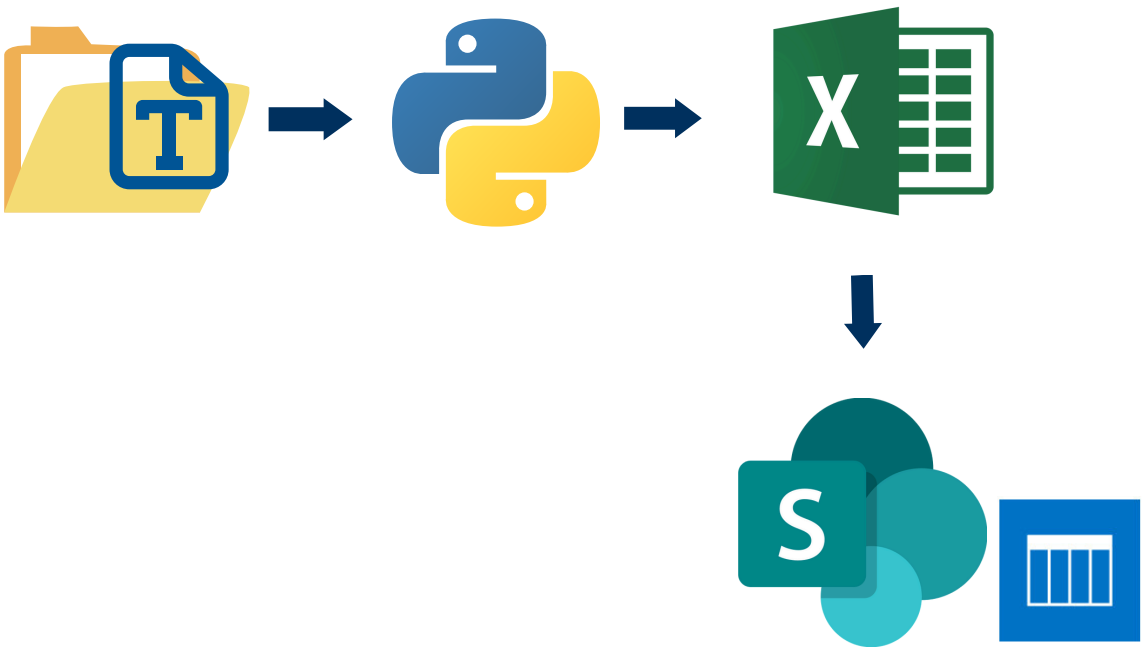

Figure 9: Metadata collection workflow

The process demonstrated in figure 9 ensures research datasets are findable by automatically collecting and consolidating metadata into a structured, tabulated dataset. The Python script, maintained by the central project, gathers all filled-out metadata files from the group drive and processes them into a standardized format. By automating this step, the script ensures that metadata remains up-to-date and consistently organized, reducing manual effort and improving accessibility.

The resulting tabulated dataset, where each row corresponds to an uploaded dataset, is stored in an Excel sheet and can also be viewed as a list in SharePoint. This provides researchers with a broad overview of all uploaded datasets, including their corresponding folder paths in the group drive. By making this information easily accessible, the workflow enhances transparency, streamlines data retrieval, and fosters collaboration across different research teams.

PUBLISHING AND ARCHIVING RESEARCH DATA

Handling research data involves secure storage, regular backups, and long-term archiving to preserve data integrity. Data publication makes findings accessible, while archiving ensures future usability, supporting ongoing research and discovery.

D. Publishing and archiving research data

D.1 Storage and Backup

Storage systems are essential for ensuring that research data is securely stored, well-organized, and easily accessible. In the SPP100+ program, research datasets are uploaded and stored on the group drive. This centralized system allows researchers to store and retrieve their data efficiently. Other organizational records, such as meeting minutes and administrative documents, are stored on the SharePoint page of the SPP100+, providing a structured environment for collaboration. Additionally, backup processes are vital for protecting data from loss due to unforeseen circumstances like hardware failures, software malfunctions, or accidental deletions. Weekly backups create duplicate copies of data, ensuring its continuity and accessibility for future analysis and sharing. These storage and backup practices ensure the effective management and security of research data within the SPP100+ program.

D.1.1 Group Drive

While each subproject is responsible for managing its own internal storage and backup IT infrastructure, the SPP100+ Group Drive offers substantial 5.00 TB storage capacity. To enhance data security further, weekly backup snapshots of all files and folders within the SPP100+ Group drive are performed. These backups regularly capture the current state of the data, providing a means to restore files in the event of loss or error, such as accidental deletions, virus attacks, or hardware failures. This comprehensive backup system acts as a reliable safety net, preserving research data and minimizing the risk of data loss, ensuring that critical information remains intact and accessible throughout the research process.

D.1.2 SharePoint

SharePoint offers a robust and scalable storage solution. To safeguard against data loss, SharePoint incorporates built-in backup features that automatically create regular snapshots of all data. Additionally, SharePoint's versioning and recycling features enhance data protection by allowing users to retrieve previous versions of documents and recover accidentally deleted files. These tools ensure that even in the event of errors or system issues, valuable data can be restored with minimal disruption. This comprehensive approach ensures that research data remains intact and accessible, further reinforcing the reliability and integrity of the data management system within the SPP100+ SharePoint environment.

D.2 Data Publication and Archiving

According to the German Research Foundation (DFG), it is highly advisable to publish associated research data, or at least their metadata, alongside the research findings. By doing so, researchers can provide a comprehensive record of the data that supports their conclusions, ensuring that others can fully understand and replicate the work. Publishing data not only fosters transparency but also enhances the reproducibility and traceability of the results, which are critical for validating the research and building trust within the scientific community. The DFG requires research datasets to be published with open access through trusted repositories (see sec. D.2.2), accompanied by comprehensive, standardized metadata to ensure transparency and reproducibility. Datasets must be assigned persistent identifiers like DOIs for easy citation and linkage to publications. The DFG emphasizes data reusability, recommending machine-readable and widely accepted formats (see sec. B.2). Long-term preservation in reliable repositories is essential to maintaining data integrity and accessibility; 10 years is the minimum recommended archiving duration. Additionally, ethical and legal considerations must be addressed, ensuring privacy and intellectual property rights are protected, particularly when handling sensitive or personal data.

D.2.1 Publishing Raw and Processed Data

The SPP100+ encourages researchers to publish their research data in its raw, processed, and fully processed forms. This comprehensive approach ensures that all stages of the research process are accessible, allowing for greater transparency, reproducibility, and verification of results. In addition to the data itself, further documentation such as metadata is necessary to provide context and clarity. Most engineering repositories now enable research dataset publishing with a specific Digital Object Identifier (DOI), which can be referenced in paper publications, making the research traceable and accessible. These repositories typically require standardized metadata, including information such as data collection methods, analysis techniques, and variable descriptions, ensuring that data can be easily understood, shared, and reused by others in the scientific community.

D.2.2 Repositories for Publishing and Archiving

Within the SPP100+, OPARA (Open Access Repository and Archive for Research Data of Saxon Universities) is recommended for publishing and archiving research data, offering a secure and reliable platform for long-term data storage. OPARA provides a structured environment for research data, ensuring proper documentation and metadata management. Subprojects within the program are encouraged to find the most suitable repositories for their specific needs or, alternatively, to utilize their institutional repositories for publishing and archiving. This flexibility allows each subproject to select the platform that best aligns with their research discipline, data types, and dissemination goals while adhering to best practices in Research Data Management.

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SCIENCE COMMUNICATION AND KNOWLEDGE TRANSFER

An essential component of SPP100+ is effective science communication and knowledge transfer, aimed at bridging the gap between academic research and practical application. This involves disseminating research findings to the public and engaging with industry partners for technology transfer.

E. Science Communication and Knowledge Transfer

E.1 Science Communication

Effective communication and the transfer of scientific knowledge are essential for driving research and innovation forward. By clearly sharing their discoveries, researchers allow the wider scientific community to expand upon their work, promote collaboration, and avoid redundant efforts. Science Communication and Knowledge Transfer ensure that research data is accessible, ethically used, and applied effectively, maximizing its impact and fostering collaboration. This dissemination accelerates scientific progress, supports informed decision-making, and helps apply research outcomes to practical challenges, thereby advancing society and enriching global understanding.

E.1.1 Open Science

Researchers within the SPP100+ are committed to open science principles, making their work publicly accessible. This includes publishing open-access research publications and making research datasets available to the public. This approach fosters global scientific collaboration and transparency.

E.1.2 Website and Social Media

The program maintains a dedicated website and social media presence to share information about research goals, methodologies, and updates. The website features detailed descriptions of research subprojects, while YouTube videos provide visual updates and insights into the program's progress and LinkedIn pages from SPP100+ subprojects to transfer the news and updates to the public.

E.1.3 Annual Meeting and PhD Workshops

The central project in SPP100+ organizes annual meetings, PhD workshops, and cluster workshops in different locations across Germany each year, as shown in figure 10. These events feature thematic sessions where researchers present their work, exchange ideas, and engage in focused discussions (see fig. 11-14).

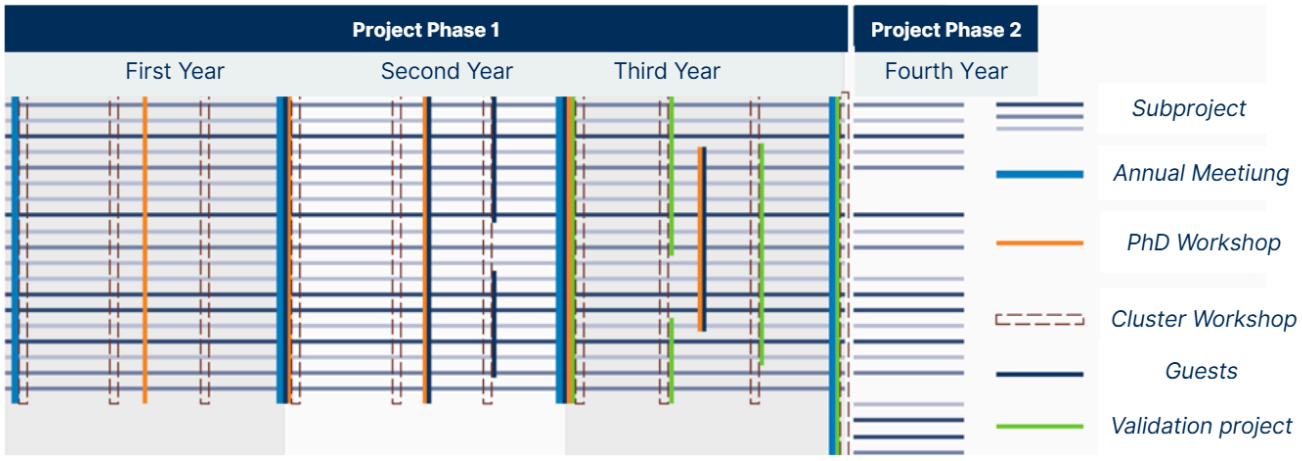

Figure 10: SPP100+ Time Plan for meetings and workshops

Figure 11: PhD Workshop in Braunschweig April 2023

Figure 12: PhD workshop in Worms November 2023

Figure 13: PhD Workshop in Berlin in May 2024

Figure 14: Hands-on Non-Destructive Testing

E.1.4 Conference and Special Sessions

SPP100+ was showcased at prominent conferences, including EWSHM 2024, LDAC 2024, and Baustatik Baupraxis 2024. The special sessions provided opportunities to introduce the program to a wider research audience (see fig.15 and 16).

Figure 15: Keynote Speaker Prof. Dr-Ing. Steffen Marx at EWSHM 2024

Figure 16: Best student award candidate at SPP 100+ special session at EWSHM 2024

E.2 SPP100+ Website

The SPP100+ website is designed for easy navigation, offering insights and updates on research topics, as shown in figure 17, which illustrates the homepage. The About Us page, in figure 18, introduces the program and its objectives. This platform aims to recognize the program's actions, accomplishments, and future plans while enhancing public transparency. Figures 19 display other website content, including the news and appointment page, and figure 20 shows the cluster and research topics page, which provides brief descriptions of all subprojects within the clusters.

Figure 17: SPP100+ Website: Homepage (www.spp100plus.de)

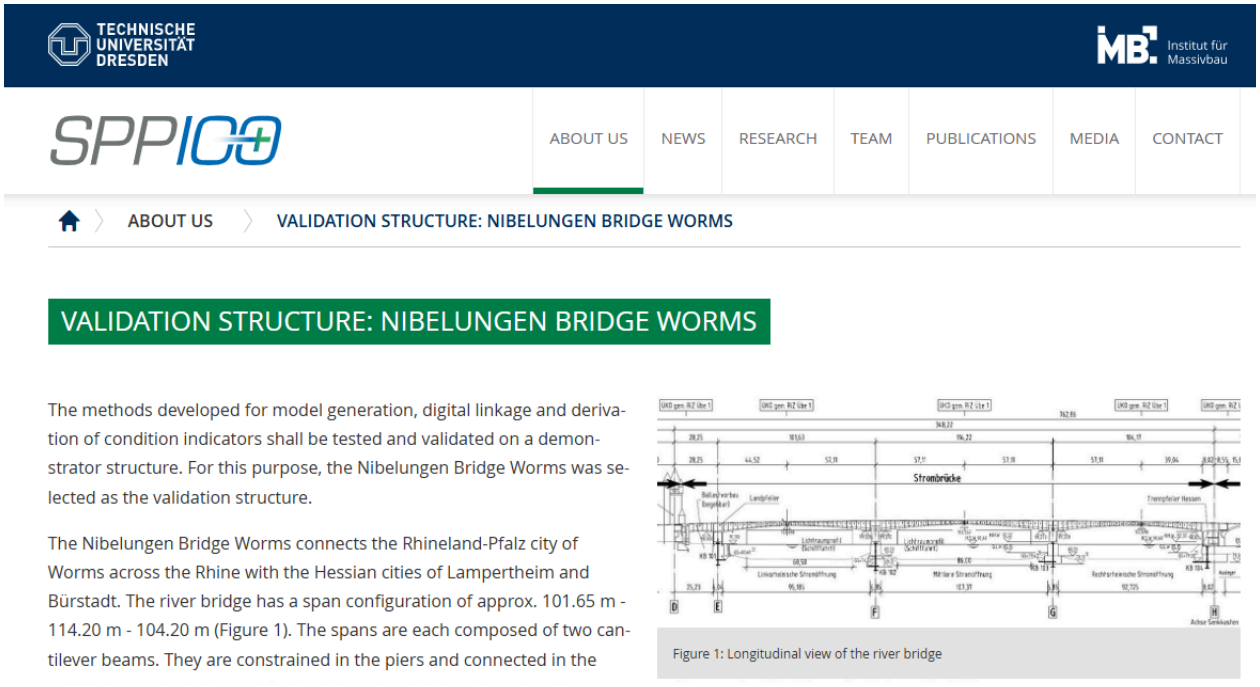

Figure 18: SPP100+ Website: Program description

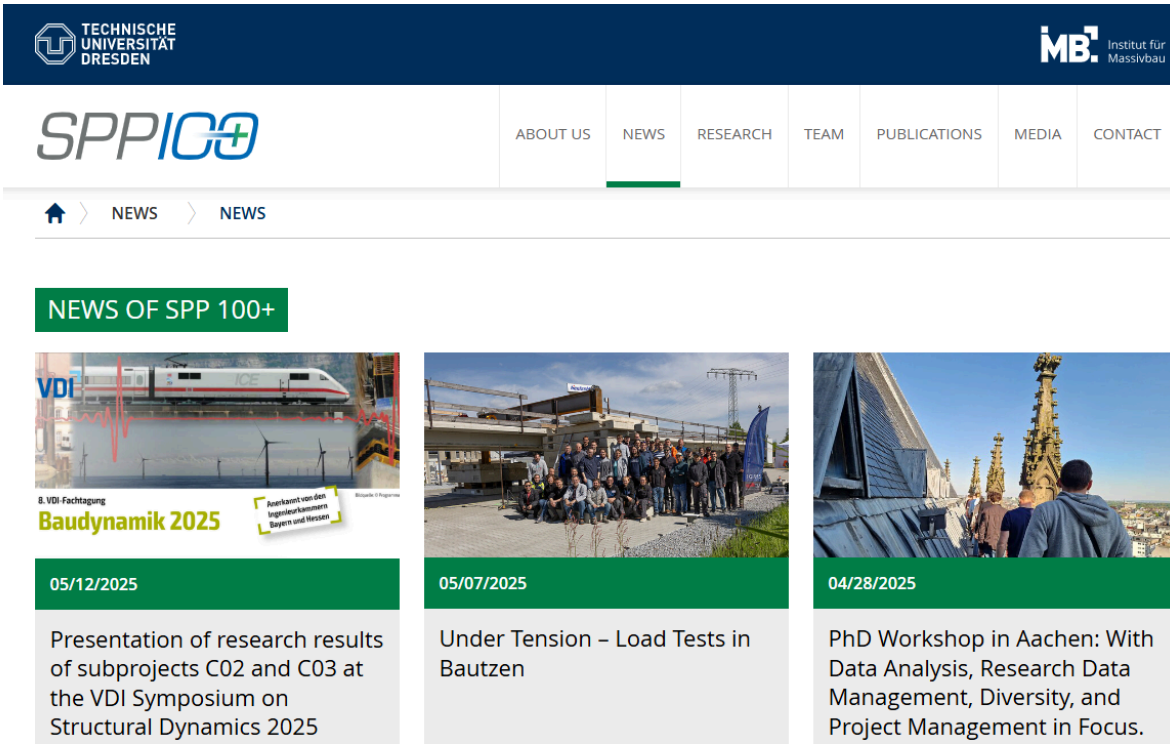

Figure 19: SPP100+ Website: News

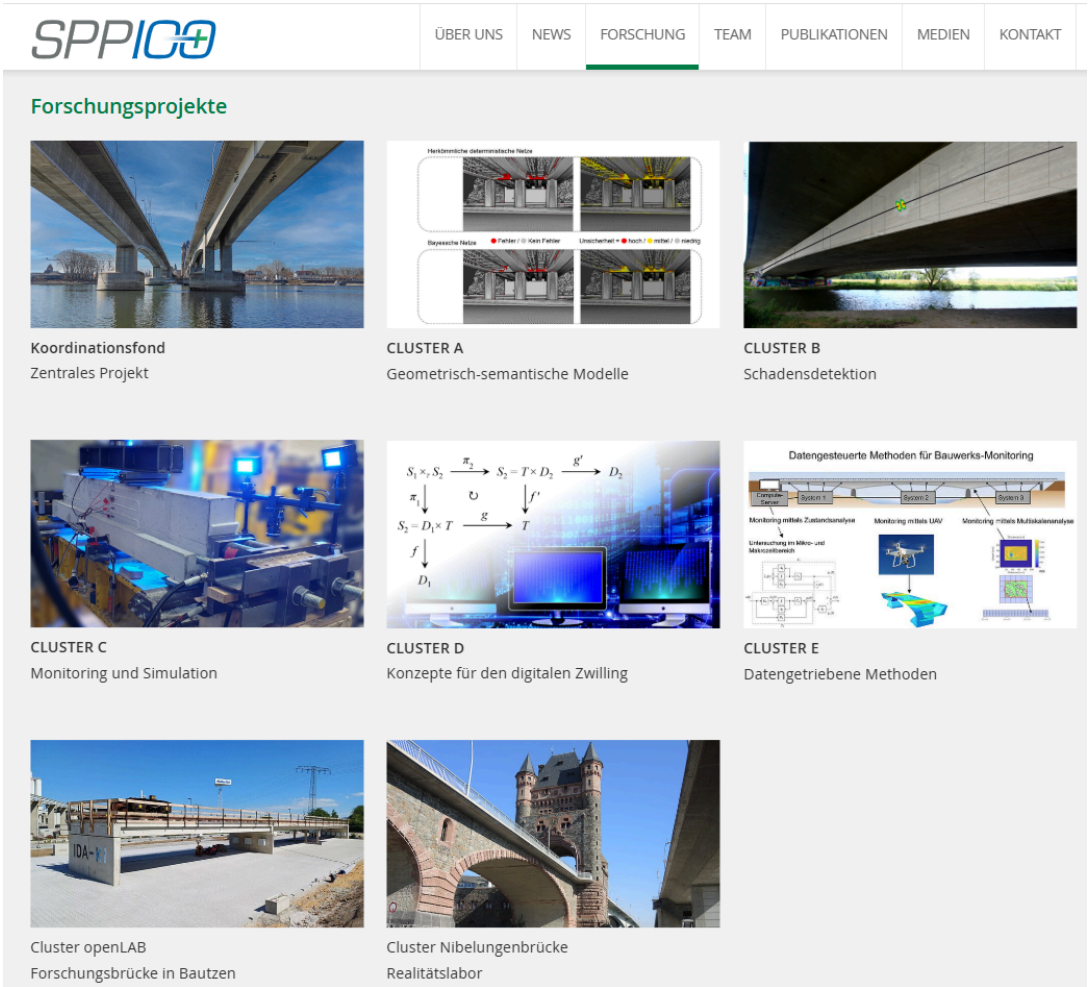

Figure 20: SPP100+ Website: Clusters and research topics

E.3 Knolwedge Transfer

SPP100+ focuses on transferring research results into practical applications, using real-world settings such as OpenLab and the Nibelungen Bridge for validation of research methods.

E3.1 Nibelungen Bridge

The methods developed for model generation, digital linkage and derivation of condition indicators shall be tested and validated on a demonstrator structure. For this purpose, the Nibelungen Bridge Worms was selected as the validation structure. In return, SPP 100+ could generate scientific results and methods which help extending the service life of the bridge.
The Nibelungen Bridge Worms connects the Rhineland-Pfalz city of Worms across the Rhine with the Hessian cities of Lampertheim and Bürstadt. The river bridge has a span configuration of approx. 101.65 m - 114.20 m - 104.20 m. The spans are each composed of two cantilever beams. They are constrained in the piers and connected in the middle by vertically braced Gerber joints. In addition, there is a short span of approx. 23.25 m in front of the bridge tower on the Worms side, which serves as the counterweight for the superstructure cantilevered on the other side of the land pier. On the Hessian side, due to a lack of sufficient space for a counterweight, the suspension had to be achieved via vertical tendons anchored to the newly installed cantilever beams of the abutment foundation. The superstructure cross-section has a deck slab width of 14.00 m between the outer edges of the parapets. It is designed as a double-webbed girder. The height of these haunched beams varies between 6.50 m at the top of the piers and 2.50 m in the joint area. For the development and validation of the methods, the subprojects will be provided with various data of this structure in different processing stages (raw data and processed data).

Figure 21: Nibelungen Bridge (Chongjie Kang)

E.3.2 OpenLab

As part of the SPP100+ priority program, innovative methods for damage detection and condition assessment of bridges are being developed, with validation relying on structural data from both undamaged and damaged states. To support this, the openLAB—a large-scale demonstrator bridge in Bautzen, Germany—was constructed within the mFUND project IDA-KI (see fig. 22 and 23) has been applied as another demonstrator in SPP 100+. This research bridge will be tested under controlled loading up to the point of severe damage, enabling comprehensive data collection and resulting in a unique database essential for method validation. The project exemplifies knowledge transfer between research and industry by bringing together the expertise of TUD Dresden University of Technology (Institute of Concrete Structures), Hamburg University of Technology (Institute for Digital and Autonomous Building), MKP GmbH, and Hentschke BauGmbH, ensuring that scientific findings are directly translated into practical applications.

Figure 22: IDA-KI demonstrator Bridge at OpenLab (Fabian Collin)

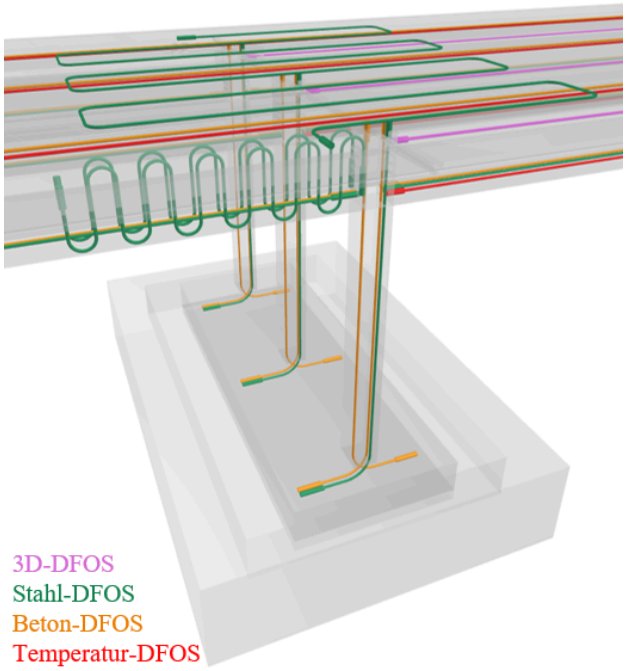

Figure 23: Different type of sensors installed inside IDA-KI demonstrator Bridge (Fabian Collin)

E.3.3 Elbe Bridge in Bad Schandau

At the beginning of April 2025, multi-day loading tests with an extensive sensor campaign were conducted on the Elbe Bridge in Bad Schandau (see Figs. 24 and 25). These three-day tests aimed to analyze the bridge's load-bearing capacity under various conditions. The results generated will serve as validation data for SPP 100+. In addition to collecting technical data, the tests also provided an opportunity for knowledge transfer among engineers, researchers, the public, and infrastructure specialists — ensuring that the insights gained from the testing process can benefit future structural assessments and bridge maintenance strategies.

Figure 24 :The heavy-duty SPMT module with additional weights on the Elbe bridge in Bad Schandau (Stefan Gröschel)

Figure 25: IMB-TUD stand for knowledge exchange with the public (Maria Walker)

APPENDIX

Data Management Plan

1. Administrative data

1.1 Details of the project:

- Project name:
- Involved persons/authors:
- Institution:

For your research data, select a coherent unit as the dataset wherein the corresponding details regarding methodology, technology, accessibility, and similar aspects are applicable.

1.2 Version history of the data management plan:

Version	Date	Brief description of changes

2. Data description

2.1 Content data description

- The nature of the generated and/or reused data:

DATA SET 1:
DATA SET 2:
DATA SET 3:

- How is new data created in your project? (if data is generated and not only reused):

DATA SET 1:
DATA SET 2:
DATA SET 3:

- Will existing data be reused? Source of reused data (if data is reused and not self-generated):

DATA SET 1:
DATA SET 2:
DATA SET 3:

2.2 data description

- Which data types, in terms of data formats, are created in your project?

DATA SET 1:
DATA SET 2:
DATA SET 3:

- How is the data processed in your project? used tools (instruments, hardware, software, etc.) and methods of data processing:

DATA SET 1:
DATA SET 2:
DATA SET 3:

- To what extent are these incurred for your data set, or what data volume can be expected for the data set?

DATA SET 1:
DATA SET 2:
DATA SET 3:

3. Documentation and data quality

3.1 Documentation

- Which approaches are followed in order to describe the data in a comprehensible manner (e.g., use of existing metadata or documentation standards or ontologies)?

DATA SET 1:
DATA SET 2:
DATA SET 3:

- What digital methods and tools (e.g. software) are required to use the data?

DATA SET 1:
DATA SET 2:
DATA SET 3:

3.2 Data quality

- What measures are taken to ensure high quality of the data?

DATA SET 1:
DATA SET 2:
DATA SET 3:

- Are quality controls planned, and if so, how?

DATA SET 1:
DATA SET 2:
DATA SET 3:

4. Storage and technical backup during the project

4.1 Storage during the project

- How is the data stored and backed up during the project period?

DATA SET 1:
DATA SET 2:
DATA SET 3:

4.2 Technical data backup during the project

- How is the security of sensitive data guaranteed during the project period (access and usage management)?

DATA SET 1:
DATA SET 2:
DATA SET 3:

5. Legal obligations and framework conditions

5.1 Publication restrictions

- Are there any impacts or limitations on subsequent publication or accessibility?

DATA SET 1:
DATA SET 2:
DATA SET 3:

5.2 Scientific specifics

- Are there important scientific codes or professional standards that should be taken into account?

DATA SET 1:
DATA SET 2:
DATA SET 3:

5.3 Restrictions

- How are usage and copyright aspects as well as ownership issues taken into account?

DATA SET 1:
DATA SET 2:
DATA SET 3:

5.3 Restrictions

- How are usage and copyright aspects as well as ownership issues taken into account?

DATA SET 1:
DATA SET 2:
DATA SET 3:

- What legal peculiarities exist in connection with the handling of research data in your project?

DATA SET 1:
DATA SET 2:
DATA SET 3:

6. Data exchange and permanent accessibility of data

6.1 Reuse

- Does this data set lend itself to subsequent use in other contexts?

DATA SET 1:
DATA SET 2:
DATA SET 3:

- According to which criteria is this data record selected in order to make it available for subsequent use by others?

DATA SET 1:
DATA SET 2:
DATA SET 3:

- When can this data set be used by third parties?

DATA SET 1:
DATA SET 2:
DATA SET 3:

6.2 Archiving

- Are you planning to archive your data in a suitable infrastructure?

DATA SET 1:
DATA SET 2:
DATA SET 3:

- If yes, how and where?

DATA SET 1:
DATA SET 2:
DATA SET 3:

- Are there any blocking periods?

DATA SET 1:
DATA SET 2:
DATA SET 3:

7. Responsibilities and resources

7.1 Responsibilities

- Who is responsible for the adequate handling of the research data (description of the roles and responsibilities within the project)?

DATA SET 1:
DATA SET 2:
DATA SET 3:

7.2 Resources

- What resources (costs, time or other) are required to implement adequate handling of research data in the project?

DATA SET 1:
DATA SET 2:
DATA SET 3:

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