Base4NFDI: Fostering A Cross-Disciplinary Service Landscape for the German National Research Data Infrastructure

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Abstract

Base4NFDI is a joint initiative by the 26 consortia of the German National Research Data Infrastructure (NFDI), aiming to develop essential cross-disciplinary basic services that enable FAIR data practices. Through a proposal-driven, bottom-up process, Base4NFDI supports technical and organisational solutions, such as identity and access management, computing, software, and workflows that serve the NFDI community. Proposals emerge from NFDI sections, where domain and infrastructure experts collaborate across disciplines.

The role of Base4NFDI is to provide and orchestrate a multi-stakeholder process to decide which services to fund and to ensure coherence through structured development phases (Initialisation, Integration, and Ramp-Up), supported by staff who facilitate coordination and quality assurance. So far, eight candidates are under development, such as IAM4NFDI, TS4NFDI, and Jupyter4NFDI. This brief report introduces the Base4NFDI approach, outlines the decision-making and support processes, introduces current service candidates, shares early experiences and challenges, and provides an outlook on sustainability and international interoperability, particularly with the European Open Science Cloud (EOSC).

Introduction

The German National Research Data Infrastructure (NFDI), funded by the German Research Foundation (DFG), is a nationwide initiative to systematically manage, share, and make research data usable across disciplines and institutions.[1] As of March 2023, 26 consortia have been established to represent the full spectrum of academic fields, from the humanities to engineering, life sciences, and natural sciences. Each consortium develops services and tools tailored to the needs of its community while aligning with the FAIR principles.

To coordinate cross-cutting topics that bridge the gap between disciplines, the NFDI has established dedicated thematic sections. These sections are collaborative spaces where domain experts and infrastructure professionals jointly address topics such as common infrastructure, metadata standards, terminology and provenance, legal and ethical aspects, training and education, as well as industry engagement. These cross-cutting groups are creating a place to discuss standards, best practices and shared solutions.[2]

As work progressed within the consortia and sections, it became increasingly clear that many technical and organisational needs, such as authentication systems, persistent identifiers, or federated compute environments, cannot be effectively solved at the individual consortia level alone. There was a growing demand for coherent, interoperable, and scalable basic services that would serve the NFDI as a whole, be easy to integrate in European frameworks, such as the European Open Science Cloud (EOSC) and significantly increase efficiency and the user experience in research data management.

It is within this landscape that Base4NFDI was launched, an initiative jointly supported by all 26 consortia to address infrastructural needs that extend beyond disciplinary boundaries. Base4NFDI provides a structured, bottom-up approach for the co-design, evaluation, and funding of cross-disciplinary basic services (Bernard et al., 2023). In the context of the NFDI, a basic service is understood as a technical–organisational solution that typically includes storage and computing services, software, processes and workflows, as well as the necessary personnel support to operate and assist via service desks. What sets the NFDI basic services apart is their strong integration into the research landscape: rather than offering generic tools, these services are continuously shaped by feedback from the consortia, who best understand the specific needs of their research communities. This ensures that basic services are widely applicable and tailored to meet real-world requirements; therefore, bridging the gap between infrastructure and impact.

Base4NFDI combines coordinated governance with technical expertise from major research organisations, including libraries, data centres, and infrastructure institutions in Germany. It establishes an agile development and decision-making process grounded in community needs and supported at all stages by expert staff.

The Base4NFDI Initiative

Governance and Decision-Making Framework

At the heart of Base4NFDI lies a decision framework designed to balance inclusivity, expertise, and accountability. It ensures that all 26 NFDI consortia contribute to and collectively decide on the development and funding of cross-disciplinary basic services.

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[1] German National Reseach Data Infrastructure: https://www.nfdi.de/?lang=en
[2] NFDI sections overview: https://www.nfdi.de/sections/?lang=en

This bottom-up, consensus-driven structure reflects the community-based approach of the NFDI.

Basic service proposals originate within the (I) NFDI sections, where experts from across consortia collaborate on shared challenges and cross-cutting topics. If a proposal is supported by a section, it proceeds to (II) a vote by all consortia, ensuring that it has relevance and demand across disciplines. Following this, (III) the Technical Expert Committee (TEC) conducts an independent review focused on technical feasibility, quality, and alignment with existing infrastructure. The final funding decision is taken by (IV) the Consortia Assembly of the NFDI.

This layered process ensures that proposed services are community-driven and rigorously evaluated. In addition, to ensure suitability for the wider scientific community and interoperability with international frameworks, Base4NFDI is advised by an International Advisory Board.

Development Model and Service Lifecycle

Base4NFDI supports the development of basic services through a structured, three-phase lifecycle: Initialisation, Integration, and Ramp-Up for operation. Each phase is designed to gradually mature a service idea into a robust, scalable, and sustainable component of the NFDI-wide service portfolio.

In the Initialisation Phase, basic service candidates are developed based on existing solutions, typically with a Technical Readiness Level (TRL) 3–4. Stakeholder needs are identified, and key architectural and organisational considerations are explored. This phase includes requirements analysis, persona development, and early outreach and typically results in a first functional prototype.

The Integration Phase begins with solutions typically at TRL 5–6 and focuses on advancing technical development and early deployment of the prototype in more NFDI consortia. Key activities include interoperability testing, integration with existing infrastructures, and piloting with users across diverse scientific disciplines. This phase also involves the exploration of key performance indicators (KPIs) to monitor service maturity and community uptake.

The Ramp-Up Phase begins with services at TRL 7–8 and focuses on stabilisation, scaling, and refinement of operational models. A key objective is to reach TRL 9, or equivalent service maturity, ensuring operational readiness and sustainability. This includes the development of a viable business model covering governance, funding, and service provision, and collaboration with established service providers to secure long-term integration into the research infrastructure landscape.

Progression through each phase requires a separate proposal and is subject to review, ensuring alignment with community needs, technical quality, and coherence within the broader NFDI ecosystem. This agile, requirement-driven approach allows for iterative refinement and early feedback, reducing the risk of misaligned development. Even if a basic service candidate does not proceed through all phases, it is developed as an open, reusable solution, potentially continuing at a smaller scale, contributing components to an NFDI-wide tool pool.

By structuring service development this way, Base4NFDI fosters transparent prioritisation, encourages collaboration, and enables a gradual yet accountable transition from promising concepts to operational services.

Support Structures and Roles within Base4NFDI

To ensure the success and adoption of basic services, Base4NFDI provides structured support across all stages of the service lifecycle. This includes community engagement and hands-on assistance for service developers and stakeholders.

A key novelty in this process is the introduction of the Service Steward role (Altenhöner et al., 2024). Service Stewards act as an engagement layer between the service development teams, the consortia, and the Base4NFDI project team. They ensure that requirements for service integration are clearly communicated, while conveying the needs and expectations of the consortia back to the service teams. Stewards actively represent services in consortia meetings, give presentations, and continuously seek opportunities for integration and collaboration by identifying relevant experts or contact persons. They help articulate and explain the purpose and features of a basic service, support the documentation of deliverables, and guide service teams through the Base4NFDI decision-making framework. In addition, Section Liaison Officers support the NFDI sections in shaping service ideas, identifying synergies, and facilitating the preparation of proposals. Together, these roles ensure that community-driven ideas and user feedback flow in both directions, between sections, consortia, and service teams, informing development, communicating service concepts, and feeding status updates back to the broader community.

In general, Base4NFDI staff offer targeted support activities, such as persona workshops, requirement elicitation, outreach, and matchmaking with potential users. These activities help ensure that services are technically viable and address real user needs across disciplines. The initiative brings together expert staff from universities, libraries, and major research organisations, such as Helmholtz, Leibniz, and Max Planck Institutes. This broad institutional base ensures a wide range of perspectives and operational expertise, strengthening the reliability and sustainability of the emerging services.

Progress and Status Quo

Over the eight submission rounds between 2023 and May 2025, Base4NFDI has facilitated the proposal, evaluation, and progression of numerous service concepts, reflecting the dynamic needs of the research infrastructure community. In total, 14 unique proposals were submitted for the Initialisation Phase, with eight accepted. Of the eight proposals, seven were initially rejected, highlighting the iterative nature of the development process, in which proposals are refined through feedback and resubmission to ensure added value for all of the NFDI and beyond. From the initial group of basic service candidates, three projects have entered the Integration Phase, with a fourth expected to begin shortly. One service is preparing to apply for the final Ramp-Up Phase later this year and, if approved, would begin that phase in February 2026.

Basic services under development

The current basic service candidates span infrastructure services (e.g., identity management), technical research services (e.g., terminology services, a JupyterHub, knowledge graph integration), and socio-technical services (e.g., PID or RDM training).[3] Table 1 provides an overview of services under development as of May 2025. To illustrate the diversity and potential impact of these efforts, three examples (IAM4NFDI[4], TS4NFDI[5], and Jupyter4NFDI) are presented in more detail.

IAM4NFDI addresses the foundational need for a federated identity and access management system across the NFDI. It aims to enable seamless, secure user authentication and role-based access control across services, institutions, and disciplines. Building on existing infrastructure expertise (e.g., DFN-AAI and Helmholtz AAI), the project integrates widely adopted protocols such as OpenID Connect and SAML. In addition, IAM4NFDI organises an incubator programme, which brings together experts

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[3] Base4NFDI Projects: https://base4nfdi.de/projects
[4] IAM4NFDI Project Page https://base4nfdi.de/projects/iam4nfdi
[5] TS4NFDI Project Page: https://base4nfdi.de/projects/ts4nfdi

and stakeholders from across consortia to collaboratively explore use cases, gather requirements, and support adoption.[6] The service is primarily aimed at infrastructure providers and service developers seeking secure, interoperable identity solutions. Now in the Integration Phase and preparing for Ramp-Up, IAM4NFDI is a key enabler for interoperable services within the NFDI and future alignment with the EOSC.

TS4NFDI develops a shared terminology infrastructure to enable semantic interoperability across disciplines. By standardising terminology management, it supports the publishing, curation, and alignment of vocabularies and ontologies essential for data annotation and integration. Key components include a harmonised API Gateway, service wrappers, a mapping service, and reusable GUI widgets[7]. It targets developers of metadata-intensive tools and services, as well as researchers working with cross-disciplinary data. Currently in the Integration Phase, TS4NFDI is expanding its coverage of disciplines and integrating additional terminology sources to meet community needs; therefore, fostering consensus and harmonisation across the NFDI landscape.

Table 1. Overview of basic service candidates (as of May 2025).

Service	Focus	Phase	Use Cases
IAM4NFDI	Identity and Access Management	Integration	Federated login enabling single sign-on across NFDI
TS4NFDI	Terminology widgets and harmonised API access	Integration	Embedding terminology widgets into metadata editors
PID4NFDI	Persistent identifier coordination hub	Integration	Standardising PID assignment across NFDI consortia
DMP4NFDI	Data management plan service	Initialisation	Discipline-specific DMP templates via a centrally hosted DMP tool
KGI4NFDI	Knowledge graph infrastructure	Initialisation	Creating a cross-consortia knowledge graph
Jupyter4NFDI	JupyterHub infrastructure	Initialisation	Unified access to preconfigured Jupyter environments
RDMT4NFDI	RDM training for professionals	Initialisation	Modular training formats with micro-certification options
nfdi.software	Research software marketplace	Initialisation	Central platform linking research software across disciplines

Jupyter4NFDI aims to provide a unified entry point for interactive computing across the NFDI and beyond.[8] Currently, multiple JupyterHub instances exist, often limited to specific institutions or disciplines, making access and onboarding difficult. In addition, institutions face challenges in opening resources to external users. The service plans to simplify integration of backend resources for infrastructure operators and offer tailored

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[6] IAM4NFDI Incubator Dashboard: https://incubators.nfdi-aai.de
[7] TS4NFDI SemLookP Widgets: https://ts4nfdi.github.io/terminology-service-suite/comp/latest/
[8] Jupyter4NFDI documentation: https://nfdi-jupyter.de/

frontend solutions, supporting reproducible research and training beyond traditional early adopters.

Challenges and Outlook

The biggest challenge for the basic service candidates is to meet a broad spectrum of disciplinary needs. In addition, the Base4NFDI framework is an area of ongoing development, driven by emerging insights from service integration, evolving requirements and policy developments. This necessitates the continuous adaptation of the framework and services, placing high demands on the service teams who must navigate evolving expectations and evaluation criteria. Establishing sustainable operating models for long-term service maintenance and funding remains another critical concern, requiring early planning and coordination with consortia and national stakeholders. In addition, the Base4NFDI team actively allocates resources and ideas to support outreach and facilitate service development, helping to address these challenges and foster a resilient service ecosystem.

Looking ahead, international integration remains a major focus. Aligning with broader infrastructures, such as EOSC, opportunities and complexities. Base4NFDI aims to play a proactive role in shaping this integration, contributing to a coherent, efficient, and sustainable European research data ecosystem (Bernard et al., 2024; Bernard et al., 2025). While other countries rely on national coordination efforts like the Australian Research Data Commons, Jisc (UK), or the Dutch National Programme Open Science to support open science and research data infrastructure, the NFDI offers a unique, federated, bottom-up model. Within this, Base4NFDI plays a crucial role by combining national coordination with community-driven service development, building on existing efforts, competences and infrastructure at the national level, potentially serving as a template for similar initiatives elsewhere.

Acknowledgements

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