






# Advancing Interoperability in Engineering Sciences with a Common Information Model

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## Abstract

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The diversity of individual research fields in the engineering sciences leads to numerous individual contributions on the topic of metadata for research data management within NFDI4ING [1]. In order to standardise these contributions and promote the consolidation of metadata schemas, this work describes the development of a **Common Information Model (CIM)**. The CIM will be realized as a comprehensive ontology based on Metadata4Ing, the mid-level ontology for the modeling of scientific workflows [2]. FAIR data concepts such as SciMesh [3] for experimental provenance metadata handling samples, DataDesc [4] for describing interfaces within computational workflows and the HPC-Ontology [5] for metadata in high performance computing workflows will be integrated. It will serve as the foundation for NFDI4ING's services while also enabling connections to other relevant terminologies. The CIM will encompass all pertinent engineering entities, including datasets, software, actors, methods, tools, instruments and their configurations, as well as mathematical models, building upon existing vocabularies and ontologies both within and outside of the consortium.

The **Metadata4Ing (m4i) ontology** serves as a bridge, linking and enriching engineering related research data with software, methods, instruments, and tools. The m4i ontology is accessible via the NFDI4ING Terminology Service [6]. The concepts of m4i can also be used in the NFDI4ING Metadata Profile Service [7] to create, share, and maintain subject-specific metadata profiles in form of SHACL shapes. Metadata profiles can themselves be used to structure knowledge graphs in platforms like Coscine [8]. The CIM aims to keep this level of service integration while coordinating and aligning with recent developments in related fields including the MatWerk Ontology [9] and PMD Core Ontology for materials science [10], as well as MathModDB [11] for mathematics.

Designed to facilitate seamless information networking, the provision of Knowledge Graphs is valuable for the standardized integration of information sources and the reduction of information silos. The CIM will form the core of the Knowledge Graphs provided by NFDI4ING

and will serve as the basis for harmonized, federated queries that enable extensive reuse of research data. NFDI4ING will offer services to integrate the creation of FAIR Digital Objects (FDOs) into existing scientific workflows. During the first funding period, NFDI4ING has already made progress in the development of Knowledge Graphs. The second funding period will focus on **establishing a federation of Knowledge Graphs** and ensuring the availability of FDOs within this framework, including the provision of interfaces for programmatic access. The instantiation of FDOs is planned in close collaboration with the Working Group on Knowledge Graphs within NFDI-MatWerk, the NFDI section on Metadata, Terminologies, and Provenance, as well as the PID4NFDI base service.

The development of a CIM as well as a federated Knowledge Graph ecosystem will assist in the harmonization of services developed within NFDI4ING. As a result, consolidation of the CIM with the NFDI Task Force Metadata and the Working Group on Ontology Harmonization will take place. In addition, the CIM will help to enable integration of NFDI4ING services into the daily work of researchers within the community.

## Resources

- Metadata4Ing. <https://nfdi4ing.pages.rwth-aachen.de/metadata4ing/metadata4ing/1.3.1/index.html> "Midlevel ontology as a starting point for the NFDI4ING Common Information Model."
- SciMesh. <https://scimesh.org/about/> "Specifications that define the representation of scientific results in form of a knowledge graph."
- DataDesc. <https://github.com/FZJ-IEK3-VSA/DataDesc> "A metadata schema for software documentation with focus on interfaces."
- HPC-Ontology. [https://git.rwth-aachen.de/nfdi4ing/metadata4ing/metadata4ing/-/tree/metadata4ing\\_hpmc?ref\\_type=heads](https://git.rwth-aachen.de/nfdi4ing/metadata4ing/metadata4ing/-/tree/metadata4ing_hpmc?ref_type=heads) "A workflow based HPMC sub-ontology within the Metadata4Ing ontology."
- NFDI4ING Terminology Service. <https://terminology.nfdi4ing.de/ts/> "A collection of curated engineering ontologies providing a single point of access to the latest ontology versions."
- Metadata Profile Service. <https://profiles.nfdi4ing.de/> "The service enables the creation of interoperable metadata schemas as RDF-compliant application profiles as well as sharing of profiles and storing and searching metadata."
- FAIR DO Implementation in Coscine. <https://doi.org/10.5281/zenodo.15180688>

## Author contributions

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## Competing interests

The authors declare that they have no competing interests.

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