Federal Ministry
for Digital
and Transport

Federal Trunk Roads BIM Masterplan

Framework document: Data management – version 1.0

Contents

Overview of the framework documents ... 5

Outline ... 6

What is data management? ... 7

Standards, guidelines and supplementary documents ... 8

Part 1 DATA EXCHANGE ... 10

1. openBIM as a public sector IT strategy ... 11

2. BIM-supported implementation of construction projects in the highway sector ... 12

3. BIM data exchange scenarios ... 13

4. Relevant information/data types in BIM projects ... 14
   Use case 010: Existing conditions modelling ... 14
   Use case 030: Planning variants ... 15
   Use case 040: Visualization ... 15
   Use case 050: Coordination of the professional trades ... 16
   Use case 080: Derivation of planning documents ... 16
   Use case 100: Quantity take-off and costing ... 17
   Use case 110: Bill of quantities, tender and contract award ... 17
   UC 190 Structure documentation ... 18

5. Data exchange formats ... 19
   5.1 Open exchange formats ... 20
   5.2 Relevant specialist systems of the road construction authorities ... 21

6. Archiving/long-term storage ... 23

Part 2 COMMON DATA ENVIRONMENT ... 24

1. What is a CDE? ... 26

2. Areas of application and objectives of a CDE ... 27
   The practical side: ... 29

3. Information in the project ... 30

4. Data structure and classification within a CDE ... 32
   The practical side (metadata for plan management): ... 33

5. Data flow within a CDE ... 34

6. **Functions of a CDE** 36
6.1 Structure/function stages of a CDE 37
6.2 Coordination/data management 38
Exchange of information 38
Structuring data 39
Project communication and collaboration 42
Configuration and administration 44
6.3 Data visualization/model application 45
Data visualization 45
Model application 47
6.4 Planning and management 49
Management functions 50
6.5 Technical equipment and digital infrastructure 50
Interfaces and integration 50
Data protection and data security 51

7. **Data protection and data security** 53
7.1 Requirements according to DIN SPEC 91391 55
7.2 Confidentiality classification of information 56
7.3 Relevant standards and guidelines for data protection and security 56

8. **Recommendations for implementation** 56

9. **Conclusion** 56

List of illustrations 57

List of tables 58

Glossary 59

Annex 60

References 61

Overview of the framework documents

This Data Management Framework Document (DMF), is part of the Model Guideline for BIM (MG BIM). The MG BIM framework documents define the uniform application of the BIM method and support the implementation strategy explained in the Federal Trunk Roads BIM Masterplan. They provide practically focused answers on the BIM-specific topics and issues that are necessary for a uniform understanding of BIM throughout Germany in the federal trunk roads sector.

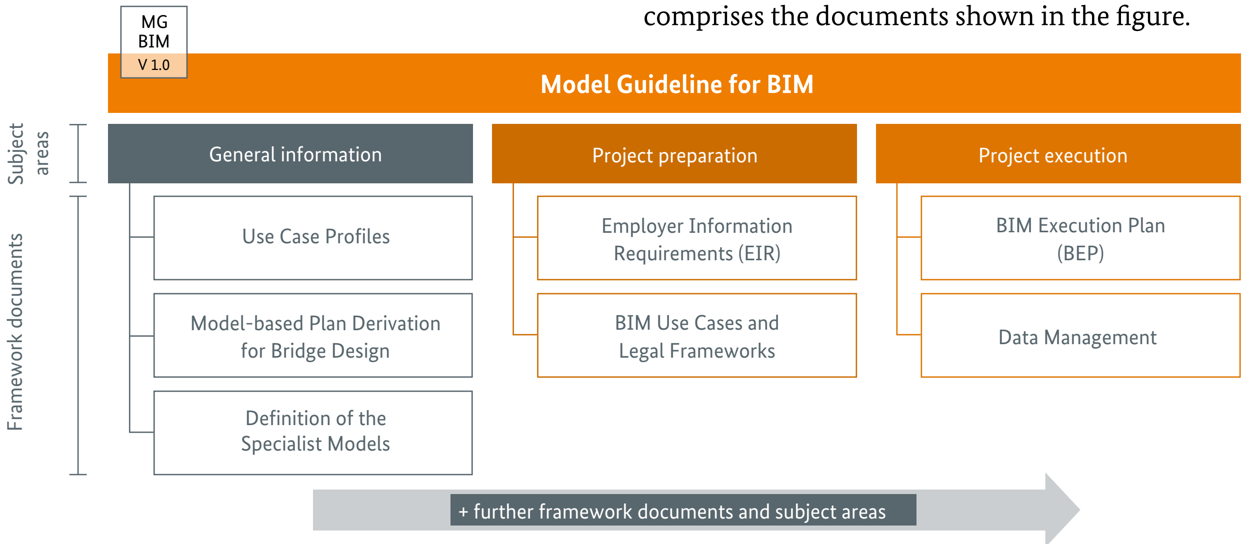
The version 1.0 framework documents were designed to facilitate updates to a new version of the Model Guideline for BIM at the beginning of phase II of the BIM implementation strategy; the same will apply again later for phase III. Finally, the documents will be transitioned to the Model Guideline for BIM for the standard process.

Framework documents are developed by the expert groups initiated by the Federal Ministry of Transport and Digital Infrastructure and in the expert groups established at the official meetings of the Federal Government and the federal states on BIM. In these groups, various technical experts – employees of the Federal Ministry of Transport and Digital Infrastructure, the Federal Highway Authority, Federal Autobahn GmbH, German Unity Planning and Construction Company for Trunk Roads (DEGES), the federal state authorities with delegated powers, the Federal Highway Research Institute (BASt) and the Road and Transport Research Association (FGSV) – are working with BIM Germany on the ongoing progress of the BIM implementation strategy for federal trunk roads. The lessons learned from completed and ongoing projects, the proven BIM4INFRA2020 toolkits and input from the continuous participation of all stakeholders were taken into account. At the same time, general developments in the BIM method were considered for national and international standardization.

As a result, the documents present the respective state of the art and progress in standardization. Reflecting these increasing knowledge levels, the framework documents replace the thematically identical parts of the BIM4INFRA2020 toolkits and should be construed as recommendations for future projects and for a potential adaptation of various standards and guidelines.

Each framework document is assigned to a thematic category based on the project schedule and is thematically self-contained. Cross-references to other framework documents are explicitly highlighted. Further information on the framework documents can be found in the document entitled ‘Explanation of the framework documents’.

Version 1.0 of the Model Guideline for BIM comprises the documents shown in the figure.



Outline

Information technology is the driving element in the Building Information Modelling (BIM) method. The Roadmap for Digital Design and Construction already contains basic statements for the development of IT procedures. The definition of BIM formulated there also provides essential starting points for information and data management in the BIM environment:

"Building Information Modelling is a cooperative work method in which, based on digital models of a structure, information and data relevant to the structure's lifecycle can be collected, managed and exchanged for further processing by way of transparent communication between stakeholders."[1]

This implies that data exchange and data management are of crucial importance in interdisciplinary collaboration as a core theme of BIM. Central consolidation and the provision of required information via appropriate interfaces is the basis for successful project management.

This document is specifically designed for all stakeholders involved in the lifecycle of a structure and for those responsible for IT and data in road construction authorities. This document compiles requirements for the exchange of open data formats in BIM use cases and the essential features of a common data environment based on available standards and guidelines. These requirements have been supplemented on the basis of lessons learned from practical applications and are intended to simplify the establishment of a common data environment for federal state authorities with delegated powers.

The currently available generally applicable guidelines are taken as a basis and supplemented by application notes. The comprehensive requirements matrix from DIN SPEC 91319 "Common Data Environment (CDE) for BIM Projects" is used as a basis for this detailed information. In order to prioritize the requirements and to make them easier to understand, the most significant requirements are described in more detail.

This implementation recommendation is also based on BIM4INFRA2020 – Toolkit Part 8.

1 Cit. BMVI – Roadmap, p. 4

What is data management?

Data management describes the handling of digital data. All processes from capture, storage, processing and use to archiving are taken into account. The holistic conceptual design must take into account internal requirements of contractors as well as project-specific requirements. Data management also incorporates the criteria of data security and data protection.

Today's construction projects generate vast amounts of information and data sets in a wide variety of formats. Rules for capture, storage, organization, access, central provision for all stakeholders, etc. are becoming increasingly important for the success of the project. Redundant data storage, for instance, can lead to inconsistent information and increase the risk of planning errors.

The BIM method requires that information and data be generally available and up-to-date for all project stakeholders. Information required or relevant for informed decisions must be available at the right time.

» **Data management**: Throughout the lifecycle of a structure, data from different disciplines is exchanged between the various stakeholders involved in the construction project on the basis of agreed procedures. The aim of data management is to provide a platform for such information exchange with a common data environment.

Source: Cit. VDI 2552 Part 5, p. 2)

Standards, guidelines and supplementary documents

Various standards and guidelines should be taken into account to define the requirements for data exchange and data and information management in infrastructure projects. The Roadmap refers to the following regulations:

"A 'common data environment' must be created for the organized storage and loss-free exchange of the data generated in the planning and construction process, which can be accessed by all stakeholders. This constitutes the basis of the processes executed in the BEP. Uniform standards and rules for the efficient use of BIM within this data environment are currently being developed in an ISO standard (ISO 19650). These standards and rules will be the basis for developing a CEN standard from which the corresponding DIN standard will be derived. National implementation will be carried out within the framework of the VDI 2552 Standards."[2]

2 Cit. BMVI – Roadmap, p. 10

Fig. 1: Standards and guidelines

DIN EN ISO 19650-1:2018 has been published since 2019 and constitutes an important basis. The development of VDI Standard 2552 is also very advanced. At the same time, the BIM4INFRA expert group produced comprehensive toolkits that provide generally applicable information and recommendations for the introduction of the BIM methodology in numerous subject areas.

DIN EN ISO 19650-1:2018, Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM) – Information management using building information modelling

"This standard defines the handling of BIM information management. This includes the exchange, documentation, version management and organization of information throughout the lifecycle of structural assets."[3]

3 Cit. ISO STANDARD 19650-1:2018, P: 1-2

VDI 2552 Part 4 BIM – Requirements for data exchange

"This standard describes the exchange of data when applying the BIM methodology between the stakeholders involved in the design, construction and operation of structures. Both the initial data for the planning activity and the data of the results required for the overall BIM process are considered. In addition to the rules described in this standard, existing rules are considered and advice is given regarding the data exchange rules to be agreed between the partners at the start of the project."[4]

VDI 2552 Part 5 BIM – Data management

"This standard defines procedures for organizing, structuring, merging, distributing, managing and archiving digital data in the context of Building Information Modelling (BIM), which is also regarded as a management approach for integral model-based project management. For this purpose, the technical and organizational requirements for the implementation of a Common Data Environment (CDE) are presented. This standard can be applied to all project sizes and requirements. It is aimed at all stakeholders involved in construction projects during the lifecycle of a structure. In particular, the requirements of small and medium-sized enterprises are also taken into account to facilitate entry into BIM-based data management."[5]

DIN SPEC 91391, Common Data Environments (CDE) for BIM projects – Function sets and open data exchange between platforms of different vendors

Part 1: Modules and functions of a Common Data Environment for a model-based and common way of working in the BIM project

"In DIN SPEC 91391-1, the added values of a common data environment for a model-based common way of working in BIM projects are further detailed and specified down to functional level. The basic components of a CDE, their tasks and use cases are presented and the minimum functional scope required to fulfil their tasks is described. Reference is made to further optional features and functions. This supports contracting entities in the assessment and commissioning of CDEs."[6]

Part 2: Open data and information exchange between different common data environments.

The aim is loss-free exchange between the different platforms used throughout the lifecycle of the structure.

"DIN SPEC 91391-2 specifies the conceptual requirements for procedures and data structures for data exchange between CDEs or between a CDE and other software products."[7]

BIM4INFRA2020 toolkits

The toolkits (parts 1 to 10) were developed by BIM4INFRA2020 for the BMVI for the implementation of the Roadmap for Digital Design and Construction. "Part 8: Neutral Data Exchange at a Glance" is worth noting in this context.[8]

4 Cit. VDI 2552–Part 4:2020-08, p. 2-3
5 Cit. VDI 2552–Part 5:2018-12, p. 2-3
6 Cit. DIN SPEC 91391-1, pp. 1 and 5
7 Cit. DIN SPEC 91391-2, pp. 1 and 6
8 Cf. BIM4INFRA – Toolkits Part 8

Part 1
DATA EXCHANGE

1. openBIM as a public sector IT strategy

The implementation of the Roadmap for Digital Design and Construction[9] makes the exchange of data between project partners and the public sector increasingly important. By supporting open data formats (openBIM), this cross-application exchange between project stakeholders can be significantly improved throughout the planning process. The Roadmap specifically prescribes the use of openBIM for deliveries to public sector contracting entities. If necessary, the agreed data deliveries can be supplemented with the native formats used by the project stakeholders in their specialist applications.

However, the path to digitalization must not restrict market access. Broad and consistent use of the openBIM approach across the entire value chain of design, construction and operation will foster innovation and create the opportunity for a fair and diversified software market.

"The public sector as developer and contracting entity (employer) can define project-specific requirements for the data formats and software products to be used in the EIR (Employer Information Requirements) for the different service phases. This issue must hence be addressed before the start of any project and the best solution found for the project in question. The public sector contracting authority is required to invite tenders in a manufacturer-neutral manner, i.e., without specifying concrete software products. In particular, it must be ensured that the data flow from preliminary planning to as-built documentation is guaranteed throughout.

In addition to the fundamental commitment to openBIM, the aspects to be considered include, but are not limited to:

- The native formats and products used by the contracting entity, if applicable
- The consequences of the specifications for the project stakeholders and hence for the course of the project
- The existence of mature, open and neutral interfaces with which data exchange between the project stakeholders can take place in the required quality

The following aspects should be additionally considered when setting up the EIR:

- Which required data will the project stakeholders hand over to the contracting entity (employer) within the project and what will this data be used for?
- Which data generated in the project can be re-used across projects?
- How will the contracting entity (employer) handle the project data after the project (re-use, for instance, in operation, archiving, reactivation)?

Currently, the openBIM approach can already be applied to many use cases in construction measures in the infrastructure sector. Infrastructure-specific new and further developments of open data formats are currently being carried out in parallel and financed by the Federal Ministry of Transport and Digital Infrastructure, among others. The common goal is to establish the openBIM approach in the project in the short term. The new format specifications developed from this are crucial for inventory data management. The specialist systems for operation operated by the contracting entities (such as road information databases) must also be further developed for data transfer or data provision in accordance with the new future standards.

9 Cf. BMVI – Roadmap

2. BIM-supported implementation of construction projects in the highway sector

The implementation of the BIM method requires the creation and continuous use of high-quality digital data, which is composed of objects with associated characteristics, relationships and a geometric representation, among other things.

"Particularly for engineering structures (bridges, tunnels, etc.), this is accompanied by the demand for the creation and use of sufficiently detailed 3D models.

With regard to route planning, however, BIM-supported implementation does not mean abolishing the established planning methodology, which is based on a separate consideration at ground plan and longitudinal section level and is sometimes also referred to as 2.5D modelling. This planning methodology enables the focus to be placed on the relevant engineering aspects (such as curve radius, gradient, sag vertical curves) in the respective view and offers the possibility of verifying compliance with relevant regulations. This design methodology is implemented by a large number of mature software tools. The possibility to generate a consistent 3D model from this data basis or to provide input variables (such as alignment, cross-sections) for the design of structures is important for the feasibility of certain BIM use cases, such as quantity take-off and interaction with the 3D design of engineering structures. Manufacturer-neutral file formats for transporting corresponding data play a significant role here.

(Source: Cf. BIM4INFRA – Implementation of the Roadmap for "Digital Construction")

3. BIM data exchange scenarios

Data exchange processes within BIM projects can, for instance, be divided into the following exchange scenarios:

- **Delivery of specialist models:**
  In this case, complete specialist models are delivered to the contracting entity as part of contractually agreed deliverables. When necessary, this data is exchanged in conjunction with other relevant documents that may be linked to the model (such as schedules, bills of quantities, 2D plans, audit reports). This includes, among other things, model acceptance and/or model clearance by the contracting entity.

- **Coordination of specialist models:**
  In this case, the relevant specialist models are combined in a coordination model for a specific purpose, such as clash detection. If collaboration is based on specialist models, model data is usually exchanged in one direction only, i.e., from the authoring tool to the coordination tool via the CDE. Change requests are made directly to the authors of the respective specialist model without exchanging model content. The authors incorporate the changes and then make the updated model available again for coordination. These requests can be made, for instance, using the open BIM Collaboration Format (BCF) established on the market.

- **Re-use of models:**
  In this case, the models are exchanged between the service phases. Recipients are put in an improved starting position and are provided with project information to effectively carry out the relevant tasks and deliverables. The model received is usually refined, adapted or supplemented with new content. The recipients typically create their own model and also take responsibility for it within the scope of the changes they make.

For other use cases, such as data exchange within a planning consortium or between a general planner and the downstream specialist planners, it may be useful and expedient to use manufacturer-specific exchange formats (native, non-open formats). However, for reasons of market neutrality and long-term archivability, only manufacturer-neutral formats should be used to transfer models transfers to the public sector contracting entity.[10]

10 Cf. BIM4INFRA – Toolkits Part 8, pp. 11–12

4. Relevant information/ data types in BIM projects

Management of a project using the BIM method involves a wide range of different information and data types. A crucial aspect in project management is fast and smooth exchange of this data.

With the BIM method, the type and scope of data exchange essentially depends on the use cases in the various project/service phases. The requirements for exchange can be verified using the input data specified in the EIR and the required deliverables of the respective use cases.

The following tables provide an overview of which data occurs within which execution phase and which exchange formats are used. (These lists do not claim to be exhaustive.)

The use cases considered here are those prioritized for phase I of the Federal Trunk Roads BIM Masterplan 8 (use cases 010, 030, 040, 050, 080, 100, 110 and 190). Further details of these use cases can be found in the corresponding annex to the Federal Trunk Roads BIM Masterplan.

Use case 010: Existing conditions modelling

The basic data and information required for the project are identified, processed, compiled, georeferenced and made available in the form of as-built models from various sources.

Table 1: Use case 010

Input data	Exchange format
Terrain models	XML (LandXML)
3D city model	XML (CityGML)
As-built plans, revision plans	PDF, DXF, TIFF
As-built models	IFC
Surveying data	E57, TIFF, LAS, D58
Subsoil information	XML, DXF, IFC, PDF, CSV
Land Register Information System	DXF, NAS
Hazardous substances/ordnance	PDF, DXF, IFC
Orthophotos	GEOTIFF, WJPEG
Documentation	DOC, DOCX, PDF, XLS, XLSX
Deliverables	**Exchange format**
As-built models	IFC
BCF documentation	BCF
Documentation	DOC, DOCX, PDF, XLS, XLSX

Use case 030: Planning variants

Creation of planning variants in the form of models to simplify analysis and evaluation with regard to the evaluation criteria to be defined.

Table 2: Use case 030

Input data	Exchange format
As-built models	IFC
Revision plans	PDF, DXF, TIFF
Surveying data	E57, TIFF, LAS, D58
Reports	DOC, DOCX, PDF, XLS, XLSX
Planning from other relevant projects	PDF, DXF, IFC

Deliverables	Exchange format
Models of the preferred option	IFC
Models of the variant	IFC
BCF documentation	BCF
Documentation	DOC, DOCX, PDF, XLS, XLSX

Use case 040: Visualization

Visualization of purposefully compiled, existing models by adding further objects, information and/or graphic processing with the primary purpose of communication.

Table 3: Use case 040

Input data	Exchange format
Project-relevant models	IFC
Orthophotos	GEOTIFF, JPEG
Visualizations	MP4, JPEG, etc.

Deliverables	Exchange format
Pictures	JPEG, TIFF
Videos	MP4

Use case 050: Coordination of the professional trades

Regular merging of the specialist models into coordination models followed by quality control and systematic conflict resolution. Interdisciplinary collaboration takes place through model-based communication via a common data environment (CDE).

Table 4: Use case 050

Input data	Exchange format
Specialist models	IFC
Deliverables	**Exchange format**
Coordination models	IFC, CPA, SMC
BCF documentation	BCF
Audit reports	DOC, DOCX, PDF, XLS, XLSX

Use case 080: Derivation of planning documents

Derivation of relevant parts of the plans from the 3D models and adding missing (semantic and geometric) information to the plans. Plan scale and content correspond to the applicable guidelines and/or project specifications. The derived plans must not contradict the model status.

Table 5: Use case 080

Input data	Exchange format
Specialist models	IFC
Deliverables	**Exchange format**
Plans	PDF, DXF

Use case 100: Quantity take-off and costing

Preparation of a cost estimate and/or cost calculation according to standard cost breakdowns (AKVS, DIN 276-4, etc.) on the basis of structured and object-related quantities (volumes, areas, lengths, quantities) from the models.

Table 6: Use case 100

Input data	Exchange format
Specialist models	IFC
Unit prices	
Structure of the cost breakdown	TXT, CSV, XLS, XLSX

Deliverables	Exchange format
Cost estimation and/or cost calculation	XLS, XLSX, CPA, cpiXML, KSPX (Kostra format)
Quantity take-off	XLS, XLSX, CPA, cpiXML
Documentation	DOC, DOCX, PDF, XLS, XLSX

Use case 110: Bill of quantities, tender and contract award

Model-based generation of quantity-related items of the bill of quantities as well as model-based tendering, contract awarding and bidding for construction services on the basis of the existing planning.

Table 7: Use case 110

Input data	Exchange format
Specialist models	IFC
Structure of the cost breakdown	XLS, XLSX

Deliverables	Exchange format
Model-based construction contract	
Tendering models	IFC
GAEB files	GAEB (D81, D83, X81, X83)

UC 190 Structure documentation

Creation of as-built models (revision models) with detailed information regarding execution, such as materials and products used as well as references to test reports and other revision documents, if applicable.

Table 8: Use case 190

Input data	Exchange format
Detailed design results	PDF, DXF
Site documentation	Word, PDF, Excel
Surveying data	E57, TIFF, LAS, D58
Planning changes	PDF

Deliverables	Exchange format
As-built models	IFC

5. Data exchange formats

During the course of construction projects, information and data from a variety of disciplines are generated and exchanged using different software systems from different manufacturers. In particularly complex environments, interoperable data exchange and a product/manufacturer-neutral approach are often the only way to enable the trades involved to continue working with their established software tools.

This interoperable exchange of information and data should be handled via a common data environment (CDE). For more details on this topic, see "Part 2: Common Data Environment" of this document.

"Quality control – At the beginning of the project, tests should be carried out regarding the interdisciplinary exchange compatibility of the software solutions used (interface tests). Examples of minimum requirements for data exchange include the following:

- Geometry, structure, classification and features must be transferred with minimum losses.
- The models must remain in the same position after data has been exchanged.
- The XY position and angles of the 2D drawings generated from the model must match the model.

5.1 Open exchange formats

Use of open, neutral as well as openly published data formats enables the common planning method in construction projects associated with BIM. The table below shows some of the data formats already established on the market today and their areas of application in construction projects. (This list does not claim to be exhaustive.)

Table 9: Open exchange formats (source: BIM4INFRA – Toolkits Part 8, pp. 21–23)

Data format	Description	Application/area
BCF	BCF supports work process communication in the BIM process, such as exchange and change requests.	Model coordination
CityGML	CityGML stores digital 3D models of cities and landscapes.	GIS
DXF	DXF is used to exchange CAD files.	CAD
E57	E57 is a data format that stores scatter diagrams, images and metadata resulting from a 3D system, such as laser scanners.	Laser scanning: Existing conditions modelling, "as-built" documentation
GAEB	The task of GAEB is the creation and revision of the Standard Service Book for Construction (STLB-Bau, *Standardleistungsbuch Bau*) with standardized texts to describe construction services for new structures, maintenance and refurbishment as well as sets of rules for electronic data exchange, the structure of the bill of quantities and descriptions of procedures for electronic quantity and construction service billing.	Tendering
IFC	IFC is an open standard for the digital description of structure models.	2D/3D CAD, structural and energy calculations, quantity and cost determination as well as applications in facility management
LandXML	LandXML is a data format for exchanging georeferenced objects. It is an xml application and allows the transmission of objects with attributes, relations and geometries mainly for surveying and civil engineering applications.	Import/export of axes, gradients, longitudinal and transverse profiles, terrain models and point data.
LAS	The LAS data format is a public standard file format for exchanging laser scanning data.	Laser scanning: Existing conditions modelling, "as-built" documentation
OGC LandInfra/ InfraGML	This OGC InfraGML encoding standard is the implementation-dependent GML translation of concepts for mapping infrastructure assets specified in the OGC Land and Infrastructure Conceptual Model Standard (LandInfra).	Route-based structures/engineering structures, outline design, planning, operation, if applicable
OKSTRA	The Object Catalogue for Roads and Transportation (OKSTRA, *Objektkatalog für das Straßen- und Verkehrswesen*) is a collection of objects from the field of roads and transportation. It was set up with the aim of achieving a common understanding of these objects in the relevant specialist areas. The direct result is, for instance, a common exchange format for a wide range of software applications from the road and transportation sector. OKSTRA® was officially introduced for the area of federal trunk roads with the General Circular Road Construction 12/2000 of the Federal Ministry of Transport. This circular was later replaced by the General Circular Road Construction 24/2010.	Road data exchange
TIFF	Tagged Image File Format	Image data exchange

With regard to the open data exchange in the infrastructure sector, the IFC format and OKSTRA are particularly worth mentioning. Formats based on these manufacturer-neutral data standards also exist. One example of this is the BIM Collaboration Format.

- **IFC – Industry Foundation Classes**
  The Industry Foundation Classes (IFC) are a comprehensive object-oriented data model for describing digital structure models. The IFC model is a manufacturer-neutral, open data format that is standardized by DIN EN ISO 16739. It thus provides an important basis for implementing openBIM projects and serves as a basis for describing details and information as well as their structure that can also be applied to native data formats.[11]

> "IFC – A completed IFC extension for infrastructure construction is at present not available. Work on adding the special requirements from the highway sector to the data format is underway. For an interim period, the project-specific requirements for data exchange are to be included in the EIR:

- **BCF – BIM Collaboration Format**
  In addition to the exchange of model content, communication between stakeholders plays an essential role in model-based planning and execution of construction projects. These processes include, in particular, the planning of tasks and deadlines as well as problem and defect management.

  The BIM Collaboration Format (BCF) was developed in order to harmonize the transmission and exchange of relevant information. A key feature of this format is that, rather than transmitting structure models, it only transmits general information about the given problem as well as corresponding markings, views and annotations. In order to link a problem to model content, references to affected components can also be stored. In this way, defects or problems in a structure model can first be marked and documented and then assigned to a responsible person for processing with the help of individual BCF objects (topics or issues in BCF).

  The resulting BCF information can be exchanged between the different project stakeholders. It is advisable to store and manage this information centrally in a common data environment and to make it accessible to all stakeholders.[12]

- **OKSTRA – Road Object Catalogue**
  The Road Object Catalogue (OKSTRA, *Objektkatalog Straße*) is a comprehensive, manufacturer-neutral data exchange format for the highway sector (planning, construction, operation), based on an object model with attributes. The main application areas of OKSTRA are tasks in the operation, management and planning of the road network, such as the planning of transport and safety scenarios. The outline design section, i.e., the part relevant for data exchange, is only a small addition. The exchange format is a standard for the manufacturer-independent data transfer of complete outline design data, including the underlying as-built data. This enables users of different road design software products to exchange such data with each other and with contracting entities on a technical level without having to use proprietary data formats.[13]

11 Cf. VDI 2552 – Part 4:2020-08, p. 16

12 Cf. VDI 2552 – Part 4:2020-08, p. 16–17

13 Cf. VDI 2552 – Part 4:2020-08, p. 17

5.2 Relevant specialist systems of the road construction authorities

The lifecycle of transport infrastructure consists of planning, construction and, in particular, operation. Data exchange with the specialist systems for inventory data management (such as road information databases) operated by the road construction authorities must therefore also be taken into account.

The list below contains the specialist systems currently used in the federal states and does not claim to be exhaustive.

Table 10: SIB exchange formats

SIB	Description	Exchange format
SIB-Bauwerke	The structure database SIB-Bauwerke (SIB-BW) was developed by the Federal Government and the federal state governments. It is used for the uniform recording, evaluation and administration of structure data as well as for inspections of structures according to DIN 1076. SIB-BW contains all important information on bridges, tunnels and other engineering structures. SIB-Bauwerke is also used to create the audit reports for the regular inspections of structures according to DIN 1076. ASB-ING (instructions for road information database for engineering structures, structure data subsystem) serves as a basis for SIB-BW for the collection and administration of structure data.	OKSTRA
TT-SIB	The road information database TT-SIB serves as a road infrastructure management tool and central road inventory repository for construction road authorities. It is a core system of the specialist information systems. The most important information includes, for instance, data regarding alignment, road cross-section, pavement structure, road condition or entity responsible for construction and maintenance of structures. Traffic load and accident information is also provided. The technical specifications are based on the “Instructions for road information database” (ASB) of the BMVI and the responsible federal state ministries as well as the road construction authorities and federal state companies. The system is largely OKSTRA-compliant and forms the data basis for all specialist highway systems.	OKSTRA
NWSIB	NWSIB is used to evaluate and maintain data for interurban roads (motorways, federal, federal state and district roads). An essential task of NWSIB is to provide basic information for other applications within and outside the road construction authority. Following ASB, NWSIB consists of the two components “network” and “inventory”.	OKSTRA
Hessen-SIB	The data of the road information database Hessen-Netz is managed in a database management system. This data is available for individual evaluations in which all data can be linked together. The data is updated in a task and/or process-oriented manner. The Hessen-Netz road information database is designed in such a way that any data groups can be attached to the road network as its central and indispensable component. The basis of the information for the road information database are the “network data” subsystem of ASB as a reference system (network node and stationing system) and the road inventory data as a description of the roads in their dimensions and physical components.	OKSTRA

6. Archiving/long-term storage

Major construction projects, especially in the infrastructure sector, can last for decades. The use phase of the resulting structures can in turn be 100 years or more. In order to maintain the usability and processability of the data and models generated during the course of planning and construction over such long periods of time, only open, neutral and well-documented data formats can be considered for long-term storage and archiving. It is foreseeable that processability of such manufacturer-neutral formats with freely accessible documentation will still be ensured after several decades. Closed, binary data formats, on the other hand, can very often no longer be used after just a few years, since they are usually bound to software products and can often no longer be correctly read and processed after just a few version steps. The respective specifications of the native data formats are the exclusive property of the individual companies and in most cases are not openly accessible.

Consistent use of open data standards in accordance with the openBIM approach significantly facilitates the long-term archiving of project data, as is, for instance, also required in inventory data management. Reactivation of this data, for instance, for provision when new projects are started, is not dependent on the existence of a single software product. Furthermore, later use of project data in future, previously unrelated disciplines is also possible.

> "The data and models of the structures must be readable and interpretable over the entire period of use."

Part 2
COMMON DATA ENVIRONMENT

The establishment and use of a common data environment (CDE) is an important building block for the implementation and application of BIM in infrastructure projects.

Building today is an interdisciplinary and cooperative process. In particular, the increased complexity of many construction projects calls for intensive cross-company and usually also distributed cooperation between project stakeholders. During the course of a construction project, enormous amounts of data and information are produced that must be stored, changed, re-used and distributed. These constraints in construction projects increasingly require a high degree of collaboration or a cooperative working method such as Building Information Modelling. BIM enables parallel planning of the trades involved, transparency of the work results and managed access to relevant information. The CDE is the foundation for this as a holistically structured and reliable data hub.

"The right stakeholders need to be provided with the right information at the right time."

1. What is a CDE?

Part 2 of VDI Standarf 2552 – Building Information Modelling – defines the common data environment as follows:

“A central system for organizing, collecting, evaluating, coordinating, archiving and providing digital data for all project stakeholders.”[14]

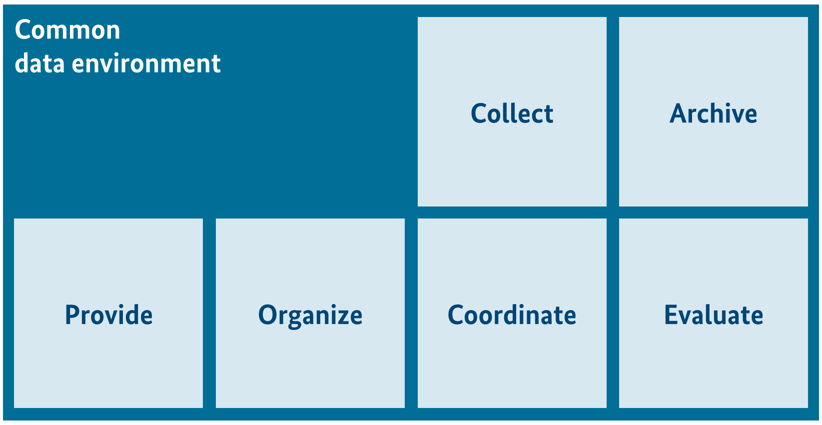


Fig. 2: Tasks of a common data environment

In a BIM-supported project workflow, all relevant project information and digital deliverables are brought together and stored centrally in a CDE over the entire lifecycle of the structure. The CDE as a source of information ensures simultaneous, location-independent access to this up-to-date data stock and to the defined tasks for all authorized stakeholders. As a result of this feature, a CDE is also described as a “single source of truth”. This single, common database enables uniform, comprehensible, documented, system-independent and smooth exchange of up-to-date information during the planning, construction and operation phases of a structure.

> “A common data environment is a tool for systematic, transparent management of all project processes. It provides all authorized stakeholders with the up-to-date status of information and enables traceability and complete documentation of every action and decision-making process.”

14 Cit. VDI 2552 – Part 2:2021-04, p. 5

2. Areas of application and objectives of a CDE

The use of a common data environment serves in particular to improve communication, transparency and documentation in project execution. Crucial aspects for the effective use of a CDE in project practice include, for instance:

- Central storage of all relevant data and access for all stakeholders according to defined rules
- A clear status and assured up-to-dateness of the data
- Clear definitions of responsibilities and data sovereignty
- Standardization of processes over the entire course of the project
- Secure storage as well as traceable and verifiable documentation of data
- Support of diverse data types and formats as well as open interfaces
- Versioning of data
- Viewer function for frequently used file formats
- Ensuring confidentiality and security of stored data

The following application areas are particularly supported by the use of a CDE and minimize the risk of planning and communication-related errors.

- **Collaboration and knowledge transfer**
  The common data environment ensures the structured and targeted exchange of information between all project stakeholders. All stakeholders access the same level of information and can thus increase their knowledge in relation to the project. This creates a common and unified basis. All information/data for project execution is distributed within the CDE in a targeted and monitored manner exclusively from this collaborative basis. A sensible authorization concept (system of rights and/or roles) controls access by internal and external project stakeholders and determines who receives and/or may use which information at what time. Use of a CDE also increases the transparency of all processes, communication and especially decisions within a project. This can enhance the project understanding of the stakeholders.

- **Structured management of information/data**
  A typical construction project generates large amounts of information that is often unstructured, poorly coordinated and difficult to find. The result is inefficient project management, which often leads to cost increases. Appropriate search features and user-customizable filters to find relevant information are thus becoming more and more important. They can, for instance, simplify the screening and generation of information and increase efficiency in the handling of project information.

A CDE provides the framework for structured storage and management of all relevant digital information/data. History management, for instance, can be used to track all the data stored, to fully recapitulate the project and to trace important decision-making processes.

- **Avoiding duplication of work and redundancies**
  Collaboration always carries the risk of redundancies of all kinds. By using a CDE as the sole source of information in the project, the latest status of information/data is available to all stakeholders. Redundancies due to double filing are avoided. All project stakeholders can execute their parts of the project and make the necessary decisions on the basis of the right data and information.

- **Model visualization**
  3D visualization simplifies collaboration and communication in a BIM project. An important function of the CDE is hence the display of 3D model data via an integrated viewer, including the linking of referenced data (for instance, linking 3D model displays with associated 2D plans). Even without using special software, there is a quick way to display models.

  Overlaying of specialist models in the viewer, displaying changes, additions to linked documents, displaying and, when necessary, creating BCF information from the viewer, etc., promote planning understanding and can speed up decision-making.

- **Process optimization and common workflows**
  Use of a CDE supports the implementation and optimization of the processes for executing infrastructure projects. Specialist functions tailored to requirements enable automated, faster and more efficient execution of processes and coordination between the stakeholders. Particularly in critical processes, such as the planning or approval process, quality can be significantly increased, as errors and complications, for instance, due to use of different plan statuses, are significantly reduced.

These processes and workflows must be defined in advance according to company/project-specific requirements. The following guiding criteria support the specification:

- Defining process objectives
- Describing all interfaces (software/roles/participants) of the process to be mapped
- Defining persons responsible and stakeholders involved in the process and describing tasks
- Creating a visual/process map to illustrate the process

The practical side:

Table 11: Standard processes

Standard process 1	Brief description
Model verification	Project-specific verification and clearance workflow for models

Definition of process objectives	Definition of interfaces	Definition of roles
Cleared and quality-assured models according to EIR/BEP	For instance, interfaces between CDE and model creator	For instance, model author, BIM manager, overall BIM coordinator

Standard process 2	Brief description
Delegate task	Ensure proper delegation of tasks to managers and appointees

Definition of process objectives	Definition of interfaces	Definition of roles
Legally compliant delegation of responsibilities and tasks	For instance, interface between task owner (manager) and case handler (appointee)	Case handler: Employee who has been assigned a task by a manager. A diagram is available for the process

- Preventing loss of data
  By applying the BIM method and using a CDE, all project stakeholders have access to relevant and necessary information throughout all project phases. Loss of information due to disruption in the flow of information, for instance, during the exchange of data between different trades or during transitions between service phases, is minimized.

3. Information in the project

Information is not only defined as the objects and deliverables (such as BIM models) owed according to the contracting entity's information requirements (EIR), but also as any kind of digital data records (drawings, documentation, flow charts, explanatory reports, clearances, etc.) that can be used and obtained, for instance, as a basis for planning, for generating further information, for analyses, etc.

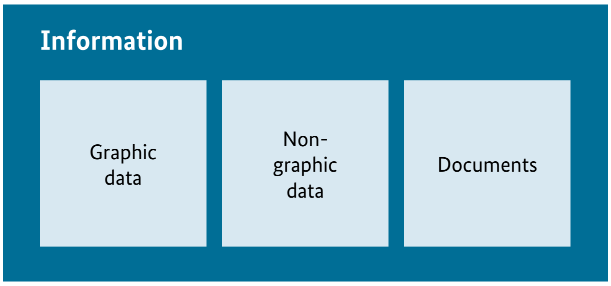


Fig. 3: Information categories

Information can generally be broken down into three categories:

- Graphic/geometric data (geometry)
- Non-graphic/non-geometric data (alphanumeric data)
- Documents (plans/drawings, reports, etc.)

Information is any type of digital data with a meaning. This meaning is derived from the context.

The information generated in the individual phases of a BIM project is retained and usually supplemented or updated in subsequent phases. A multitude of information is created during the life of a structure that can be used across different trades, during different phases and independent of location. With regard to the subsequent re-use of this information during the operational phase, a distinction must be made between project information and information related to the structure (infrastructure measure). The following diagram can help to explain this distinction.

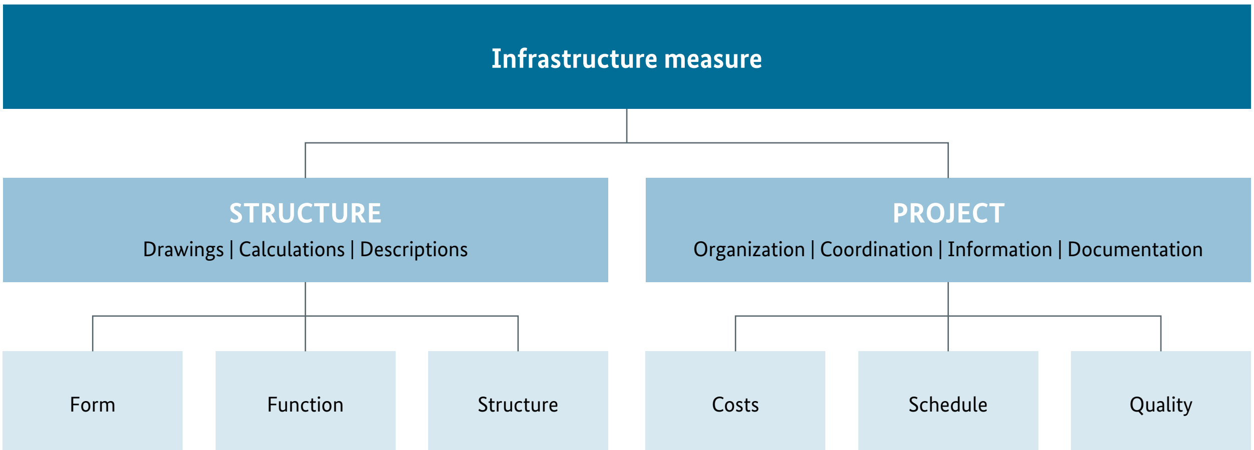


Fig. 4: Information in infrastructure projects (source: own presentation based on Walter Volkmann, Projektabwicklung für Architekten und Ingenieure, Hubert Wingen Verlag 2003)

The term “structure” is understood here to mean the visible, physically implemented solution with regard to the use of a transport route, for instance. A project, on the other hand, is an undertaking with defined objectives, a defined beginning and an end defined by the achievement of objectives, with its characteristics being uniqueness, complexity and (sometimes also) novelty. The project is determined by the elements of costs, deadlines and quality. In addition, there are contracts, performance and responsibility, system functions and local structure.

> The aim of the project is to select precisely the construction data at the end of the project that is required as a basis of information for operation (inventory/maintenance management) and to make such data available to the specialist systems of the road construction authorities (see Part 1: Data exchange, section 5.2).
>
> After a project has been completed, only part of the project information (such as legal and contractual information and requirements that continue to apply) needs to be transferred to operations, but most of it only needs to be archived.

This differentiation between project-specific and structure-specific information across all project phases specifically requires the definition of processes and rules for information/data management. A CDE is thus not just a piece of software and a project space, it also supports the necessary processes and rules (for instance, for archiving – see Part 1: Data exchange, Chapter 6).

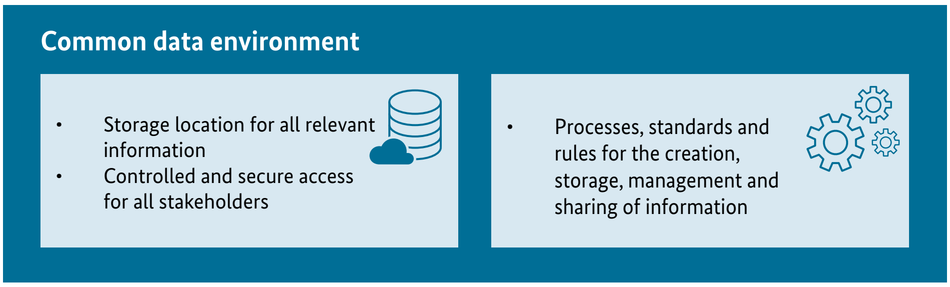


Fig. 5: Common data environment

4. Data structure and classification within a CDE

Effective information management requires stringent structuring of all data for which various options and different combinations are used. The framework conditions, such as internal company filing, security classifications, software interfaces, etc. must always be taken into account.

Suitability codes
The suitability codes of a file indicate what the information (file) can be used for (coordination, tendering, execution of construction work, etc.).

Metadata
Metadata is used to classify data for a managed filing system. Metadata contains important information about how the digital data is used. It constitutes supplementary features and provides information about, for instance, origin, authors, version, file format, etc. Metadata-oriented management in a CDE significantly supports the processes within a project.

File naming conventions
Precise and unambiguous naming of data simplifies its retrieval and storage, among other things. Uniform, overarching file naming conventions for all stored files support the use of the CDE. This is also highly relevant with regard to the later archiving of the data. A cross-project naming convention additionally means that stakeholders in a project can quickly find their way around a CDE without much training.

Trust classes
Both confidential and public information and data are generated, used and shared in projects. By classifying information with regard to confidentiality (trust classes), security incidents can be avoided in conjunction with the handling and disclosure of data. The trust classes define which information may be disclosed to whom, how and under which conditions (to protect business secrets, for instance).

Status
A status describes the processing status of information (model or file). It determines who can use information and when. It additionally shows which data has already been cleared or is still being processed, for instance.

Table 12: Metadata for plan management

The practical side (metadata for plan management):

Metadata name	Description
Project number	Project number of the plan
Service area	Service area of the plan (such as object planning, transport planning, etc.)
Service phase of the statutory fee schedule for architects and engineers (HOAI)	HOAI service phase (such as pre-design, outline design, etc.)
Author	Author of the plan (such as company, trade, etc.)
Component/object	Relevant component/object
Plan type	Plan type (such as site plan, route plan, construction site setrup plan)
Consecutive number	Consecutive number of the plan
Index	Version of the plan
Status	Status description of the plan
Author	Publisher of the plan
Date	Date of input or creation

5. Data flow within a CDE

The common data environment is the basis for the controlled exchange of information/data. It provides a common, digital and manageable space. This enables, among other things, the workspaces to be set up (for instance trade-specific) and information to be categorized.

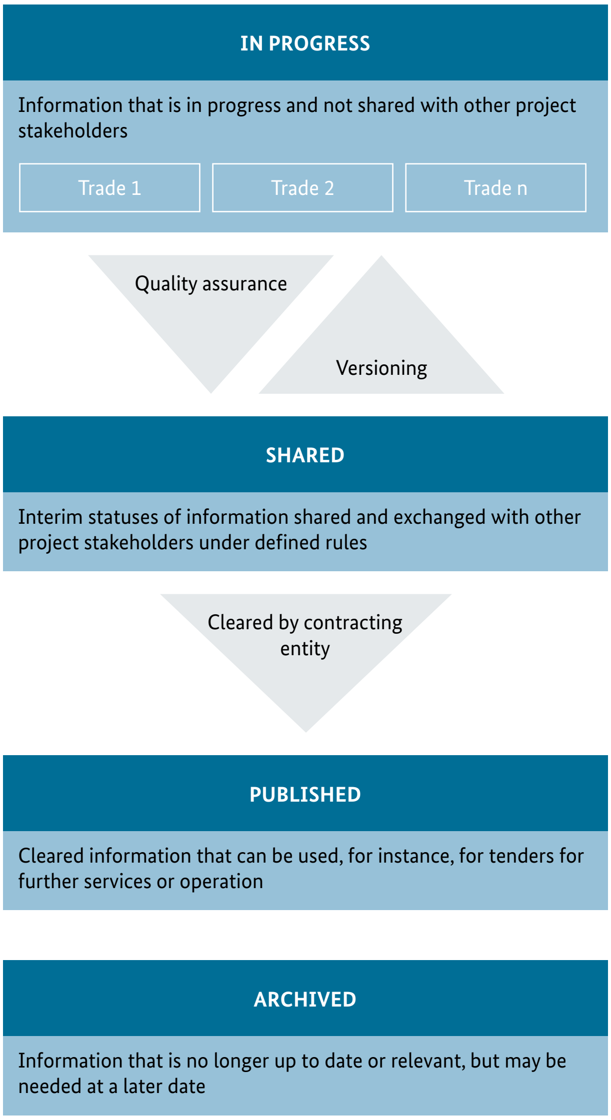


Fig. 6: Data flow within a CDE (source: own presentation based on DIN EN ISO 19650–1:2018)

Standardized processes and workflows control the flow of information and secure access to information by project stakeholders. The processing status of information (individual models or files) is described by means of an organizational structure and/or status that is defined upfront. This status indicates who can use information (a file) and when. This is controlled in the CDE via the corresponding access rights, so that project stakeholders can only obtain the information intended for them and are only involved in the processes required for their respective deliverables.

The diagram on the left shows an example of this data flow within a CDE. Adjustments according to project-specific or company-specific requirements are common practice.

The CDE can provide a separate workspace for each trade (project team). The information/files stored there are given “in progress” status and cannot be used by other project stakeholders. After successful verification, this information/these files are cleared and given “shared” status. Exchanging data with the other trades is now possible.

Once information processing is completed, it is given “published” status. This status requires prior quality control (for instance, for conformity with the requirements of the EIR) and clearance by the contracting entity.

If information is no longer needed or used for project execution, it is given “archived” status. If necessary, it can be re-used later. The question as to whether further statuses are required for the data flow must be agreed on a project-specific and company-specific basis. It is usually possible to adjust the configuration.

At transitions between statuses, the contractor must in most cases conduct a quality control (such as clash detection, EIR and BEP compliance, file and naming convention, etc.) which the contracting entity must clear.

The table below explains the individual statuses in detail.

Table 13: Status according to DIN EN ISO 19650 (source: ISO standard 19650-1:2018)

Status	Description
In progress	▪ Information that is currently being processed ▪ Non-verified information ▪ Use in contractor's own trade only ▪ No exchange between trades (disciplines)
Shared	▪ Exchange of information between trades (disciplines) ▪ Models with this status are merged into a coordination model, for instance, for carrying out quality control. ▪ Verifying information for conformity with the EIR and BEP (BIM manager/ overall BIM coordinator) ▪ Models of other trades are referenced as read-only models in the contractor's own planning
Published/cleared	▪ The information is accessible to all project stakeholders. ▪ Authorization from the contracting entity and prior quality control (BIM manager) are required to clear the information. ▪ Editing/modification of the information is completed. ▪ The data is up to date and valid and can be used for further planning or execution. ▪ A digital signature can also be used for clearance.
Archived	▪ The project data is no longer used, but remains available for re-use.

6. Functions of a CDE

The areas of application of a CDE in a construction project are extremely diverse. The common data environment must provide the functions necessary to meet the requirements of the objectives listed in Chapter 2.

6.1 Structure/function stages of a CDE

A common data environment should be successively established and further developed. The development stages 1 to 3 shown below describe the functional levels and further development of a CDE.

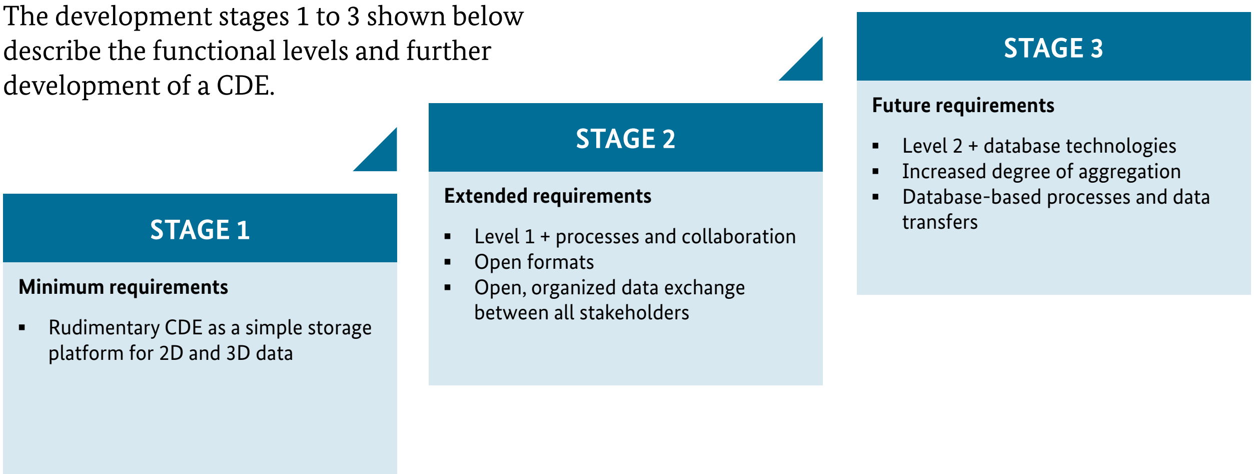


Fig. 7: Upgrading/function stages of a CDE

Stage 1
Rudimentary CDE as a simple storage platform for 2D and 3D data

Stage 2
Level-1 functions + organized data exchange between all project stakeholders; processes for collaboration; use of open exchange formats

Stage 3
Level-2 functions + use of database technologies; all information is stored in databases and can be retrieved from there and used for different processes

In the following sections 6.2 to 6.5, CDE functions are categorized and marked with the requirement level for the respective development stage (minimum requirement: level 1, extended requirement: level 2, future requirement: level 3).

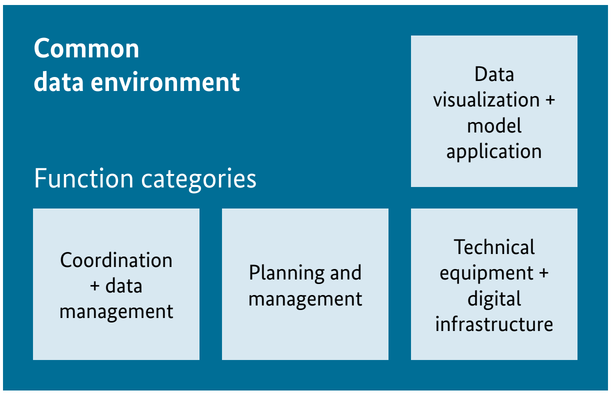


Fig. 8: Function categories (source: own presentation based on DIN SPEC 91391–1:2019-04)

6.2 Coordination/data management

- Exchange of information: Delivering, filtering, searching for and providing data
- Structuring data: organizing project space data
- Project communication and collaboration: communication, workflows, processes
- Configuration and administration: configuring and administering the project space

Table 14: Requirements regarding information exchange – (source: own presentation based on DIN SPEC 91391-1)

Exchange of information

Provision		Minimal	Extended	Future
Multiple upload/download of files	Bulk downloads and bulk uploads must be possible. (Bulk editing and/or changing means changing several entries, positions, elements, etc. in one go. Bulk editing allows several elements to be updated within one or more work steps at the same time.)	■		
Interfaces for data exchange	Manual data exchange via user interface	■		
API interface for data exchange	Data exchange via API interface		■	
No file size limit	Storage of files of any size in the CDE	■		
Central data storage	Holistic storage of data in a central location	■		

Delivery management		Minimal	Extended	Future
Classification according to data type	Specification of the delivered (uploaded) files as a model, plan, drawing or document		■	
Creation of delivery deadlines	Setting delivery deadlines within the CDE		■	
Delivery deadline controlling	Deadline monitoring of the delivery date, including warning signs, for instance, on file names		■	
Delivery list	Generation of delivery lists from partial/total delivery		■	
Indexation	Textual file content is automatically indexed (keyworded) when uploaded		■	
Logging	Metadata of the delivery is recorded in a log		■	
Deadline monitoring	Monitoring of deliveries on time/not on time/outstanding deliveries, warning, when necessary		■	

Filter/search function		Minimal	Extended	Future
Search via metadata	Search for data using metadata	■		
Search via full text (indexation)	Full text search: Documents are searched for keywords.		■	
Customized filters	Selection of metadata for filtering. Fixed filters can be set up by the user. Restricting the search result based on value ranges		■	
Search via metadata of communication processes	Metadata of communication processes can be used as a filter criterion.		■	
Search via metadata of workflows	Metadata of workflows can be used as a filter criterion.		■	
Combining filters	Filter criteria can be combined with each other.		■	
Saving filters	Saving of project-wide and individual filters; filters can be set up for the individual user only or also for user groups or representatives, when necessary.		■	
Structuring evaluations/results	Results of the search or filter operation can be displayed in tabular form or in folder structures.		■	
Prioritizing evaluations/results	Configurable prioritization of columns and/or folder hierarchies. Ad-hoc folder structure, folder levels according to metadata, levels can be swapped as desired (prioritization)		■	

Table 15: Requirements regarding structuring of data (source: own presentation based on DIN SPEC 91391-1)

Structuring data

Organization		Minimal	Extended	Future
Project space organization	User-defined structuring of data storage	■		
Packaging	Storage of technical models, plans, documents and other project information in data containers with single or multiple files	■		
Structuring and categorizing metadata	Storage of data (specialist models, plans or documents) according to different metadata categories, such as project, phase, author, trade, etc.	■		

Data structuring		Minimal	Extended	Future
Mandatory classification for upload	Classification of each file with metadata on upload. Metadata can be defined on a project-specific basis (project configuration).		■	
Technical classification	Technical metadata coding when delivering files (for instance, BIM specialist models, documents) according to project-specific criteria, such as domain, trade, level of information, level of geometry, etc.		■	
Spatial classification	Spatial metadata coding of files (for instance, BIM specialist models, plans, documents) upon delivery according to project-specific criteria, such as sub-projects, components, construction stages		■	
Process-oriented classification	Process-specific metadata coding according to criteria such as phases, quality gates, use cases, processing and clearance status		■	
Checking classification	Procedure to verify compliance with pre-set conventions with integrated warning and/or upload denial function		■	
Checking file formats	Procedure for verifying compliance with specified data formats		■	
Plan coding	Upload of plans according to strict project-specific nomenclature		■	
Versioning	Automatic setting of the version identifier when files are delivered; identification of the version; retroactive display of older versions	■		

Linking/referencing		Minimal	Extended	Future
Data linkage (linking)	In order to avoid redundancy or double filing, it must be possible to map references and links between files of all types. The data search is accelerated.		■	
Linking data with models	Linking data with models and model objects. (If viewer available and writable in IFC)		■	

Archiving		Minimal	Extended	Future
Project archiving	Transfer of data as required, for instance, after project completion as an archive (file or folder)	■		
Archive connection	Transfer of data from the project space into the archive system, including transfer of classifications, links and metadata		■	
File archiving	Archiving of individual files over the entire project lifecycle	■		

Table 16: Requirements regarding project communication and collaboration (source: own presentation based on DIN SPEC 91391-1)

Project communication and collaboration

Communication processes		Minimal	Extended	Future
Outgoing/incoming mail area	Listing of messages sent and received		■	
Message (mail) search	Search in list according to selectable criteria		■	
User-defined forms for form-based communication	Creation of user-defined forms, for instance, for construction site journals, defect management, checklists, reports or tasks. Integration of stored metadata		■	
Attachments (to form)	Attaching data to a form (for instance, mail)		■	
Attachments (to process)	All documents/plans, entire file groups or link groups can be transferred to a communication process.		■	
Data volume	No restrictions regarding size and number of attachments		■	
Optimization of data volume	The platform automatically replaces attachments with web links, for instance, in order to minmize mail size.		■	
Forwarding messages and files	Message with attachment is forwarded to predefined recipients or groups.	■		
Creating deep links	Sending files via deep links from the system to external parties who are not authorized to access the CDE		■	
Creating mailing lists	Distribution of data to participants, roles as well as according to distribution matrices		■	

Workflows		Minimal	Extended	Future
Customized workflows	A sequence of activities can be configured and executed according to project requirements. Status, approval statuses, etc. can be assigned.		■	
Processing and clearance status	Basic processing status according to DIN EN ISO 19650. Verification and clearance status for BIM specialist models, plans, documents and other files	■		
Configuring processing and clearance status	Clearance status for specific uses (“cleared for …”) for instance, “released for execution”	■		
Integrating user-defined forms	Integrating forms within workflows		■	
Scaling workflows	Simple incrementing/decrementing of steps within workflows		■	
Sharing workflow templates	Re-using workflows within the company, project-wide or in other projects		■	
Updating delivery lists	Automatic updating of delivery lists when files are submitted		■	
Forwarding within workflows	Forwarding of data to specific project participants or participant groups for review or further processing		■	
Notifications	Configurable notification of project participants about the receipt (upload and/or forwarding) of data when a process is triggered, at status transitions and when tasks are assigned or terminated	■		

Collaboration		Minimal	Extended	Future
2D redlining, track changes and comment function	Redlining and markups of plans and 2D screenshots of models, attaching comments – communication via BCF exchange		■	
3D redlining and track changes	Spatial marking in models, attaching comments – communication via BCF exchange		■	
Online editing	Updating shared documents (for instance, MS Office)		■	

Table 17: Requirements regarding configuration/administration – (source: own presentation based on DIN SPEC 91391-1)

Configuration and administration

Project space administration		Minimal	Extended	Future
Project space administration	Optional administration by contracting entity or platform provider	■		
Company administrator	User administration of own company area in the CDE is carried out by an authorized project employee.	■		
Roles and rights	Administration rights can be defined for different areas and levels, such as users, workflows, access rights, additional services.	■		
Authorization groups	Definition of user groups and assignment of authorizations	■		
Rights management	Managing visibility, access and editing rights based on participants, roles, properties (metadata) and specific clearances	■		
Locking data	Locked files (for instance, contracts) are set to unchangeable status.	■		

Project space configuration		Minimal	Extended	Future
Configuring project templates	Multi-project capability: New projects can be created on the basis of standardized templates; dedicated user administration per project; modifiable metadata structure per project.	■		
Configuring metadata	Use of catalogues for defined metadata fields (document type keys, project filing structures, etc.)	■		
Configuring naming conventions	Definition of a project-specific and/or company-specific file naming convention. It must be possible to assign this to files via metadata.	■		
Language settings	Setting different languages (German, English, etc.)	■		
Scalability	It must be possible to adapt the functionalities of the CDE to the requirements of projects (expanding functionalities, adding workflows, increasing storage volume, expanding the number of participants, etc.).	■		

6.3 Data visualization/model application

- Data visualization: openBIM formats, native formats, drawing formats, display of graphical and non-graphical information
- Model application: Selecting, navigating, enriching

Table 18: Requirements regarding data visualization (source: own presentation based on DIN SPEC 91391-1)

Data visualization

Interoperability		**Minimal**	**Extended**	**Future**
Model import and presentation	Viewer compatibility: IFC (all versions), CPIXML, LandXML, CityGML, FBX, DWG, DWF, DWFx, geo-referenced image formats, DTM, scatter diagrams, GIS, OKSTRA	(■)*		
BCF import and presentation	BCF (all formats)	(■)*		
Displaying document and 2D drawing formats	DXF, DWG, PDF: Displaying 2D graphics in viewer (browser, app) Additional annotation (text, markups)	(■)*		
Viewing and editing MS Office documents	XLS, DOC, PPT: browser-based online display		(■)*	

Viewer		**Minimal**	**Extended**	**Future**
Online (desktop)	Display in browser; supporting up-to-date versions of common Internet browsers; optional support of common web browsers on mobile devices	(■)*		
App-based viewer	Display in mobile app; CDE manufacturer's app for mobile devices		(■)*	

Graphic model data		**Minimal**	**Extended**	**Future**
Combined display of specialist/sub-models	Visual combination of models from different model files	(■)*		
Transparent presentation of model objects	A transparent presentation is assigned to selected objects and/or a colour is assigned to all selected objects.	(■)*		
Isolating/hiding model objects	Hiding all unselected and/or selected model objects	(■)*		

Non-graphic model data		Minimal	Extended	Future
Showing spatial model structure	For instance, hierarchy tree: property/building/floor/room/object	(■)*		
Showing object types and categories	Showing objects of a type	(■)*		
Showing feature names and values	Showing the list of feature names and feature values of an object	(■)*		
Showing type information	Details of the object type	(■)*		
Classification assignment	Classification code of an object	(■)*		
Document references	Showing the list of documents linked to the object	(■)*		
Workflows/communication processes	List of communication processes in which the object is used		(■)*	

* if a viewer is integrated in the CDE

Table 19: Requirements regarding model application (source: own presentation based on DIN SPEC 91391-1)

Model application

Selecting model objects		Minimal	Extended	Future
Displaying navigation instruments	Presentation of basic navigation and selection options in the model viewer	(■)*		
Selection in hierarchy node or structural element	Selection of one or more model objects in a topology presentation, for instance, by selecting a node ("all caps")	(■)*		
Filtering model objects	Filtering by name/value pairs; combination of several filters by Boolean operations	(■)*		
Model sections		**Minimal**	**Extended**	**Future**
3D section	Presentation of sections in the model viewer		(■)*	
Model views		**Minimal**	**Extended**	**Future**
Saving views	Saving current view		(■)*	
Visualizing saved view in viewer	Defining view in viewer/defining camera position, sections, hidden and transparent objects		(■)*	
Additional properties of a view	Comments, screenshots (possibly with markings), 3D pins in the model		(■)*	
Predefined views	View from predefined directions		(■)*	

Measuring function		Minimal	Extended	Future
Measuring in the model	Distance, polygon, area, area distances, point/area distance, including options such as point snap, area normal, etc.		(■)*	
Communicating measurement results	Communicating the measurement result in an integrated way		(■)*	

Supplementing information		Minimal	Extended	Future
Linking documents with selected model objects	Enriching model objects with references to documents in the document management system (attachments)	(■)*		
Displaying linked documents and 2D formats	See "interoperability" (DWG, PDF, Office formats)	(■)*		
Displaying workflows involved	List of workflows in which the model is used		(■)*	

BCF/BIM collaboration format		Minimal	Extended	Future
Importing BCF	Reading in model-based notes and displaying them in the viewer. Controlling the camera position in the model, displaying markups, comments, editors, status, etc.	(■)*		
Creating BCF	Creating a BCF error report on the platform; documenting a problem by selecting the affected model objects in the viewer		(■)*	
Exporting BCF	Exporting file-based BCF reports as a bcfzip file		(■)*	
Linking BCF with model objects	Linking the BCF report with model objects		(■)*	
Exchanging BCF via web-based interface	BCF data exchange between the application (for instance, plug-in) and CDE			(■)*
Filtering and summarizing	Selecting and summarizing for troubleshooting by responsible persons		(■)*	
Associating or loading models referenced in the BCF error report	Information in the BCF data record refers to a specific model (file, version, revision). When displaying BCF data in the viewer, this model must be displayed and reloaded, when necessary.	(■)*		
Displaying and verifying results from model verification processes in the viewer	Error messages in BCF format from verification software (for instance, from the clash detection) are displayed in the viewer. Automatic setting of view (camera position, hidden objects) according to BCF information	(■)*		
Selecting BCF notes and assigning these in bundled form to a workflow for correcting errors	Selection contains imported BCF data (import from external tools) and BCF data generated internally in the viewer.		(■)*	

Model verification		Minimal	Extended	Future
Checking modelling rules	Finding missing/prohibited objects (visual inspection)			(■)*
Checking property guidelines	Finding missing/prohibited properties (visual inspection or using external inspection tools)			(■)*

* if a viewer is integrated in the CDE

6.4 Planning and management

- Management functions: Information and reports for project control and tracking

Table 20: Requirements regarding management functions (source: own presentation based on DIN SPEC 91391-1)

Management functions

Project information		**Minimal**	**Extended**	**Future**
Configuring the dashboard	Graphical display (dashboard) of the history of an indicator that is meaningful in the project context		■	
Link to detailed information	Linking information with details		■	

Reporting		**Minimal**	**Extended**	**Future**
Compilation of meta-information for reporting	Preparing cause and effect reports on influencing factors		■	
Standard reports	Predefined project reports/company reports		■	
Report levels	Project, company		■	
Project-specific reports	Selected metadata from workflow, communication or status		■	

Comprehensibility		**Minimal**	**Extended**	**Future**
Logging	Legally compliant recording of the delivery and/or download in the contractor's own company area. This can be further restricted by role-specific rights, when necessary.	■		
Process tracking	Logging of process steps		■	
Delivery date, process progress	Monitoring of due processes and deliveries		■	
Warnings	Notification when due dates occur		■	

6.5 Technical equipment and digital infrastructure

- Interfaces and integration: connection, integration and use of third-party software
- Data protection and data security: physical security, data security, failure safety

Table 21: Requirements regarding interfaces and integration (source: own presentation based on DIN SPEC 91391-1)

Interfaces and integration

Integration in third-party software		**Minimal**	**Extended**	**Future**
Plug-ins	Integrating CDE functions via plug-ins into third-party software		■	
Via URL	Access by third-party software via web interface of the CDE (URL)			■

Programming interface (API)		**Minimal**	**Extended**	**Future**
APIs for accessing CDE functions and data	Interfaces for communication between systems		■	
OpenAPI	Specifying web interfaces		■	
OAuth	Secure authentication methods		■	
OData	Using parameters for searching, sorting and filtering queries according to specific criteria		■	

Integrating external software		**Minimal**	**Extended**	**Future**
Integrating software according to project-specific/company-specific requirements	Examples: MS Project, Autodesk AEC Collection, VESTRA Infravision, CARD/1, RIB iTWO, ProVI, Solibri, Nemetschek Allplan, etc.		■	

Table 22: Data protection and data security (source: own presentation based on DIN SPEC 91391-1)

Data protection and data security

Building safety and security		**Minimal**	**Extended**	**Future**
Avoiding sources of risk, indoor protection against exposure to harmful substances	Safety-conscious design of the facility	■		
Fire alarm, fire fighting; avoidance of critical climate conditions	Protective measures against damage caused by hazardous indoor conditions, i.e., air conditioning.	■		
Burglary protection, access control	Avoiding damage due to unauthorized intrusion (early detection, resistant material)	■		
Redundancy of operation-critical supply and disposal lines and pipes	Emergency power supply, cooling	■		
Safe location	EU member state	■		

Data security		Minimal	Extended	Future
Authentication	Verifying the identity of a user	■		
Authorization	Approval of activities in the CDE according to the role of the authenticated user	■		
Software change control	Preventing unauthorized/unnoticed software changes. Software changes only after review and clearance. Reset to initial state if security vulnerabilities occur.	■		
Strong password	Ensuring secure passwords according to customary security rules	■		
Password renewal	Ensuring regular password renewal	■		
Limited session duration		■		
Maximum permissible number of login attempts	Locking user account after a sequence of failed login attempts	■		
Supporting secure web browsers only	Recommending web browsers	■		
Use and structure according to data security standards		■		

Reliability, performance		Minimal	Extended	Future
Web accelerator	Web accelerator		■	
Internet connection performance	Internet provider with high performance connection		■	
Backup and restore	Scheduled data backup concept (cyclical)	■		
Archiving	Transfer of data after the end of the project as a self-supporting archive, i.e., all data can be viewed in its original context even without using the project space.	■		
Performance	Server and storage capacity designed for peaks and growth		■	
Use without installation	No local administration rights required on the user side, no installation of programmes, plug-ins and components (such as Java, Active-X, Flash, etc.)	■		
Availability	Reliable/mandatory information on minimum availability (for instance, percent on an annual average). Maintenance dates and scheduled shutdowns	■		
High availability	Reliable/mandatory information on minimum availability (for instance, percent on an annual average). Maintenance dates and scheduled shutdowns	■		

Precautionary measures		Minimal	Extended	Future
Penetration tests	Penetration tests (comprehensive security test)	■		
Monitoring	Security event streams are monitored by a dedicated security operations centre. Immediate investigation and resolution of security issues. Measures against ▪ exceeding of hardware resources ▪ unforeseen events Action plan in the event of an alarm	■		
Backup and recovery	Standards: secure cloud storage and full backup. Information is managed according to ISO-27001.	■		
Staff readiness	Staff availability in the event of an alarm	■		
Replacement hardware	Availability of replacement hardware	■		
Data centres	Mirrored data centres Protection against data loss in the event of network failure	■		

7. Data protection and data security

Using a common data environment also places increased demands on data protection and data security. Data protection should meet the highest security standards and compliance with the General Data Protection Regulation (GDPR) is mandatory. The provider of a CDE solution must therefore be certified according to recognized security standards (such as DIN EN ISO/IEC 27001).

"A common data environment is typically a cloud-based solution to simplify access for all project stakeholders and to outsource server capacity to external providers.

Use of cloud services requires compliance with legal provisions, regulatory standards as well as further ethical standards and requirements (compliance requirements) which are usually set by the company itself.

Prior to procurement, a corresponding risk assessment should be carried out in coordination with the in-house IT and data protection officers in order to create a uniform understanding of requirements and framework conditions. Potential risks should be considered and assessed in order to identify possible mitigation methods, if necessary, to meet compliance requirements.

A company-specific cloud computing policy is still recommended for use of a cloud-based CDE. The example below is an excerpt from the HPA guideline:

"A non-disclosure agreement (NDA) must be concluded with all cloud providers for the protection of the data processed in the cloud provider's area of responsibility (in the sense of the shared responsibility model).

The following aspects must be contractually agreed with the cloud providers:

1. All data processing procedures must be encrypted according to their need for protection (data in rest/data in transit)
2. Backup/recovery must be agreed upon during processing
3. Disaster recovery processes must be agreed
4. A security event and incident management process must be agreed through which security incidents can be reported and addressed promptly
5. Proof of the IT security level through suitable norms or standards (see Chapter 7)
6. Proof of regular IT security checks, such as penetration tests
7. Cloud operation at EU locations must be agreed in principle (region of data processing)

If personal data is to be processed, a processor agreement must also be concluded in accordance with Art. 28 GDPR."

If, for instance, the CDE is operated in a cloud, the technical infrastructure (data centres, servers, etc.) must be kept redundant and at different locations. In addition to the type and location of data storage or the method of data encryption, access to the platform is another essential security aspect. Important requirements for data protection and data security are listed in DIN SPEC 91391. When it comes to integrating CDE solutions into a company's own IT infrastructure, its internal specifications and rules regarding data protection and data security should be taken into account.

7.1 Requirements according to DIN SPEC 91391

Table 23: Data security and data protection (source: DIN SPEC 91391-1)

Data security	CDE function	Description	Notes and examples
Data access	Authentication	Verifying a user's identity Single sign-on (SSO, unification and simplification of login and account management using existing functions of internal authentication systems)	
	Authorization	Approval of activities in the CDE according to the role of the authenticated user	
	Software change control	Preventing unauthorized/unnoticed software changes. Software changes only after review and clearance. Reset to initial state when security vulnerabilities occur	Hardened software configuration. Changes are tracked and checked for security vulnerabilities
	Secure (strong) passwords	Ensuring secure passwords according to customary security rules	Appropriate password complexity
	Password renewal	Ensuring regular password renewal	Appropriate intervals for password expiration
	Limited session duration	Automatic user logout from the CDE to prevent unauthorized access by third parties	Users are, for instance, logged out from the CDE portal in the browser after a defined period of inactivity so that no third party can access the data.
	Maximum permissible number of login attempts	Locking user account after a sequence of failed login attempts	
End user system	Support for secure web browsers only	Web browser recommendation	Examples: IE, Firefox, Chrome, MS IE
Standards	Data security standards		ISO 27001, FedRAMP

7.2 Confidentiality classification of information

Public infrastructure projects involve highly sensitive information and data. When handling this information and data, security incidents must be avoided. In order to be able to guarantee security, guidelines should be used for handling and sharing information and data on the basis of a confidentiality class. The confidentiality/ information class describes which information and data may be passed on to whom, how and under which conditions. The definition of the individual classes is company-specific. Possible levels of confidentiality are shown in the table below.

> "Confidentiality classes can be used to maintain security when handling trade secrets."

Table 24: Confidentiality classes

Confidentiality class	Description
Strictly confidential	▪ Group of participants in a meeting ▪ Only direct recipients of written correspondence ▪ Sharing prohibited ▪ Serious legal consequences ▪ Significant financial losses ▪ Damage to life and limb
Confidential	▪ Company internal – need-to-know basis ▪ Business processes affected ▪ Legal consequences ▪ Personal data
Internal	▪ Company internal ▪ Minor irritation in the media ▪ No far-reaching consequences
Public	▪ Public information – without restrictions

Medium / Class	Letter	E-mail	Internet publication	Internet transmission	Cloud storage or transfer	Mobile data carriers	Fax	File storage	Print	Disposal
Strictly confidential	Personally delivered registered mail	Encrypted	✗	Encrypted	✗	✗	✗	Encrypted	Personal printer or with a PIN (card)	File destruction according to DIN 66399
Confidential	✓	Encrypted	✗	Encrypted	Encrypted	Encrypted	Only with direct dialing and verified direct dialing	✓	Personal printer or with a PIN (card)	File destruction according to DIN 66399
Internal	✓	✓	✗	✓	Encrypted	Encrypted	Only with direct dialing	✓	Personal printer or with a PIN (card)	File destruction according to DIN 66399
Public	✓	✓	✓	✓	✓	✓	✓	✓	✓	Trash

Fig. 9: Example of confidentiality classes according to HPA

7.3 Relevant standards and guidelines for data protection and security

- **DIN EN ISO/IEC 27001 – Information security management systems**

  The ISO/IEC 27001 standard is the internationally recognized management system standard for information security. It is designed to support organizations in ensuring the security of their information.[15]

- **DIN EN ISO/IEC 27017 – Code of practice for information security controls for cloud services**

  The ISO/IEC 27017 standard specifically addresses the security of the transmission of data and provides key implementation controls and guidance for cloud service providers (CSPs) and cloud users to complement ISO 27001 and ISO 27002.[16]

- **DIN EN ISO/IEC 27018 – Code of practice for protection of personally identifiable information in public clouds**

  The ISO 27018 standard sets out data protection requirements for cloud service providers and formulates monitoring mechanisms and guidelines for implementing measures to ensure the protection of personal data in a cloud environment.[17]

15 Cf. ISO 27001, p. 1
16 Cf. ISO 27017, p. 1
17 Cf. ISO 27018, p. 1

8. Recommendations for implementation

Some key aspects are described below that may be helpful in planning a common strategy for centralized information provision. Well thought-out planning and set-up of a CDE ensures efficient and transparent access to relevant information and can significantly shorten the overall project duration and drastically reduce costs.

When setting up a common data environment, the requirements regarding use must be defined in advance and the boundary conditions (data security, IT landscape, legal requirements, etc.) for using the CDE must be determined. Which use cases are to be supported by a common data environment? What adjustments to internal and external processes are required? What hardware and software must be provided? Who is responsible for operation of the CDE and the contact person for users when problems arise? What are the qualifications of the employees using the CDE? These are just some of the important questions that need to be answered when procuring and configuring a common data environment.

In principle, it should be noted that clear rules are defined in the project-specific EIR and BEP for application and use of the common data environment that must be mandatory for all project stakeholders. The advantages of a CDE can only take effect if all project stakeholders adopt and consistently apply the project-specific rules for using the CDE. Consistently active participation of all project stakeholders requires a high level of system acceptance, which is significantly influenced, for instance, by intuitive usability and consideration of specific interests. When setting up a common data environment, the requirements of all stakeholders must therefore be taken into account right from the start. The illustration below shows examples of the fields of action to be considered.

> When it comes to procuring a CDE, fundamental questions must be answered regarding integration into the system landscape and application in the project.

Processes	Technology	Guidelines	People
Definition of the use cases of a CDE	Setting up and configuring the necessary processes, interfaces and workflows	Setting standards for working with a CDE	Training and testing of the CDE within projects

Fig. 10: Activities for introducing a CDE

Working with the BIM method requires new and/or extended skills. Project stakeholders must be supported and qualified with regard to the changed collaboration and communication processes. Staff using the CDE should have basic skills in using project platforms and/or common data environments and in implementing data security and data protection.

A common data environment is typically integrated into an existing system landscape. Furthermore, the CDE is supported by additional software solutions and/or further applications and tools. Interoperability between these systems and software products is required for the exchange of information and especially metadata. The CDE must be designed as a holistic solution that can process a wide variety of information to ensure, among other things, compatibility with the file formats of all project stakeholders.

It is also important to set clear rules for data sovereignty and the rights to use the data over the entire lifecycle of the structure. Binding rules should be set up, for instance, in special contract clauses, as to who owns the data and who has a right to use, reproduce or publish the data.

> "Data sovereignty and rights of use should be contractually determined."

9. Conclusion

The construction industry is in a state of transition. At the same time, the technology for planning, building, maintaining and operating is also changing at a tremendous pace. In today's world, the problem is not a lack of data, but rather a lack of up-to-date, easily interpretable and usable information. Incorrect or insufficient communication often leads to confusion, costly rework and an enormous loss of time.

The key to successful collaboration is efficient and transparent communication. Correct interpretation and effective use and distribution of information require easy and constant access to a clear and reliable data source as well as a comprehensible structure of relevant and up-to-date data that must be available in common formats. The special boundary conditions in today's construction industry (including cross-company, location-distributed and time-delayed processing) additionally require increased cooperation and/or efficient collaboration between all stakeholders. Use of a common data environment can support these requirements of digital planning, construction and operation significantly throughout the entire lifecycle.

There is no standard solution for a common data environment. How such a data space is configured depends on company-specific and especially project-specific requirements and boundary conditions. Setting up and implementing a CDE should therefore be preceded by an intensive needs assessment and concept design in order to create a good basic solution that can be adapted to the requirements of the respective projects and adapted and/or expanded as needed.

List of illustrations

Fig. 1:Standards and guidelines 8

Fig. 2: Tasks of a common data environment 26

Fig. 3: Information categories 30

Fig. 4: Information in infrastructure projects (source: own presentation based on Walter Volkmann, Projektabwicklung für Architekten und Ingenieure, Hubert Wingen Verlag 2003) 30

Fig. 5: Common data environment 31

Fig. 6: Data flow within a CDE (source: own presentation based on DIN EN ISO 19650–1:2018) 34

Fig. 7: Upgrading/function stages of a CDE 36

Fig. 8: Function categories (source: own presentation based on DIN SPEC 91391–1:2019-04) 36

Fig. 9: Example of confidentiality classes according to HPA 52

Fig. 10: Activities for introducing a CDE 54

List of tables

Table 1: Use case 010 14

Table 2: Use case 030 15

Table 3: Use case 040 15

Table 4: Use case 050 16

Table 5: Use case 080 16

Table 6: Use case 100 17

Table 7: Use case 110 17

Table 8: Use case 190 18

Table 9: Open exchange formats 20

Table 10: SIB exchange formats 22

Table 11: Standard processes 29

Table 12: Metadata for plan management 33

Table 13: Status according to DIN EN ISO 19650 (source: ISO standard 19650–1:2018). 35

Table 14: Requirements regarding information exchange 37

Table 15: Requirements regarding structuring of data. 38

Table 16: Requiremements regarding project communication and collaboration 40

Table 17: Requirements regarding configuration/administration 42

Table 18: Requirements regarding data visualization. 43

Table 19: Requirements regarding model application 44

Table 20: Requirements regarding management functions. 46

Table 21: Requirements regarding interfaces and Integration 47

Table 22: Data protection and data security 47

Table 23: Data security and data protection 51

Table 24: Confidentiality classes. 52

Glossary

In addition to the BIM4INFRA2020 glossary (as at: April 2019)

Terms	Description
Dashboard	Graphical user interface where information or data from different sources is brought together, processed and visualized. *
Data	Data is the building block of information. Can be shared. Becomes information in the respective context and by way of interpretation.
Information	Information is data with a meaning. Information can be used to filter, sort, review, compare and analyse objects, among other things.**
Metadata	Metadata can also be used to structure data. Metadata is data that describes other data but does not contain the actual primary data. Metadata is used to make it easier to capture, organize, find and use data. Metadata should be chosen in such a way that it is machine-readable and evaluable. Metadata describing a (specialist) model can be, for instance, the author, the construction stage, the model number, the version number and the date of modification.***
Process	A process is the linking of tasks and activities to achieve a defined objective in the form of a product or service.
Single Source of Truth (SSOT)	The only source of truth. A uniform and holistic information source of consolidated data for all stakeholders in a project.
Workflow	A sequence of activities to achieve an objective that is specified by a use case, for instance. Note 1 on the term: Stakeholders or systems involved in the process carry out these activities and create or change information in the process. After the objective has been achieved, the result of the workflow is returned to the requester, for instance, project management.****

* Source: Cf. DWDS

** Source: Cit. ISO 17412, p. 7

*** Source: Cf. VDI 2552 – Part 5, p. 5

**** Source: Cit. DIN SPEC 91391 – 1, p. 9

Annex

The following annex is attached to this document:

I. Table of CDE requirements (Excel)

The annex is only available as a download on the BMVI website under “Masterplan BIM – Bundesfernstraßen”.

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