Federal Ministry
for Digital
and Transport

Federal Trunk Roads BIM Masterplan

Framework document: Definition of specialist models – version 1.0

Contents

Overview of the framework documents ... 4

Outline ... 5

1. Introduction ... 6

2. Model types ... 7
   2.1 Specialist model ... 8
   2.2 Submodel ... 8
   2.3 Coordination model ... 8
   2.4 Other models ... 9
      2.4.1 Operating model ... 9
      2.4.2 Construction process model (4D model) ... 9
      2.4.3 Quantity and costing model (5D model) ... 9

3. Description of the specialist models ... 10
   3.1 Specialist surrounding area model ... 11
   3.2 Specialist surveying model ... 12
   3.3 Specialist environment model ... 13
   3.4 Specialist geotechnical engineering/subsoil model ... 14
   3.5 Specialist traffic facility/line model ... 15
   3.6 Specialist civil engineering/structure model ... 16
   3.7 Specialist technical equipment model ... 17
   3.8 Specialist landscaping model ... 18
   3.9 Specialist line construction model ... 19

4. Level of Information Need (LOIN) ... 20

5. Recommendations for implementation ... 22
      Georeferencing ... 22
      Model ranges and model boundaries ... 22
      Object-oriented parametric modelling ... 22
      Object classification ... 22
      Interoperability and interfaces ... 23
      Granularity ... 23
      Test data exchange ... 23
      Quality assurance ... 23

6. Summary ... 24

7. References ... 25

Table of figures ... 26

List of tables ... 26

Overview of the framework documents

This framework document, 'Definition of specialist models', 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.

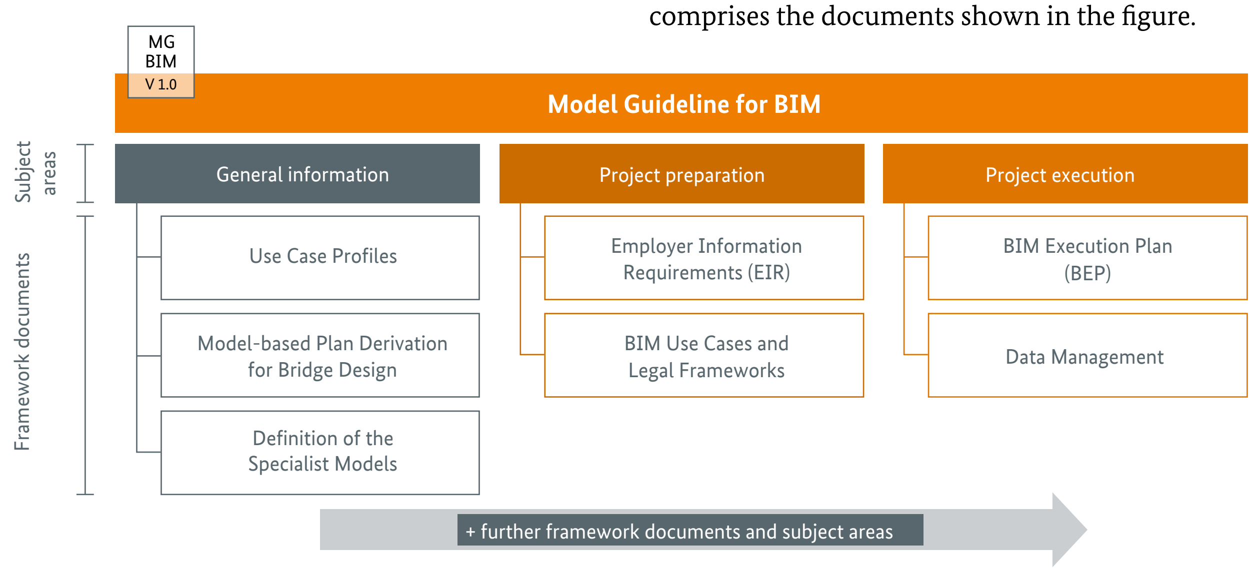
The version 1.0 framework documents were designed to facilitate updating to a new version of the model guideline for BIM at the beginning of phase II of the BIM implementation strategy; the same will apply again later for phase III. Finally, the documents will be transitioned to the model BIM guideline 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 talks of the Federal Government and the federal states on BIM. In these groups, various technical experts consisting of employees of the Federal Ministry of Transport and Digital Infrastructure, the Federal Highway Authority, 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 the input from the continuous participation of all stakeholders were taken into account. At the same time, the general developments in the BIM method were considered for national and international standardization.

As a result, the documents mirror 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 process 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 'Explanation of the framework documents'.

Version 1.0 of the model guideline for BIM comprises the documents shown in the figure.



Outline

This framework document is intended for all users of the BIM method. It fleshes out the ‘Part 7 – BIM Specialist Models and Level of Development’ toolkit of the BIM4INFRA project partnership with regard to the federal trunk road infrastructure. A specialist model is a model which contains only the model elements of one specialist discipline or trade. It is created, checked and delivered by the respective specialist planner in accordance with the project-specific specifications for modelling in the EIR and in the BAP.

The document provides the user with a description of the specialist models required for federal trunk road construction projects. The following key aspects will be addressed:

- Working with subject-specific models
- Relevant specialist models
- Design, structure and contents of the respective specialist models
- Dependencies between the various specialist models
- Definition of the required geometric and alphanumeric information (level of information need (LOIN))
- General recommendations for implementation

Users will find important information for working with and on subject-specific models in this document. The document includes both structural and content requirements for the specialist models and defines important elements for the model-based realization of federal trunk road infrastructure projects.

1. Introduction

With Building Information Modelling (BIM), a model-based working method is taking root in the planning, construction, maintenance and operation of structures. Instead of using a central digital model for project handling, each subject discipline creates their own specialist model [1], and individual models are merged and coordinated at regular intervals. This procedure corresponds to the work with federated models according to DIN EN ISO 19650 [2].

Model-based work in the context of BIM is characterized by geometric building models being enriched with semantic information. Information can be better captured, structured and described in a machine-readable way by BIM than by conventional methods. The level of geometric detail of a technical construction model and the semantic information it must contain are to be determined by the project participants and the employer. All project participants need to provide their services in accordance with the agreed specifications.

This framework document describes the key terms and relations with regard to the model-based implementation of construction projects using specialist models. First, the terms specialist model, submodel and coordination model will be described and their different features and elements distinguished [1, 3, 4, 5]. This is followed by a detailed presentation of the subject-specific models relevant in the context of federal trunk road construction projects in the form of fact sheets. Specifications are also given for the definition of the information (geometric as well as alphanumeric) requirements on which the models are based [6]. Finally, some overarching recommendations for implementing model-based working with subject-specific models are explained. Among other things, these address the specific requirements for model-based working in the federal highway infrastructure.

2. Model types

The BIM methodology is based on a model-based approach. Digital building information models are created and used to plan, execute, operate and maintain structures. Models are not created simultaneously in a common central model, but all project participants work autonomously on their own **specialist model**.

To coordinate the different specialist models and check for geometric and semantic consistency, individual specialist models are merged at regular intervals to form an overall **coordination model** (see Figure 1).

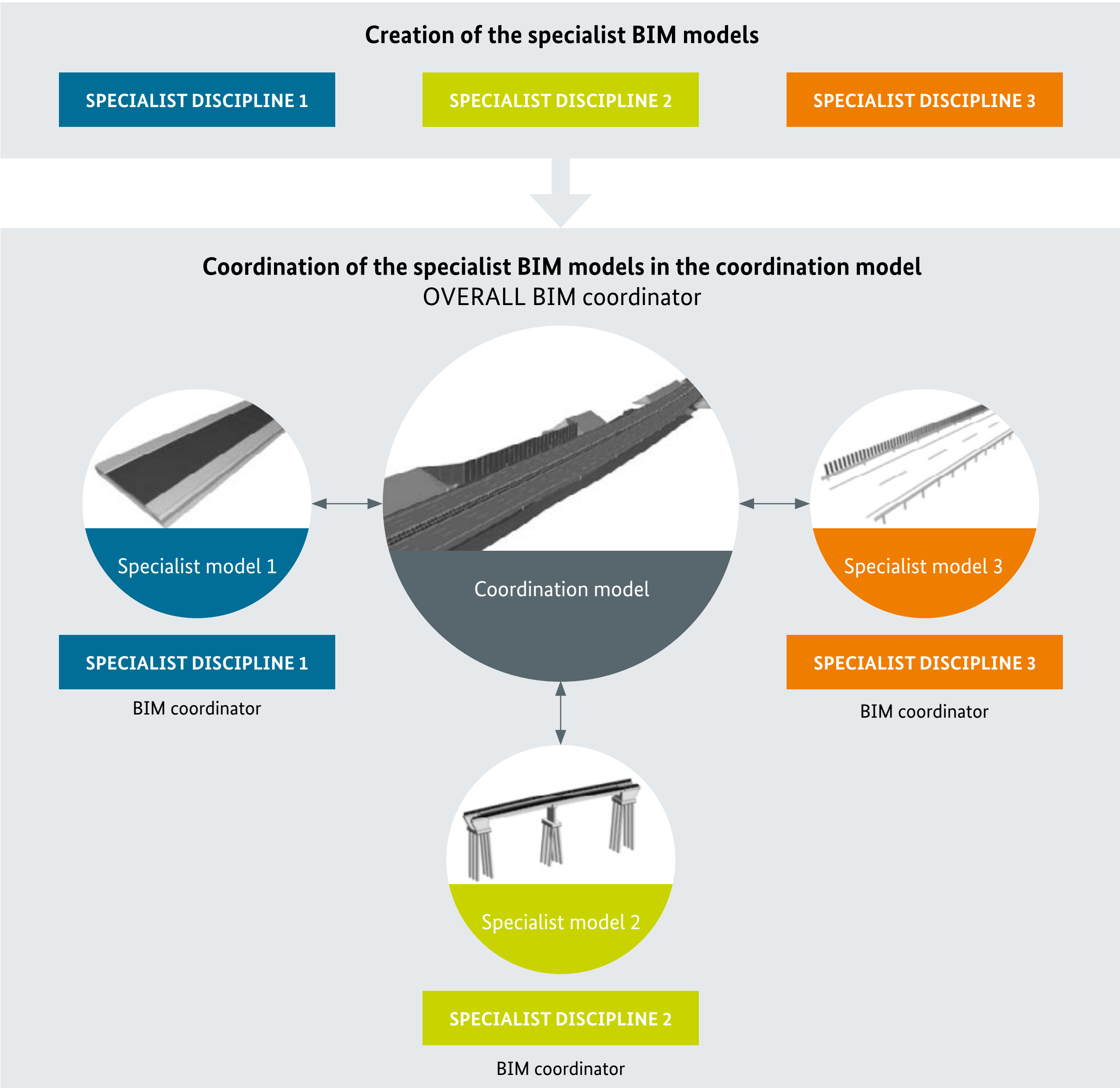


Figure 1: Planning coordination based on building models (© Schüßler-Plan/ STRABAG)

2.1 Specialist model

The term **specialist model** describes the entire model-based planning of a single specialist discipline or trade. A specialist model contains only the model elements of the corresponding discipline or trade. Specialist models are created by the corresponding object or specialist planners in corresponding BIM-capable authoring software. Each specialist discipline is responsible for creating a consistent model and must ensure the quality of their project-specific standards. Quality assurance is the responsibility of the BIM coordinators of the individual disciplines or trades. Ideally, the specialized models are handed over in the standardized, manufacturer-neutral IFC (Industry Foundation Classes) format [7]. If necessary, other handover formats are to be agreed upon to exchange the information in digital form. A special role is played by multi-model containers which are used to transfer linked information units in a container. A typical example is an IFC model linked with a GAEB format (Gemeinsamer Ausschuss Elektronik im Bauwesen - Joint Committee on Electronics in the Construction Sector) for describing the bill of quantities [8].

A list of relevant specialist models in the context of federal trunk road construction projects can be found in section 3 of this framework document.

2.2 Submodel

A **submodel** is a subset of a corresponding specialist model. It represents a partial content of the specialist discipline. This can refer to the **spatial** extent (e.g. individual sections or structures) as well as to the further **technical** subdivision (e.g. superstructures and substructures for bridges). The overall specialist model of a discipline is the sum of all partial contents of this discipline. The submodels are usually edited in the same authoring software as the superordinate specialist model. Redundant data within the submodels of a discipline should be avoided.

2.3 Coordination model

Individual specialist models and submodels are combined in a **coordination model** (see Figure 1). For this purpose, quality-assured models of the specialist disciplines and, if possible, manufacturer-neutral formats, such as IFC, are to be used. The individual models are merged using a coordination software which also allows to evaluate and analyse them. In the coordination model, the consistency of the different specialist models or submodels is verified. The overall BIM coordinator is responsible for creating the coordination model.

Coordination models are created for specific purposes and at defined points in time (e.g., work status, defined milestones, or deliverables at the end of a specific service phase). Model-based tasks and discrepancies identified during model coordination are documented and communicated to specialist planners. For this purpose, usually issues are created in the BIM Collaboration Format (BCF) [9]. Individual specialist models are not adapted in the coordination software, but in the corresponding authoring software.

In the context of infrastructures, in particular with regard to corrective maintenance and strengthening measures as well as replacement structures, it it very important to map the existing situation. The contents of an as-built model are multi-layered and can include, for example, surrounding area and survey data, transport facilities, bridge structures, pipes and wires as well as other data. As-built models are therefore usually not individual specialist models, but coordination models which contain the fundamentals relevant for planning and construction in the **as-built state**.

After completion of the as-built modelling at the end of the basic evaluation (LPH 1), the specialist models form the basis for the elaborations in the subsequent service phases. In the course of preliminary planning and subsequent service phases, they are sometimes updated. The various as-built specialist models are integrated accordingly in the coordination models for **planning, construction, maintenance and operation**.

During construction, the planning specialist models are updated as as-built models or operating models at the end of service phase 9 in the sense of construction documentation for operation. Further explanations can be found in the description of other model types in section 2.4.

When all available specialist and submodels are merged, the coordination model is referred to as **overall model**. The creation of an overall model is required in particular to complete a corresponding service phase.

2.4 Other models

2.4.1 Operating model

The operating model is developed based on the "as-built" model. Information for operation and maintenance is added to the model. Accordingly, structural elements as well as information on planning and construction execution are sometimes discarded to facilitate model-based operations and maintenance activities.

2.4.2 Construction process model (4D model)

By linking a 3D model with the construction process planning, construction processes can be both visualized and simulated. Ideally, model elements are linked with activities of the schedule based on rules. By adding further content to the 4D model, both the construction logistics and the required resources (personnel, materials, construction machinery, etc.) can be represented. In addition, the 4D model allows conflicts in the process to be identified at an early stage before construction begins.

2.4.3 Quantity and costing model (5D model)

The quantity and costing model is the result of the determination and evaluation of component quantities and associated costs. Corresponding quantities are derived from the models and incorporated into a quantity or costing structure.

3. Description of the specialist models

The principles described in section 2 for working in different specialist models are based on the disciplines or trades represented in planning and construction. The following specialist models are usually relevant in the context of federal highway construction projects:

Table 1: Specialist models and possible submodels for federal trunk road construction projects

Specialist model	Possible partial contents
Surrounding area	▪ Digital terrain model ▪ City model ▪ Digital orthophotos ▪ Official land register ▪ Digital maps/specialist maps ▪ Explosive ordnance
Surveying	▪ Building survey ▪ Site survey/digital terrain model ▪ Laser scan or photogrammetry scatter diagrams
Environment	▪ Species protection ▪ Nature conservation ▪ Water management ▪ Immission control
Geotechnical engineering/ subsoil	▪ Subsoil explorations/drilling profiles ▪ Subsoil layers/soil layers ▪ Hydrological data/water levels
Traffic facility/ line	▪ Alignment ▪ Superstructure ▪ Earthworks/substructure ▪ Drainage
Civil engineer-ing/structure	▪ Bridge ▪ Superstructures ▪ Substructures ▪ Tunnels ▪ Retaining walls ▪ Protective walls
Technical equipment	▪ Traffic signs ▪ Direction signage ▪ Pavement markings ▪ Vehicle restraint systems ▪ Traffic signals/light signals ▪ Street lighting ▪ Safety systems ▪ Mechanical engineering
Landscaping	▪ Roadside greenery ▪ Greening of noise barriers
Line construc-tion	▪ Water pipelines ▪ Wastewater pipelines/sewers ▪ Gas pipelines ▪ Power lines ▪ Telecommunication lines

In the following sections 3.1 to 3.9, the listed specialist models are specified in more detail. For this purpose, the content of each specialist model is described in a profile, responsibilities for its creation are determined, possible submodels are listed, and input data and dependencies are defined. In addition, it is shown at which life cycle phases (basic evaluation, planning, execution and operation) these models are usually primarily implemented.

Not every specialist or submodel is necessarily represented by a three-dimensional geometry. Among other things, the geodata to be included in the context of infrastructures are often integrated as 2D geometry using raster or vector data.

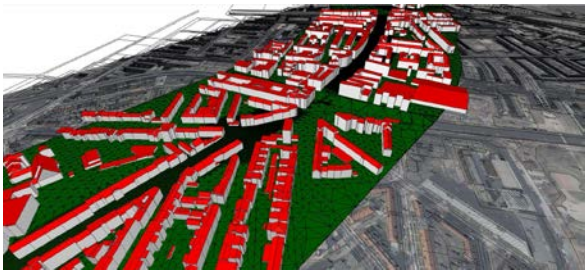
The contents and possible submodels mentioned do not claim to be complete. These are to be detailed and defined on a project-specific basis.

3.1 Specialist surrounding area model

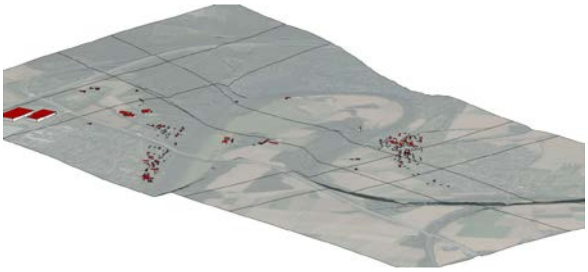
Specialist surrounding area model

Description

The specialist surrounding area model essentially comprises general information or information on the existing situation in the surrounding area of the construction project, such as terrain, urban planning conditions or land register data. Surrounding area data is collected and merged in a defined corridor along the line. The individual contents are available in the form of geodata, which can often be obtained from geoportals of the respective federal states. In this context, it must be clearly defined which data structures as well as formats are provided and how they can be integrated while preserving relevant semantic information.



© Schüßler-Plan/HOCHBAHN



© Schüßler-Plan/DEGES

Author

The data are primarily collected by the federal state geodesy/surveying offices. The integration of the data is carried out by the overall BIM coordinator responsible for the project.

Primary implementation

- [x] Basic evaluation
- [ ] Planning
- [ ] Execution
- [ ] Operation

Possible submodels

In the specialist surrounding area model, individual technical subdivisions are made, such as:

- Digital terrain model
- City model
- Digital orthophotos
- Official land register
- Digital maps/specialist maps
- Explosive ordnance

A spatial subdivision into individual (line) sections is possible.

Input data

- Publicly available data from the geoportals of the federal states

Dependencies

- To be updated if necessary in case of changes in the surrounding area
- Digital terrain model sometimes to be integrated into the survey

3.2 Specialist surveying model

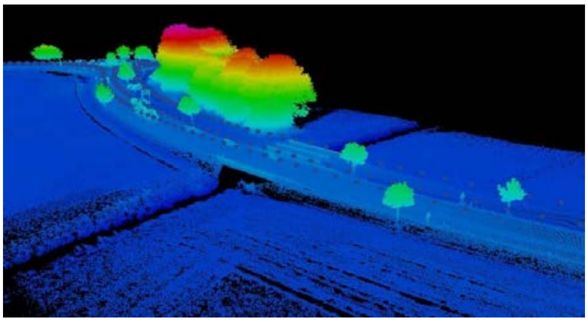
Specialist surveying model

Description

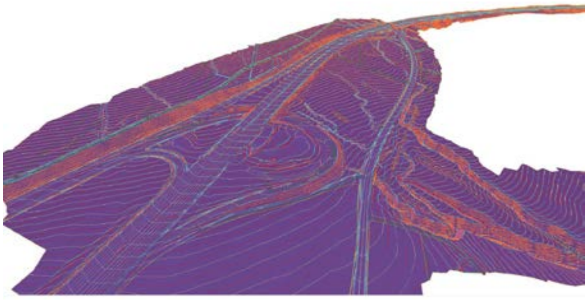
The specialist surveying model is used to describe and derive the current state. This includes surveying existing building structures as well as the surrounding area or terrain. Specialist surveying models serve as the central basis for all other specialist models, from the basic evaluation for planning to construction and operation. The level of detail of the surveying is defined at the beginning of the project between the contracting entity and the survey engineer.

Surveying activities must be documented in a clear and transparent manner. These include, for example, a complete triangulation and description of break-off edges in digital terrain models or the unambiguous description of component edges in building surveys.

The generated data must be compatible with the respective authoring software of the object and specialist planners. For this purpose, manufacturer-neutral handover formats are to be used wherever possible.



© STRABAG



© Schüßler-Plan/DEGES

Author

Survey engineer

Primary implementation

Basic evaluation	Planning	Execution	Operation
■	■	■	■

Possible submodels

Among others, the following submodels can be generated:

- Building survey
- Site survey/digital terrain model
- Laser scan or photogrammetry scatter diagrams

Spatially, the specialist model is to be subdivided according to the individual structures and, if necessary, (line) sections.

Input data

- No separate input data required
- Often integration of raster digital terrain models from the specialist surrounding area model for terrain surveying

Dependencies

- Central basis for all further specialist models

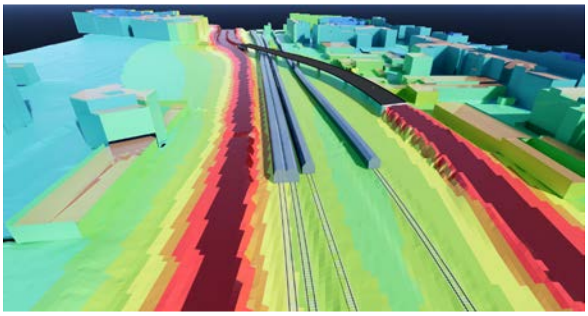
3.3 Specialist environment model

Specialist environment model

Description

The specialist environment model includes all biogeographic and protection-related data. The corresponding information is stored in geographic information systems (GIS) in the form of vector and raster data, often as 2D representations.
The data structures sometimes vary. Interoperability of geodata in the context of BIM must be ensured. Therefore, suitable interfaces and handover formats must be selected for data integration to ensure a loss-free transfer of the geometry-based representation and, above all, of the semantic information. This requires close coordination between the specialist environment planner and the overall BIM coordinator.

© Schüßler-Plan



© Schüßler-Plan/DEGES

Author

Specialist environment planner

Primary implementation

Basic evaluation	Planning	Execution	Operation
■	■	□	□

Possible submodels

In the specialist environment model, individual technical subdivisions are made, such as:

- Species protection
- Nature conservation
- Water management
- Immission control

A spatial subdivision into individual (line) sections is possible.

Input data

- Specialist surrounding area model
- Specialist surveying model
- Specialist traffic facility/line model
- Specialist civil engineering/structure model

Dependencies

- Interaction with the specialist landscaping model where species and site protection planning measures are defined

3.4 Specialist geotechnical engineering/subsoil model

Specialist geotechnical engineering/subsoil model

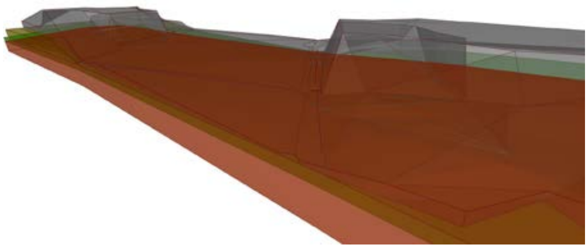
Description

The specialist geotechnical engineering or subsoil model is used to describe the subsoil situation. This includes, for example, subsoil explorations and soil layers established or interpolated on that basis, groundwater and waterlogging conditions and the division of the subsoil into homogeneous areas. As semantic information, the specialist model contains the corresponding data from the geotechnical report. Examples are characteristic soil parameters, LAGA* classes, properties of homogeneous areas and characteristic water levels.

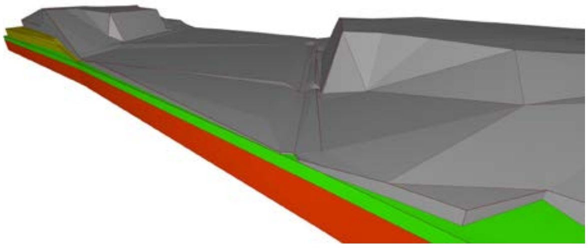
To ensure data consistency, the longitudinal geological section has to be established on the basis of the subsoil model.

The uncertainties associated with the subsoil model are equivalent to that of conventional 2D representations in the geotechnical report. However, this should be explicitly stated in the contracts if necessary.

* Bund/Länder-Arbeitsgemeinschaft Abfall (LAGA), German Working Group on Waste Issues of the Federal States and the Federal Government



© Schüßler-Plan/Autobahn GmbH des Bundes



© Schüßler-Plan/Autobahn GmbH des Bundes

Author

Specialist geotechnical engineering planner/subsoil expert

Primary implementation

Basic evaluation	Planning	Execution	Operation
■	■	□	□

Possible submodels

In the specialist geotechnical engineering/subsoil model, individual technical subdivisions are made, such as:

- Subsoil explorations/drilling profiles
- Subsoil layers/soil layers
- Hydrological data/water levels
- Contamination

A spatial subdivision into individual line or structure sections is possible.

Input data

- Specialist surrounding area model
- Specialist surveying model

Dependencies

- Basis for the specialist engineering/structure and traffic facility/line models

3.5 Specialist traffic facility/line model

Specialist traffic facility/line model

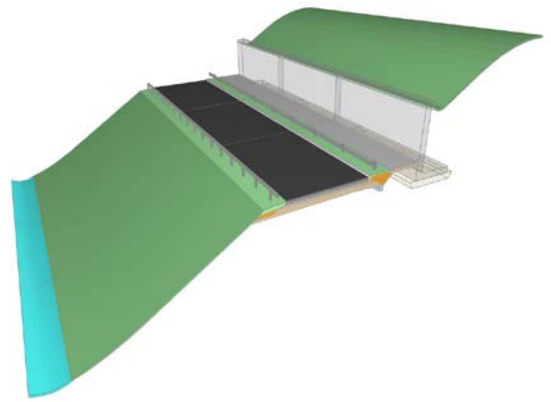
Description

The specialist traffic facility or line model contains the object planning of the traffic facility. This includes all data on the alignment (axes, gradients, etc.) as well as the complete roadway (superstructure, earthworks, drainage, etc.).

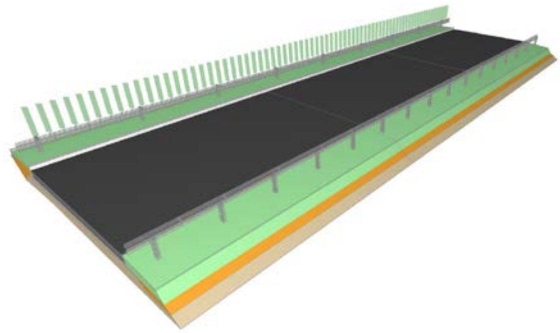
Individual layers of the road body are to be modelled and classified as individual model elements. Along the alignment, the model objects are to be divided into blocks. Earthwork fillings or excavations are to be taken into account to allow for model-based quantity determination. Safety spaces of carriageway, bike lanes, sidewalks, etc. are to be represented in the model.

The specialist model is based in particular on surveying and surrounding area data; corresponding data is to be integrated into the authoring software.

Under certain circumstances, it may be useful to integrate certain technical equipment elements, such as road markings or vehicle restraint systems, into the specialist traffic facility/line model. Corresponding specifications are to be coordinated on a project-specific basis.



© Schüßler-Plan



© Schüßler-Plan

Author

Transport facility object planner

Primary implementation

Basic evaluation	Planning	Execution	Operation
■	■	■	■

Possible submodels

Among others, the following subdivisions can be used:

- Alignment
- Superstructure
- Earthworks/substructure
- Drainage

A spatial subdivision can be made according to the respective need (e.g. into line sections).

Input data

- Specialist surrounding area model
- Specialist surveying model
- Specialist environment model
- Specialist geotechnical engineering/subsoil model
- Specialist civil engineering/structure model

Dependencies

- Interaction with all other specialist models possible
- In particular, dependency on the specialist civil engineering/structure model; corresponding interfaces (e.g. modelling boundaries) must be coordinated

3.6 Specialist civil engineering/structure model

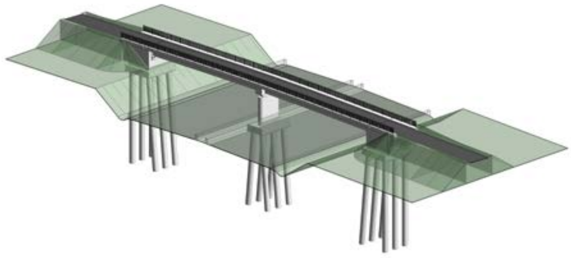
Specialist civil engineering/structure model

Description

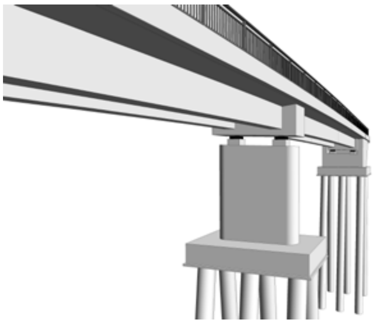
The specialist civil engineering or structure model comprises the object planning of civil engineering structures. This includes bridges, tunnels, retaining walls and noise barriers as well as protective walls. The individual model objects are to be modelled and classified by component (for bridges, e.g. foundation, pier, abutment, bearing, superstructure, equipment, etc.).

When creating the specialist model, the focus is primarily on the specifications from the alignment of the line and the interaction of the structure with the surrounding area (digital terrain model). Corresponding data must be integrated into the authoring software. Terrain adjustments, such as construction pit excavation, backfill, or slopes, are to be considered in the model to allow for model-based quantity determination.

Possibly, it may be useful to integrate certain technical equipment elements, such as road markings or vehicle restraint systems, into the specialist civil engineering/structure model. Corresponding specifications are to be coordinated on a project-specific basis.



© Schüßler-Plan



© Schüßler-Plan

Author

Civil engineering structures object planner

Primary implementation

Basic evaluation, Planning, Execution, Operation

Possible submodels

Spatial subdivision happens by individual structures within the project area. This includes the following structure typologies:

- Bridge
- Tunnels
- Retaining walls
- Noise barriers and protective walls
- etc.

In addition, individual technical subdivisions can be made (e.g. substructure submodel, superstructure submodel, etc.).

Input data

- Specialist surrounding area model
- Specialist surveying model
- Specialist environment model
- Specialist geotechnical engineering/subsoil model
- Specialist traffic facility/line model

Dependencies

- In particular, dependency on the specialist traffic facility/line model; need for coordinating corresponding interfaces (e.g. modelling boundaries)

3.7 Specialist technical equipment model

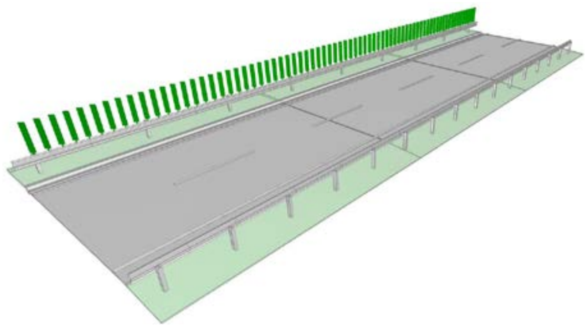
Specialist technical equipment model

Description

The specialist technical equipment model contains the technical traffic and operational equipment objects of the traffic facility. The creation of the specialist model must take into account the alignment of the line.

The representation of the equipment elements varies from a simplified representation to a detailed modelling.

Under certain circumstances, it may be useful to include certain technical equipment elements, such as road markings or vehicle restraint systems, in the specialist traffic facility/line or civil engineering/structure model using a different level of detail. Corresponding specifications are to be coordinated on a project-specific basis.



© Schüßler-Plan

© Schüßler-Plan/DEGES

Author

Specialist planner for traffic facilities and specialist planner for operational facilities

Primary implementation

Basic evaluation	Planning	Execution	Operation
☐	■	■	■

Possible submodels

From a technical point of view, for example, a subdivision into the following submodels is possible:

- Traffic signs
- Direction signage
- Pavement markings
- Vehicle restraint systems
- Traffic signals/light signals
- Street lighting
- Safety systems
- Mechanical engineering

A spatial subdivision, e.g. into (line) sections or structures, can also be made.

Input data

- Specialist surrounding area model
- Specialist surveying model
- Specialist traffic facility/line model
- Specialist civil engineering/structure model

Dependencies

- In particular, the interactions with the specialist models traffic facility/roadway and civil engineering/structure are to be taken into account.

3.8 Specialist landscaping model

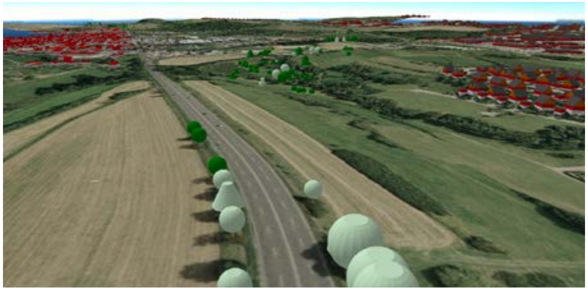
Specialist landscaping model

Description

The specialist landscaping model includes all measures of nature conservation and landscape management. This includes the creation, securing and maintenance of compensation or replacement measures for unavoidable impact in terms of species and area protection.

Accordingly, it represents the planning implementation of the natural space and protection-related data recorded in the specialist environment model.

The contents of the specialist landscaping model are based on the corresponding management and implementation planning and the concept of measures defined therein. These include, above all, design measures such as the creation of roadside greenery or the greening of noise barriers.



© Schüßler-Plan/card_1

© Schüßler-Plan/card_1

Author

Specialist landscaping planner

Primary implementation

Basic evaluation	Planning	Execution	Operation
☐	■	■	☐

Possible submodels

In the specialist landscaping model, individual technical subdivisions are made on the basis of planning measures related to prevention, compensation, replacement and design.
A spatial subdivision into individual (line) sections is possible.

Input data

- Specialist surrounding area model
- Specialist surveying model
- Specialist environment model
- Specialist traffic facility/line model
- Specialist civil engineering/structure model

Dependencies

- Strong dependence on the specialist environment and traffic facility/line models

3.9 Specialist line construction model

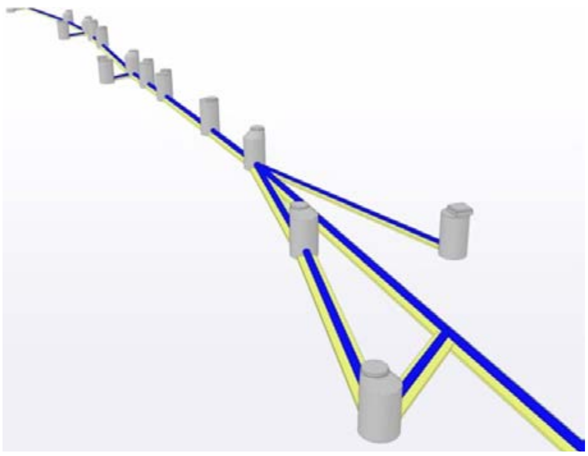
Specialist line construction model

Description

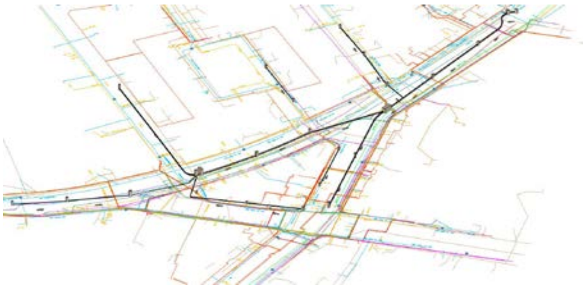
The specialist line construction model represents all project-relevant lines and shafts. These range, for example, from municipal drainage to supraregional network upgrades.

When representing the existing situation, it is often difficult to record the height of the lines (water, electricity, gas, telecommunications), so that sometimes no 3D representations are possible and corresponding data can only be integrated into the model as 2D geometry. A volumetric 3D representation of wastewater pipelines and ducts is usually possible.

In order to be able to represent existing position tolerances, extended line corridors are often stored in the model. In the case of overhead lines, protective spaces are to be included in the model.



© STRABAG



© Schüßler-Plan/HOCHBAHN

Author

Object and specialist planners of the affected trades

Primary implementation

Basic evaluation	Planning	Execution	Operation
■	■	■	■

Possible submodels

Depending on the granularity, a functional subdivision can be made into supply and disposal lines or into further submodels, e.g.:

- Water pipelines
- Wastewater pipelines/sewers
- Gas pipelines
- Power lines
- Telecommunication lines

A spatial subdivision according to individual (line) sections or structure areas is sometimes useful.

Input data

- Specialist surrounding area model
- Specialist surveying model
- Specialist geotechnical engineering/subsoil model
- Specialist traffic facility/line model
- Specialist civil engineering/structure model

Dependencies

- In particular, the interactions with the specialist models traffic facility/roadway and civil engineering/structure are to be taken into account

4. Level of Information Need (LOIN)

For the specialist models described in section 3, information requirements regarding the geometric and semantic elaboration of the models are to be defined by the employer during the tendering and awarding of the project. This is done in the project-specific employer information requirements (EIR). Additional information on these requirements can be found in the Employer Information Requirements (EIR) framework document. In the following section, the main definitions for the structure of digital building model information requirements and their elements are established.

The elaboration is based on DIN EN 17412-1 "Building Information Modelling – Level of Information Need – Part 1: Concepts and Principles". The **Level of Information Need** or **LOIN** describes the scope and level of detail of information exchanged in terms of geometry, data and documentation [6]. Since the information requests of the individual project participants differ depending on the point in time and the specialist discipline, the level of information need (LOIN) specifies precisely which information is needed for which use objective at which point in time and by which actor. The LOIN, which, according to [1] was formerly referred to as LOD (level of development), is divided into geometric information, alphanumeric information and documentation.

For specifying the **geometric information**, which, according to [1] was formerly referred to as LOG (level of geometry), of an object or set of objects the following aspects can be used:

- Detail (complexity of the object)
- Dimensionality (point, line, surface or volume)
- Location (positioning and alignment)
- Appearance (visual representation)
- Parametric behaviour (degree of dependence on other information)

For specifying the **alphanumeric information**, which, according to [1] was formerly referred to as alphanumeric level of detail or level of information (LOI), of an object or set of objects the following aspects are relevant:

- Identification of the object in the structure plan (e.g. name, type, index, classification)
- Information content (list of necessary features)

Documentation for an object or set of objects to support processes, decisions, approvals, and verification of information deliveries should be specified as a set of required documents:

- Document quantity (frequency)
- Document type (data sheets, manuals, calculations, etc.)
- Document format (IFC, PDF, XLSX, etc.)

Verification and validation processes are simplified by delineating the application goals of each level of information need (LOIN), setting up information delivery milestones, identifying stakeholders, and specifying the objects desired for delivery. The purpose of the LOIN is thus to minimize misinformation and misinterpretation of the requirements made. The risk of redundancies is reduced.

In practice, geometric information in particular is often subdivided into intermediate steps or levels.[1] Level 100 describes the lowest level of information and level 500 the highest. General qualitative descriptions or specific descriptions with sample components can be used for the levels. However, both at national level (e.g. DEGES, BIM.Hamburg, Deutsche Bahn) as well as at international level, there are some discrepancies between descriptions. In future, definitions must be harmonized. In the following, the definition of BIM.Hamburg [10] is presented as an example:

Table 2: Levels of geometric information according to the definition of BIM.Hamburg [10]

Level	Description
100	The model with its elements can consist of simpler and rougher visualizations. It does not necessarily have to contain individual model elements. Model elements can also be represented by a symbol or other generic representations.
200	The essential model elements are shown in the model according to type as components or groups of components with information on dimension, shape, position and geographical reference. Each model element is graphically represented in the model by a generic object. These objects can serve as placeholders. They do not yet have to be recognizable as the component they represent.
300	A model element is shown geometrically as an object with exact quantities, size and shape, as an exact solid. The orientation of the elements can be measured directly in the model without having to resort to other sources. It is possible to derive information about quantities and other data from the model for bills of quantities.
400	A model element is sufficiently detailed and accurately shown to include all the information necessary to produce the component. The quantity, size, form, location and orientation of the elements can be measured directly in the model without having to resort to other sources.
500	A model element corresponds to the representation of the real component as checked or recorded on the construction site. The minimum requirement is the representation of all components that are decisive for the operation in the required level of detail. Complex geometries are removed or simplified.

The concrete contents and individual differences between geometric information and alphanumeric information are to be defined in the EIR on a project-specific basis. In the project, a uniform LOIN structure is intended to support an efficient exchange of information in the BIM process, to limit information to what is required, and to simplify the award, approval and review processes. To ensure uniform structures and reusability of the defined requirements in other projects, the federal BIM portal is to be used to define the LOIN. Corresponding modules are available here, in particular for the creation and management of properties and property sets, as well as EIR.

1 Levels for describing geometric information are not explicitly defined in EN 17412-1. However, since this standard for distinguishing between the level of detail is already established nationally and internationally, the selected subdivision is recommended.

5. Recommendations for implementation

The specialist models described in section 3 are to be created by the respective persons responsible for the individual specialist disciplines. The processes of modelling differ between the specialist models and authoring systems used. However, there are some principles and standards which must be taken into account when creating models, regardless of the specialist discipline:

Georeferencing

The specialist models are to be created in the position and elevation system defined for the project. A handover of the model in real overall coordinates is often not possible, because the large numerical values in the software applications lead to numerical inaccuracies. Therefore, a project origin with geodetic coordinates is defined for the models, specifying the geodetic coordinate reference system, and the modelling is done in a local coordinate system whose origin is in the project origin. The handover of the specialist models with reference to the specific project origin must be ensured. The underlying geodetic coordinate reference system (position status with EPSG code and elevation status) must be identified in the models.

It must be taken into account that, in the course of the project, the geodetic reference systems to be applied at a higher level are usually transferred to local construction site systems for execution. A transformation of the models between the different systems results in the chosen lengths and angles being distorted. Depending on the extent of the distortion, it must be considered together with the surveying whether this fact is addressed in practice with a remodelling of the structure, a translational fitting of the model or a transformation of the model.

Model ranges and model boundaries

For each specialist model, a corridor must be defined in which the modelling is to take place. This concerns both the model boundaries in parallel with and along the road. Especially in the interaction between different disciplines, the transition areas of the models have to be coordinated individually. For example, the embankment and the slopes can be modelled up to a defined area behind the abutment in the specialist civil engineering model before, after a model boundary, the modelling in the specialist traffic facility model follows.

Object-oriented parametric modelling

The specialist models in the authoring software are usually created using parametric object-oriented modelling approaches. The models are created on the basis of essential geometric boundary conditions (main and secondary axes, gradients, stationing, cross slope, etc.). Compared to a direct modelling, parametric modelling allows to react faster and more efficiently to changes of these boundary conditions, because the (partially) associative geometry is adapted automatically. Ideally, component libraries are built up in which templates for modelling are created. These can be used in various projects.

Object classification

The model objects of the individual specialist models must be clearly classified. This requires an appropriately structured, type-compliant modelling of components and component groups. Classification can be used to delimit and order the components. Through the data structure, uniform model elements can be identified. Currently, objects are classified using properties. This means that a classification via the IFC format can already be implemented today.

Interoperability and interfaces

For interoperability between the disciplines and for coordination, handover formats and exchange processes must be defined. This applies in particular to data that is to be integrated into other authoring systems as a basis, such as the alignment of the traffic facility. Furthermore, in the context of infrastructures, the integration of geodata in geoinformation systems (GIS) in particular plays a decisive role. Therefore, interoperability between geospatial and model data should be the goal. The transfer of data from the proprietary systems of the disciplines into open data formats must be ensured by the specialist discipline.

Granularity

The objects of the model are to be modelled in line with execution at a later stage on the construction site. This means that the model elements are to be subdivided geometrically according to their natural boundaries. The granularity of the model is to be adapted to the use cases defined in the EIR. The use cases to be realized in the project should therefore already be taken into account at the beginning of the project when considering the modelling. They significantly influence the model structure and classification. The model must be structured in such a way that, for example, the construction process can be simulated (4D model) or the model objects can be assigned to individual cost items according to the cost structure (5D model).

Test data exchange

At the beginning of the project, all project participants must exchange data for test purposes. This serves to coordinate the compliant handover of the defined delivery items. In particular, the basic practicability of the defined level of information need (geometric and alphanumeric information) for a specific project must be ensured in the test for all project participants.

Quality assurance

The quality of the models must be continuously ensured. Decisive here are the IFC files or models in other agreed exchange formats to be handed over, but not the native files of the respective authoring software. Quality assurance concerns both the conformity of the individual specialist models as well as that of the coordination models (conformity of different specialist models with each other). For the specialist models, quality assurance is performed by the BIM coordinators and for the coordination models it is performed by the overall BIM coordinator. When carrying out the test, the correct modelling is verified both in specialist and technical terms.

Only quality-assured models are handed over to the client. Quality assurance can also include only partial aspects if certain information is not required. In the early project phases, the focus of model check is usually on the geometric conformity of the models. However, in the further process, semantic model checks, in addition to geometric checks, become more important, since the corresponding use cases (including cost calculation, tendering and awarding) are derived from the semantics.

When delivering the models at the end of a service phase, a final quality report has to be handed over. On the client side, the BIM manager checks the models for conformance to the specifications defined in the EIR and the BIM execution plan (BAP). At the end of the quality assurance by the BIM management, the models are released.

6. Summary

In the model-based design, construction, maintenance and operation of building projects, collaboration within the different (specialist) models is a central component when applying the BIM method. In this context, the framework document compiles the essential aspects for working with and on federal highway infrastructure models.

The framework document provides an overview of relevant specialist models for federal trunk roads construction projects and their contents. The disciplines and trades usually responsible for creating the individual specialist models are listed here and possible submodels are shown. Together with the input data and their dependencies, they provide an overview of which models are usually created by the individual trades during the course of the project and how they relate to other trades.

In addition, the procedure for defining the level of information need (LOIN) is described. The LOIN forms the basis for the information depth of the individual models through the client's specifications for geometric and alphanumeric information of the specialist models.

For the elaboration of the specialist models, general recommendations for implementation are given, which can be taken into account regardless of the specialist discipline or the software used in the creation of the model.

7. References

[1] BIM4INFRA: Handreichung Teil 7 – BIM-Fachmodelle und Ausarbeitungsgrad, April 2019, URL: https://bim4infra.de/wp-content/uploads/2019/07/BIM4INFRA2020_AP4_Teil7.pdf, letzter Aufruf: 3 February 2021

[2] DIN EN ISO 19650: Organisation und Digitalisierung von Informationen zu Bauwerken und Ingenieurleistungen, einschließlich Bauwerksinformationsmodellierung (BIM) – Informationsmanagement mit BIM, August 2019

[3] DEGES: BIM-Leitfaden, July 2019, URL: https://www.deges.de/wp-content/uploads/2019/08/1_DEGES-BIM-Leitfaden_V15.pdf, last retrieved: 3 February 2021

[4] DEGES: BIM-Anwendungsfälle, September 2019, URL: https://www.deges.de/wp-content/uploads/2020/02/BIM-Anwendungsfälle_V23.pdf, last retrieved: 3 February 2021

[5] DEGES: BIM-Modellierungsrichtlinie, May 2021, URL: https://www.deges.de/wp-content/uploads/2021/05/BIM-Modellierungsrichtlinie_V2.0.pdf, last retrieved: 19 August 2021

[6] DIN EN 17412-1: Building Information Modelling - Level of Information Need - Part 1: Concepts and principles, June 2021

[7] buildingSMART: Industry Foundation Classes (IFC), URL: https://www.buildingsmart.org/standards/bsi-standards/industry-foundation-classes/, last retrieved: 19 February 2021

[8] Bundesamt für Bauwesen und Raumordnung im Geschäftsbereich des Bundesministeriums des Innern, für Bau und Heimat (BMI): Gemeinsamer Ausschuss Elektronik im Bauwesen (GAEB), URL: https://www.gaeb.de/de/produkte/gaeb-datenaustausch/, last retrieved: 30 February 2021

[9] buildingSMART: BIM Collaboration Format (BCF), URL: https://technical.buildingsmart.org/standards/bcf/, last retrieved: 19 February 2021

[10] BIM.Hamburg: LOG-Beschreibungen, Interne Arbeitsmaterialien, as at: 29 March 2020

Table of figures

Figure 1: Planning coordination based on building models 7

List of tables

Table 1: Specialist models and possible submodels for federal trunk road construction projects 10

Table 2: Levels of geometric information according to the definition of BIM.Hamburg [10] 21

Publication details

Published by
Federal Ministry of Transport and Digital Infrastructure
Invalidenstraße 44
10115 Berlin

Authors
Andreas Meister (BMVI, Division StB 27)
Nils Schluckebier, M. Sc. (BIM Deutschland)
Dr.-Ing. Andreas Bach (BIM Deutschland)
Boris Gerbersgagen, B. A. (BIM Deutschland)

Technical support, editing and design
BIM Germany - Centre for the Digital Transformation of Construction

As at
October 2021

Printed by
Federal Ministry of Transport and Digital Infrastructure, Prepress | Ministry Printers

www.bmdv.bund.de