Federal Ministry
for Digital
and Transport

# Federal Trunk Roads BIM Masterplan

## Framework document: Profiles of use cases - version 1.0

# Contents

# Overview of Framework Documents

The present 'Use Case Profiles' framework document is part of the Model Guideline for BIM (MG BIM). The framework documents of the MG BIM call for consistent application of the BIM method and support the implementation strategy explained in the Federal Trunk Roads BIM Masterplan. They provide practical answers to BIM-specific topics and issues that are an essential prerequisite for ensuring a uniform nationwide understanding of BIM in connection with federal trunk roads.

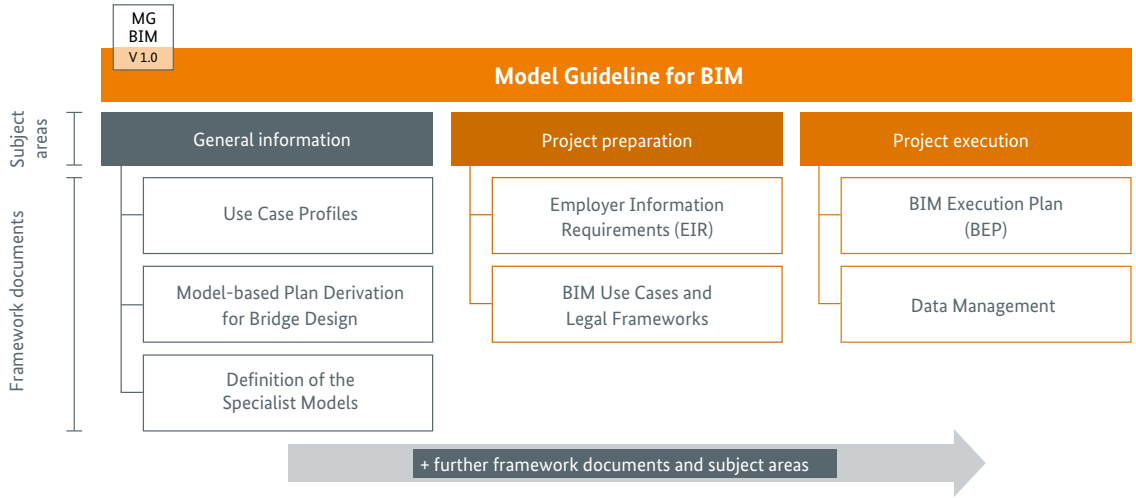
The version 1.0 framework documents have been prepared in such a way as to allow their incorporation into a new version of the Model Guideline for BIM at the start of phase II of the BIM implementation strategy; the same approach will then apply analogously to phase III. At the end, the documents will be integrated into the Model Guideline for BIM for the standard process.

The framework documents are prepared by specialist groups initiated by the German Federal Ministry of Transport and Digital Infrastructure (BMVI) and established by the official meetings of the Federal Government and the federal states on BIM. In these groups, a variety of experts – comprising staff of the Ministry, the German Highway Authority, Autobahn GmbH, DEGES (the German Unity Planning and Construction Company for Trunk Roads), 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 continuing application of the BIM implementation strategy for federal trunk roads. Experience gained in completed and ongoing projects, the proven BIM4INFRA2020 toolkits and contributions arising from the ongoing participation of all parties have also been taken into account. In addition, the general evolution of the BIM method within the scope of national and international standardization has been considered.

The documents therefore reflect both the state of the art in technology and advances in standardization. In view of this growth in knowledge, the framework documents replace the thematically corresponding parts of the BIM4INFRA2020 toolkits and are intended as recommendations for future projects and the possible adjustment of a wide range of standards and guidelines.

Each framework document is thematically self-contained and assigned to a category aligned with the project's planned trajectory. Interconnections with other framework documents are explicitly emphasized. Additional information on the framework documents is available in the document 'Explanation of the Framework Documents'.

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



# Abstract

Defining and achieving a common understanding of the main use cases of BIM are key for introducing and applying this technology in Germany. Having clear, uniform descriptions of these use cases, based on a uniform model and described using standardized nomenclature, is regarded as essential for the introduction and harmonized use of BIM for federal trunk roads.

Detailed descriptions of use cases take the form of profiles that supply basic information on them and the details of their implementation, as well as additional materials that provide a broad overview of the use cases and additional information relevant to their implementation.

The profiles primarily reveal what a particular use case involves, the project phase in which use cases are ordinarily implemented, the anticipated benefits, and the prerequisites for implementing them. The implementation details provide more exhaustive explanations of the steps involved in implementing a specific use case and the most important BIM roles involved. Supplementary materials then explain the details of practical implementation.

The profiles and implementation details of use cases, as well as additionally prepared materials, are intended for road construction administrations that use the BIM method within the scope of contracting the building of infrastructure and therefore also to define use cases and BIM requirements for projects. These standardized use case descriptions also address other stakeholders in the value chain comprising planning, construction and operation that wish to be involved in future projects in which BIM is used to build federal trunk roads (e.g. planning offices, construction firms and service providers).

The prepared profiles, implementation details and other materials for standardized descriptions of use cases supply essential information in summarized form on the eight prioritized use cases that have been selected for phase I of the Federal Trunk Roads BIM Masterplan. They include:

- Use Case 010 –Existing Conditions Modelling
- Use Case 020 – Requirement Planning
- Use Case 030 – Planning Variants and/or Preparation of Documents Substantiating the Budget
- Use Case 040 – Visualization
- Use Case 050 – Coordination of Professional Trades
- Use Case 060 – Planning Progress Review and Quality Control
- Use Case 070 – Dimensioning and Verification
- Use Case 080 – Derivation of Planning Documents
- Use Case 100 – Quantity Take-off and Costing
- Use Case 110 – Bill of Quantities, Tender, Contract Award
- Use Case 190 – Project and Structure Documentation

# Information on Documents

# 1. Relationship to Other Documents

The available profiles, implementation details and other materials have been prepared by BIM.Hamburg within the scope of the Federal Trunk Roads BIM Masterplan. They are based on the model profiles developed by BIM Germany and the use case project group as well as the harmonized list of use cases. The model profile in turn builds on the older, already acknowledged document BIM4INFRA2020 'Profiles of the Most Important BIM Use Cases' and analyses of additional profiles from various institutions and contracting entities.

As opposed to the BIM4INFRA toolkit, the following additions and adjustments have been made to the detailed use case descriptions within the scope of the Masterplan:

- Based on a consistent model profile, individual profiles have been developed for use cases in all four areas: federal building construction, federal trunk road construction, waterway construction and railway construction.
- Implementation details and other materials containing supplementary information on implementing use cases have been added.
- Technical aspects of federal trunk road construction have been described in greater detail.
- Existing content has been updated and/or supplemented.

# 2. Structure of the Document

Each use case is described by the following documents:

- The core document – the profile – which is uniformly structured across all areas and is a mandatory part of the standardized use case descriptions

as well as

- implementation details containing additional helpful information for implementing the use cases in the respective areas and an optional part for standardized description of the use cases. For the case of federal trunk road construction, the information contained in the profile itself is supplemented by implementation recommendations and a process diagram; and
- additional materials specific to the area concerned, such as lessons learnt, practical experience gained while implementing the use cases and training materials in the form of brief presentations and videos that concisely and informatively explain and visually present each of the use cases.

The individual documents build on one another and flesh out the content of the profile. The indicated documents describing the use cases and answering the questions posed in the brief depictions are graphically illustrated below and characterized in greater detail in the subsections.

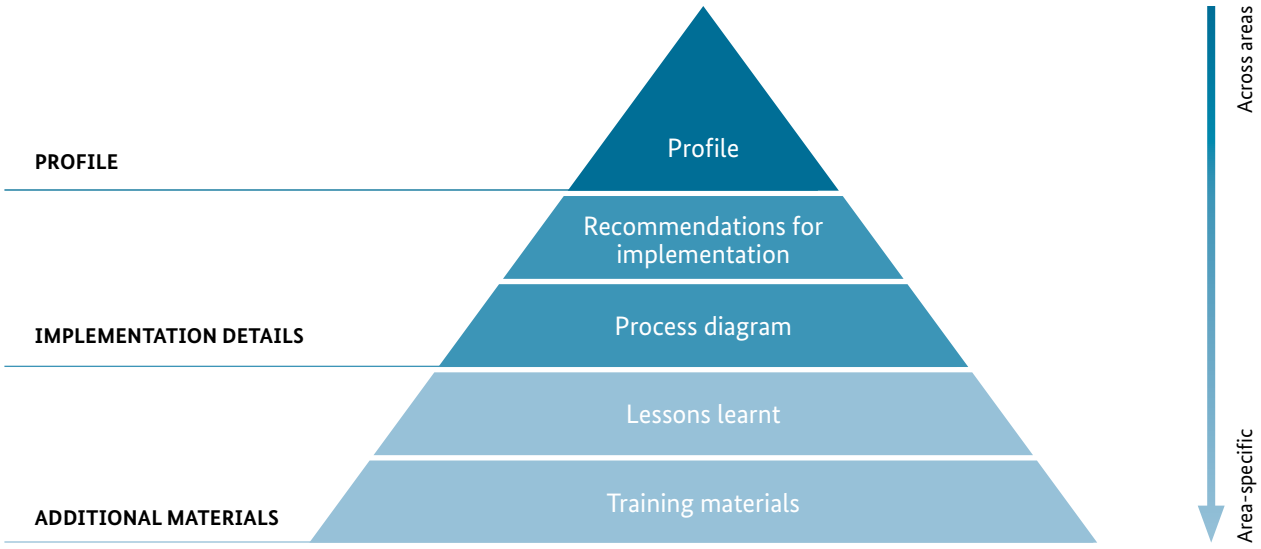



Figure 1: Structure of use case descriptions for federal trunk roads

## 2.1 Profile

A profile contains basic information on a given use case and a general overview of its benefits and implementation. It includes:

- Assignment to project phases
  Use cases are assigned to project phases in which their implementation may be expected. This temporal classification does not constitute a binding assignment of use cases to certain project phases but only an approach that will probably be taken, so they should therefore be understood as suggestions. Alongside the service phases as per the Fee Schedule for Architects and Engineers (HOAI), the body responsible for a measure may additionally assign use cases to the corresponding project phases.

- Definition of the use case
  The definition should ensure a basic understanding of the use case.

- Benefit
  Description of the benefits that implementation of the use case is expected to provide.

- Requirements
  Description of the required work and specific prerequisites that must be met before starting to implement the use case.

- Implementation
  Description of the general work steps that must be carried out to implement the use case. More detailed, in-depth descriptions and information are provided in the separate document 'Implementation Recommendations'.

- Input and output
  This point contains information on the typical data, models and formats that can be relevant to a particular use case, as well as data and information that form the results of the use case.

- Practical examples
  The use case concerned is also graphically depicted and verbally described as an example with the aid of screenshots and/or pictures from sample projects from actual practice.

## 2.2 Implementation Details

### 2.2.1 Implementation Recommendation

The information in the profile for implementing a use case is always added to the implementation recommendations. These describe in greater detail which work steps are required to implement the use case and which aspects need to be considered while doing so. It is also explained what does not constitute part of the use case, in order to clearly distinguish it from other use cases and prevent any misunderstandings in interpreting use cases. After being initially drawn up to level of implementation I, the implementation recommendation is considered in progressively greater detail as higher levels are developed.

### 2.2.2 Process Diagram

A process diagram helps describe the individual work steps and their dependencies, interfaces and decision points, the data and information to be exchanged and the corresponding BIM roles involved in implementing the use case. Only the most basic process building blocks are modelled. The process diagram is based on the BPMN (Business Process Model and Notation) 2.0 description standard. After being initially drawn up to level of implementation I, the process diagram is considered in progressively greater detail as higher levels are developed. The process diagram provides an overview of which BIM roles have primary responsibility for implementing each step of the process.

## 2.3 Additional Materials

### 2.3.1 Lessons Learnt

The document describes experience gained while implementing different use cases. These are broken down into five categories: people, technology, processes, framework conditions and data. The goal is to continually update and flesh out the lessons learnt document as more project experience is gained in the individual federal states.

### 2.3.2 Training Materials

The training materials visualize the content of a profile and implementation details in the form of short videos and brief presentations. Each of these contains a short summary of its core content and benefits as well as the principal steps involved in implementing the corresponding use case.

The information provided in the profiles, implementation details and additional materials is always generic and should therefore be treated as non-binding suggestions. It does not lay any claim to completeness, instead constituting recommendations for the standardized use of BIM. For actual application, they should be adapted and fleshed out in greater detail. Similarly, the provided figures and illustrations are mainly intended to provide inspiration for ideas. No conclusions should be drawn from them regarding the expected accuracy of models or their required use for particular purposes.

The document versions presented here may need to be adapted or supplemented in response to new requirements. Each new updated version of the profiles is made available on the BIM portal.

# Use Case 010
# Existing Conditions Modelling

# 1. Profile

## Assignment of the use case to project phases

In which service phase will the use case be implemented?

| No. | Use case | Service phase acc. to German fee schedule for architects and engineers (HOAI) | Operation |
|---|---|---|---|
| Use Case 010 | Existing Conditions Modelling | ■ ■ □ □ □ □ □ □ □ (1 2 3 4 5 6 7 8 9) | ■ (B) |

## Definition

The basic data and information required for the project is identified and obtained from a variety of sources, processed, merged, georeferenced and provided in the form of as-built models.

## Benefits

What value can implementing a use case be expected to add?

- It can serve as the basis for other use cases.
- Inconsistencies or missing information in as-built documentation can be spotted more easily.
- Risks are reduced (e.g. by timely identification of conflicts between as-built and new structures).
- Management of as-built data is enabled with intuitive, rapid usability of all available data (visual support for and localization of project information).
- Use of the models generated in this use case improves communication with all project stakeholders.

## Prerequisites

What is required to implement the use case?

- EIR and coordinated BEP
- Suitable role-specific software with BEP-compliant interfaces
- Qualified personnel for this use case

## Implementation

How is the use case implemented?

1. Identify and take into account requirements of the EIR and BEP.
2. View and check input data.
3. Identify and capture/query additional required data.
4. Convert digitally processable input data to a consistent geodetic reference system.
5. Create specialist as-built models.
6. Perform and document the quality control (contractor).
7. Perform and document the quality control (contracting entity).
8. Provide the quality-controlled results.

## Input

Available information, such as:

- Terrain model (e.g. LANDXML, ASCII)
- 3D city model (e.g. CITYGML)
- As-built plans (e.g. PDF, DXF)
- Survey data in the form of e.g. scatter diagrams, photographs, as-built models (e.g. LAS, E57, TIFF, IFC, ASC)
- Geotechnical site information, geospatial reference data, legacy mining activities (e.g. XML, DXF, IFC, PDF, CSV)
- ALKIS – Official Land Register Information System (e.g. DXF, NAS)
- Hazardous goods, ordnance, contaminated sites (e.g. PDF, DXF)
- Databases (e.g. ASCII, WMS, WFS)
- Orthophotos (e.g. WJPG, GEOTIFF)
- Audit plans (e.g. PDF)
- etc.

## Output

- Quality-controlled as-built models
- Associated reports and documentation

# Project/Practical Examples

## Example 1: Folding bridge at the Holzhafen harbour complex in Hamburg

For the folding bridge at the Holzhafen harbour complex in Hamburg, an as-built model (see Figure 2) was created on the basis of as-built documents (see Figure 1). A scatter diagram from a laser scan (see Figure 3) was also available for purposes of comparison.

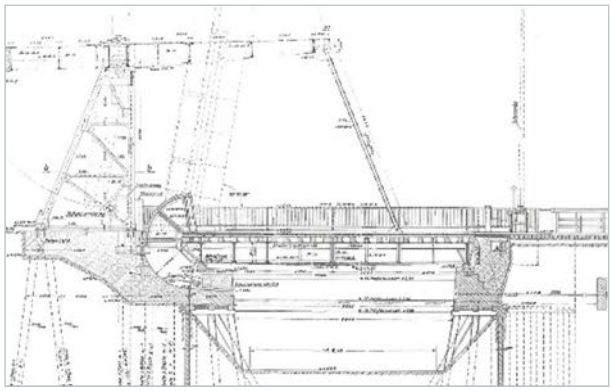


Figure 1: As-built plan of the folding bridge at the Holzhafen harbour (source: LSBG/LGV)

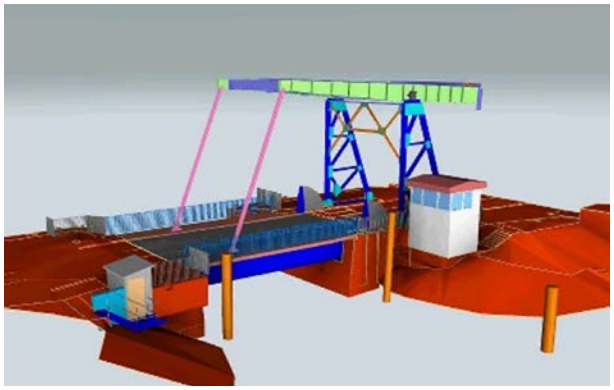


Figure 2: As-built model (source: LSBG/LGV)

Figure 3: Scatter diagram of Holzhafen folding bridge (source: LSBG/LGV)

## Example 2: Högerdamm urban street in Hamburg – specialist model showing as-built pipes and cables

The as-built pipes and cables along a 450-metre-long section of an inner city street were modelled on the basis of as-built 2D plans and current DIN standards (cf. Figure 4).

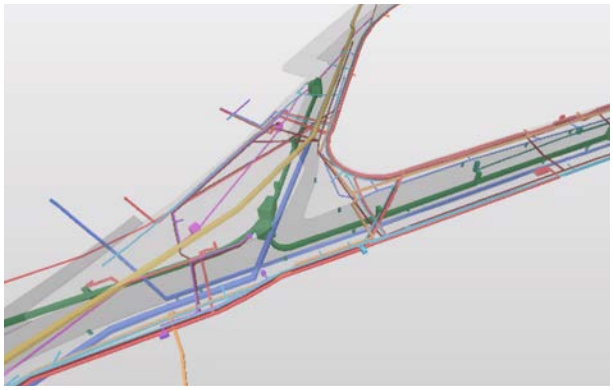


Figure 4: As-built pipes and cables at the Högerdamm urban street (source: LSBG/LGV)

## Example 3: New crossing at Köhlbrand Bridge

- In this example, specialist models of a wide range of disciplines were merged in a coordinated model depicting the as-built situation (cf. Figure 5). These specialist models from the indicated sources were made available for this purpose:

| | |
|---|---|
| ▪ DTM (LandXML) | HPA |
| ▪ 3D city model (LandXML) | LGV |
| ▪ Pipes (dxf) | Hamburg Wasser |
| ▪ Köhlbrand Bridge (ifc) | WTM |

Supplementing the existing models, the general planner created the still-missing specialist models of bridges, shore structures, buildings, locks, pipes etc. in accordance with the EIR and BEP, then merged them in a coordinated as-built model and cross-linked them with the as-built documents.

The as-built models are the basis for implementing the use case planned for this project. With its links, the use case then serves as a 'digital table of contents' for the as-built data and enables quick access to it.

Figure 5: Coordinated model of the as-built status of the 'New Köhlbrand Crossing' project (source: HPA/Schüßler-Plan)

# 2. Implementation Recommendation

## Application level (level of implementation) + + +

### Implementation

#### How is the use case implemented?

1. **Identify and take into account requirements from the EIR and BEP, such as:**
   - Compliance with the modelling guidelines
   - Compliance with the levels of model detail
   - Compliance with model limits
2. **View and check input data.**

- Check whether input data meets technical and data processing requirements for generating as-built models.
- To the required extent, process available input data (e.g. by converting file formats).

3. **Identify and capture/query additional required data.**
   - Determine the need for additional information.
   - If required, capture missing information e.g. by surveying, extracting cores, digitalizing analogue data etc.
4. **Convert digitally processable input data to a consistent geodetic reference system.**
   - Transform the input data into a consistent reference system (location and elevation).
5. **Create specialist as-built models.**
   - Depending on the required specialist model (e.g. DTM, pipes etc.), relevant as-built information must be merged in suitable software for the case at hand.
   - Create objects needed for the required specialist model.
   - Create the required links between generated objects and input data (e.g. via hyperlink to the CDE).
   - Export specialist as-built models to the required file format.
6. **Perform and document the quality control (contractor).**
   - Check for completeness and conformity with requirements in implementation point 1.
   - Perform and document the quality control in accordance with the processes stipulated in the EIR and BEP.

7. **Perform and document the quality control (contracting entity).**

   - Check for completeness and conformity with the requirements in accordance with implementation point 1.
   - Perform and document the quality control in accordance with the processes stipulated in the EIR and BEP.

8. **Provide the quality-controlled results.**

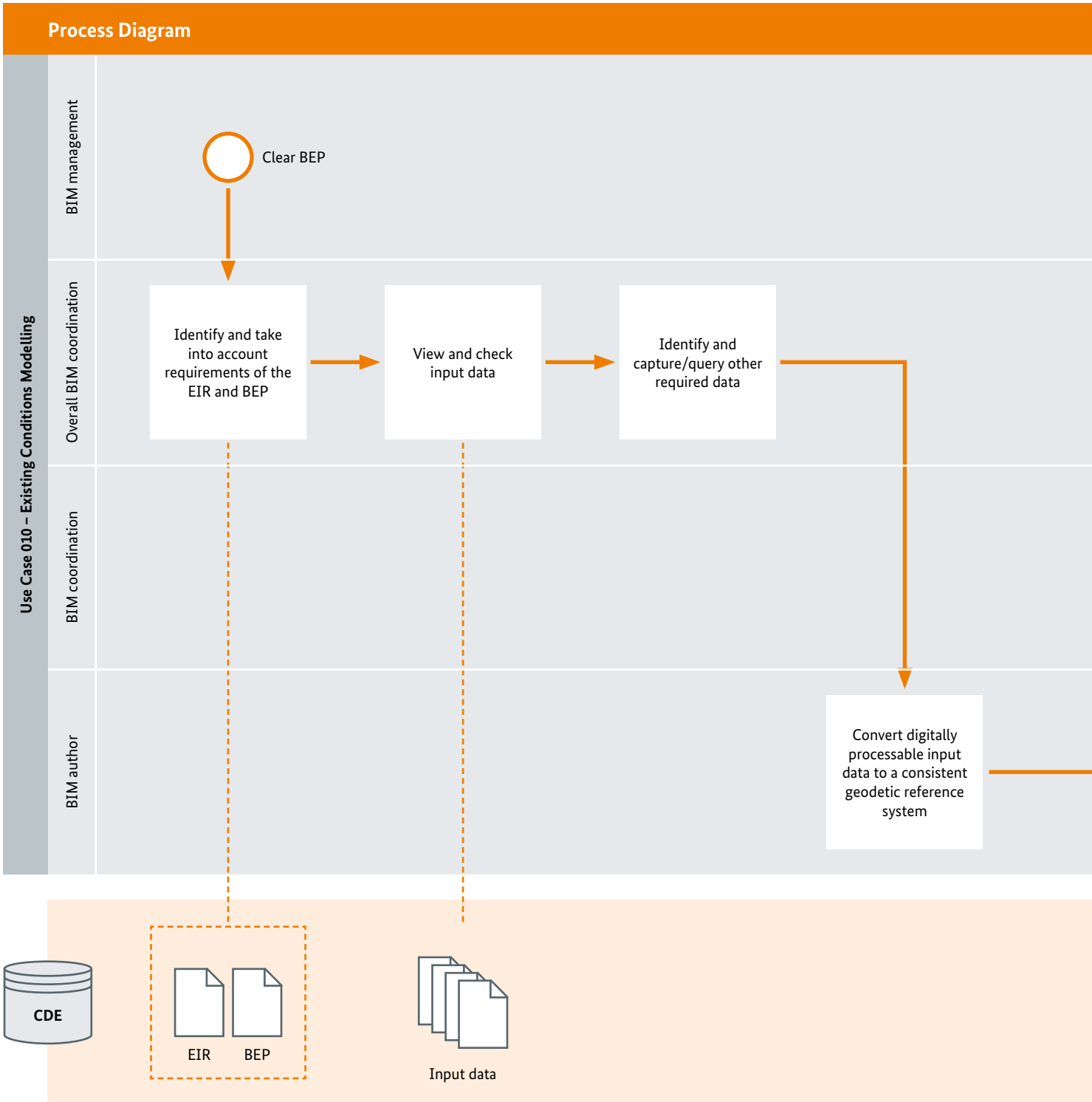
   - Provide deliverables on schedule.
   - Targeted communication with the stakeholders.

## Non-goals

### What is not part of/a goal of the use case?

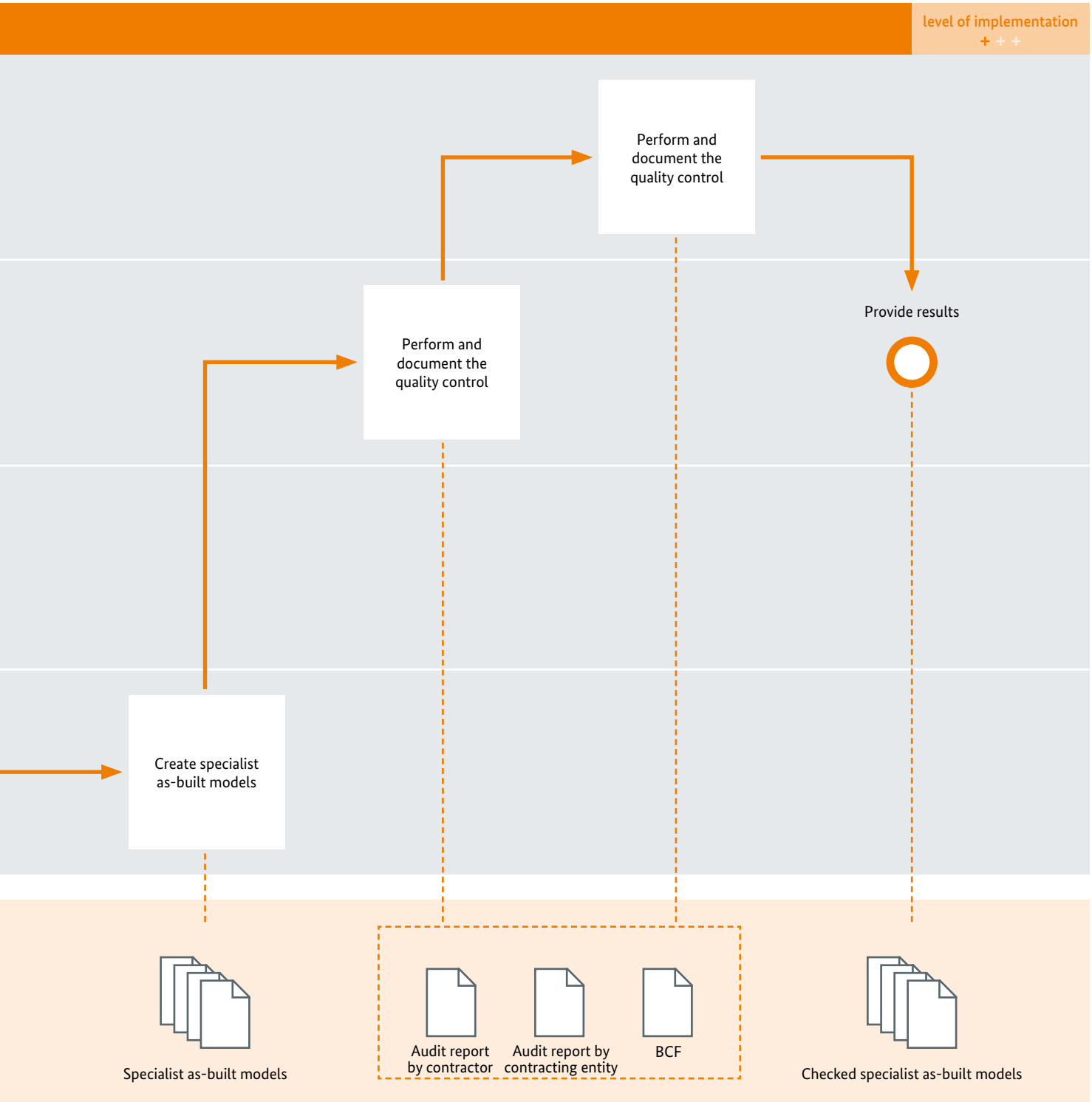
- Improve the quality of as-built information (a model is only as good as the available documents).
- Replace on-site inspections with as-built models.

# 3. Process Diagram | Use Case 010 – Existing Conditi




The process diagram shown here is intended to provide an overview of the implementation of this use case. No subprocesses (e.g. individual steps of quality controls) are shown. The depiction is limited to the process steps from the profile and implementation recommendation.

# ons Modelling




The diagram shows which BIM role has primary responsibility for a given step. When lines separating BIM roles are crossed by a process arrow, the corresponding BIM roles must be involved in the corresponding process step.

# 4. Lessons Learnt

Tips based on experience with this use case, divided into five action areas: people, technology, processes, framework conditions and data.

## Action area: people

- The contracting entity must be aware that all input data has to be available in a digital format.
- It must be clear to all stakeholders that an as-built model can only be as precise as the groundwork used to prepare it.
- Consequently, it is necessary to stipulate the required degree of accuracy of the model properties (e.g. the precision of a pipes' location, specification of the level of geometry – LoG, etc.). These properties must be described in the EIR and if necessary specified in detail in the BEP.
- It must be clear to all stakeholders that a soil model in the form of a layered model is misleading in the sense that it suggests a non-existent level of accuracy. Like in conventional reports, the reviewers make assumptions based on the provided information. The reason that presenting the layers in a 3D model is superior to a 2D cross-section is the more faithful depiction.
- Qualified personnel focusing on (among others):
  - Use of authoring software to create models
  - Experience in using survey data to create models
  - Experience with data transformation

## Action area: technology

- Every measurement and calculation method is subject to inaccuracies, and therefore the actual situation can be depicted in a model only as far as these methods allow.
- When processing measurement results (e.g. scatter diagrams etc.), as a rule it is necessary to manually edit the results.
- The measurement approach used (e.g. laser scanning, ground-penetrating radar etc.) must be chosen depending on the requirements that the as-built models must meet. The advantages and disadvantages of different methods should be weighed.

## Action area: processes

- Attention must be paid to preparing as-built models as comprehensively as possible in order to also meet the requirements of additional use cases. However, it may be necessary to supplement or adapt them during the further course of the project.
- In accordance with the requirements that as-built models must meet, prior to beginning a project, the extent to which the existing structures will be modelled and the approach used must be clarified to ensure an appropriate cost-benefit ratio.

## Action area: framework conditions

- Going forward, the results of documenting a project and structures (use case 190) and operating them will be taken as the basis for modelling existing conditions (use case 010).

## Action area: data

- As the basis for implementing use case 010, the contracting entity must strive to provide standardized data sets from as-built information (e.g. DTM, orthophotos, land registers etc.).

- Attention must be paid to ensuring uniform georeferencing, as a greater effort is required to transform models retrospectively.

# Use Case 030
# Planning Variants

# 1. Profile

**Assignment of the use case to project phases**

In which service phase will the use case be implemented?

| No. | Use case | Service phase acc. to German fee schedule for architects and engineers (HOAI) | Operation |
|---|---|---|---|
| Use Case 030 | Planning Variants | ☐ 1 ■ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 | ☐ B |

## Definition

Preparation of planning variants in the form of models to simplify analysis and criteria-based evaluation, followed by creation of models corresponding to the preferred variant.

## Benefits

What value can implementing the use case be expected to add?

- Improved communication with third parties, thanks to visual support from models
- Clearer depiction of planning versions
- Improved decision-making basis for projects
- Better quality because quantities and costs are uniformly derived from models
- Bundling of all relevant boundary conditions in models and/or linking with the models ('single source of truth' architecture)
- (Partially automated) evaluation of individual criteria possible with the aid of models and associated information

## Prerequisites

What is required to implement the use case?

- Definition of evaluation criteria in EIR and/or BEP
- Suitable software for the specific roles involved, with BEP-compliant interfaces
- Qualified personnel for this use case

## Implementation

1. Identify and take into account requirements of the EIR and BEP.
2. Create appropriate models of variants for individual planning phases.
3. Check models for suitability for variant analysis.
4. Perform model-supported variant analysis.
5. Present and document the comparison of variants.
6. Have the contracting entity decide on a preferred variant.

7. Create/update models of preferred variant.

8. Perform and document the quality control (contractor).

9. Perform and document the quality control (contracting entity).

10. Provide the quality-controlled results.

## Input

- As-built information relevant to the project (e.g. as-built models, audit plans, survey data, maps, expert reports etc.)

- Other information relevant to the project (e.g. planning status of other projects)

## Output

- Checked models of preferred variant

- Models of variants

- Depictions and documentation (e.g. evaluation matrix) of the variant comparison

## Project/Practical Examples

### Example 1: Grevenau Bridge

In this example, various superstructure and railing variants were modelled with a low degree of geometrical detail (see Figure 1) to provide a basis for choosing one of the variants.

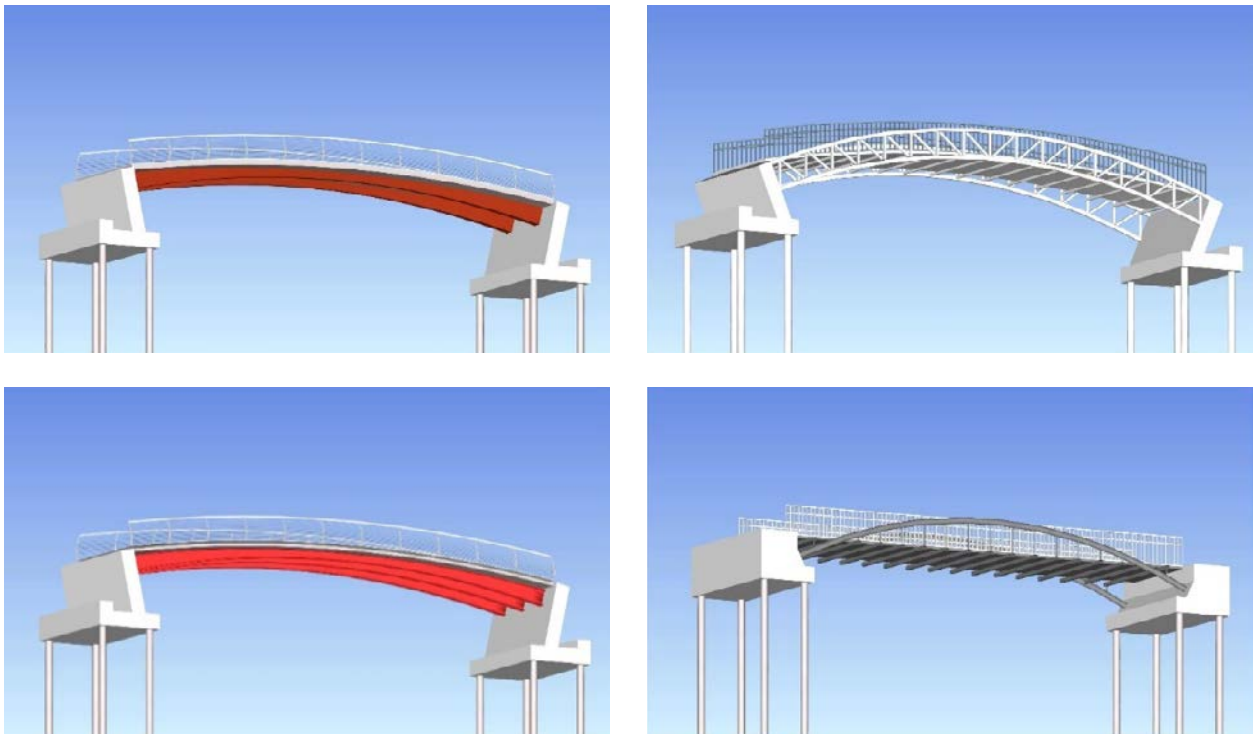


Figure 1: Variants of the Grevenau Bridge (source: LSBG)

## Example 2: structures 16b (am Bahndamm) and 17b (Tunnelstrasse)

In this example, the as-built and variant specialist models were checked for clashes.

Based on these clash checks, the variants were optimized and then evaluated. In the evaluation, foundation elements remaining in place in the ground were coloured grey, elements to be demolished yellow and new elements that needed to be built red (see Figure 2). The visual comparison of the 3D models made it easy to quickly show the differences between the variants.

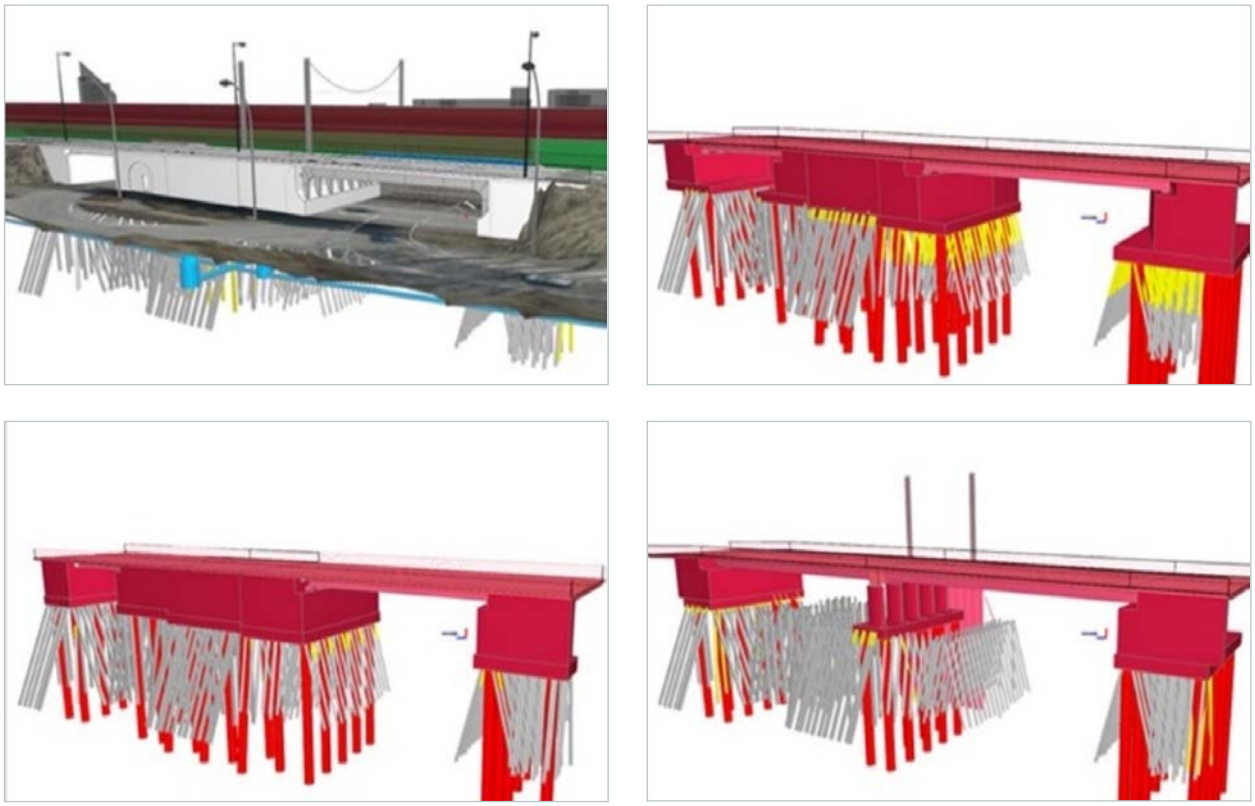


Figure 2: Study of variants of structure 16b Am Bahndamm and structure 17b Tunnelstrasse (source: HPA/Schüßler-Plan)

# 2. Implementation Recommendation

## Application level (level of implementation) + + +

### Implementation

How is the use case implemented?

1. **Identify and take into account requirements from the EIR and BEP, such as:**
   - Consider defined and agreed evaluation criteria (e.g. costs, deadlines, environmental factors etc.).
   - Compliance with the modelling guidelines
   - Compliance with the levels of model detail
   - Compliance with the stipulated number of variant models
2. **Create appropriate models of variants for individual planning phases.**
   - Merge relevant input data (e.g. results of existing conditions modelling, use case 010).
   - Create objects for the variant model in line with the requirements for analysing variants.
3. **Check models for suitability for variant analysis.**
   - Check whether all criteria for analysing variants have been met in the models.
   - Perform a general quality control of the variant models.
4. **Perform model-supported variant analysis.**
   - Analyse variant models by applying the defined criteria.
     - Generate an evaluation matrix.
     - Use the variant models to derive additional information (e.g. by checking for clashes between the planned structure and the environment).
     - Compare and evaluate the information in the evaluation matrix.
   - If relevant, support findings with the following use cases:
     - Use Case 070 – Dimensioning and Verification
     - Use Case 100 – Quantity Take-off and Costing
     - Use Case 120 – Execution Scheduling
     - Use Case 130 – Logistics Planning
5. **Present and document the comparison of variants.**
   - Document the comparison of variants (e.g. in the form of a report or evaluation matrix).
   - If appropriate, cross-reference the documentation with the models from the variant comparison.
   - If appropriate, support with visualizations from use case 040.

6. **Have the contracting entity decide on a preferred variant.**

   - On the basis of the variant comparison provided by the contractor, the contracting entity chooses a preferred variant.

7. **Prepare models of the preferred variant.**

   - Prepare the models of the preferred variant on the basis of the results of the study of variants.
   - It may be necessary to adjust and remodel objects.
   - Export the specialist models of the preferred variants to the required data format.

8. **Perform and document the quality control (contractor).**

   - Check for completeness and conformity with the requirements in accordance with implementation point 1.
   - Perform and document the quality control in accordance with the processes stipulated by the EIR and BEP.

9. **Perform and document the quality control (contracting entity).**

   - Check for completeness and conformity with the requirements in accordance with implementation point 1.
   - Perform and document the quality control in accordance with the processes stipulated by the EIR and BEP.

10. **Provide the quality-controlled results.**

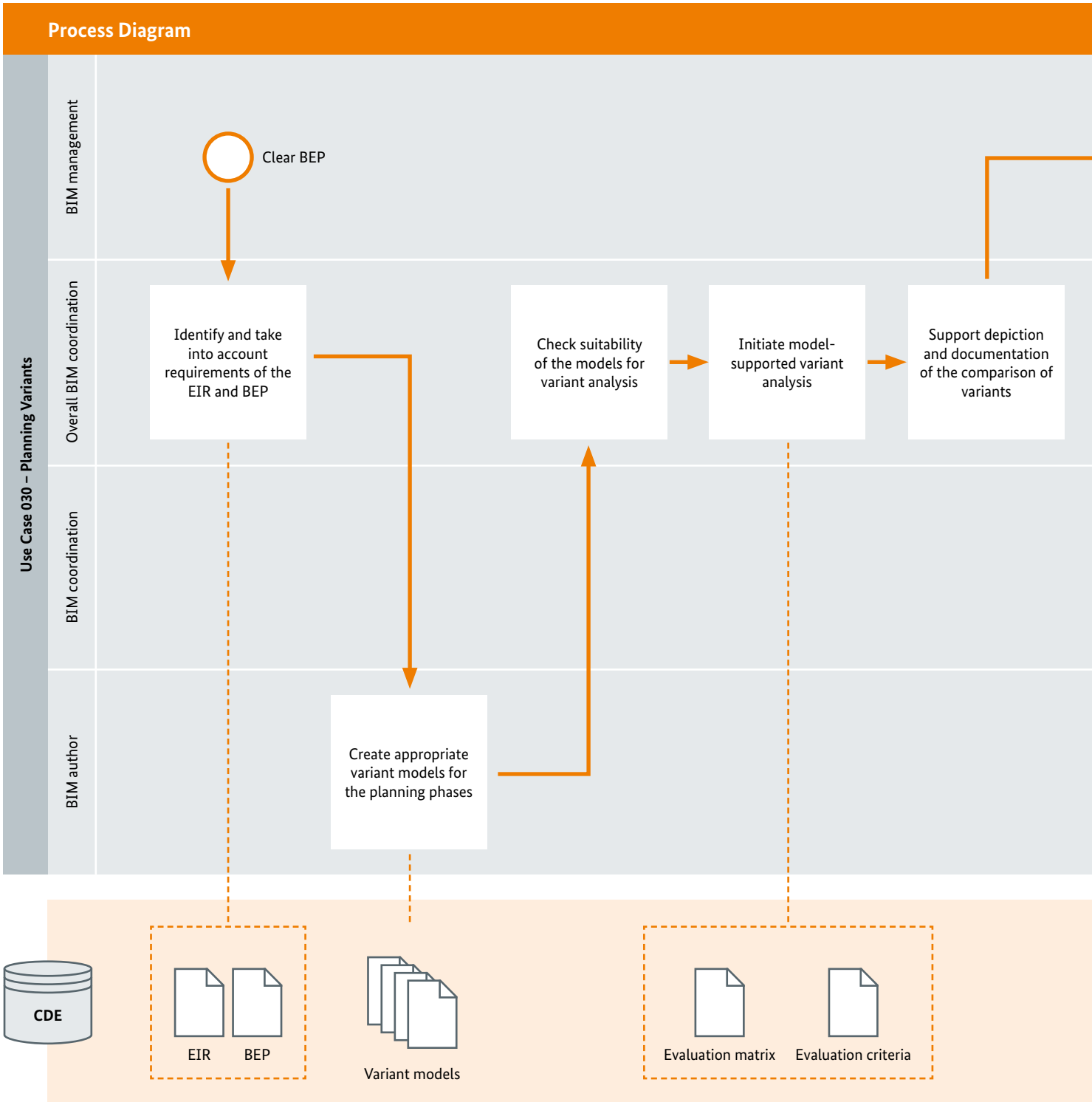
    - Provide deliverables on schedule.
    - Targeted communication with the stakeholders

## Non-goals

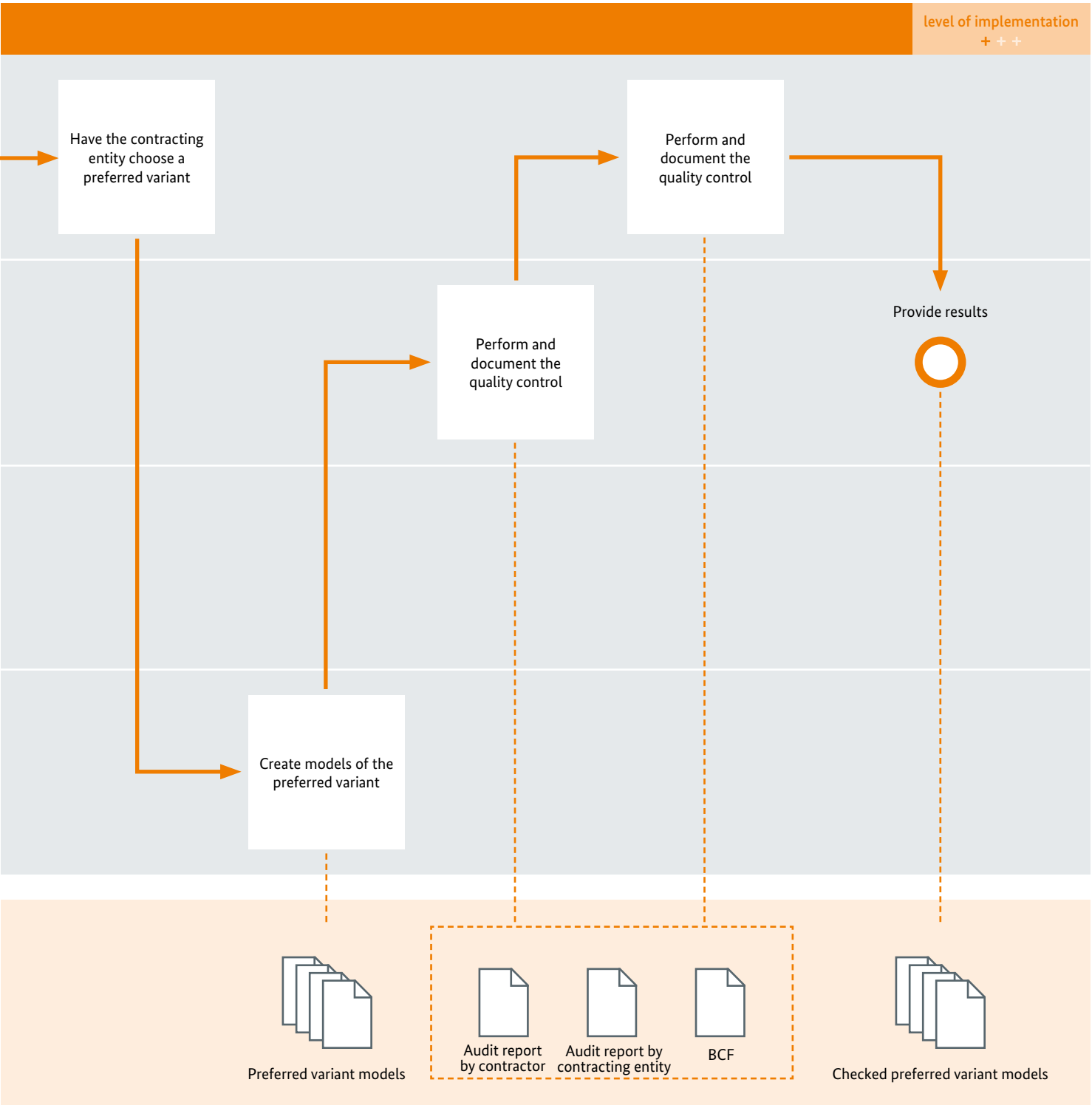
### What is not part of/a goal of the use case?

- Visual presentations (part of visualization, use case 040)

# 3. Process Diagram | Use Case 030 – Planning Variant




The process diagram shown here is intended to provide an overview of the implementation of this use case. No subprocesses (e.g. individual steps of quality controls) are shown. The depiction is limited to the process steps from the profile and implementation recommendation.




The diagram shows which BIM role has primary responsibility for a given step. When lines separating BIM roles are crossed by a process arrow, the corresponding BIM roles must be involved in the corresponding process step.

# 4. Lessons Learnt

Tips based on experience with this use case, divided into five action areas: people, technology, processes, framework conditions and data.

## Action area: people

- In order to be able to optimally implement use case 030, it is particularly important to be aware of and understand the evaluation criteria and goals of the use case before proceeding to creation of the model.
- The more precisely the evaluation criteria and need for evaluation are described prior to concluding the contract, the easier it is to calculate the work and costs for implementing use case 030.
- Qualified personnel focusing on (among others):
  - Use of authoring software to create models
  - Use of models for evaluating the valuation criteria with the aid of work coordination software

## Action area: technology

- The more extensively modelling and evaluation processes are automated, the faster and easier it is to consider and evaluate how changes impact variants (e.g. for route planning).

## Action area: processes

- The variant models should be created to a level of detail that meets the requirements in order to take the required costs and benefits into account.
- Depending on the goals in a given case, less geometrically detailed variant models can be created with relatively little effort. As a rule, less detailed variant models are sufficient.
- It should be clarified at an early stage whether models of the preferred variant will be reused.
- To enable evaluation of different combinations of variants, it can be helpful to appropriately implement them in different models.

## Action area: framework conditions

- Model-based consideration of variants makes it possible to dispense with 2D plans in the preliminary planning phase.
- Analyses become easier to perform with increasing standardization of modelling parameters (e.g. with object catalogues).

## Action area: data

- None

# Use Case 040
# Visualization

# 1. Profile

## Assignment of the use case to project phases

In which service phase will the use case be implemented?

| No. | Use case | Service phase acc. to German fee schedule for architects and engineers (HOAI) | Operation |
|---|---|---|---|
| Use Case 040 | Visualization | ☐ 1 ■ 2 ■ 3 ■ 4 ■ 5 ☐ 6 ☐ 7 ■ 8 ☐ 9 | ☐ B |

## Definition

Visualization of existing models, appropriately assembled and supplemented by additional objects and information and/or graphically processed, primarily for communication purposes

## Benefits

What value can implementing the use case be expected to add?

- Greater transparency and acceptance by understandably communicating the construction project
- Understandable geometric and visual presentation of complex interrelationships to support decision-making
- New technologies (e.g. virtual reality/augmented reality) make it possible to communicate planned construction projects in ways that let them be experienced.

## Requirements

What is required to implement the use case?

- An adequate description of the goal, purpose, file format, quantity and quality of the visualizations within the EIR and BEP
- Suitable software for the specific roles involved, with BEP-compliant interfaces
- Qualified personnel for this use case

## Implementation

1. Identify and take into account requirements of the EIR and BEP.
2. Identify the precise requirements and technical approach for visualizations with consultation between the contractor and contracting entity.
3. Identify the required models.
4. Create the visualizations.
5. Quality control of the visualization (contractor)
6. Quality control of the visualization (contracting entity)
7. Provide the quality-controlled results.

## Input

- Existing models
- As appropriate, orthophotos, photographs, 360° images

## Output

- Images
- Videos
- Interactive visualizations (e.g. virtual reality/ augmented reality)

## Project and Practical Examples

### Example 1: Bergedorfer Strasse in Hamburg/ A1 motorway

In this example, a simple visualization of a planning variant on the basis of existing models was supplemented with details such as vehicles and vegetation (see Figure 1).

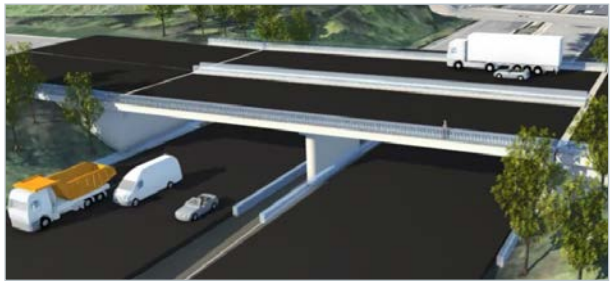


Figure 1: Bergedorfer Strasse in Hamburg/A1 motorway (source: LSBG/WTM)

### Example 2: Haynspark Bridge

In this case, a photorealistic visualization of a planning variant was created using special software, independently of existing models (see Figure 2).

Figure 2: Haynspark Bridge in Hamburg (source: LSBG/Grassl Ing.)

## Example 3: Virtual reality model of the Port of Hamburg – virtual view of Köhlbrand Bridge

For public relations purposes, the as-built specialist models (in IFC format) of Köhlbrand Bridge were imported into the VR model of the port by HPA. This makes it possible to virtually stroll across and experience the structure (cf. Figure 3).

Figure 3: VR model of the Port of Hamburg (source: HPA)

## Example 4: A99 BW27-1

In this example, individual components were visually highlighted to clearly communicate them (see Figure 4).

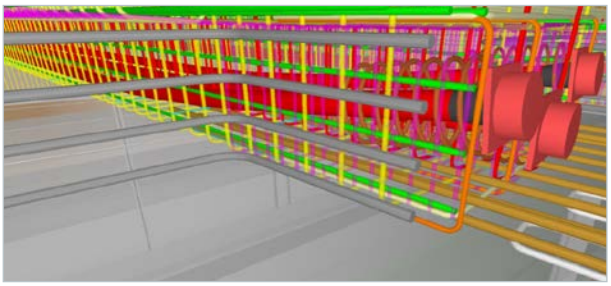


Figure 4: Visually highlighted components (source: TUM – Borrmann)

# 2. Implementation Recommendation

## Application level (level of implementation) + + +

### Implementation

#### How is the use case implemented?

1. **Identify and take into account requirements of the EIR and BEP.**
   - Goal, purpose, file format, quantity and quality of visualizations
   - Additionally identify points and issues that have not yet been clarified for actual implementation.
2. **Identify the precise requirements and technical approach for visualizations with consultation between the contractor and contracting entity. This includes:**
   - Choosing locations and viewing direction
   - Time of year, time of day and shadows
   - Objects to be depicted
   - Photographs for backgrounds
3. **Identify and capture/query additional required data.**
   - Source models of the common data environment.
4. **Create the visualizations.**
   - Compile the required models.
   - Check models to ensure that they fulfil the purpose of visualization.
   - Edit the models (if necessary by remodelling, adding textures etc.).
   - Use suitable software to create the visualizations.
5. **Quality control of the visualization (contractor)**
   - Check for completeness and conformity with the requirements in accordance with implementation point 1.
   - Perform and document the quality control in accordance with the processes stipulated by the EIR and BEP.

6. **Quality control of the visualization (contracting entity)**

   - Check for completeness and conformity with the requirements in accordance with implementation point 1.
   - Perform and document the quality control in accordance with the processes stipulated by the EIR and BEP.

7. **Provide the quality-controlled results.**

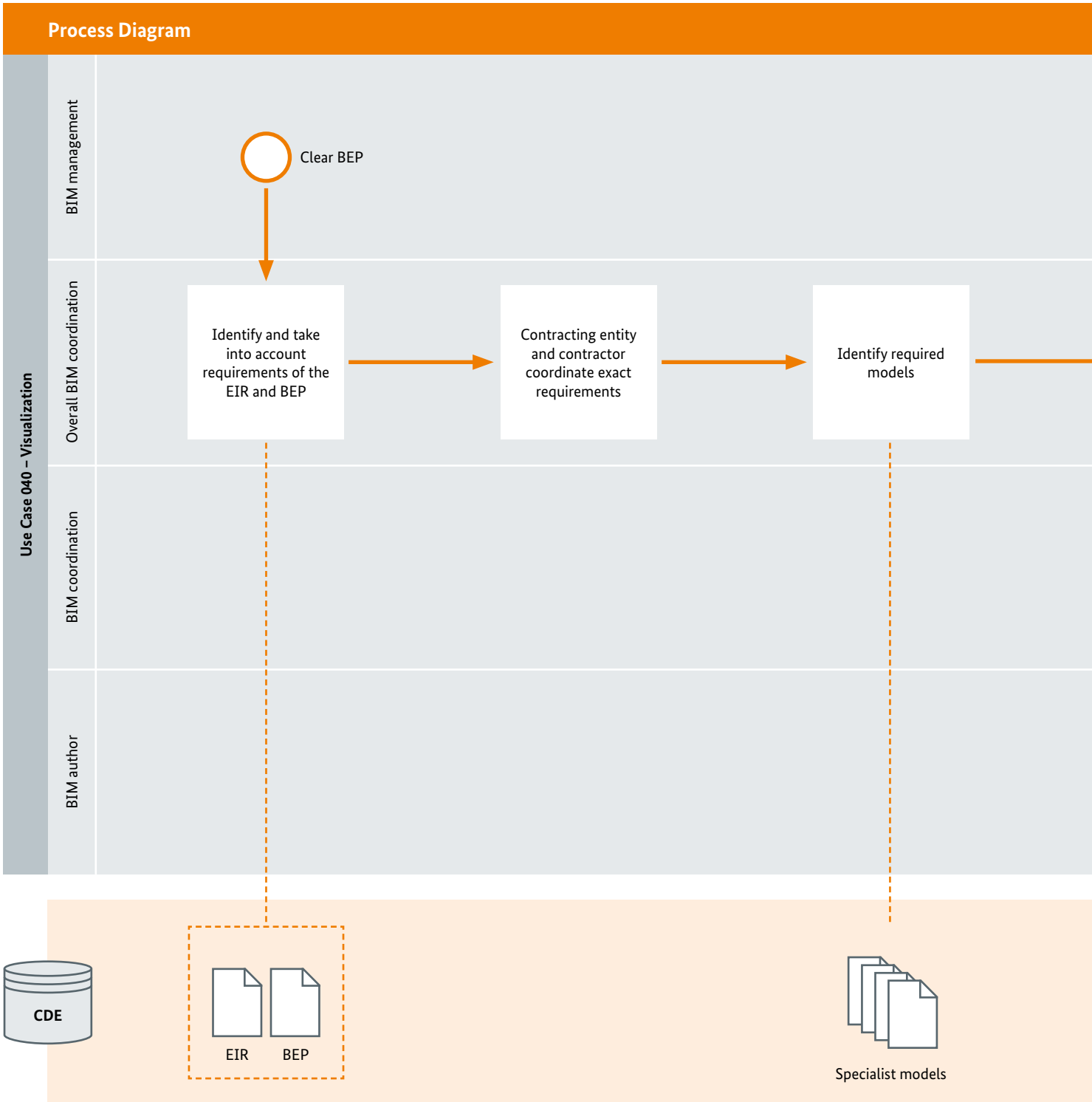
   - Provide the visualization in the common data environment.

## Non-goals

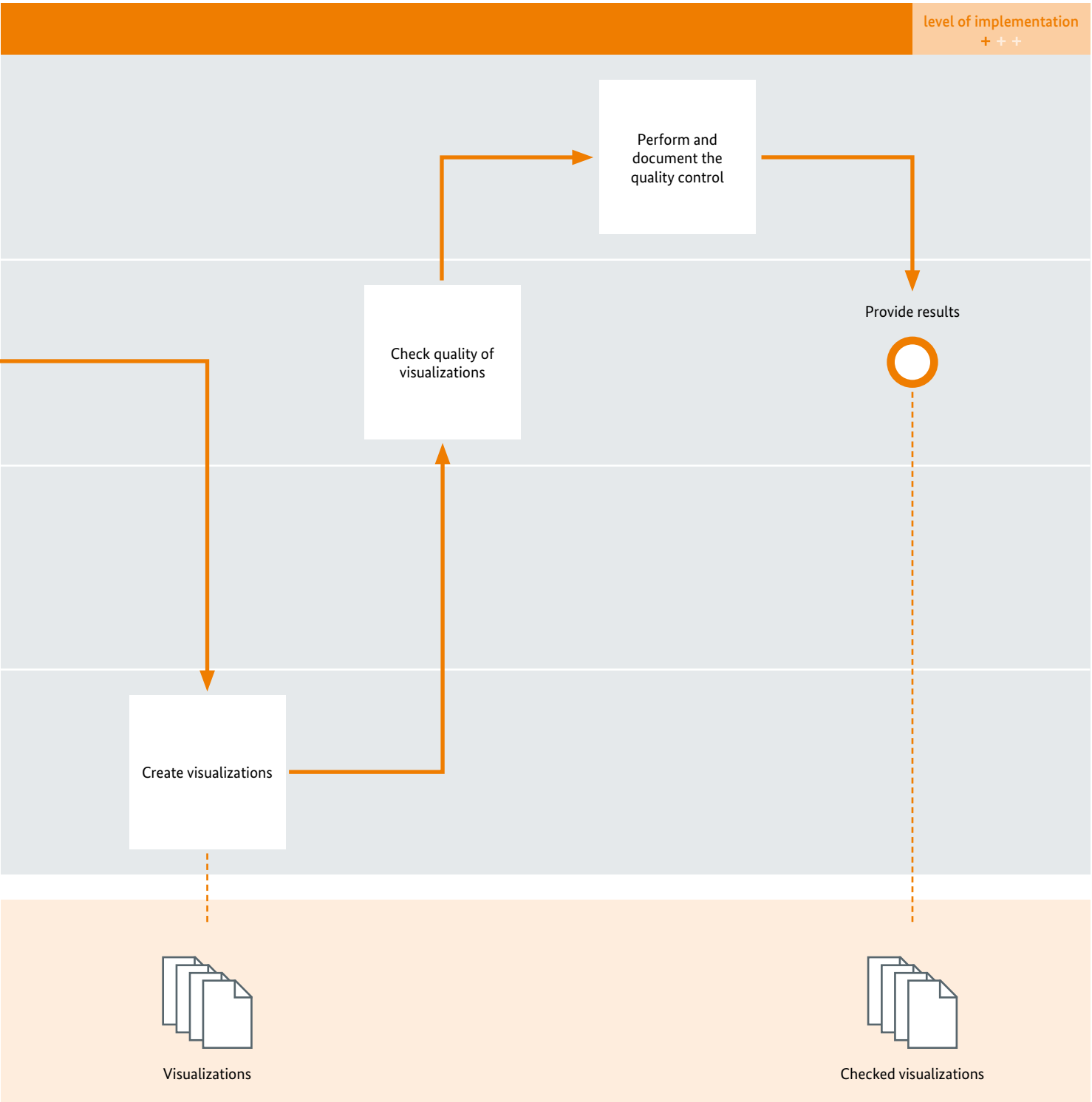
### What is not part of/a goal of the use case?

- Execution scheduling (use case 120) and logistics planning (use case 130)
- Use of models in meetings (this is not a visualization in the sense of use case 040)

# 3. Process Diagram | Use Case 040 – Visualization




The process diagram shown here is intended to provide an overview of the implementation of this use case. No subprocesses (e.g. individual steps of quality controls) are shown. The depiction is limited to the process steps from the profile and implementation recommendation.




The diagram shows which BIM role has primary responsibility for a given step. When lines separating BIM roles are crossed by a process arrow, the corresponding BIM roles must be involved in the corresponding process step.

# 4. Lessons Learnt

Tips based on experience with this use case, divided into five action areas: people, technology, processes, framework conditions and data

## Action area: people

- It must be clear to all stakeholders that copyrights, patents and the usability of visualizations (sound and pictures) must be contractually clarified in good time.

- Qualified personnel focusing on (among others):
  - Use of authoring software to create visualizations
  - Image design and composition

## Action area: technology

- Visualizations must be as realistic as possible but cannot copy reality 100%.

- The desired visualization results should be described in terms of image design requirements. This includes e.g. lighting conditions, viewing depths, image content in addition to the model itself etc.

## Action area: processes

- Delimitation from use cases 030, 120 and 130
  - A visualization is not a planning tool.
  - Use case 040 primarily involves planning for communication purposes.
  - Visualizations can contain deviations and simplifications

- A visualization is based on existing models. The effort involved in creating a visualization diminishes with increasing levels of detail. This fact must be taken into account when describing requirements.

## Action area: framework conditions

- The cost and work involved in implementing a visualization diminish as the level of detail of the EIR increases. It is worthwhile to prepare a checklist for implementation, specifying for example the visualization goals, image quality, shadows, locations, textures etc.

## Action area: data

- The desired results of visualization should be described in terms of data formatting requirements. These include for example file formats, resolution, image rates etc.

# Use Case 050
# Coordination of Professional Trades

# 1. Profile

## Assignment of the use case to project phases

In which service phase will the use case be implemented?

| No. | Use case | Service phase acc. to German fee schedule for architects and engineers (HOAI) | Operation |
|---|---|---|---|
| Use Case 050 | Coordination of Professional Trades | ■ 1 ■ 2 ■ 3 ■ 4 ■ 5 ■ 6 □ 7 ■ 8 ■ 9 | ■ B |

## Definition

Regular merging of technical modules into coordinated models followed by quality controlling and systematic resolution of conflicts. Cooperation is interdisciplinary with model-supported communication via a common data environment (CDE).

## Benefits

What value can implementing the use case be expected to add?

- Better planning and preparation of work
- Reduced cost and scheduling risks as a result of coordinating trades and eliminating conflicts in the planning process
- Easier communication, collaboration and subsequent tracing and documentation of decisions
- Efficient data and information management
- Avoidance of redundant information
- Support for technical checks
- Transparent, consistent understanding among involved experts

## Prerequisites

What is required for implementing the use case?

- EIR and coordinated BEP
- Common data environment (CDE)
- Suitable software for the specific roles involved, with BEP-compliant interfaces
- Qualified personnel for this use case

## Implementation

How is a use case implemented?

1. Identify and take into account requirements of the EIR and BEP.
2. Merging of the quality-controlled specialist models in a consistent reference system
3. Perform and document the quality control.
4. Manage conflict resolution and coordination processes.
5. Document conflict resolutions and decisions.

6. Perform and document the quality control (contracting entity).

7. Provide the quality-controlled results.

In general: prepare for and monitor model-based meetings

## Input

- Quality-controlled specialist models

## Output

- Quality-controlled coordinated models
- BDF documentation
- Audit reports

# Project and Practical Examples

## Example 1: Example process for checking models

Shown here is an example checking process (see Figure 1) based on the use of BCF formats with role-specific assignment of tasks.

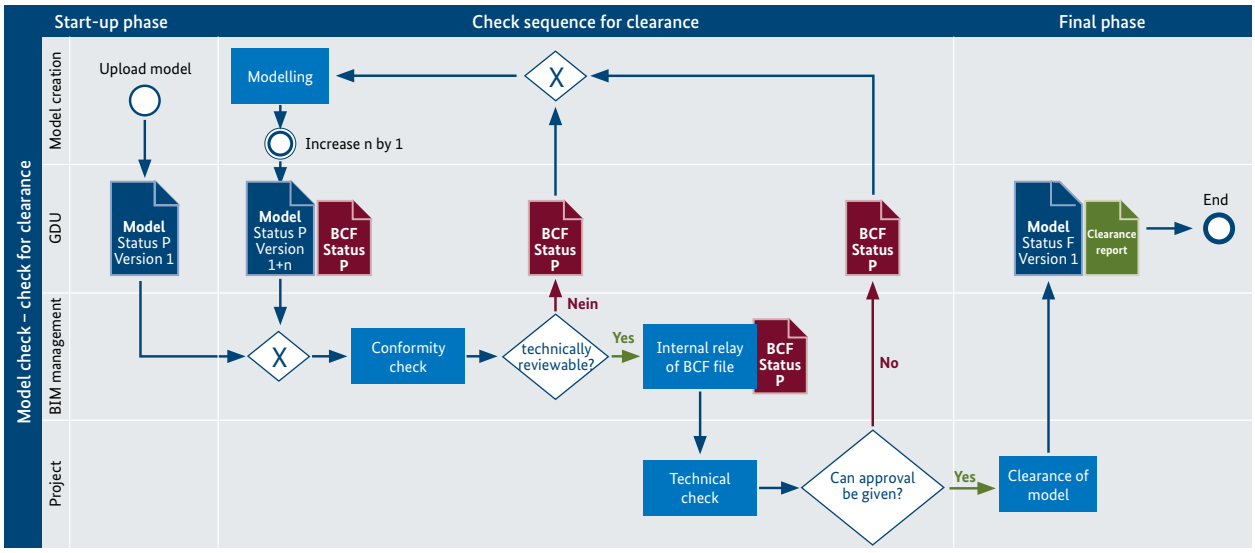



Figure 1: Sample BCF checking workflow (source: HPA)

## Example 2: BIM.Hamburg sample model

This example presents coordination of the specialist models of a street, pipes and two bridges in a coordinated model (see Figure 2).

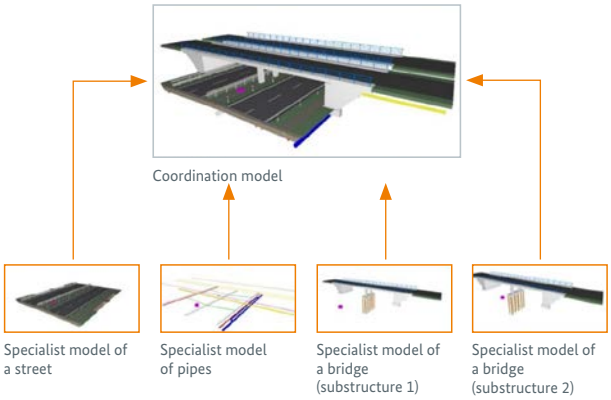



Figure 2: Sample model from BIM.Hamburg (source: BIM.Hamburg)

## Example 3: Bergedorfer Strasse in Hamburg/ A1 motorway

This example issue (see Figure 3) in a BCF audit report shows a clash between a pipe in the specialist model of the bridge components and the cap reinforcement in the reinforcement specialist model.

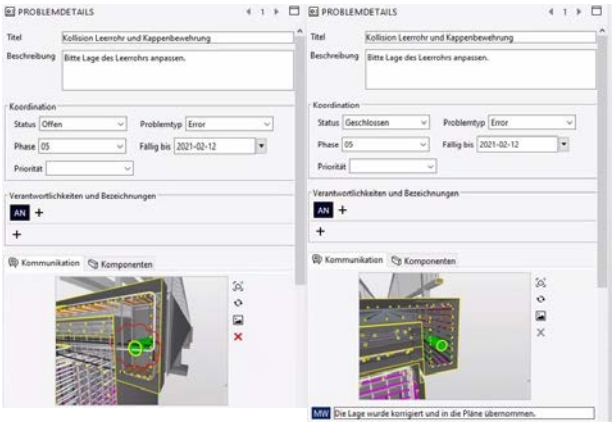



Figure 3: Example issue of an avoided clash (source: LSBG)

# 2. Implementation Recommendation

## Application level (level of implementation) + + +

## Implementation

### How is the use case implemented?

1. **Identify and take into account requirements from the EIR and BEP, such as:**
   - Compliance with coordinates and model content
   - Compliance with required processes for cooperation
   - Compliance with the task distribution as defined in the BIM role description
   - Compliance with the agreed delivery deadlines
2. **Merging of the quality-controlled specialist models in a consistent reference system**
   - Use of the coordination software stipulated in the BEP for merging the IFC models and other input data
   - Checking of the reference system stipulated in the BEP
3. **Perform and document the quality control.**
   - Check for conformity with the EIR and BEP (data format, naming conventions etc.)
   - Visual check (model structure, completeness, conspicuous errors etc.)
   - Check of the LOIN (level of information need)
     - Semantic check (consistency with object catalogues, value ranges etc.)
     - Geometrical check (clash check, level of detail etc.)
     - Check of linked documents
4. **Control and implement conflict resolution and coordination processes**
   - Communication via BCF workflow
   - Control and monitoring of the quality control process
5. **Document conflict resolutions and decisions.**
   - Preparation of audit reports (quality reports on coordination models)
   - Preparation of BCF documentation (e.g. on planning decisions made during meetings)

6. **Perform and document the quality control (contracting entity).**

   - Check for completeness and conformity with the requirements in accordance with implementation point 1.
   - Perform and document the quality control in accordance with the processes stipulated by the EIR and BEP.

7. **Provide the quality-controlled results.**

   - Provide deliverables on schedule.
   - Targeted communication with the stakeholders

In general: prepare for and monitor model-based meetings

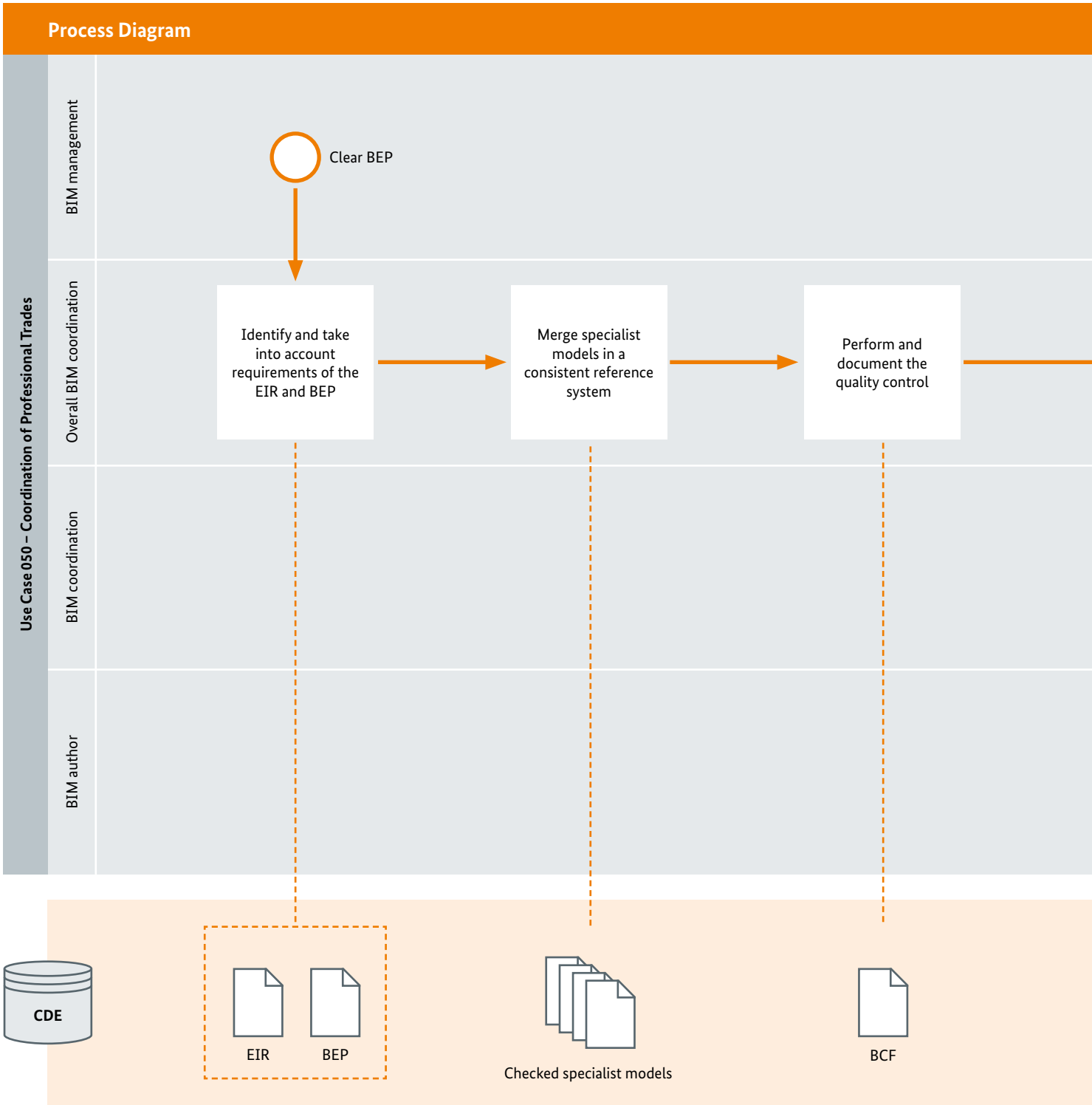
- Appropriate preparation of models for meetings
- If relevant, presentation/control of the models at a meeting

## Non-goals

What is not part/not the goal of the use case?

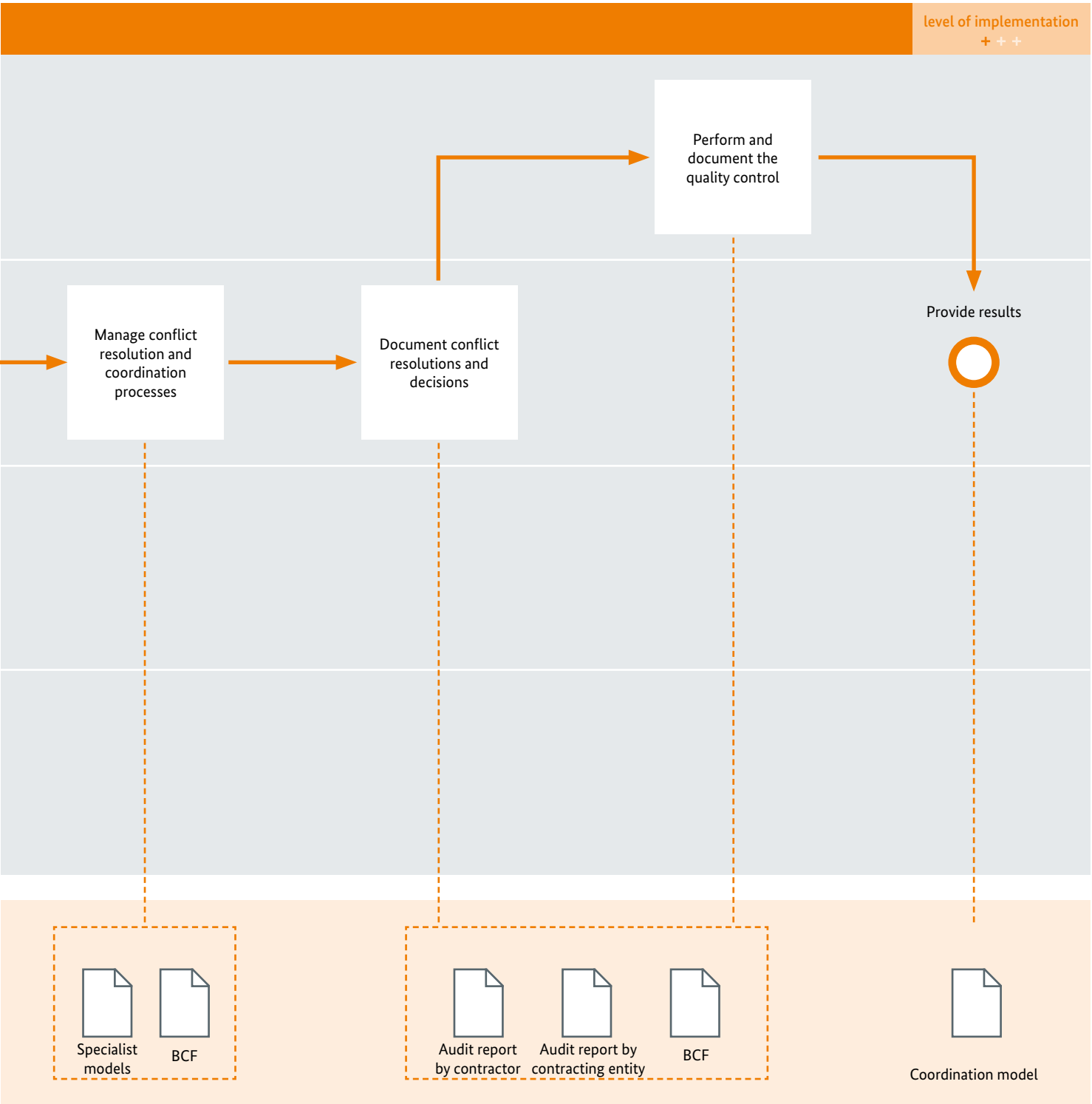
- Creation of specialist models

# 3. Process Diagram | Use Case 050 – Coordination o




The process diagram shown here is intended to provide an overview of the implementation of this use case. No subprocesses (e.g. individual steps of quality controls) are shown. The depiction is limited to the process steps from the profile and implementation recommendation.

# f Professional Trades




The diagram shows which BIM role has primary responsibility for a given step. When lines separating BIM roles are crossed by a process arrow, the corresponding BIM roles must be involved in the corresponding process step.

# 4. Lessons Learnt

Tips based on experience with this use case, divided into five action areas: people, technology, processes, framework conditions and data.

## Action area: people

- All stakeholders should be aware of the fact that this use case cannot replace a site inspection. A model can, under certain circumstances, evoke a false sense of security.
- It is important to involve all project stakeholders, including those that are not required to submit or use models.
- For coordination purposes, the plans for all individual disciplines should be included in the BIM project, also those in 2D (e.g. safety and occupational health coordination, environmental and landscape planning).
- Qualified personnel focusing on (among others):
  - Use of coordination software (e.g. model review tools, CDE etc.)
  - Definition and application of check rules
  - Use of BCF management software

## Action area: technology

- It is a good idea for the contracting entity to specify a project origin.
- Using a model checker to perform a geometrical check is an efficient way to reveal deviations or changes from previous model versions.
- A semantic check can be more efficiently performed with rule-based model review software.

## Action area: processes

- Automated workflows are suited for initiating subsequent processes (issue management).
- Working with BCF files requires a disciplined approach, as mistakes can easily happen unless work is done in a consistent manner. This includes in particular how issues are named and described.
- The deliverables and the delivery cycle (where appropriate, also work statuses) should be agreed in the BEP.
- The exact points in time at which models and other documents are to be provided should be indicated beforehand in a delivery list and documented.

## Action area: framework conditions

- Standardized object catalogues are required as the basis for largely automated semantic checks.
- For performing quality controls, it is a good idea to create and use checklists with recommendations on the most important aspects to be checked.
- It can make sense to give these checklists to the contractor to simplify the preparation of audit reports.

## Action area: data

- Uniform model locations and elevations must be agreed on before starting the modelling process. Retrospective transformation of 3D models can cause problems.

- As a rule, coordinated models can only be handed over in a native format. Submitting a global IFC model can result in loss of ‘intelligence’ and querying and analysis possibilities. This does not run contrary to the open-BIM approach, as the contractor has a free hand to choose which coordination software to use. The prerequisite is stipulating specialist models in non-proprietary formats.

- Before initiating the process, it is a good idea to test the authoring software’s ability to exchange data.

# Use Case 080
# Derivation of Planning Documents

# 1. Profile

## Assignment of the use case to project phases

In which service phase will the use case be implemented?

| No. | Use case | Service phase acc. to German fee schedule for architects and engineers (HOAI) | Operation |
|---|---|---|---|
| Use Case 080 | Derivation of Planning Documents | ☐ 1 ■ 2 ■ 3 ■ 4 ■ 5 ☐ 6 ☐ 7 ■ 8 ☐ 9 | ■ B |

## Definition

Derivation of relevant parts of the plans from the 3D models while adding missing (semantic and geometrical) information. The scale and plan contents correspond to the applicable guidelines and/or project specifications. The derived plans may not contradict the model version.

## Benefits

What value can implementing the use case be expected to add?

- It enables rule-compliant handover of model-based planning work in the form of conventional plans (e.g. for approvals and construction work).
- If plans and the model are linked to one another, less effort is required to update one or the other in the event of changes.
- The geometrical consistency of all plans derived from the same models is ensured.

## Prerequisites

What is required to implement the use case?

- Detailed and checked models as appropriate for the project phase
- Stipulation of the guidelines to be applied to plan contents in the EIR
- An agreement on the use and implementation of guidelines on plan contents in the BEP
- Suitable software for the specific roles involved, with BEP-compliant interfaces
- Qualified personnel for this use case

## Implementation

How is the use case implemented?

1. Identify and take into account the requirements according to the EIR, BEP and the guidelines coordinated for the project for drawing up plans.
2. Merge the models required for drawing up plans.
3. Create sections, ground plans, elevations, perspectives and details.
4. Prepare, adjust and supplement the plan in accordance with requirements.
5. Perform and document the quality control (contractor).
6. Perform and document the quality control (contracting entity).
7. Provide the quality-controlled results.

In general: planning changes must be integrated in the models first in order to derive the plan.

## Input

- Quality-controlled specialist models

## Output

- 2D plans

# Project and Practical Examples

## Example 1: Haynspark Bridge

The outline design was derived from the bridge model (cf. Figure 1). Many details had to be manually added to the plan (cf. Figure 2).

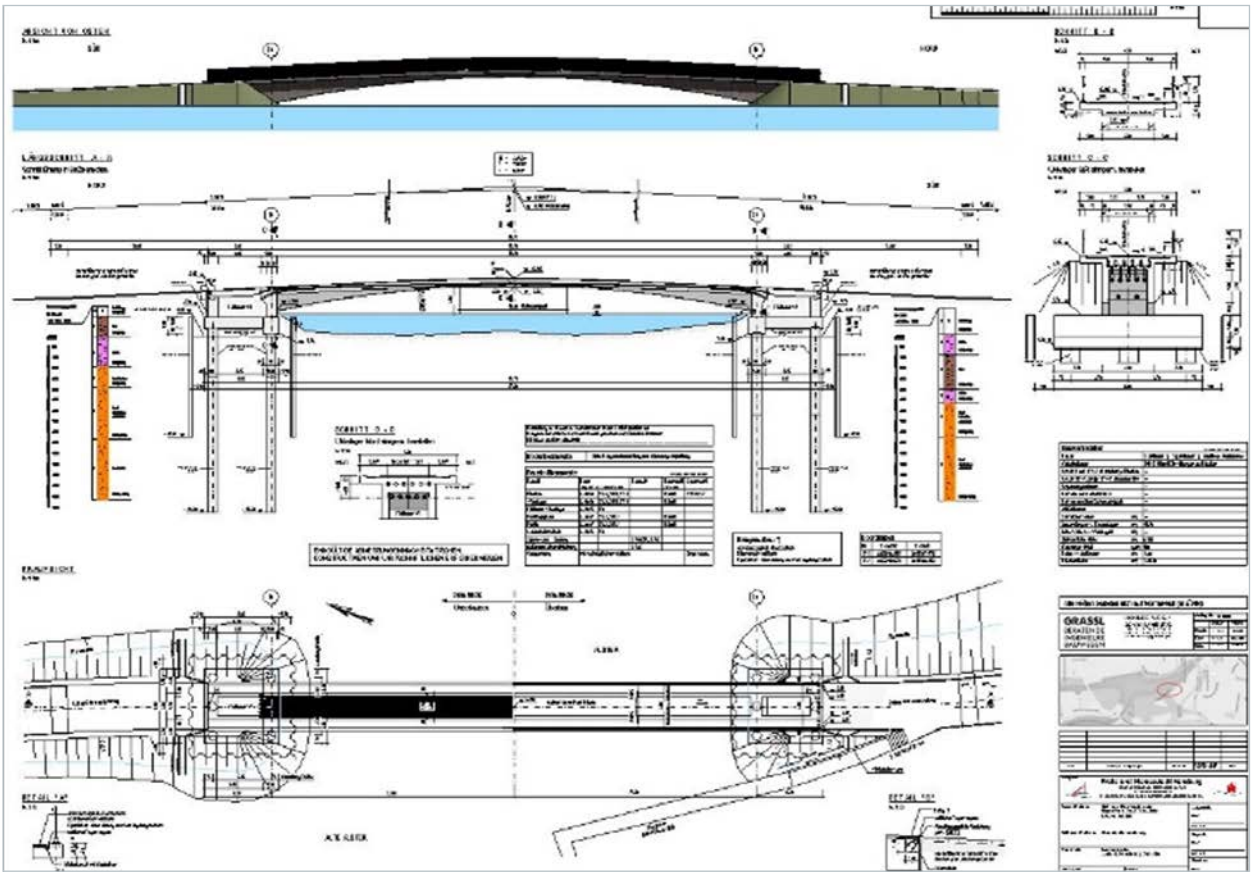



Figure 1: Status of outline design in 2017 (source: LSBG/Grassl Ing.)

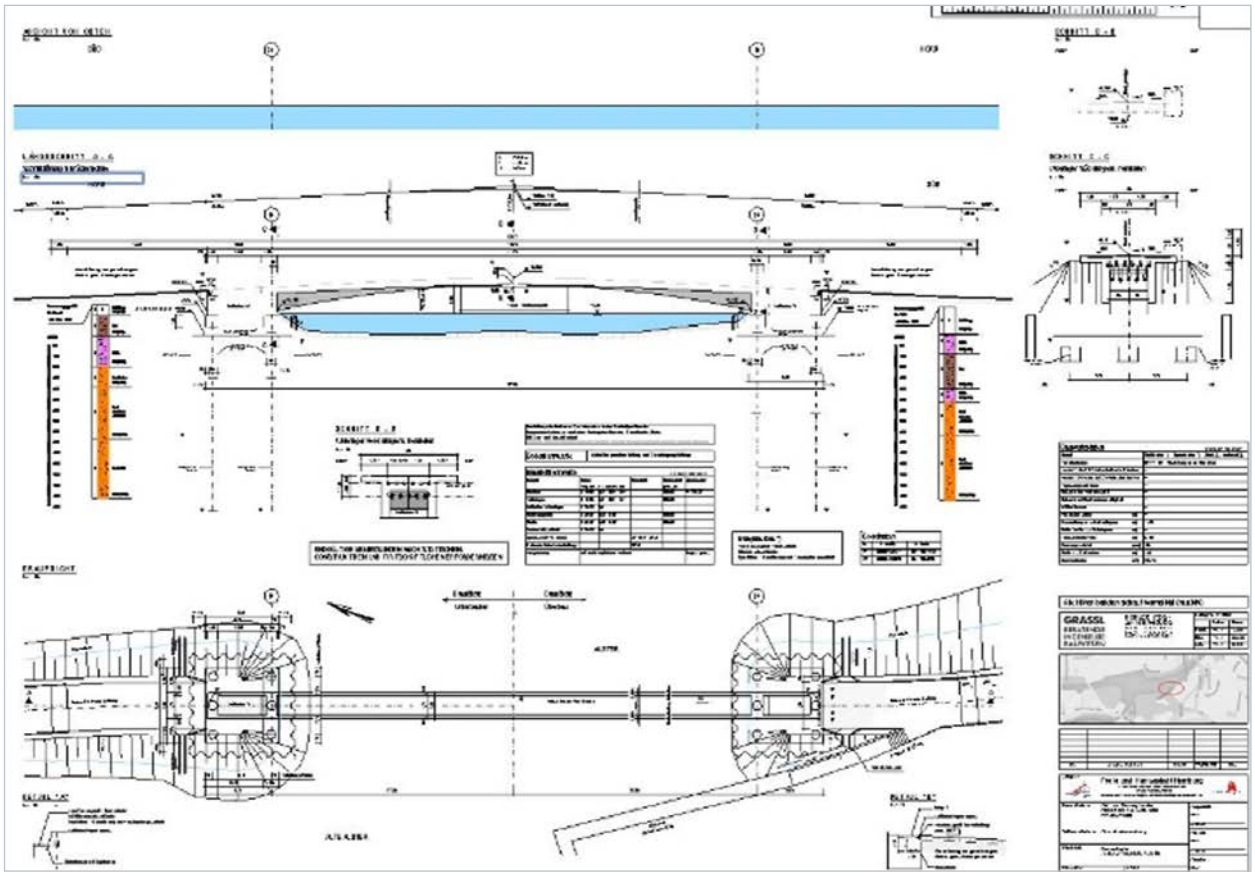


Figure 2: Depiction of the requirements of all elements requiring rework as of 2017 (source: LSBG/Grassl Ing.)

## Example 2: Grevenau Bridge

In this example, it was easy to derive 3D representations from the models and add them to the plans. Isometrics proved to add value by helping to understand complex components and supporting orientation in the plan.

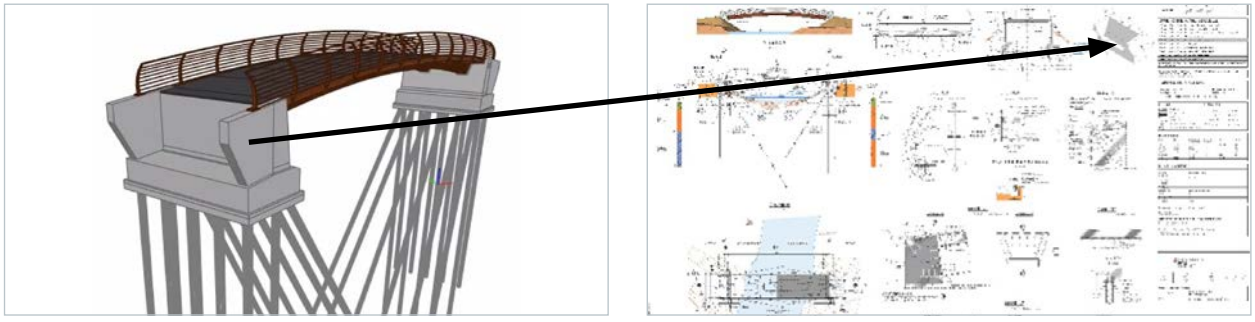


Figure 3: Use of isometrics in a 2D plan (source: LSBG/Ed. Züblin AG)

# 2. Implementation Recommendation

## Application level (level of implementation) + + +

## Implementation

### How is the use case implemented?

1. **Identify and take into account the requirements of the EIR and BEP and the guidelines coordinated for the project for drawing up plans, for example**
   - Take into account the agreed guidelines for creating plans in the project.
   - Consider which plans are needed and for which purposes.
2. **Merge the models required for drawing up plans.**
   - Identify the required and coordinated models from the common data environment.
   - Merge the models using suitable software.
3. **Create sections, ground plans, elevations, perspectives and details.**
   - Derive the relevant parts of the plans from the models.
     - Define the sections/elevations.
     - Place the sections and elevations on the plan.
     - Define the scale.
4. **Prepare, rework and supplement the plan in accordance with requirements.**
   - Create the title block/sheet frame.
   - Adjust the elevations and sections in accordance with the rules.
     - Observe the requirements of the CAD guideline
     - Hide unrequired drawing content.
     - Adapt drawings to sections.
   - Create/supplement required dimensioning, cross-hatching and legends in accordance with rules.
5. **Perform and document the quality control (contractor).**
   - Check for completeness and conformity with the requirements in accordance with implementation point 1.
   - Perform and document the quality control in accordance with the processes stipulated by the EIR and BEP.

6. **Perform and document the quality control (contracting entity).**

   - Check for completeness and conformity with the requirements in accordance with implementation point 1.
   - Perform and document the quality control in accordance with the processes stipulated by the EIR and BEP.

7. **Provide the quality-controlled results.**

   - Provide deliverables on schedule.
   - Targeted communication with the stakeholders

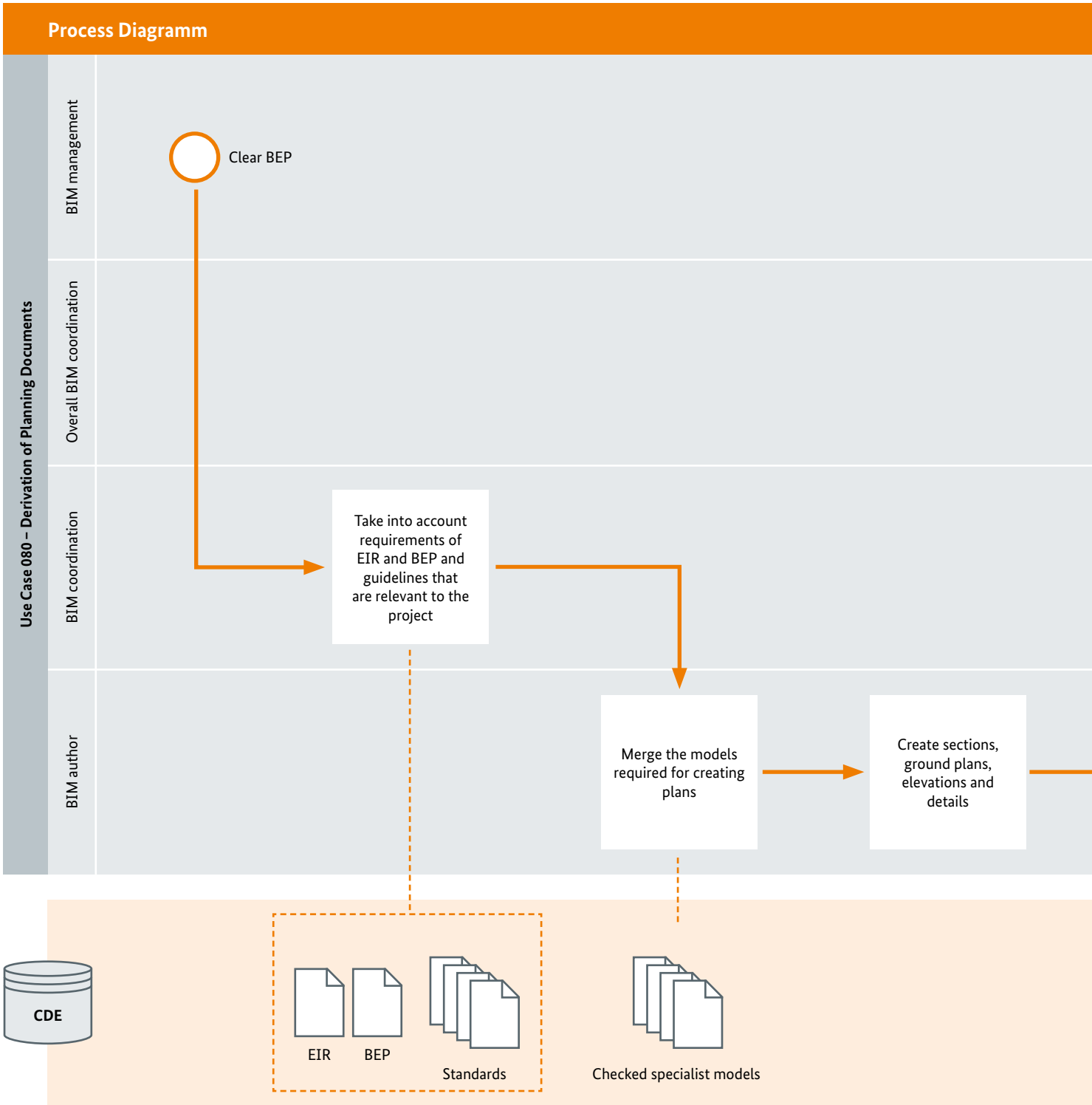
In general: planning changes must be integrated in the models first in order to derive the plan.

## Non-goals

### What is not part of/a goal of the use case?

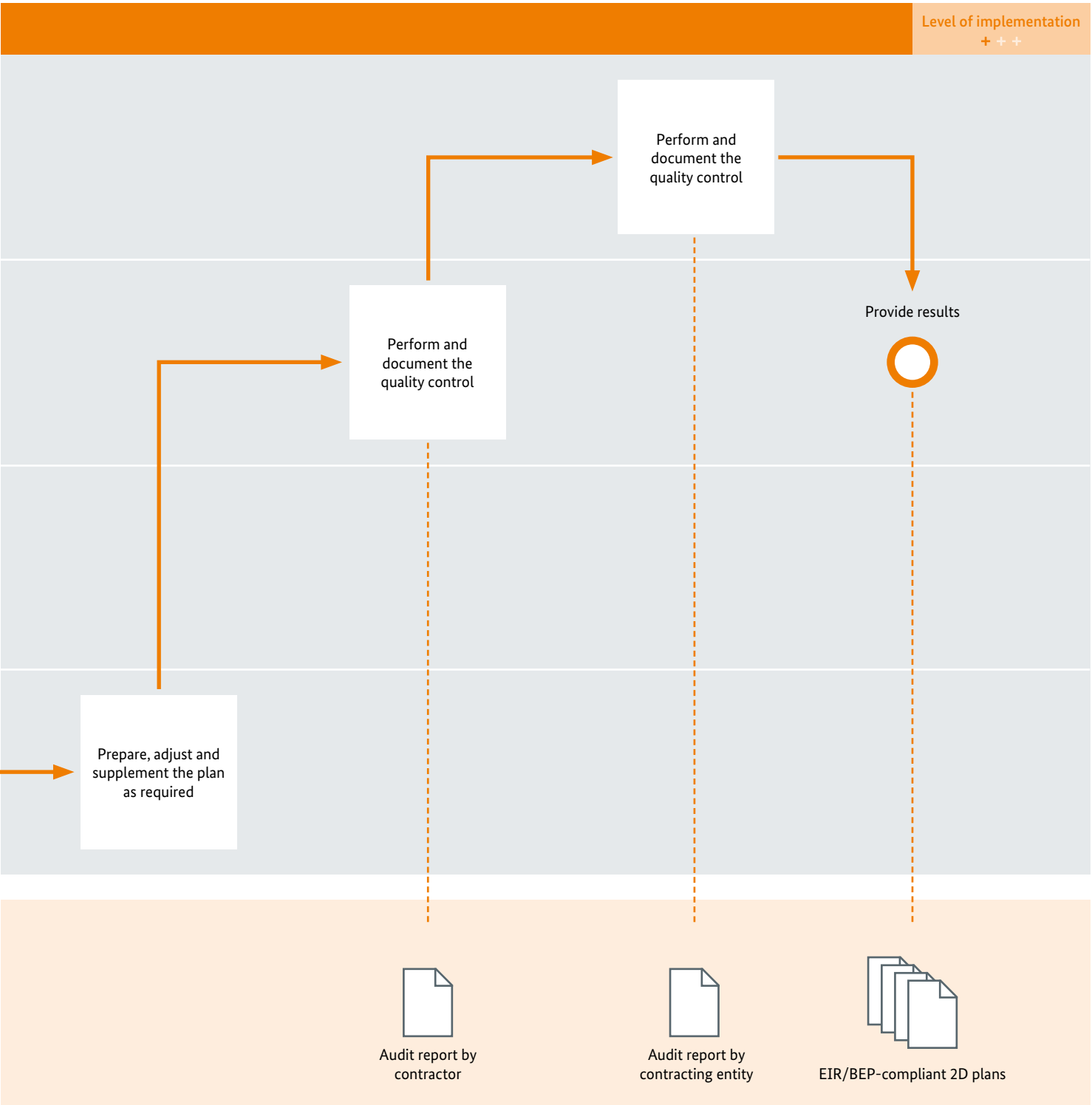
- Checking specialist models

# 3. Process Diagram | Use Case 080 – Derivation of Pla




The process diagram shown here is intended to provide an overview of the implementation of this use case. No subprocesses (e.g. individual steps of quality controls) are shown. The diagram is limited to the process steps from the profile and implementation recommendation.

# nning Documents




The diagram shows which BIM role has primary responsibility for a given step. When lines separating BIM roles are crossed by a process arrow, the corresponding BIM roles must be involved in the corresponding process step.

# 4. Lessons Learnt

Tips based on practical experience with this use case, divided into five action areas: people, technology, processes, framework conditions and data

## Action area: people

- This use case should only be implemented if it is absolutely necessary to derive plans from the model (e.g. for approval plans). It is therefore important to make the benefits of model-based work and also model-based communication clear to all project stakeholders in order to avoid unnecessary creation of plans.
- Qualified personnel focusing on (among others):
  - Use of authoring software to derive planning documents from models

## Action area: technology

- The expediency of use case 080 must be evaluated in advance for each specialist area.
- It is not necessary to model every detail in 3D; details such as seals can be supplemented by 2D elements in 2D plans.
- In the event of changes to the plans, it is important to have links between models and plan. This way, changes to models can be directly applied to the plans to avoid inconsistencies. It is then necessary to adjust the 2D elements in the plans.
- To aid understanding, 3D views can be easily derived from the models and inserted in the plans.
- High-quality, informative plans can be generated.

## Action area: processes

- It is difficult to ensure consistency between a model and plan as no established workflow for this currently exists, either automated or manual.

## Action area: framework conditions

- To minimize the risk of undetected errors, plans should not be derived until after the models have been coordinated and quality-controlled.
- It is not always possible to implement every detail of different specifications and standards in plans, for example layer structures, line thicknesses etc.
- It would make sense to adjust the guidelines on drawings.
- It makes sense to establish clear rules in the EIR on when details are to be separately depicted in the plans rather than be modelled, e.g. starting at a scale of 1:20.

## Action area: data

- To increase the processability of derived 2D data, it should be in DXF format or a vector-based PDF file.

# Use Case 100
# Quantity Take-off and Costing

# 1. Profile

## Assignment of the use case to project phases

In which service phase will the use case be implemented?

| No. | Use case | Service phase acc. to German fee schedule for architects and engineers (HOAI) | Operation |
|---|---|---|---|
| Use Case 100 | Quantity Take-off and Costing | ☐ 1 ■ 2 ■ 3 ☐ 4 ☐ 5 ■ 6 ☐ 7 ☐ 8 ☐ 9 | ☐ B |

## Definition

Compilation of a cost estimate and/or cost calculation with the usual cost breakdown (acc. to AKVS – instructions for calculating and estimating costs in road construction schemes, DIN 276-4 etc.) on the basis of structured and object-specific quantities (volumes, areas, lengths, numbers of units) from the models.

## Benefits

What value can implementing the use case be expected to add?

- Rapid quantity take-off by automated processes
- Changes to plans can be easily taken into account.
- Results can be readily visualized, understood and technically checked.

## Prerequisites

What is required to implement the use case?

- Detailed and checked models as appropriate for the project phase
- Structure of cost breakdowns (e.g. AKVS – instructions for calculating and estimating costs in road construction schemes, DIN 276-4 etc.)
- To fully tap the potential of the use case, the greatest possible degree of standardization is essential (e.g. catalogues of partial services, objects etc.).
- Unit prices (e.g. from a price database)
- Suitable software for the specific roles involved, with BEP-compliant interfaces
- Qualified personnel for this use case

## Implementation

How is a use case implemented?

1. Identify and take into account requirements of the EIR and BEP.
2. Merge the quality-controlled specialist models required for determining quantities.
3. Ascertain the derivable model-based quantities according to the cost breakdown (e.g. AKVS – instructions for calculating and estimating costs in road construction schemes, DIN 276-4 etc.).
4. Manual take-off of quantities that cannot be derived on the basis of models
5. Derive costs from the quantity take-off.
6. Perform and document the quality control of the quantity take-off (contractor).
7. Plausibility check (contracting entity)
8. Provide the quality-controlled results.

## Input

- Quality-controlled specialist models
- Structure of cost breakdowns (AKVS – instructions for calculating and estimating costs in road construction schemes, DIN 276-4 etc.)
- Unit prices

## Output

- Cost estimate and/or calculation
- Quantity take-off
- Documentation of quality control

# Project/Practical Examples

## Example 1: BIM-Hamburg sample model

In this example, object catalogues and catalogues of partial services were used and interlinked via a module in the tender, award and invoicing software. This enabled use of the models' properties to automatically assign foundation elements to the corresponding cost items.

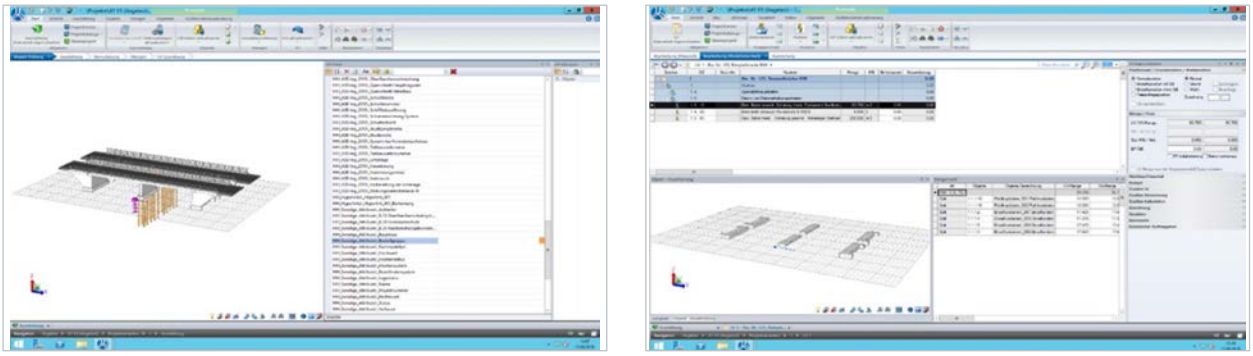


Figure 1: Assignment of foundation elements to the corresponding cost items (source: BIM.Hamburg)

# 2. Implementation Recommendation

## Application level (level of implementation) + + +

## Implementation

### How is the use case implemented?

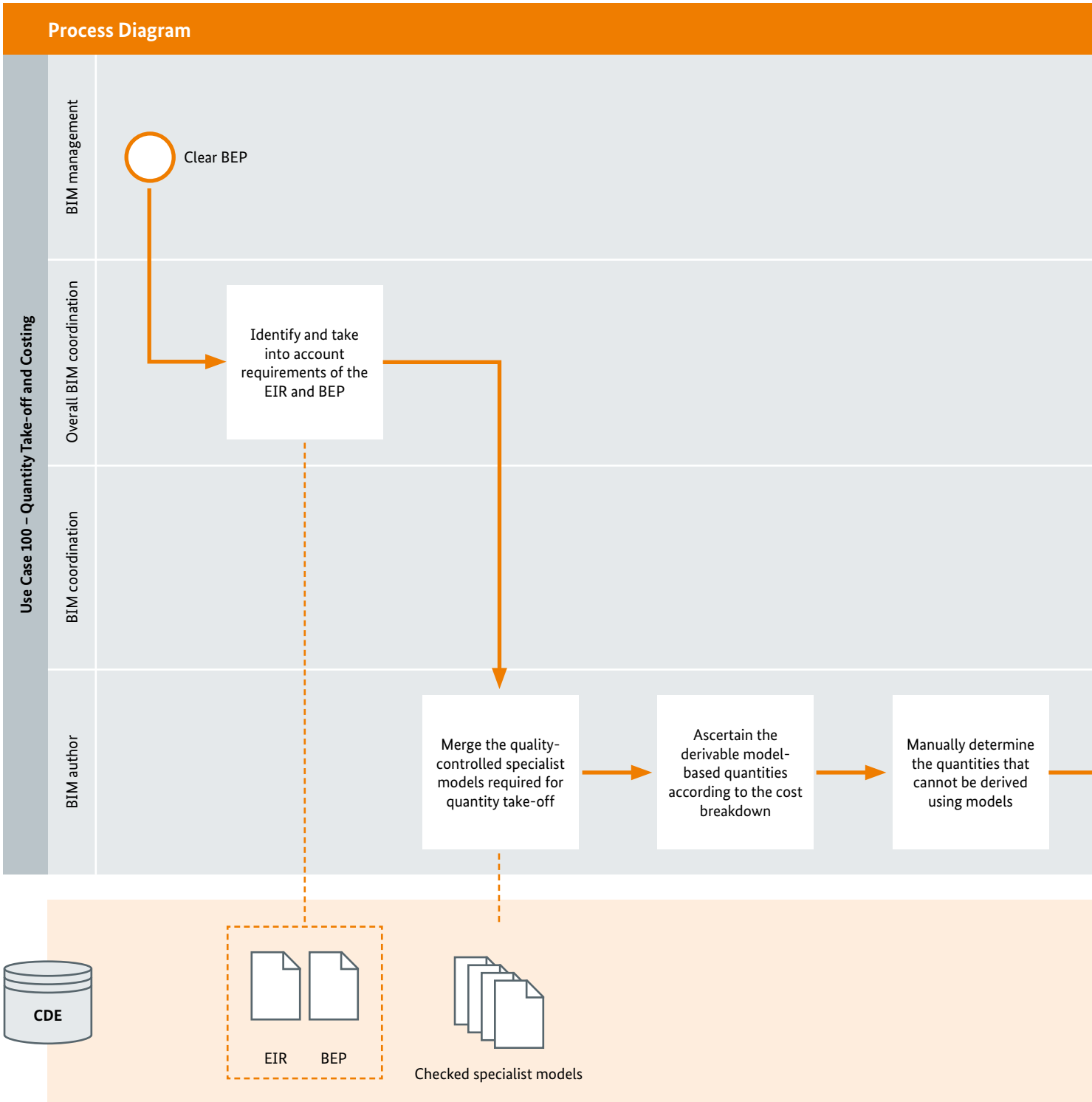
1. **Identify and take into account requirements of EIR and BEP, for example:**
   - Consider the requirements for the cost structures to be used.
   - Consider catalogues of objects and partial services
2. **Merge and document the available quality-controlled specialist models required for quantity take-off.**
   - Identify the required models from the common data environment.
   - Merge the models.
3. **Ascertain the derivable model-based quantities in accordance with the cost breakdown (e.g. AKVS – instructions for calculating and estimating costs in road construction measures, DIN 276-4 etc.)**
   - Select the required cost breakdown (ideally a tender, award and invoicing template).
   - Ideally, the tender, award and invoicing template should comprise e.g. structure filters, rules for quantity take-off, a pricing database, a catalogue of cost components etc.
   - Adapt the tender, award and invoicing template for the specific project.
   - Perform the quantity take-off.
4. **Manual take-off of quantities that cannot be derived on the basis of models**
   - Add the quantities from the manual quantity take-off to the structure of the automatic quantity take-off within the project-specific cost structure.
5. **Derive costs from the quantity take-off.**
   - Information: derivation and linking depend on the specific software used and cannot be described generally.
6. **Perform and document the quality control (contractor).**
   - Document detailed solutions for the quantity take-off.
   - Document project-specific adjustments (if the template is provided by the contracting entity).
7. **Plausibility check (contracting entity)**
   - Spot check the results.
8. **Provide the quality-controlled results.**
   - Provide deliverables on schedule.
   - Targeted communication with the stakeholders

## Non-goals

### What is not part of/a goal of the use case?

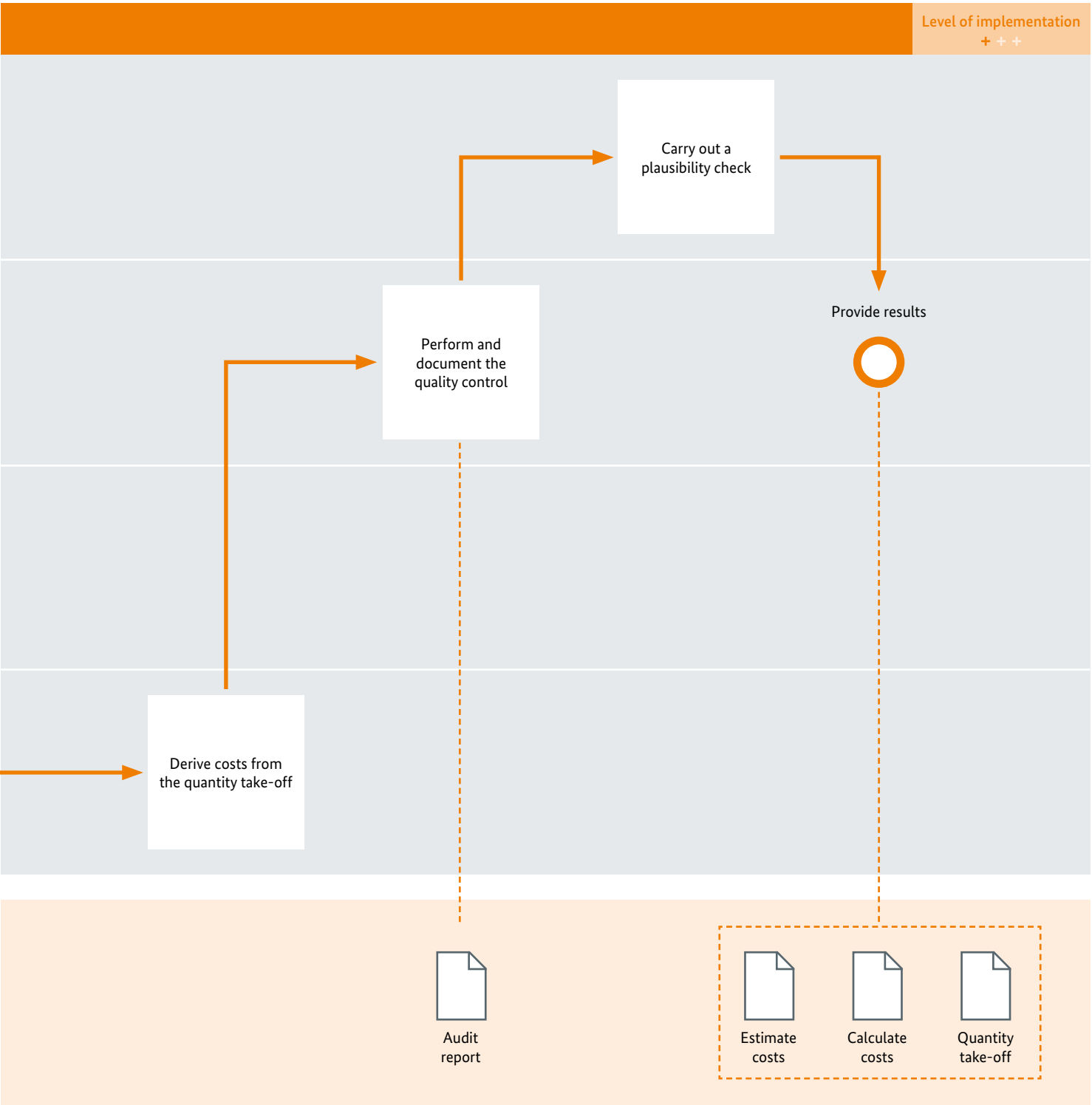
- Choice of cost structure (AKVS –instructions for calculating and estimating costs in road construction schemes, DIN 276-4 etc.). This requirement must be defined in the respective project.
- Prepare a bill of quantities for awarding contracts. This takes place in use case 110.
- Build and maintain price databases.

# 3. Process Diagram | Use Case 100 – Quantity Take-




The process diagram shown here is intended to provide an overview of the implementation of this use case. No subprocesses (e.g. individual steps of quality controls) are shown. The depiction is limited to the process steps from the profile and implementation recommendation.

# -off and Costing




The diagram shows which BIM role has primary responsibility for a given step. When lines separating BIM roles are crossed by a process arrow, the corresponding BIM roles must be involved in the corresponding process step.

# 4. Lessons Learnt

Tips based on practical experience with this use case, divided into five action areas: people, technology, processes, framework conditions and data.

## Action area: people

- It is not obligatory for the same individuals to prepare the models and derive quantities from them. These tasks call for specific skills. The overall approach must be defined and documented in the BEP.

- Qualified personnel focusing on (among others):
  - Model-based quantity take-off
  - Use of tender, award and invoicing software in a BIM context (not mandatory in use case 100, however)

## Action area: technology

- The software used for quantity take-off and costing should make it as easy as possible to update the models. Assignments of model elements to quantities/items should be preserved when doing so in order to permit automatic updating.

- To fully tap the potential of the use case, it is recommended to use tender, award and invoicing templates (e.g. catalogues of partial services, templates/specifications for links, templates for automatically calculating quantities etc.).

- Access to a price database is advantageous.

- Software products use different calculation methods, which can result in minor differences in the quantity take-off. Ideally, these should be clarified ahead of time to make sure that guidelines and sets of rules in the employer information requirements (EIR) are met. Any adjustments made during the course of a project should be documented in the BEP.

## Action area: processes

- At the start of a project (prior to modelling), the interfaces between the model and software used for quantity take-off and costing should be coordinated and tested.

- The quantities and costs to be derived from the model must be described in the EIR. Ideally, this should be done dynamically so that quantities and costs are updated largely automatically when changes are made to the model.

- There may be quantities and costs that cannot be derived from the model and must be determined by conventional means instead (e.g. construction site management, auxiliary products, job site area mobilization etc.).

- Use cases 100 and 110 overlap considerably, and their execution should therefore be coordinated and delimited.

- The contracting entity should perform random plausibility checks of quantity take-off and costing. It is not possible to describe in general terms how these checks should be carried out.

## Action area: framework conditions

- The cost structure (for example, according to AKVS, the instructions for calculating and estimating costs in road construction schemes) must be defined in order to clarify the requirements for creating the model.

- If possible, perform a manual quantity take-off on the basis of formulas in order to get automatically updated quantities in the event of changes.

## Action area: data

- The tender, award and invoicing software must be able to process models and should be able to read IFC data.

- During modelling, attention must be paid to assigning objects so that quantities can be determined as required (e.g. concreting sections).

- When converting data formats, minor differences can occur in the quantity take-off. These should be checked to make sure that the requirements of applicable guidelines are met, but as a rule they are negligible.

# Use Case 110
# Bill of Quantities, Tender, Contract Award

# 1. Profile

## Assignment of the use case to project phases

In which service phase will the use case be implemented?

| No. | Use case | Service phase acc. to German fee schedule for architects and engineers (HOAI) | | | | | | | | | Operation |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | B |
| Use Case 110 | Bill of Quantities, Tender, Contract Award | ☐ | ☐ | ☐ | ☐ | ☐ | ■ | ■ | ☐ | ☐ | ☐ |

## Definition

**Model-based generation of quantity-related items of the bill of quantities as well as model-based tendering, awarding of contracts and submission of bids for construction work on the basis of existing plans.**

## Benefit

What value can implementing a use case be expected to add?

- Reduced work for preparing bills of quantities and repeated creation of quantity excerpts
- More reliable costing of the overall project by minimizing the need for subsequent changes when quantity excerpts in bills of quantities contain incorrect figures
- Improved verifiability and transparency of items in the bill of quantities, thanks to cross-references to the corresponding items
- A consistent, machine-readable database for creating tender documents across projects, resulting in better quality
- Use of the models by bidders for calculation purposes in the tender process

## Prerequisites

What is required to implement the use case?

- Detailed and checked models as appropriate for the project phase
- Structure of cost breakdowns (AKVS – instructions for calculating and estimating costs in road construction schemes, DIN 276-4 etc.)
- To fully tap the potential of the use case, a consistent, machine-readable database is required for creating tender documents across projects (e.g. catalogue of standard services, catalogues of partial services).
- Suitable software for the specific roles involved, with BEP-compliant interfaces
- Appropriate digital sharing of tender documents
- Qualified personnel for this use case

## Implementation

How is the use case implemented?

1. Identify and take into account requirements of the EIR and BEP.
2. Identify and assign models required for the tender according to the requirements for creating the bill of quantities.
3. Use a model bill of quantities as the basis.
4. Supplement/rework model-independent items of the bill of quantities.
5. Link and perform quantity take-off of model-based items of the bill of quantities.
6. Compile the tender documents.
7. Check the tender documents.
8. Contracting entity conducts the contract award process.
9. Evaluate bids (plausibility check, supported by models where appropriate).
10. Award contract.

## Input

- Quality-controlled specialist models
- Structure of cost breakdowns (AKVS – instructions for calculating and estimating costs in road construction schemes, DIN 276-4 etc.)/ catalogue of partial services

## Output

- Construction contract
- Tendering models
- GAEB files

# Project/Practical Examples

## Example 1: Grevenau Bridge

The invitation to tender was issued for selected items involving model-based quantities. Decimal fractions were intentionally left unrounded in order to show that model-based quantities eliminate the need for rough quantity take-offs (see Figures 1 and 2).

| Ordnungszahl | Leistungsbeschreibung | Menge | ME | Einheitspreis in EUR | Gesamtbetrag in EUR |
|---|---|---|---|---|---|
| 1.6.20. | Bew. Beton einschl. Schalung herst.<br>Pfahlkopfplatte Ost+West<br>Stahlbeton C30/37<br>Bewehrten Beton einschließlich Schalung nach Unterlagen des AG herstellen. Schalung vorhalten und beseitigen. Leistung einschl. Traggerüst der Bemessungsklasse B. Bewehrung wird gesondert vergütet.<br>Bauteil 'Pfahlkopfplatte Ost+West'.<br>Art der Verwendung = Stahlbeton.<br>Druckfestigkeitsklasse C30/37.<br>Festigkeitsentwicklung = langsam.<br>Expositionsklasse 'XC2, XD2, XA1'. | 20,135 | m³ | [redacted] € | [redacted] € |

Figure 1: Excerpt from the bill of quantities: Pile cap item with model-based quantities (source: LSBG)


Figure 2: Example of model-based quantity take-off for pile caps for the bill of quantities (source: LSBG)

## Example 2: Kattunbleiche in Hamburg

Using tender, award and invoicing software, items from the standard catalogues of services and partial services were linked to objects of a model (Figure 3). The model-based quantities were quantitatively parametrized and inserted in long and short descriptions of the bill of quantities.

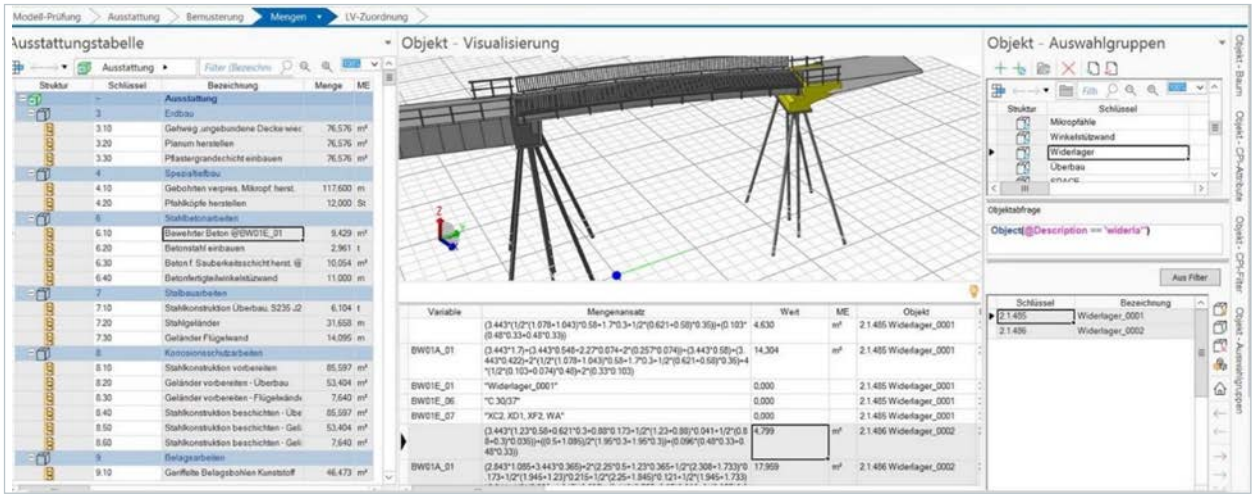



Figure 3: Linking of work items and quantities in tender, award and invoicing software (source: LSBG)

# 2. Implementation Recommendation

## Application level (level of implementation) + + +

## Implementation

### How is the use case implemented?

1. **Identify and take into account requirements from the EIR and BEP, such as:**
   - Structure of cost breakdowns (e.g. AKVS – instructions for calculating and estimating costs in road construction schemes, DIN 276-4 etc.)
   - Specifications for linking tender, award and invoicing software with the models
2. **Identify and assign models required for the tender according to the requirements for creating the bill of quantities.**
   - Identify the required models.
   - Benefits of using the tender, award and invoicing software stipulated in the BEP to import the models
   - If relevant, conversion of models into a format required for the tender, award and invoicing software
3. **Use a model bill of quantities as the basis.**
4. **Supplement/rework model-independent items of the bill of quantities.**
   - If necessary, add missing work items.
5. **Link and perform quantity take-off of model-based items of the bill of quantities.**
   - Link model objects with the corresponding work items (note: linking is software-specific and cannot be described in general terms).
   - Perform the model-based quantity take-off, including quantities that cannot be directly derived from the model.
   - Insert the quantities from the quantity take-off into the bill of quantities.
6. **Compile the tender documents.**
   - These comprise, among other things, of models, the EIR, BIM suitability criteria and criteria for awarding the contract, catalogue of long texts, construction description, schedules etc.
7. **Check the tender documents.**
   - Check for completeness and conformity with the requirements in accordance with implementation point 1.
   - Perform and document the quality control in accordance with the processes stipulated in the EIR and BEP.

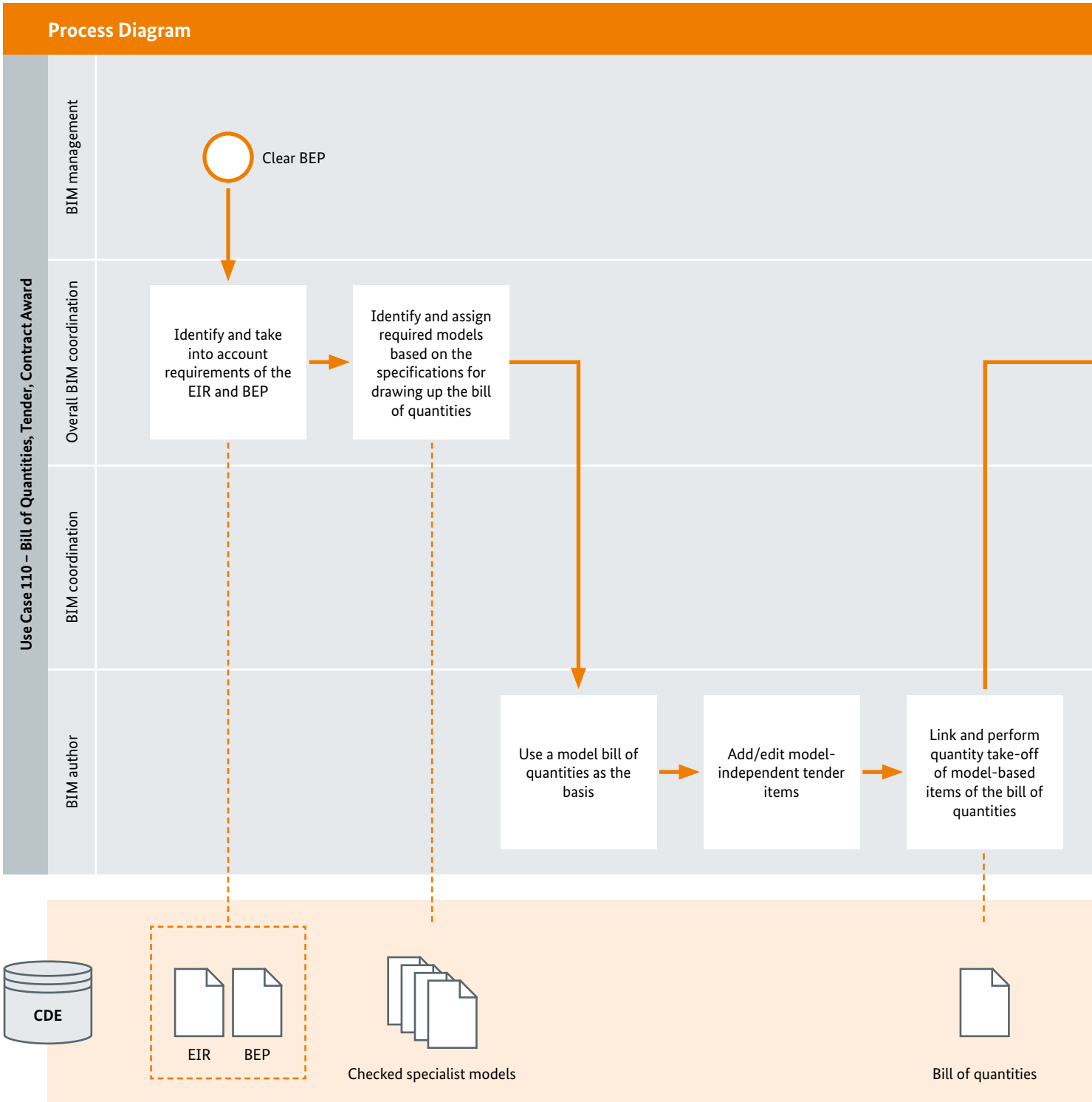
8. **Contracting entity conducts the contract award process.**
    - Publish the tender documents on a tender platform
    - Answer bidders' questions.
    - Bidders prepare bids, possibly supported by models
9. **Evaluate bids (plausibility check, supported by models where appropriate).**
    - Evaluate bids independently of the BIM method.
    - Check BIM contract award criteria (e.g. BEP for bid).
    - Check BIM suitability criteria (e.g. documentation of qualifications and reference projects).
10. **Award contract.**

## Non-goals

### What is not part of/a goal of the use case?

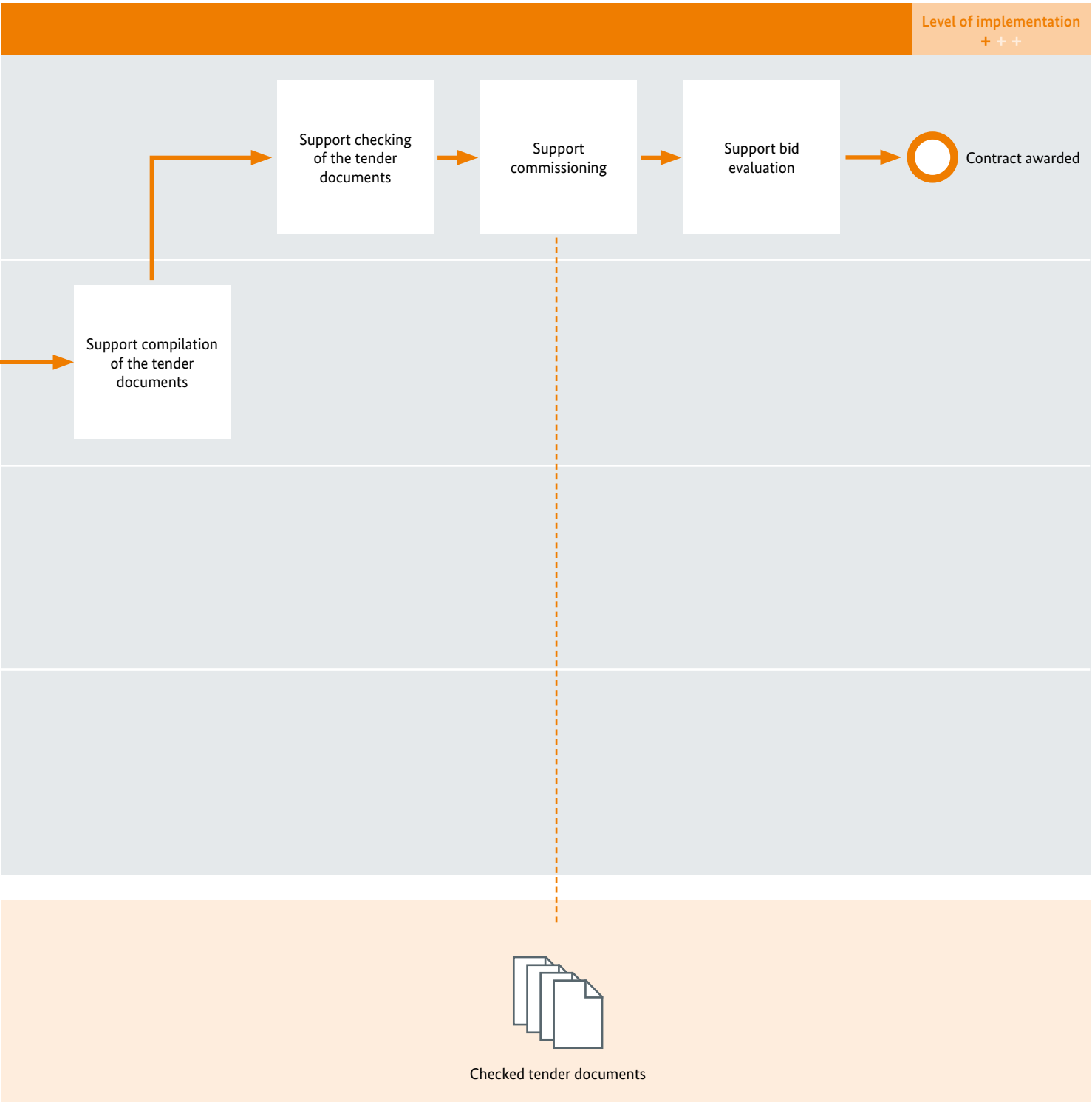
- Cost estimation and cost calculation, this takes place in use case 100.
- Generation of consistent, cross-project, machine-readable databases.

# 3. Process Diagram | Use Case 110 – Bill of Quantitie




The process diagram shown here is intended to provide an overview of the implementation of this use case. No subprocesses (e.g. individual steps of quality controls) are shown. The depiction is limited to the process steps from the profile and implementation recommendation.

# es, Tender, Contract Award




The diagram shows which BIM role has primary responsibility for a given step. When lines separating BIM roles are crossed by a process arrow, the BIM roles in question must be involved in the corresponding process step.

# 4. Lessons Learnt

Tips based on practical experience with this use case, divided into five action areas: people, technology, processes, framework conditions and data

## Action area: people

- In the infrastructure sector, the most time-consuming part of drawing up a bid is clarifying execution of the construction project, not quantity take-off. A model-based tender is therefore better-suited for communicating the construction work. The benefits increase further if all stakeholders work with a bill of quantities that is linked to models.
- Qualified personnel focusing on (among others):
  - Use of tender, award and invoicing software in the context of BIM
  - Model-based quantity take-off

## Action area: technology

- Tender, award and invoicing software must be able to process models.
- Ideally, the corresponding items of the bill of quantities are stored in the model as properties of the objects. This permits direct assignment and linking, also independently of the tender, award and invoicing software.
- It is only possible to directly derive quantities for bills of quantities from a model for a subset of the items:
  - The volumes and numbers of objects can be directly derived from the model
  - Deriving surfaces, lengths and the like calls for formula-based quantity take-off methods, which require in-depth knowledge of databases and programming skills.
  - Surfaces, lengths etc. can also be taken from properties of the models.
  - Information on items that are not referenced to a modelled object has to be calculated by hand. Because this is subject to human error, it should be kept to a minimum.

## Action area: processes

- At the start of the project (prior to modelling), testing/tuning of the interfaces between the model and tender, award and invoicing software should be specified in the EIR in order to enable timely responses to any problems that may arise.
- The structures of the project, model and bill of quantities need to be harmonized.

## Action area: framework conditions

- Use cases 100 and 110 overlap considerably, and execution of them should therefore be coordinated and delimited.
- Results from use case 100 can be a good basis for manually linking objects with the bill of quantities.
- As a rule, quantity take-off from the models is not fully compliant with VOB/C (part C of the German Construction Contract Procedures).

## Action area: data

- As of the time of this writing, the ability to exchange bill of quantities containers in GAEBXML format has not yet been fully implemented and cannot be presupposed.
- It is essential to be able to submit models in a non-proprietary format in connection with the invitation to bid and awarding of contracts.

# Use Case 190
# Project and Structure Documentation

# 1. Profile

## Assignment of the use case to project phases

In which service phase will the use case be implemented?

| No. | Use case | Service phase acc. to German fee schedule for architects and engineers (HOAI) | Operation |
|---|---|---|---|
| Use Case 190 | Project and Structure Documentation | ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ■ 8 ☐ 9 | ☐ B |

## Definition

Creation of as-built models (auditing models) with detailed information on execution, e.g. materials and products used as well as, as far as is relevant, references to audit reports and other auditing documents.

## Benefits

What value can implementing the use case be expected to add?

- Localization of audit documents ('single source of truth') by making it easier to find information on links with objects in models
- Long-lived digital data, ensured by the use of non-proprietary data formats for archiving purposes
- Better information base for operation

## Prerequisites

What is needed to implement the use case?

- EIR and coordinated BEP
- Suitable software for the specific roles involved, with BEP-compliant interfaces
- Coordinated data storage structure
- Qualified personnel for this use case

## Implementation

How is the use case implemented?

1. Identify and take into account requirements of the EIR and BEP.
2. View the detailed design (if relevant, with models).
3. View the construction site documentation.
4. Create the as-built models (if appropriate, on the basis of existing models).
5. Perform and document the quality control (contractor).
6. Perform and document the quality control (contracting entity).
7. Provide the quality-controlled results.

## Input

- Results of detailed design
- Construction site documentation
- If relevant, changes to plans
- If relevant, survey data for execution

## Output

- Quality-controlled as-built models

## Project/Practical Examples

### Example 1: Haynspark Bridge

This example shows an as-built model including surroundings, remaining temporary structures and old legacy piles (blue) below the waterline (cf. Figure 1). ASB-ING-compliant information (Figure 2) and audit documents were linked with the objects.

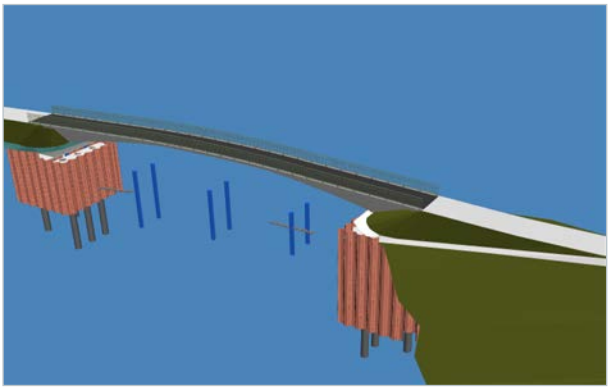


Figure 1: As-built coordinated model (source: LSBG/Ed. Züblin AG/ WeltWeitBau GmbH)

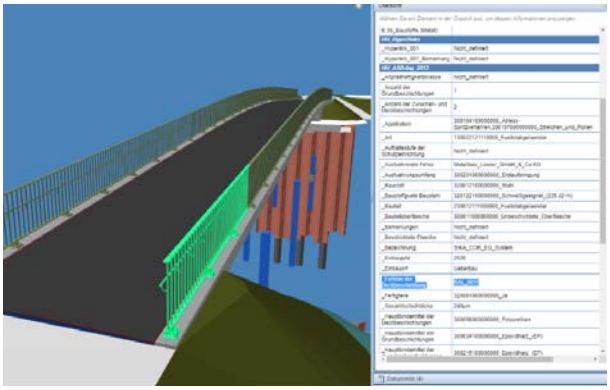


Figure 2: Excerpt of the contained information (source: LSBG/Ed. Züblin AG/WeltWeitBau GmbH)

### Example 2: Grevenau Bridge

This example shows an as-built specialist model of a drainage culvert and Grevenau Bridge in a coordinated model (cf. Figure 3). The as-built models were created on the basis of the execution models.

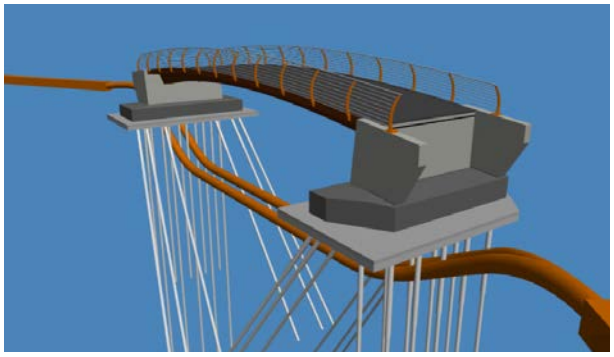


Figure 3: As-built coordinated model of Grevenau Bridge (source: LSBG/Ed. Züblin AG)

# 2. Implementation Recommendation

## Application level (level of implementation) + + +

## Implementation

### How is the use case implemented?

1. **Identify and take into account requirements from the EIR and BEP, such as:**
   - Compliance with the modelling guidelines
   - Compliance with the levels of model detail
   - Consideration of the storage location of the data to be linked with the models
2. **View the detailed design (if relevant, with models).**
   - View and evaluate the relevant information in the construction site documentation for suitability for use in/with the as-built models e.g.
     - Cleared detailed designs
     - Data sheets on asphalt formulations, coatings, concrete formulations etc.
     - Existing execution models
   - Consideration of changes (geometrical/ semantic) to planning of execution
3. **View the construction site documentation.**
   - View and evaluate the relevant information in the construction site documentation for suitability for use in/with the as-built models e.g.
     - Remaining components and temporary structures
     - Delivery notes
     - Inspection records
     - Defects
     - Survey data
4. **Create the as-built models (if appropriate, on the basis of existing models)**
   - If appropriate, merge the relevant models using suitable software.
   - Create as-built models.
     - Adapt the existing objects to the as-built state.
     - Create new objects.
     - Adapt and supplement the properties.
     - Create links.
   - Export the as-built models to the required file format.
5. **Perform and document the quality control (contractor).**
   - Check for completeness and conformity with the requirements of implementation point 1.
   - Perform and document the quality control in accordance with the processes stipulated by the EIR and BEP.
6. **Perform and document the quality control (contracting entity).**
   - Check for completeness and conformity with the requirements of implementation point 1.
   - Perform and document the quality control in accordance with the processes stipulated by the EIR and BEP.

7. **Provide the quality-controlled results.**

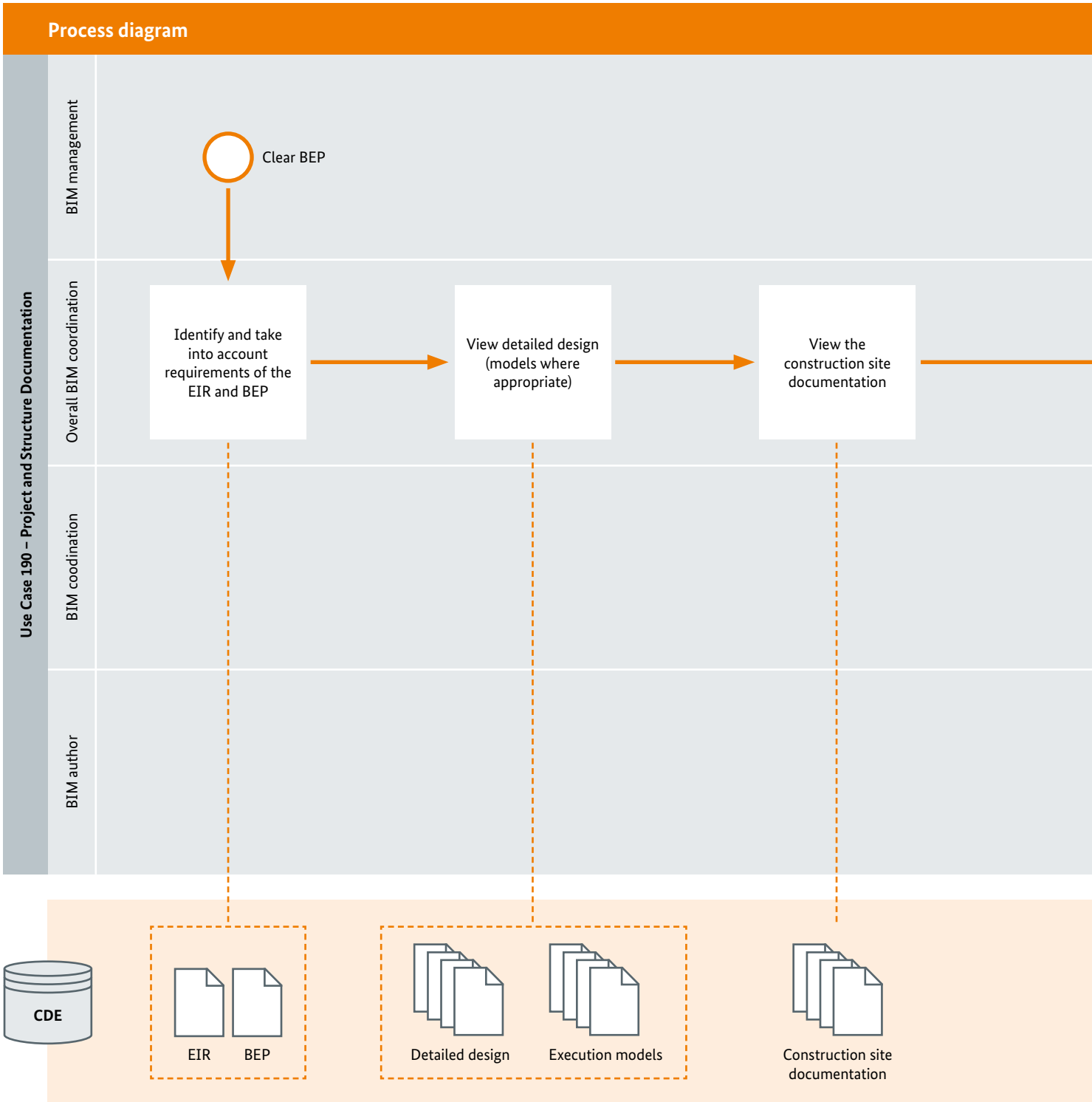
   - Provide deliverables on schedule.
   - Targeted communication with the stakeholders.

## Non-goals

What is not part of/a goal of the use case?

- Final preparation of the review documents for use on site

# 3. Process Diagram | Use Case 190 – Project and Stru

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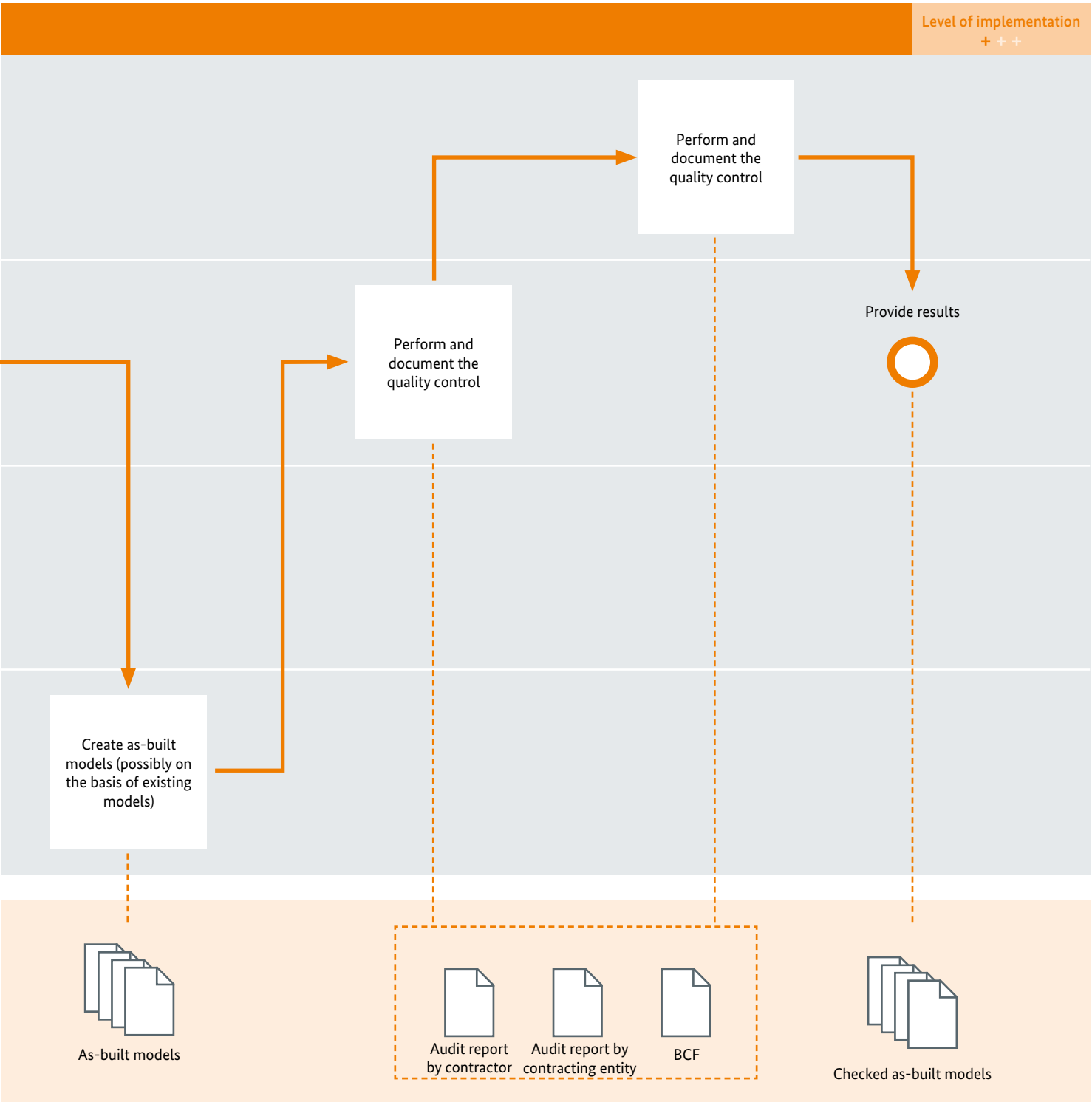
# ucture Documentation




The diagram shows which BIM role has primary responsibility for a given step. When lines separating BIM roles are crossed by a process arrow, the BIM roles in question must be involved in the corresponding process step.

# 4. Lessons Learnt

Tips based on practical experience with this use case, divided into five action areas: people, technology, processes, framework conditions and data

## Action area: people

- The place where the documents linked to the models are stored must be clearly indicated.
- The documents to be linked should be clearly indicated (e.g. inspection reports, asphalt recipes, maintenance notes, product data sheets etc.).
- So that all relevant information is taken into account, downstream contractors that have not created any models should also be involved in the information gathering process.
- Qualified personnel focusing on (among others):
  - Use of authoring software to create models
  - Experience in using survey data to create models

## Action area: technology

- It makes sense to use a common data environment so that everyone can use links to documents.
- The as-built model is often created from the relevant specialist models of the detailed design by integrating the deviations from the actual built structure. In addition, it can be a good idea to check the model using a digital survey (e.g. scatter diagrams).

## Action area: processes

- Information relevant to the as-built model should be continuously captured during implementation to prevent the loss of data and information. This requirement must be clearly stated in the EIR, as it can otherwise entail extra work. Overlaps with other use cases should be noted.

## Action area: framework conditions

- Use case 190 does not yet eliminate the need to create a structure log for the SIB-Bauwerke database, as no technical interface is available yet.

## Action area: data

- Working with non-proprietary file formats ensures the long-term usability of generated data.

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