CAD manual - Banedanmark

banedanmark

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Version 01.01

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Revision log

Revision date	Version	Responsible	Section	Description
2015-10-07	01.00	SBAC SHSH XAMBI XLESO	Whole document	First final edition
2016-04-18	01.01	XMABI XLESO	Section 3.2.3, 3.2.4, 3.2.5, 3.2.6	BTR added to file naming. Punctuation mark changed to dash (-)

1 Information

The present CAD manual describes common standards, structure, documentation and exchange formats while working on the projects for Banedanmark. Each project defines which sections of the CAD manual are relevant for the deliveries in the specific project in the Information and Communication Technology Cooperation Agreement, (ICT contract/IKT aftale).

The CAD manual is an extension to Banedanmark's Requirements for technical documentation (Krav til teknisk dokumentation i Banedanmark). The valid document in Danish can be found at the following link:
http://www.bane.dk/visArtikel.asp?artikelID=3643

This CAD manual aims to establish general guidelines for CAD work at Banedanmark. The guidelines must be used by all parties to ensure a structured and consistent preparation of CAD data to benefit all parties involved.

The current version of the CAD manual is available at http://www.bane.dk and will be continually updated.

In case of disagreement between the present CAD manual and the ICT agreement for each contract, the ICT agreement applies.

1.1 Different contract types

Banedanmark operates with different contract types. The detailing level of Banedanmark's deliveries and the requirements for deliveries to Banedanmark will differ depending on the type of contract.
This CAD manual applies for all the different contract types within the projects.
The ICT contract for each project or contract will include further information.

1.1.1 Consultancy Contract

In the Consultancy Contracts Banedanmark engages consultants to perform the different stages of design including Preparatory works and preparation of the tender material. Preparatory works define the general frameworks for the design in Definition Phase and Program phase and could include expropriation, utility Relocation, geotechnical and hydro geological detailed studies etc. Depending on tender strategy the tender material can have different level of information and be delivered as Basic Design or Detailed Design.

1.1.2 General Contract

In the General Contracts, Banedanmark delivers tender documents as Detailed Design and engages a contractor to carry out the project accordingly and deliver the required data back to Banedanmark. The consultants who have been involved in performing the

tender material bear the responsibility for controlling and delivering the as-built models and drawings.

1.1.3 Design & Build Contract

In the design & build contracts, the contractor is engaged to carry out both the design of a given structure and the construction of it. Banedanmark delivers the extension limits of the structure. The contractor bears the responsibility for preparing basic design, detailed design, construction and as-built, drawings and documentation.

1.2 CAD organization and responsibility

Each party as well as Banedanmark must appoint a CAD coordinator. Contact information about the CAD coordinators as well as the different parties' responsibilities is to be found in ICT Contract.

1.3 Common tools

For every major project in Banedanmark, a CAD exchange server will be created in order to exchange data between parties. The access to the server is further described in the ICT contract.

A set of common tools will be available on the CAD exchange server:

- Templates for generating new MicroStation and Autocad files, containing model block, revision log and two coordinate points.
- Banedanmark's title block
- Cell libraries for drawing frames and most used symbols
- Colortable
- Layer/Level structure for relevant disciplines
- Templates for drawing- and model file list

2 Basis for CAD production

2.1 File and folder structure

Each party to the project defines an appropriate folder structure in accordance with the company's internal standards.

If an exchange server is chosen to exchange the CAD files, they have to be placed in the folders and by metadata approved by Banedanmark.

If a common Banedanmark server is chosen, Banedanmark defines the folder structure and belonging metadata. This structure must be followed by all parties. Changes are only to be made after agreement with Banedanmark's CAD coordinator.

2.2 Coordinate system

Referring to the Danish rail norms (Banenorm) the horizontal coordinate system KP2000 and the vertical coordinate system (elevation) system DVR 90 have to be used.

All plan files and 3D models shall comply with the project's elevation and coordinate system. When files are received from other parties, and data are not placed in the project's elevation and coordinate system, the files must be transformed before use.

An exception to this is GIS data that must be converted to UTM32. See Section 8.2.5.

2.2.1 Unit system

All model files must use the same metric unit system in all 3 dimensions. Work shall be carried out in 1:1.
In MicroStation files 1 drawing unit/master unit = 1 m and subunits shall be mm with an accuracy of 0.1 mm.

If there is a need to use millimetres as master unit, the file must cover the same "Working Area" as defined in the meter file.

The unit system is defined in the templates delivered by Banedanmark, which have to be used by all parties.

2.3 Model block

All model files must have a model block containing Tags/Attributes. Each Consultant must place its logo or name in the block, on the right of the BDK logo, so that the owner of the file can be easily identified. The model block shall be placed under the model outside the drawing area in the same layer/level as a normal title block. The

model block is found by default in the template/seed file but can also be found in the cell library. The tags/attributes in the model block have to be kept as they are named. Changes are not permitted.

In order to register the revision history of the model files, a revision log is placed in a table below the model block. The revision log must be filled out each time the model changes and is uploaded to the Exchange server.

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Designer's logo

Model file

Coordinate System:

SUBJECT		INTERNAL REFERENCE
xx xx		xxxxxx
DATE dd.mm.yyyy	INITIALS XXX	SCALE 1:xxx

REVISION LOG		
DATE	INITIALS	REVISION DESCRIPTION (AND NAME OF SAVED VIEW, IF CREATED)
dd.mm.yyyy	XXX	xxx xxx xxx
dd.mm.yyyy	XXX	xxx xxx xxx
dd.mm.yyyy	XXX	xxx xxx xxx
dd.mm.yyyy	XXX	xxx xxx xxx
dd.mm.yyyy	XXX	xxx xxx xxx
dd.mm.yyyy	XXX	xxx xxx xxx

Figure 2.3-1 Model block

2.4 Title block and drawing frame

2.4.1 Banedanmark's title block

Banedanmark's title block is to be used for all drawings. The current version can be found at www.bane.dk.

The title block contains tags/attributes, which shall be used by all parties and have to be kept as they are named. Changes are not permitted.

"Krav til teknisk dokumentation" describes the layout and different fields in the title block further. For revisions and versions management, see section 3.3.
For drawing numbers in design and construction phases, see appendix 1. For as-built drawing numbers see "Krav til Teknisk documentation".

2.4.2 Drawing frames

Drawings shall be provided with a highlighted border so the top, bottom and right margins are 10 mm and left margin 25 mm. Besides standard ISO A formats (A0 - A4) A-frames must be used. A-frames contain a number of folds in multiples of 210 mm wide and 297 mm high.

See also DS102 and DS103 for instructions.

Frames can be found at www.bane.dk as a cell library for MicroStation.

2.5 Drawing layout

Drawings must consist of a maximum 8 A4 folds wide and 2 A4 folds height.

The title block is to be placed in the bottom right corner of the drawing frame.

The north arrow is placed inside the drawing field in the upper right corner.

The plan drawings have to be rotated so the railway stationing increases from left to right. Exceptions from here are the crossing roads where a rotation could be needed so the stationing of the roads can be the focus.

The scale symbol is placed on relevant drawings in the bottom left corner. The symbol is to be used on large scale drawings (1:40000 – 1:500).

North arrow and examples of scale and other relevant symbols to be used on drawings can be found at www.bane.dk.

In addition to the title block, the fold containing the title block must only be used for revision log, notes, legend and key map.

The key map must be used on relevant plan drawings. The frame for the key map is included in the title block cell in a separate layer/level. This level must be turned on and the frame has to be filled with the relevant keymap as well as empty rectangles indicating all drawing frames along the specific discipline of the project. The current drawing is marked by filling in the corresponding rectangle. Location names must be added on the key map for localization.

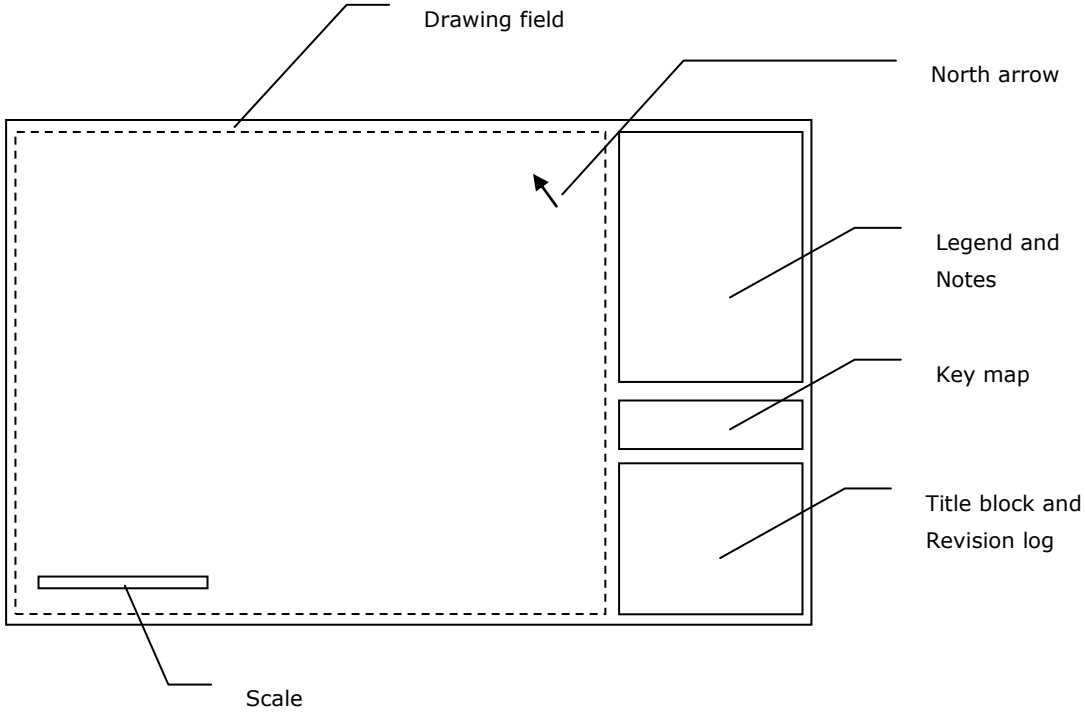

Figure 2.5-1: Principle for drawing layout.

2.6 Text and dimensioning

The text on drawings must be written in upper and lowercase. When specifying decimal separation (text and measurements) commas must be used, e.g. "9,65". If a 1000 delimiter is required, it must be indicated by full stops/period, e.g. "120.650,00". Stationing for roads and tracks must be indicated with + for 1000 delimiter, e.g. "60+000".

On drawings in general, text height is 2,5 mm for descriptive text, measurements and text for illustrations, and 3,5 mm for headlines and specification of location. In drawings with a high level of detail, a text height of 2,0 and 1,8 mm may be used.

Superscripts such as headings below illustrations should be written with an underlined text, height of 3.5 mm, block letters and below the illustration e.g. PLAN, 1:100, SECTION B, 1:20, DETAIL 2, 1:5.
Align text with the illustration's left side.

A text that is logically coherent may not consist of several text sections.

Text relating to geometry, stationing etc. must be placed either in the 3D model file or in a separate 2D file. If the text for constructions etc. needs to be placed in the drawing file, it must be placed in the drawing file's model environment.

Use the True Type font Arial as the default text font.

Symbol fonts are often used in files received from, for example, surveyors. As these fonts are difficult to convert to other CAD formats, it is recommended that cells/blocks are used instead of fonts, to show symbols. If symbol fonts are necessary, these shall be uploaded to the project server together with CAD files.

It is recommended that dimensioning is associative. Drawing-related changes must always be executed by changing the geometry first and then changing the dimension. Amendments must never be made to the dimension text alone, instead of revising the geometry.

2.7 Line types

Using DDA layer structures the line types are defined for the different layers and disciplines. A resource file containing the line types to be used for utilities is available at www.bane.dk - both for MicroStation and AutoCAD.

3 Structuring of CAD files

3.1 Geometry

Constructions and technical elements are designed as 2D/3D geometry and/or 2D/3D construction objects, and are placed in the model files to which they belong in terms of theme and responsibility.

3.1.1 Discipline data

When using applications like Bentley "InRoads", Bentley "Rail Track" and similar applications to design the models, a number of external data files will be generated. These data do not have a graphical interface by itself, but can be displayed as graphics in a DGN- or DWG-file. These data files are called discipline data and are the basis for generating the 3D models, 2D extractions and quantities.

3.1.2 2D geometry

2D geometry is either:

- extractions of discipline data (e.g. cross sections)
- extraction of 3D geometry
- supplements to extractions from 3D models (e.g. patterns and symbols)
- manually created 2D geometry (e.g. details)

3.1.3 3D geometry

3D geometry is either:

- graphically displayed 3D discipline data
- 3D elements modelled directly

3.2 File types and naming

10 types of CAD files are defined as described below. When naming files, none of the Danish characters "Æ, Ø, Å, æ, ø, å" are permitted. Similarly, file names may not contain full-stops, commas, spaces or special characters other than underscore "_" or hyphen "-".

File type	Description
Template /Seed files	Templates for all files generated in the project.
Discipline data files	From design tools in relevant disciplines.
Model files	For creating, processing and storing the design.
Interdisciplinary models	For QA of consistency, quantities etc.
Drawing files	For creating and maintaining drawing layouts.
Assembly files	For information about a coherent system of files.
Sketch files	For temporary sketches which are not a part of the final design.
Notation files	For frames, folder markers and notes.
Digital plots	For documentation of drawings.
Archive files	For documenting design history and exchange of drawing files in CAD format.

Table 3.2-1 File types

Appendix 1 contains principles for naming the individual files.

3.2.1 Template/seed files

Template files (seed files in Bentley applications) are to be used when generating new files. Templates/seed files delivered from Banedanmark are available as MicroStation and AutoCad files. The 3D MicroStation seed file and AutoCAD template file contain color table, dimension styles, text styles, and model block. At project start-up the template/seed file has to be stamped with geo coordinates and 2 coordinate marks with label within the project area have to be inserted. The used coordinate system have to be indicated above the model block.

The 2D MicroStation seed file is to be used for generating drawing files and does not include the model block.

3.2.2 Discipline data files

Applications generating discipline data produce different types of file formats. Discipline data files are the files that contain these data.

Discipline data files are typically used to generate model files for terrain, utilities, embankments, alignment (plan and profile) and cross sections, but might be used for other kinds of output, for example in connection with quantities and machine control. When using compatible applications it is a benefit to exchange the data files in the native file format together with the relevant model files. Otherwise the files have to be exchanged in LandXML format together with the outputs in DWG/DGN. Regarding file formats, please see chapter 6.2.

This CAD manual defines principles for naming the most important types of discipline data, which can be exchanged between the different parties. Appendix 1 has defined the naming convention.

Banedanmark uses Bentley products and is able to receive and control discipline data in Bentley ALG- and DTM-formats. When using other applications than Bentley products for generating alignments and surfaces, the files must be exchanged in LandXML format, supplemented with geometry reports on demand. The LandXML format from other applications has to be tested and approved by Banedanmark by upstart of the project.

3.2.3 Model files

A model file contains a discipline-specific collection of 2D/3D geometry and/or construction objects. All amendments to the project are made in the model files.

Each area of responsibility (discipline) shall establish and maintain its own model files. No amendments may be made in anybody else's model files.

Supplementary models are gathered in drawing files. At the same time, one model file can be part of several different drawing files and can also be shown in different scales.

The following systematisation for naming CAD model files is used:

- [*File type*][*Contract*][*Discipline*]-[*BTR*]-[*Locality*]-[*Type*]-[*Theme*]-[*Serial number*]

The individual codes are given in appendix 1. Examples for file names and deliveries in different phases are available in appendix 2.

The revisions of model files are tracked via the revision log in the model block. Version and revision naming are not included in the actual CAD file name.

The level of detail and information must correlate with the specific aim of the model file cf. section 3.4.

3.2.4 Interdisciplinary models

An interdisciplinary model is a model composed of references to model files from different disciplines. Several interdisciplinary models can be created to suit different purposes, e.g. clash detection and visualization.

The interdisciplinary model contains no geometry but can contain other information such as Saved Views and collision control reports.

Each party is responsible for its own interdisciplinary models and their maintenance.

The following systematisation for naming interdisciplinary files is used:

- [*File type*][*Contract*][*Phase*]-[*BTR*]-[*Locality*]-[*Type*]-[*Serial number (optional)*]

The individual codes are given in appendix 1.

3.2.5 Drawing files

Drawing files are used for setting up and maintaining drawing layouts. Supplementary models are referenced into drawing files. At the same time, one model file can be referenced into several different drawing files and can also be shown in different scales. The model files used to generate the drawings have to be based on 3D models or 2D extractions from the 3D models with supplementary information.

The drawing file contains:

- Frame
- Title block
- References to model files
- Text containing Tags/Attributes are copied into the drawing file and maintained there.

In addition, the drawing file may include:

- Notes
- Legend
- Key Map
- Scale signature
- North arrow (if plan view)
- Two system axes including the belonging coordinate text (if plan view)
- Copyright label when using basis or cadastral maps, if applicable.

Regarding the layout of drawings see figure 2.5-1.

The drawing number must always be identical with the name of the associated drawing file. Revision management of drawing files is carried out by filling in revision fields in the title block as well as using revision clouds around the revised areas.

The following systematisation for naming and numbering drawing files shall be used:

- [*File type*][*Contract*][*Phase*]-[*Discipline*]-[*BTR*]-[*Locality*]-[*Serial number*]

The individual codes are given in appendix 1.

The As Build drawing files have to be named in accordance with Banedanmark's "Krav til Teknisk dokumentation".

For generating and naming of the multipage drawings see "Krav til Teknisk documentation".

3.2.6 Assembly files

Assembly files contains no elements, but are meant as a service for others parties to tell which references are useful. An example is the assembly file for all designed roads within the contract area or specific locality.

The following systematisation for naming of Assembly files shall be used:

- [*File type*][*Contract*][Phase]-[*Discipline*]-[*BTR*][Locality]_[*Type*] *_[Serial number (optional)*]

The individual codes are given in appendix 1.

3.2.7 Sketch files

Sketches are temporary drawing files with a limited lifetime. Sketches must have a title block that provides information on content, but needs not be as detailed as the official drawings described in section 3.2.5. The title block shall at least contain the same information as mentioned in the model block.

Sketches are to be named as follows:

- [*File type*] [*Contract*][*Discipline*]_[*Serial number*]

The individual codes are given in appendix 1.

3.2.8 Notation files

Notation files contain the cells/blocks used to supply the models and drawings with information, e.g. symbols and patterns, drawing frames, Title blocks, notes, etc. There are no requirements for naming notation files since they are for internal use and are not assumed to be exchanged. Notation files provided by Banedanmark are available on project's exchange server.

3.2.9 Digital plots

Digital plots are plots of drawing files in formats such as PDF, TIFF, etc. and are used as basis for, and exchange of, the paper prints digitally. Digital plots are also used for documentation.

Digital plots are named identically with the name of the drawing file.

3.2.10 Archive files

Archive files are copies of a specific version of drawing files in CAD format except that all references are merged into the drawing. Archive files can be used internally to document the content of the drawing at a given time or for exchanges with external

suppliers/contractors. The files may only be exchanged after further agreement with Banedanmark.

The archive files must not be used for amendments. Only the original model files and drawing files may be revised.

Archive files are named in the same way as drawing files although the letter A is added in front of the filename to designate the file type.

The following systematisation shall be used:

- [*A*] [*Drawing Number*]

3.3 Version and revision management

Amendments to the project will lead to changes in several different file types. The table below provides an overview of how amendments are handled in different file type.

File type	Method
Model file	Revisions are managed in the log beneath the model block. The file name remains the same.
Drawing file	Version and revisions are managed in the title block and documented in the log. The file name remains the same.
Digital plot	Version and revisions are managed as in drawing files.
Archive file	Version and revisions are managed as in the drawing files.

Table 3.3-1: Version and revision management

Drawings, digital plots and archive files generated before tender, shall use capital letters for version. The first version of the tender drawings has to be named 00.01. The procedure for revision management after tender is described in "Krav til Teknisk documentation".

3.4 Information levels

Information levels are used to describe the content and detailing level of model files. Information levels are to be indicated for each file when exchanging to other parties. The information must to be defined in the model block.

Information levels used in the CAD manual respects the design process for a railway project and refers to the phases defined in NAB (Ny anlægsbudgettering) by the Ministry of Transportation for a railway project. Further information is to be found at the Ministry's website. The following sections describe the relationship between Banedanmarks phases and the level of information for the CAD files.

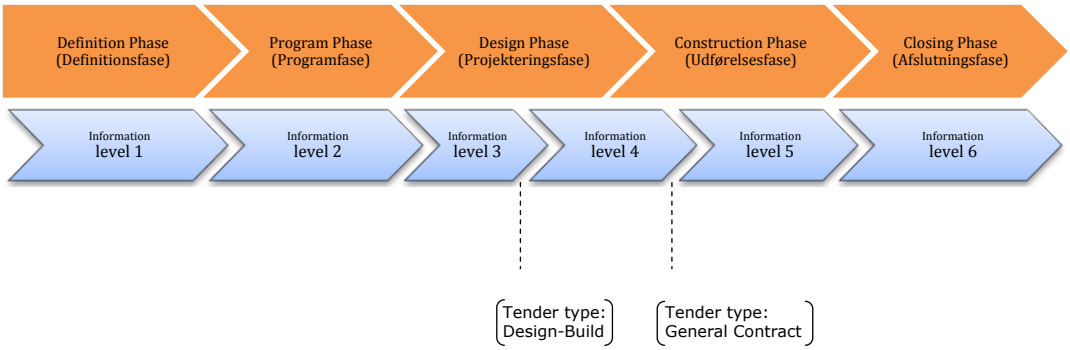

Figure 3.4-1: Relations between Banedanmark's phases and information levels.

This CAD manual defines requirements for modelling and drawing production regarding information level 2, 3, 4, 5 and 6, but all information levels are described.

3.4.1 Information level 1

Information level 1 is used in connection with the conceptual design and describes the design concepts in the Definition Phase. The model describes the corridor for the railway with draft alignment and physical dimensions, and contains the basic requirements for the functionality of the design.

3.4.2 Information level 2

Information level 2 is used in connection with the preliminary design for the project proposal in the Program Phase. The position and geometry of the alignment is decided within the reasonable tolerances. Types of crossing structures (bridges, tunnels etc.) are defined. The models describe the geometry by defining the overall concepts and limitations for the major design.

3D models with information level 2 should have a level of detail that corresponds to a scale of > 1:2000 in a drawing context.

3.4.3 Information level 3

Information level 3 is used at the scheme design phase (basic design) in the Design Phase to allow the overall structure of the construction to be determined and to provide the basis for the regulatory process. At this phase the negotiations with the authorities and municipalities will be carried out. The preparatory works are done and the basis for starting a detailed project will be prepared. In order to define the requirements and limitations, some detailed investigations are performed. 3D models with information level 3 indicate the outer geometry of the constructions.

In Design & Build type of contracts, the major part of the 3D models must be prepared for tender with level 3 of information. In this case the tender documents include 3D models of the limitations for the outer geometry supplied with drawings extracted from the 3D models with a low level of detailing.

After tender the contractor bears the responsibility for carrying out 3D models and drawings showing the chosen design. The models and drawings designed by the contractor include the whole geometry with low level of detailing and are the basis for the Authority's approval.

The models should have a level of detail that corresponds to a scale of 1:2000 or 1:1000 in a drawing context for earthworks and rail works. For structures the level of detailing should correspond to a scale of 1:200 to 1:100 on drawings.

3.4.4 Information level 4

Information level 4 is used in the Detailed Design phase, which provides the basis for realization of the design, estimating of quantities and production planning. At this point all details about the geometry are clarified enough to create the model files, discipline data files and drawings. Models and digital data are usable for generating setting out data and quantities. Design basis and detailed design of the structures are to be approved by third parties as well as Banedanmark's Technical system responsible (TSA).

In a Design & Build contract, design on this level will be finalized by the Contractor.

In General contracts Banedanmark's consultants will finalize this level as a basis for tendering.

3D models with information level 4 should have a level of detail that corresponds to a scale of 1:1000 to 1:20 in a drawing context depending on type of models. For structures the level of detailing should correspond to a scale of 1:50 to 1:20 on drawings. For earthworks, roads and rail works the level of detailing should correspond to a scale of 1:1000 to 1:50 on drawings. Different disciplines within rail works might need different levels of detailing, according to the relevant norms and specifications.

3.4.5 Information level 5

Information level 5 is used in the Construction Phase as the basis of production. This level contains sufficient information for constructing the structures, including production planning, logistics and planning deliveries e.g. building elements, components and materials. The models with information level 5 can be used for simulation of construction as well as earth balance planning and machine control.

Models and drawings with information level 5 is carried out by the contractor with the needed level of detailing to carry out the construction works.

3.4.6 Information level 6

Information level 6 is used as documentation of the completed construction. The models must be updated to reflect the as-built construction and must be transferred for use in the operation and maintenance organisation.

The 3D models created in the Detailed Design phase with information level 4, have to be compared with the measurement of the as-built constructions. If the models meet the requirements for the tolerances in the relevant discipline, the detailed design models and drawings can be delivered as as-built documentation. Otherwise the models and drawings have to be updated according to the measurements.

3.5 Layer/levels

Layer/Level structures defined by "Det Digitale Anlæg (DDA)" are to be used. The level libraries for the most used disciplines are to be found on the project's exchange server. Where DDA has not defined the layer/level structure for a discipline, the latest version of bips publication C201 Level structure 2005 can be used. If there are areas of the project without a defined level structure, the following coding principles are to be used for naming the necessary levels:

A	**F**	**_**	**T**	**_**	**U**	**U**	**U**	**_**	**E**	**E**	**E**	**E**	**E**	**_**	**Z…**

Where:
A is the Responsibility Code
F is the Discipline
T is the Theme
U is the Sub-theme
E is the Element
Z… is the unlimited number of capital and lower case letters for other sub-elements.

Any suggestions for new layers/levels must be confirmed by Banedanmark.

3.6 Reference technology

Information is generated in one file only!

If there is a need of information from another model, reference file technology must be used.

All drawing files must use reference file technology, thereby gathering information from supplementary model files.

3.7 Modelling discipline

Continuous lines must not consist of several line segments and there should be no remnants of the old congruent lines. Do not place several identical entities on top of each other.

Geometry shall be placed correctly in relation to the coordinate system. Geometry shall be modelled in exact dimensions corresponding to the physical elements.

Entities shall always be placed with the appropriate snap method or the exact coordinates. They must not be placed approximately or by rule of thumb.

The graphics in the model files should be divided into layers/levels in a manner that will allow other parties to turn off elements that are irrelevant to them (e.g. utility pipes on a different level than texts and dimensions relating to them). Model files,

which are uploaded on the exchange server, must only contain relevant elements and layers/levels.

Shapes (types: shape, complex shape, polyline and ellipse) shall, for the sake of further processing, always be executed as closed elements. Where lines define a delimited area, the lines should be drawn as a closed shape (continuous line without cessation or duplication).

Shapes that are to be plotted as filled shapes (with a raster pattern or with a colour) must have the fill and the border placed on separate layers/levels, so that each part can stand alone.

Model files should be of an appropriate size, depending on the chosen application and content of the files. A maximum of 10 MB will be usable for most types of files. Terrain models may generate larger files. It is recommended that these size limits are agreed on during the design process.

Models must be divided in relevant disciplines, and only contain elements of that discipline.

4 Use of models

3D models and discipline data are used for multiple purposes and the area requires a great deal of coordination and exchange in order to get optimal benefit of the information.

The models and discipline data can be used in the following processes:

- Drawing production – preparation of drawings
- Simulation – technical analyses
- Consistency control – geometrical checks, clash detection, interfaces
- Visualization – project reviews/coordination and presentation
- Data extracts – quality assurance and quantities
- Exchange

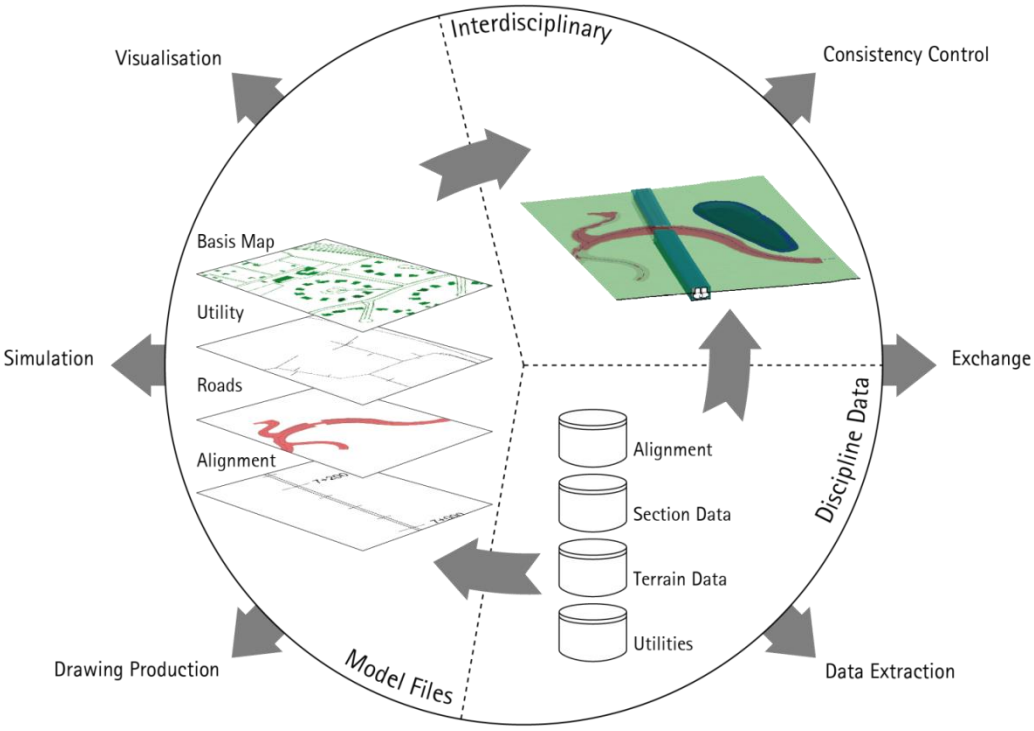

Figure 1: Use of models.

4.1 3D models and discipline data

The following sections describe the 3D models and discipline data to be generated within the project:

Existing Conditions:

Model type	Content	Format
Existing terrain	Based on laser scanning of existing terrain, optionally supplied with detail surveys.	DGN/DTM DWG/XML
Existing subsurface	Indicative model of existing geological layers, based on information registered in geotechnical investigations.	DGN/DTM DWG/XML
Existing track	Based on BDK "kurveregister" supplied with survey data	DGN/ALG/ TXT
Existing structures	Based on existing drawings, surveys, registrations and documentation.	DGN/DWG/ I.DGN
Existing utilities	Indicative model of existing utilities, based on information received from utility owners.	DGN/DTM/ DWG

Table 4.1-1, 3D models, existing situation

Designed Models:

Model type	Content	Format
Alignment for tracks	3D alignments for designed tracks	DGN/ALG/ XML/ASCII
Alignment for roads and paths	3D alignments for designed roads and paths	DGN/ALG DWG/XML/ ASCII
Corridor for railway	Corridor for the new track	DGN/DTM DWG/XML
Platforms	Structures and fixtures for platforms at railway stations	DGN/DTM DWG/XML
Corridors for roads and paths	Corridors for designed or relocated roads and paths.	DGN/DTM DWG/XML
Road geometry and equipment	Model containing road geometry and equipment, e.g. curbs, grating, crash barriers	DGN/DTM DWG/XML
Clearance for railway	Clearance profile for railway	DGN/DTM DWG/XML
Clearance for crossing constructions	Clearance profile for crossing roads, paths and fauna passages	DGN/DTM DWG/XML
Groundwater level	Model indicating maximum level of groundwater	DGN/DTM DWG/XML
Structures of over- & underpasses and associated works	Model of over- and underpasses, retaining walls and similar structures	DGN/DWG
Excavations	Model containing excavations and backfill for constructions and structures.	DGN/DTM DWG/XML

Technical installations	Model of e.g. signal control system, lighting masts and M&E.	DGN/DWG
Relocated Utilities	As-built model of relocated utilities	DGN/DTM DWG/XML
Rainwater basins	Model of rainwater basins incl. in- and outlets	DGN/DTM DWG/XML
Drainage	Model of drainage pipes and manholes	DGN/DTM DWG/XML
Spoil areas	Model of spoil areas	DGN/DTM DWG/XML
Terrain model	As-built model of the terrain surface	DGN/DTM DWG/XML

Table 4.1-2, **Fejl! Brug fanen Startside til at anvende Heading 2 på teksten, der skal vises her.**3D Designed models

4.1.1 Existing Conditions

The models for existing conditions will be created at project start-up and will be used during the whole design and construction phase with the necessary updates. The extent of the models, which are necessary for different type of project, can vary. The requirements will be clarified in the ICT contract.

Besides the 3D models, existing conditions are defined in 2D files as basic maps and cadastral maps, which are to be provided at the beginning of the design process. The ICT contract defines which part bears the responsibility for providing the data.

4.1.1.1 Existing terrain

Usage:
The 3D models showing existing terrain define the existing situation before the construction works begin. The models can be used to understand the limitations and possibilities in the project's area, generate the designed models and estimate volumes during the design phases.

Description:
In the Program Phase the existing terrain model can be based on data from "Danmarks Højdemodel, DHM".

The 3D model for existing terrain used in basic and detailed design is to be based on laser scanning along the alignment, supplemented by data from detailed survey. The model for existing terrain is the basis for all design and calculations and is to be used and updated by all parts and contracts. Guidelines for updating the existing terrain including time interval for updates and media for registration of changes have to be agreed on at project start-up.

The models of the existing terrain have to be available for all parties. If the project is divided into tender packages, the relevant portions of the terrain model have to be available for the contractors.

Detailing level:
The level of detailing depends on the used media and as minimum it has to fulfil the requirements in the current Banenorms and guidelines.

Formats:
Based on the chosen application to generate the terrain model, the 3D models have to be available in either DTM/DGN or XML/DWG format.

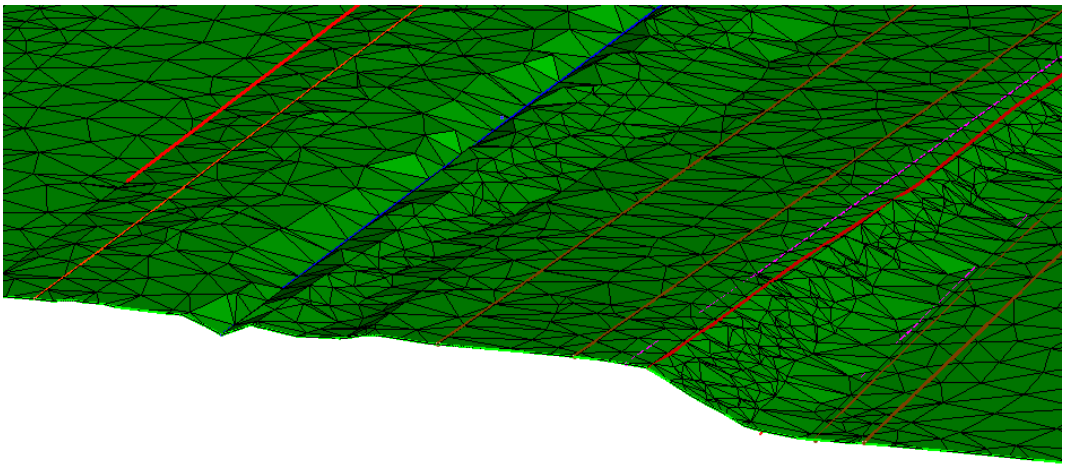

Figure 4.1.1.1-1 Existing terrain

4.1.1.2 Existing subsurface

Usage:
The models define the critical dimension regarding geotechnical layers. The models are based on estimates from the geotechnical investigations and can be used for choosing solutions for design of foundation as well estimating the volumes and prices.

Description:
Based on Geotechnical investigations rough 3D models of the primary aquifer (limestone) and soft soils within the railway corridor are to be modeled as 3D surfaces. The models have to indicate the bottom level of the occurrence and are only regarded as supplementary information. Further description of the modeling methods and assumptions for modeling has to be delivered to Banedanmark. The documentation will be available for the relevant consultants and contractors together with the 3D models.

Detailing level:
The models are to be delivered as gridded surface models based on geotechnical assumptions and reports. Depending on the relevant area and collected information the grid size will vary.

Formats:
The models for subsurfaces have to be delivered in DTM or LandXML format. A 3D model in DGN or DWG format has to be delivered as well, showing the occurrences as mesh components.

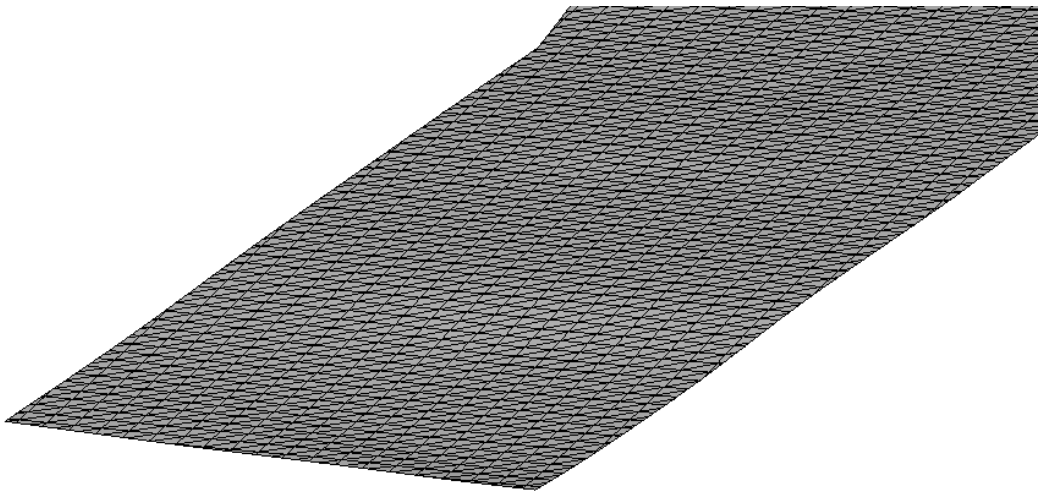

Figure 4.1.1.2-1 Existing subsurface

4.1.1.3 Existing track

Usage:
Working along an existing track or having an interface to it, the model for existing tracks will be used to respect the limitations and connections.

Description:
The model for the existing track has to be based on BDK's "Kurveregister" supplemented with survey data. Survey data used to generate the alignment have to fulfil the requirements from the relevant railway codes. The Bentley software "Rail Track" or "Power Rail Track" have to be used to model the alignment for existing tracks. The alignment model has to be completed using regression tools. Cant information from the surveyed rail or Banedanmark's "Kurveregister" has to be added.

When the existing track is moved sideways for more than +/- 200 mm, it is to be considered as a designed track and have to follow the requirements described in section 4.1.2.1.

Detailing level:
The alignment for the existing track is to be modelled respecting the requirements in the current Banenorms and guidelines.

Formats:
Alignment for tracks has to be delivered in ALG and DGN format. Alignment data have to be available in LandXML and as geometry reports in Excel/ASCII format on demand. Information about the alignment has to be delivered in a 2D DGN file with annotations.

The original data from "Kurveregister" and "Længdeprofilregister" will also be available as additional information.

4.1.1.4 Existing structures

Usage:
When working close to an existing structure or having an interface to it, the models will be used to respect the limitations and connections.

Description:
The 3D models have to include the outer geometry of the major structures. The models are indicative and only meant as an extra assistance to the different parties. Modelling has to be based on the available existing drawings, and must be verified by surveys and registrations. The outer geometry has to include any hidden structures such as foundations.

Detailing level:
The models have to include the outer geometry of the major structures corresponding to information level 3 (see section 3.4.3).

Formats:
Depending on the chosen design application the 3D models have to be delivered in DGN/DWG format. When applicable the models have to be delivered as i-models as well.

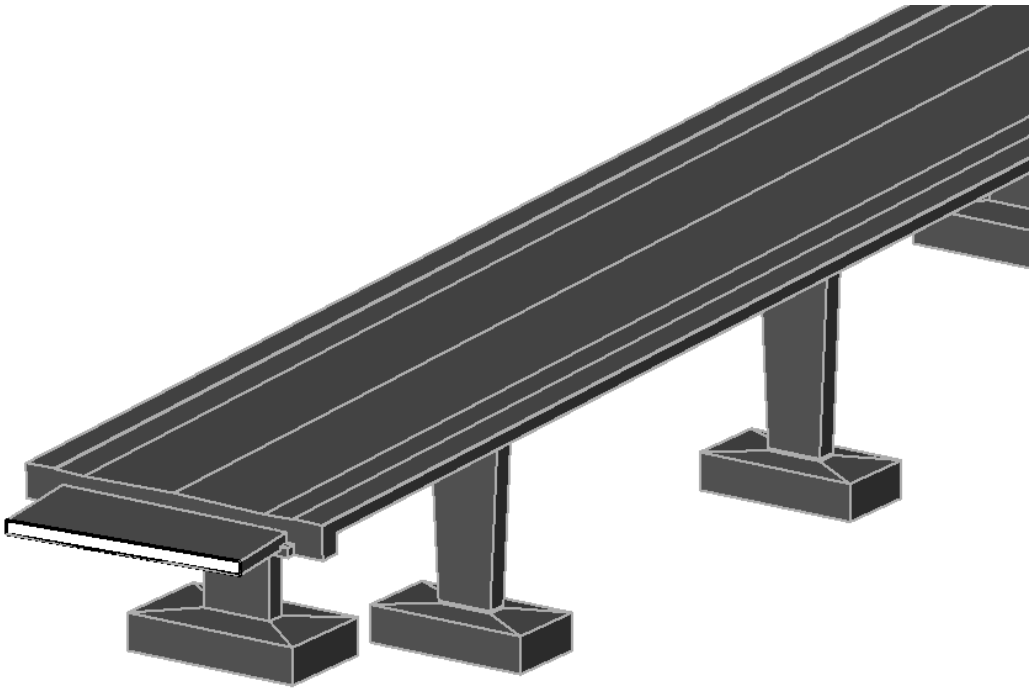

Figure 4.1.1.4 Existing structures

4.1.1.5 Existing utilities

Usage:
Existing utilities are one of the major challenges within the infrastructure projects. Registering the information about existing utilities in 3D models gives the possibility to respect their placement in design phase and avoid fracture in utilities during the construction phase. The models are also necessary to decide the extent of the necessary relocations.

Description:
Information about the existing utilities have to be gathered through LER (The Danish Register of Underground Cable Owners) and registered either as 2D or 3D CAD files to be used during the design and construction phase. The models are only meant as an

extra assistance to the different parties. The information regarding elevations depends on received information from the utility owner and will mostly be generated from indicative placement of the specific type of utilities where other information is not available.

Depending on the project's extent and needs, the major pipes and utilities have to be modelled in 3D based on information received from utility owners. As minimum the models have to contain the following utilities within the contract limits:

- gas pipes
- high voltage cables
- water pipes
- waste water pipes
- rain water pipes
- district heating pipes
- major associated structures

The output is 3D components including the outer geometry for the utilities as well as the reference line for each utility. For information regarding relocated utilities se section 4.1.2.13.

The ownership for each pipe/cable has to be indicated in the file name. The layer structure has to include information about precision of the data used for modelling the utilities. The belonging documentation has to be included and available for all parties together with the 3D models.

Detailing level:
The models have to include the outer geometry for the pipes, manholes and major associated structures. Reference lines for the pipes and manholes have to be included as well. Detailing level depends on the received information from the utility owner.

Formats:
Depending on the used software for modelling, the models have to be delivered either:

- as solids/components in DGN or DWG format
- as i-models

When using any applications to generate the models, the delivery formats of the discipline data have to be agreed on with Banedanmark.

4.1.2 Designed models

Structures must be modelled as solids. All objects forming the outer geometry must be included in the model as logical coherent solid elements. It must be possible to extract volumes from each element as well as relevant quantities (area, length, number). The models have to be used for setting out of the structures. Using applications to generate the 3D models (e.g. Revit, Tekla, or similar) the models have to be delivered as i-models as well. Section 6.2 describes the exchange formats further.

In models containing surfaces (e.g. terrain models, basins, road surfaces), each layer has to be presented as a 3D surface including the breaklines and points used to

construct the model. Surfaces have to be presented as meshes or mesh components. Surfaces and the belonging breaklines have to be placed in separate files. It has to be possible to extract volumes from the surfaces either directly from the CAD format or by delivering the discipline data used to generate the surface. The exchange and delivery format has to be agreed on with Banedanmark. Section 6.2 describes the exchange formats further.

Models including earthwork design have to include the necessary information for setting out and to be used for machine control. Further agreements about formats and content of models have to be done between the designer and contractor.

Discipline data, 3D and 2D models, including drawing files, archive files and digital plots have to be available for exchange and delivery to Banedanmark on demand at any phase of the project.

The ICT contract for each project defines which design models are relevant to deliver for the specific contract and which party has the design responsibility.

When several contracts are involved in modelling different parts of the same construction, the interfaces between them have to be clearly defined and each contract bears the responsibility for designing and updating their own models according to the interface agreements. Section 6 describes the exchange process.

Models, drawings and discipline data have to be delivered by each shift of phases.

The designed models have to be delivered with information level 6 according to requirements in section 8.2 by the end of the construction works.

4.1.2.1 Alignment for tracks

Usage:
The alignment is to be used to design and build the geometry of the designed rail and is the basis for all track works.

Description:
The alignment for the track will be used during the whole design process to define the limitations for the related constructions. The alignment has to be generated and maintained in Bentley "InRail" or "PowerRailTrack".

Both the 3D center line for tracks and the 3D lines of the rails have to be displayed in the corridor model for the railway as coherent 3D line strings. Setting out data has to be generated from the discipline data file (ALG-file) directly.
The center line for the alignment has to be displayed and annotated in a 2D model file.

The design has to follow requirements in the current "sporregler", "Banenorms" and guidelines for the respective type of railway.

Working with alignments in ALG format it is important not to copy the Geometry projects and the belonging horizontal, vertical or cants. It is only allowed to modify the geometry for the individual elements in order to keep the ID's for the alignments.

The ALG files have to be cleansed for alternatives not in use before exchange with other parties and delivery to Banedanmark.

Detailing level:
The alignment has to describe the horizontal and vertical elements including cant and turnouts annotated in meter with 4 decimals.

Formats:
Alignment for tracks has to be delivered in ALG and DGN format. Alignment data have to be available in LandXML and as geometry reports in Excel/ASCII format on demand.

4.1.2.2 Alignment for over- and underpasses

Usage:
The alignment is to be used to design and build the geometry of the designed over- and underpasses.

Description:
Alignments for over- and underpasses describe the geometry for the related construction and might be designed in the chosen application. Choice of application has to be approved by Banedanmark in advance.

The designed alignment has to follow the requirements for the type of construction, which are agreed with the respective authority.

The reference line for the designed alignment has to be displayed and annotated in a 2D model file. The 3D representation of the reference line has to be displayed in the corridor model for the relevant construction as 3D coherent line string.

The discipline data used to generate the alignment have to be available for exchange with other parties as well as for delivering to Banedanmark.

Detailing level:
The alignment has to describe the horizontal and vertical elements as well as super-elevation annotated in meter with 4 decimals.

Formats:
Depending on the used software the alignment for over- and underpasses have to be delivered in ALG/DGN or LandXML/DWG format. On demand alignment data have to be available as geometry reports in Excel/ASCII format as well.

4.1.2.3 Corridor for railway

Usage:
The models are to be used to design and build the substructures of the designed railway. The models have to be prepared for using in machine control.

Description:
Based on the alignment for track and requirements in the "Banenorm" for railway design, the corridor for the new track has to be modelled and delivered in 3D. The model has to include following components:

- Ballast
- Subballast
- Top of subsoil/formation level (råjordsplanum)
- Ditches
- Slopes connecting the corridor to existing terrain

Each surface has to be presented on a separate layer/level as 3D mesh components. The break lines and points used to construct the model have to be delivered either in the same file or in a separate file using the respective levels. These surfaces must be included in the same model file, if they are designed by the same contract.

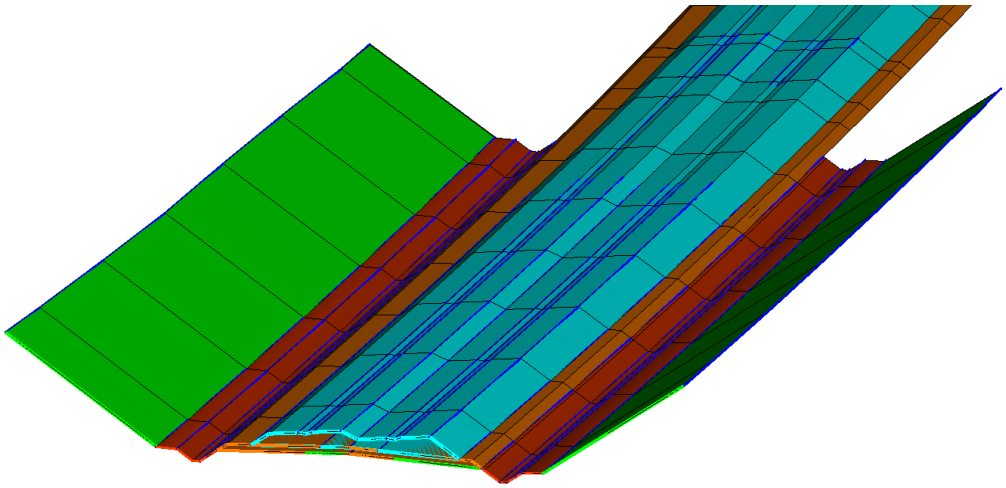

Figure 4.1.2.3-1 Railway corridor

Detailing level:
Models with information level 3 have to include all the elements describing the geometry. Details around connections at crossing constructions are not required modelled in 3D at this level.

The connection to crossing constructions as well as details around connection to the embankments, ditches and the drainage system is to be modelled and displayed at information level 4.

The as-built models have to include the completed construction as well as the necessary information for maintenance of the rail corridor corresponding to information level 6.

Formats:
The models have to be delivered in either DGN/DTM or DWG/LandXML format. Discipline data to generate the models have to be available on demand during the entire process.

4.1.2.4 Platforms

Usage:
The models have to define the geometry of the platforms during the design phase and are to be used by the contractor to execute the structures in the construction phase.

Description:

The models include the geometry for the platforms at railway stations.
As a minimum the following structures are required in the model:

- Front edge and back plates
- Foundation
- Consoles
- Platform coatings
- Tactile tiles
- Safety markings
- Ramps, elevators and stairs within the platform area
- Permanent fixtures, e.g. ticketing machines

The placements of the platforms' front edges have to be based on the alignment for the tracks as well as assumptions in the special work descriptions. Setting out of the individual object in the 3D models has to follow the nominal dimensions defined in the current Banenorms and guidelines. The models do not include the tolerances. The levelling at the beginning and end of platforms has to be included in the models.

Detailing level:
Models in basic design include the outer geometry for the front edge plate, foundations and major structures corresponding to information level 3.

Models in detailed design have to include all the objects corresponding to information level 4.

As-built models have to include objects corresponding to the same detailing level as detailed design, confirmed or revised by detailed surveys corresponding to information level 6.

Formats:
The models have to be delivered in DGN/DTM or DWG/LandXML format. Solid objects designed directly in the CAD software do not need to be included in the discipline data.

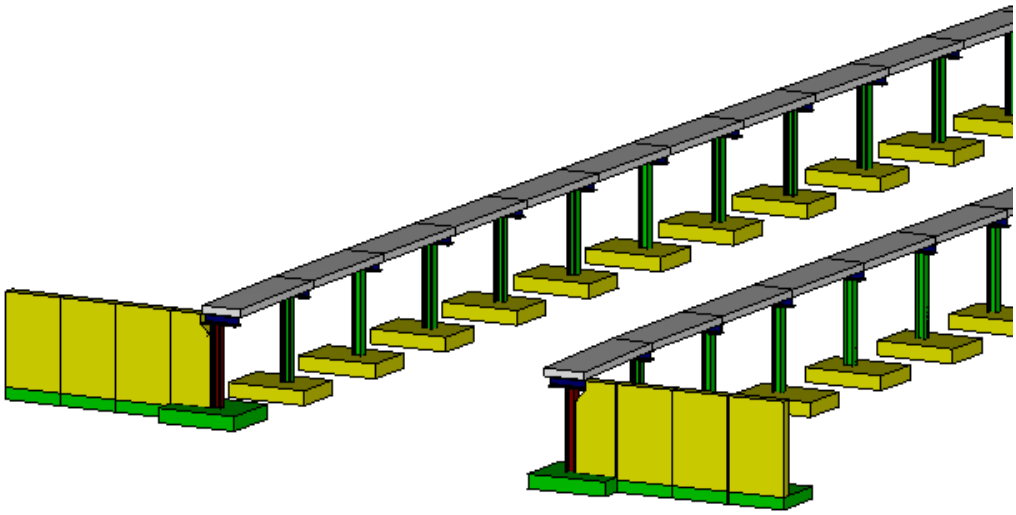

Figure 4.1.2.4-1 Platform

4.1.2.5 Corridors for roads and paths

Usage:

The models will be used to design the geometry of the designed or relocated roads and paths within the project at basic design.

Description:
Based on the crossing roads' alignments and Vejdirektoratet's "Vejregler" as well as agreements with the relevant municipalities and authorities, the corridors for the crossing roads as well as the roads and paths included in the contract, have to be modelled and delivered in 3D.

The models have to include the surface and breaklines for the top layer of the roads including slopes and connection to the existing terrain. The 3D reference line has to be included in the models.

Models for the road corridors may be delivered in separate files for each locality or in one file for each contract. When using separate files for the corridors within the same contract, it is recommended to use an assembly file (see section 3.2.6) to gather the relevant files for the whole contract.

The discipline data used to generate the corridors have to be available for exchange with other parties as well as for delivering to Banedanmark.

Detailing level:
The models are only made for basic design corresponding to information level 3. The models will be replaced by the models for road geometry and equipment (section 4.1.2.6) at the detailed design phase. Details around connections to crossing construction are not required modelled in 3D at this level.

Formats:
Depending on the chosen application the 3D models for corridors have to be delivered in either DGN/DTM or in DWG/LandXML format as mesh components.

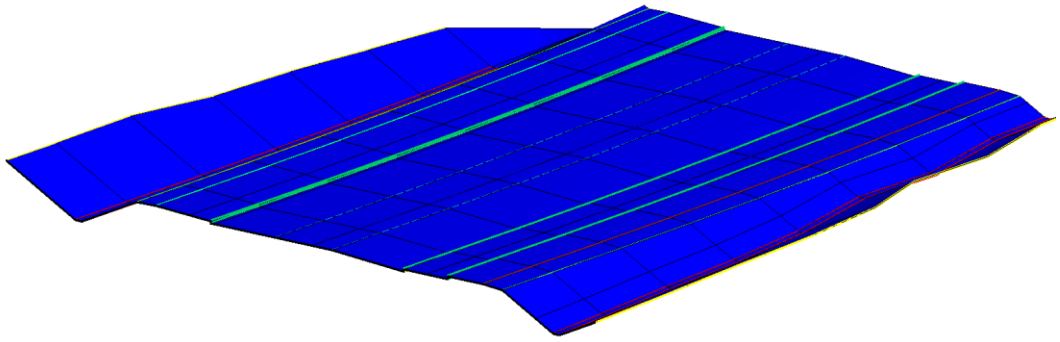

Figure 4.1.2.5-1 Road corridor

4.1.2.6 Road geometry and equipment

Usage:
The models will be used to get final approval from the authorities as well as for building the constructions. The models have to be prepared for use in machine control.

Description:

During detailed design the models for road corridor will be replaced by the models for road geometry and equipment. The corridor models have to be completed and supplemented with the necessary information for setting out of all layers and objects included in the design. The models have to include different layers in the road construction including:

- Final road levels
- Top of subsoil/formation layer
- Different layers of materials for construction of the road
- Embankment slopes and the final end conditions for connection to the existing terrain and other connecting constructions
- Equipment such as curbs, grating and crash barriers

The geometry for the different layers of the road construction has to be delivered as separate mesh components in the same file. The belonging breaklines and points, which are used to generate the model have to be delivered in a separate file. The models for equipment have to be delivered as whole elements, either as solid elements or as coherent surfaces.

The models for road geometry and equipment may be delivered in separate files for each location or in one file.

Detailing level:
The models have to include the necessary information for setting out of all objects. Details around connecting constructions and existing terrain have to be clarified at the detailed design phase corresponding to information level 4.

The as-built models have to include the necessary information for maintenance of the roads and belonging equipments according to the requirements from the relevant client organization corresponding to information level 6.

Formats:
Depending on the chosen application the 3D models have to be delivered in DTM/DGN or LandXML/DWG format as mesh components.

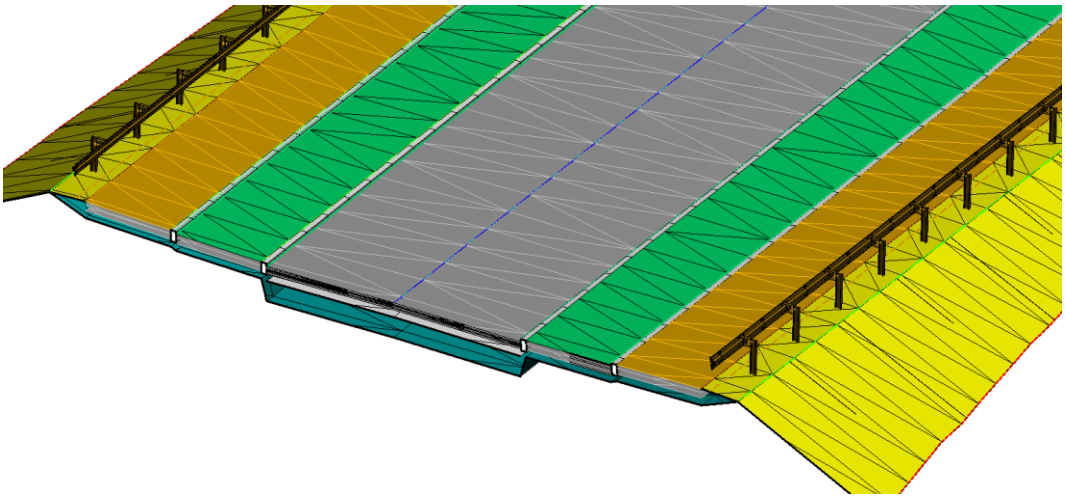

Figure 4.1.2.6-1 Road geometry and equipments

4.1.2.7 Clearance for railway

Usage:

The 3D geometry of the clearance profile will be used to ensure free passage of the trains as well as the necessary volume for belonging constructions. During the design process the models will be used to for clash-detection.

Description:

For railways, 3 types of clearance have to be modelled:

1. Clearance profile for the train (Kinematic envelope) as defined by Danish railway norms and the publication "Fritrumsprofiler", defining the restriction area necessary for free passage of trains
2. Clearance for the structures (Minimum Infrastructure gauge) as defined by Danish railway norms and the publication "Fritrumsprofiler", which indicates minimum volume for establishing the installations and structures around the trains
3. Clearance for ballast, which defines the minimum volume of the ballast layer according to the requirements in the current Banenorms and guidelines.

The clearance profiles must be based on the alignment for tracks and modeled through the whole alignment as 3D components, respecting the cant and curvatures.. The chosen profiles for each project have to be documented so all parties are informed about the requirements.

Minimum infrastructure gauge is to be defined by given swept volume inside which no obstacle must be located or intrude. This volume has to be determined on the basis of the reference kinematic profile and take into account the gauge of catenaries and the gauge for lower parts.

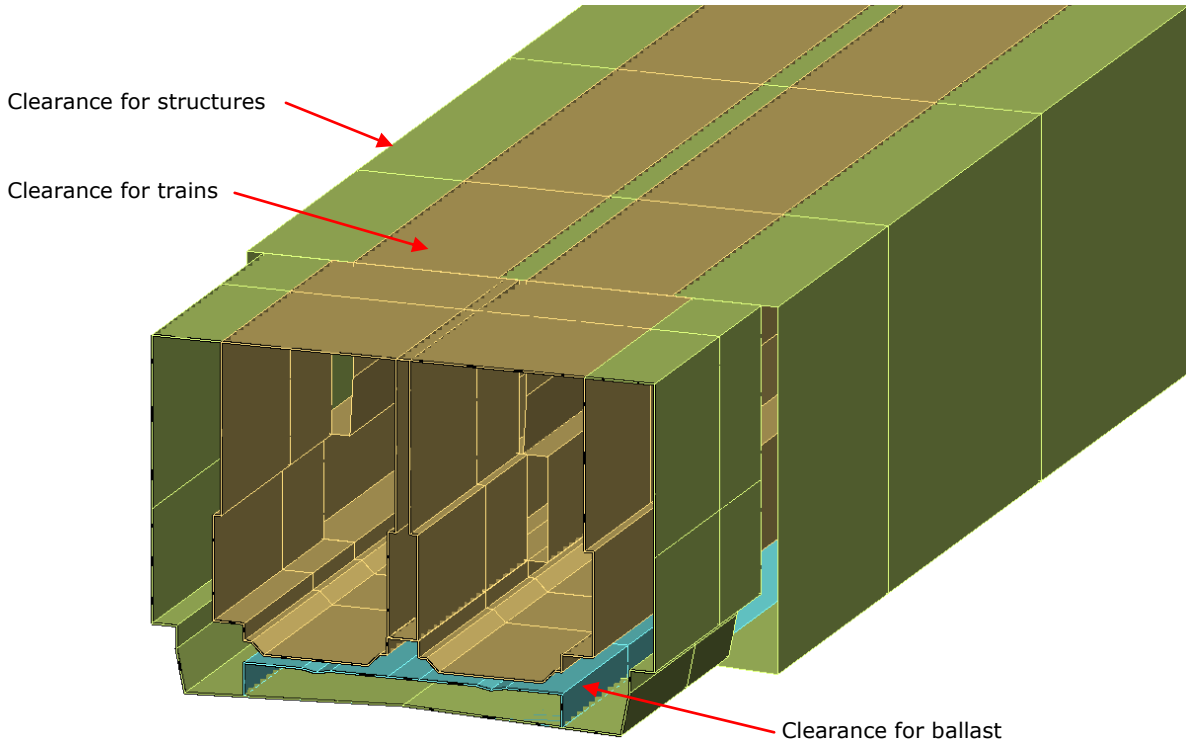

Figure 4.1.2.7-1 Railway clearances

Detailing level:
The level of detailing has to fulfil the tolerances and requirements mentioned in the publication "Fritrumsprofiler" as well as the current Banenorms and guidelines. The models have to include supplements for the cant and curvatures through the whole alignment and be updated during the whole design process and delivered together with as-built documentation showing the final clearances within the project area. The models do not include building tolerances.

Formats:
Clearances have to be modelled in Bentley "Rail Track". For curves with small radius the necessary assumptions have to done to cover the curvature supplements. The models are to be exchanged and delivered in DGN/DTM format as mesh components. Discipline data used to design the models have to be available for Banedanmark during the whole process on demand.

4.1.2.8 Clearance for crossing constructions

Usage:
3D geometry of the clearance profile will be used to ensure free passage for the relevant usage of the construction. During the design process the models will be used for clash-detection.

Description:
For crossing structures, the clearances of designed or existing roads have to be modelled according to the requirements in the Danish road norms ("Vejregler"). The requirements for the clearance for fauna passages are to be defined by respecting the relevant requirements defined by the EU-Habitat Directive and other relevant legislation.

Detailing level:
The models have to include all the necessary assumptions, which respect the free passage for the relevant construction. The models do not include building tolerances.

Formats:
Depending on the chosen application the 3D models have to be delivered in either DGN/DTM or DWG/LandXML format as mesh components.

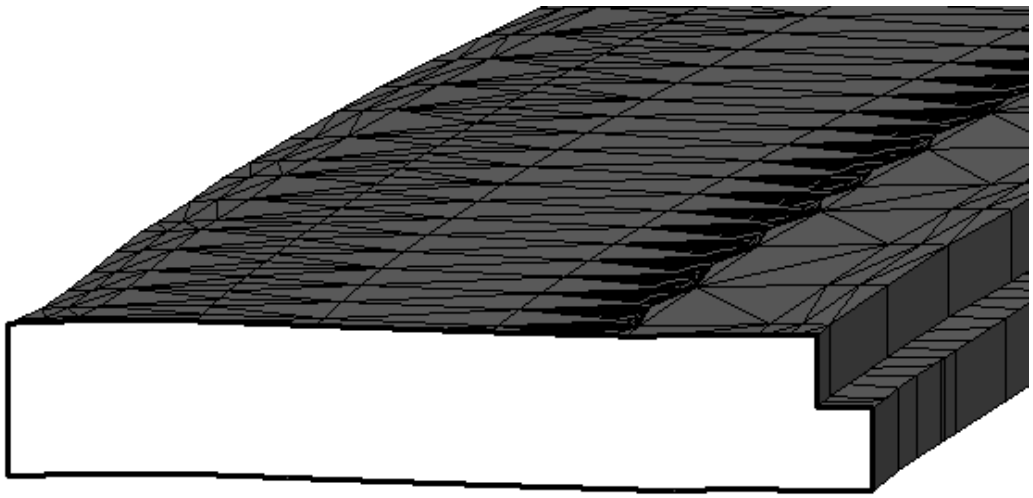

Figure 4.1.2.8-1 Road clearance

4.1.2.9 Groundwater level

Usage:
The 3D models of the groundwater level will be used to identify the critical areas within the project and to optimize the design and establish the necessary precautions to avoid damages to the constructions. The models are indicative and only meant as an extra assistance to the different parties, and must be verified by registrations.

Description:
Based on the geotechnical investigations a model of the groundwater level has to be generated as a 3D surface model within the railway corridor. The assumptions made to design the 3D model have to be agreed on between the parties and documented so it is available during design and construction phases.

Where the groundwater models influence the design of constructions, the model has to be verified during the detailed design based on further groundwater registrations. In case of major changes of the groundwater level, the models have to be modified and delivered to Banedanmark for approval and registration.

Detailing level:
Modeling methods and detailing level has to be agreed on with Banedanmark.

Formats:
Depending on the chosen application the 3D models have to be delivered in DTM/DGN or LandXML/DWG format as mesh components.

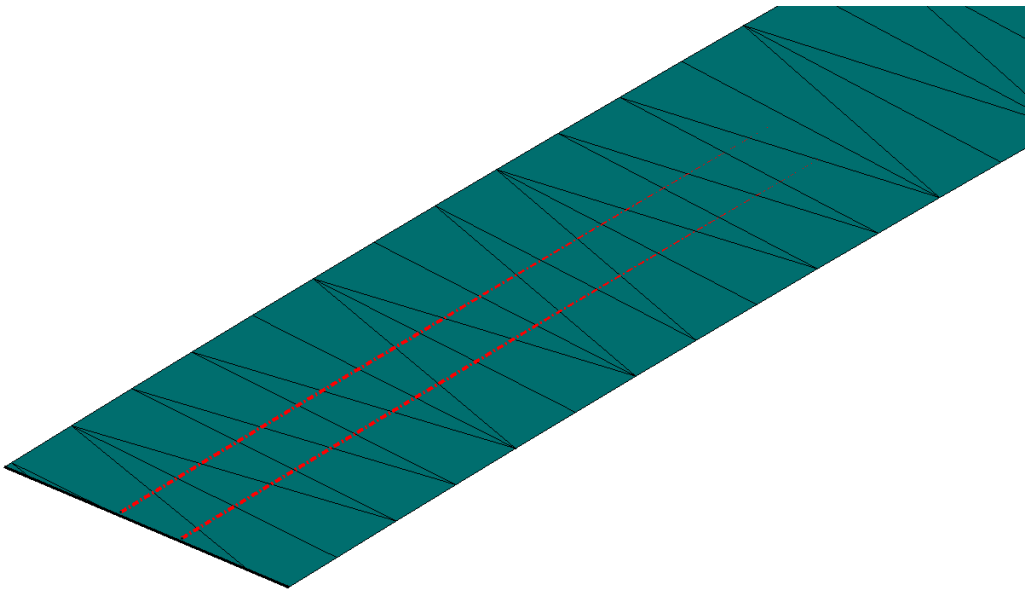

Figure 4.1.2.9-1 Groundwater level

4.1.2.10 Structures of over- & underpasses and associated works

Usage:
The models will be used to design and build the structures. The models have to be used to extract setting out data during the construction phase.

Description:
Structures crossing the railway or placed within the contract limits have to be modelled in 3D. The structure models include:

- Bridges
- Tunnels
- Fauna passages
- Retaining walls
- Waterproof trough
- Other major structures

The models have to be used to define the geometry, generate drawings and calculate quantities.

Detailing level:
The models with information level 2 include the limitations for placement, height and width of the structures defined at the critical positions regarding to the free passage. The models include the lower limitation for the bridge/crossing structure based on requirements defined in the relevant documentation. Within the areas where the water proof trough is needed, the model includes the upper surface of the trough. Depending on tender strategy the models for structures can be delivered at tender with information level 2 or 3 in Design & Build type of contracts.

At basic design the models have to include the outer geometry of the major structures as whole elements corresponding to information level 3.

The models for detailed design with information level 4 must describe the outer geometry of the construction as whole elements. All objects included in the outer

geometry must be part of the model as logical coherent solid elements. It must be possible to extract volumes from each element. The models must include the hidden geometry such as foundations, piles, ground anchors and similar. The joints within the structures must be defined in the model. Also the 3D models must include the reference points and lines for the structures e.g. reference lines for columns and beams, reference points on top of the foundation and similar. The information will be used for control calculating of the design.

Formats:
Depending on the chosen application the 3D models have to be delivered in DGN/DWG format. When applicable the models have to be delivered as i-models as well.

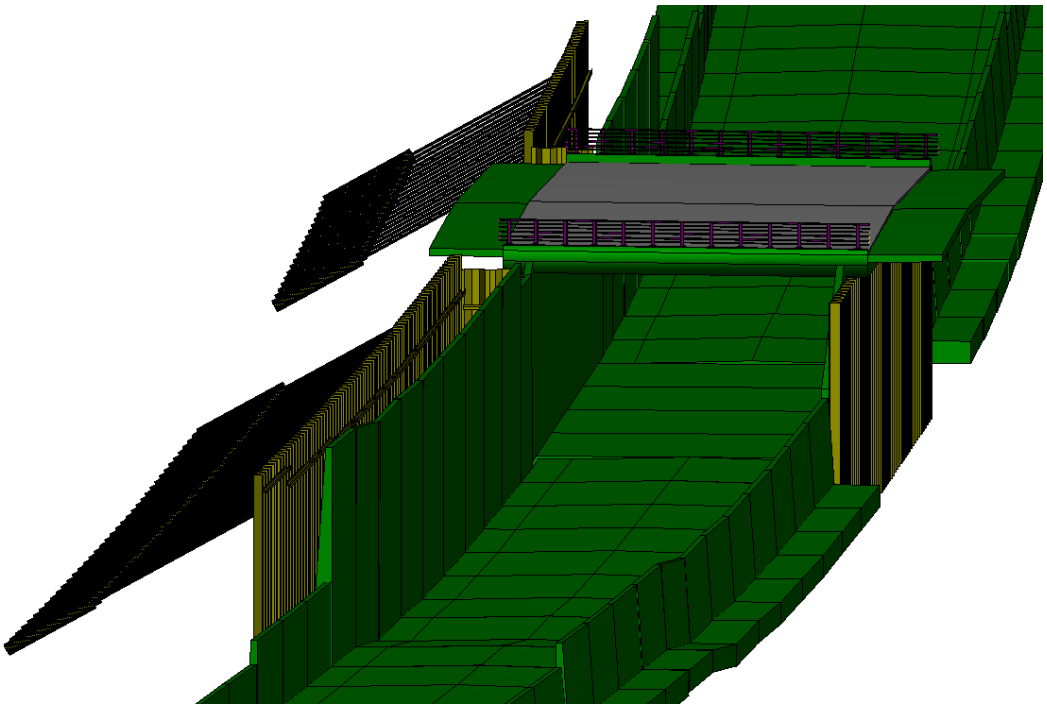

Figure 4.1.2.10-1 Structures

4.1.2.11 Excavations

Usage:
The models will be used to calculate the excavated volumes and planning earth logistics as well as being used for machine control.

Description:
In order to carry out the constructions, it might be necessary to dig out for foundations and other types of constructions. The following models might be relevant to deliver the excavation model for:

- Rail corridor
- Road geometry
- Structures

The excavation profile has to be modelled in 3D. Besides the excavated profile the model has to include the backfill, which is necessary to finish the construction works.

The models will be carried out at the detailed design phase and have to include surfaces indicating the extent of excavations including slopes and connection to the existing terrain.

The models have to include breaklines and surfaces, which define the geometry. The Excavation model may be delivered in separate files for each locality or in one file for each contract. The excavation and backfill geometry can be included in the relevant discipline's model.

Detailing level:
The models for excavations and backfill have to be delivered at detailed design corresponding to information level 4 and as-built corresponding to information level 6.

Formats:
Depending on the chosen application the 3D models for excavations have to be delivered in DTM DGN or LandXML/DWG format as mesh components.

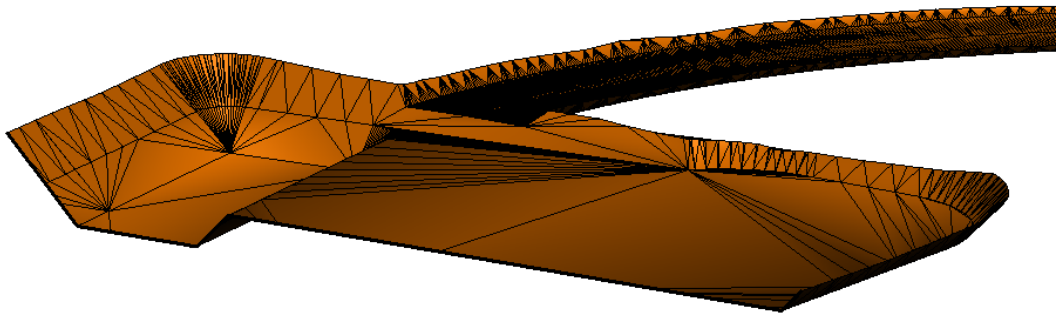

Figure 4.1.2.11-1 Excavations

4.1.2.12 Technical installations

Usage:
The models will be used for placement of the necessary volume of the technical installations as well as extracting setting-out data. If tags with necessary information on the different objects are used in as-built models, they will be used for maintenance.

Description:
During the detailed design, the technical installations for different disciplines have to be modelled in 3D with their outer geometry as minimum. The models have to include for example:

- Traffic light masts
- Signposts
- Catenary systems
- Mechanical & Electrical installations (M&E)
- Ventilation
- Signal masts

- Foundations
- Man-holes
- Cable channels
- Cable underpasses
- Similar constructions

The technical installations related to each discipline have to be included in separate files. The extent of delivery for each discipline has to be agreed on with Banedanmark at project start-up.

Detailing level:
M&E and ventilation models inside tunnels must be delivered in 3D for the main technical equipments as space proofed blocks during the basic design. The models have to indicate the necessary space for cable trays, cabinets and similar equipment. Fire mains and pressure pipes have to be shown with allowance for flanges.

The necessary volumes for the catenaries have to be included in the 3D model for clearances. Foundations for catenaries during basic design can be modeled as space proofed blocks along the railway.

During the detailed design the models for M&E have to include more details such as brackets and lids for the cable trays and all flange locations for fire mains and pressure pipes. The 3D model for M&E does not replace the use of M&E design reports, schedules, circuit diagrams, drawings and similar.

The models for other technical installations in detailed design have to indicate the outer geometry for the main elements including the hidden geometry such as foundations, trenches and similar.

At the as-Built phase the main technical installations and M&E elements have to be tagged in 3D models. The tags have to include sufficient metadata to allow practical operation and maintenance use of the 3D model to locate the necessary design reports, schedules, circuit diagrams, drawings and the like.

Formats:
Depending on the chosen application the 3D models have to be delivered in either DGN or DWG format. When applicable the models can also be delivered as i-models. Using discipline data the models have to be delivered in original format as well as LandXML.

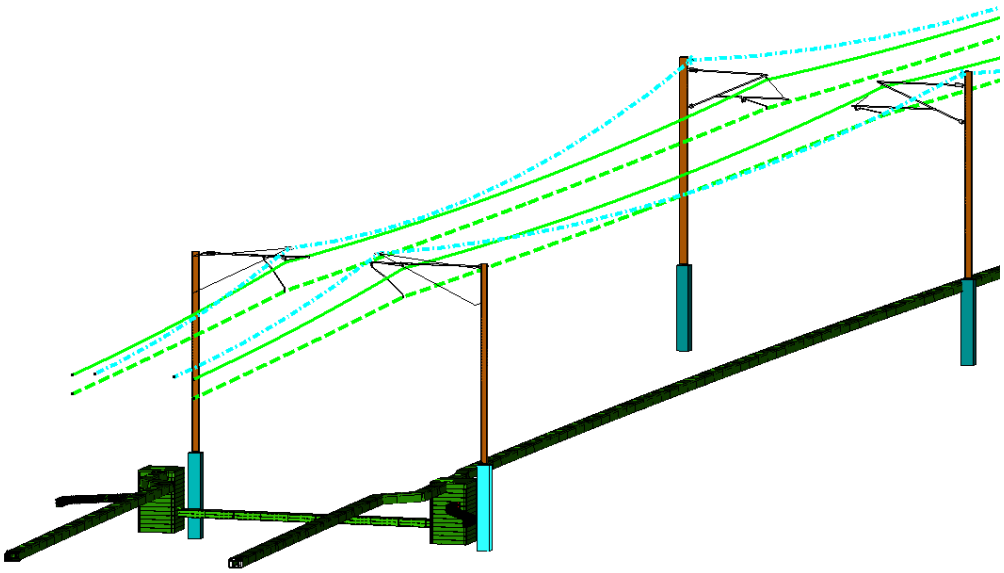

Figure 4.1.2.12-1 Technical installations, catenaries

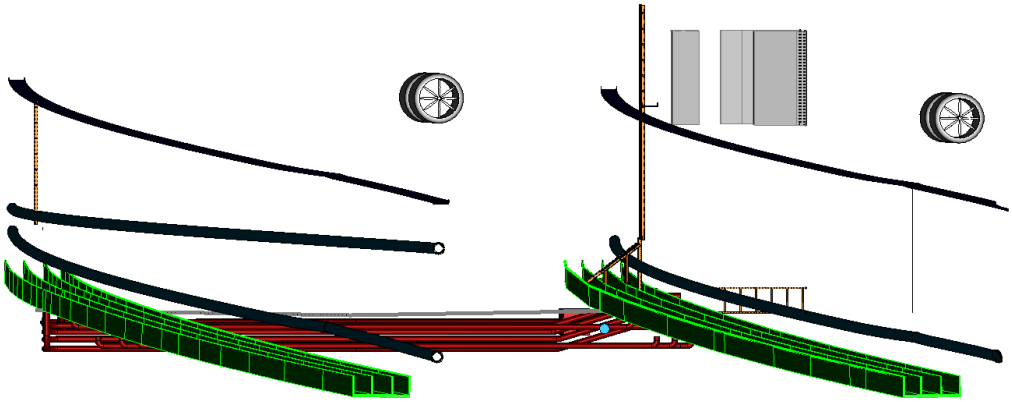

Figure 4.1.2.12-2 Technical installations, M&E

4.1.2.13 Relocated Utilities

Usage:

The models will be used for setting-out as well as avoiding unwanted clashes during the different phases of design and construction.

Description:

During the construction of the railway it may be necessary to relocate the existing utilities. In order to protect the utilities within the project area the relocated utilities and belonging constructions must be modelled in 3D. The models have to include for example:

- Pipes
- Man-holes
- Cable channels
- Cable underpasses
- Constructions associated with the above

The models have to include the outer geometry of the utilities in full dimension with belonging reference lines and points for the pipes and man-holes. Each utility type has to be displayed in a separate file. Regarding more information about the content of models see section 4.1.1.5.

The utilities, which will be removed as a part of relocation, have to be removed from the models for the existing utilities. The utilities, which are out of function, but will not be removed, have to be marked in the models for existing utilities by moving them to the relevant layers.

Detailing level:
The models have to be delivered as outlines in 2D during negotiations with the utilities' owner.

The models have to be delivered in 3D during the detailed design and contain information corresponding to level 4.

After relocating the utilities, the pipes and the connections have to be measured and the models updated to information level 6 – as-built. The models have to include information about type, dimension and owner of the utilities as tags or items.

Formats:
Depending on the chosen application the 3D models have to be delivered as components in DGN or DWG format. If applicable the models have to be delivered as i-models as well. Using special applications to model the utilities, the exchange and delivery format have to be agreed with Banedanmark at project upstart.

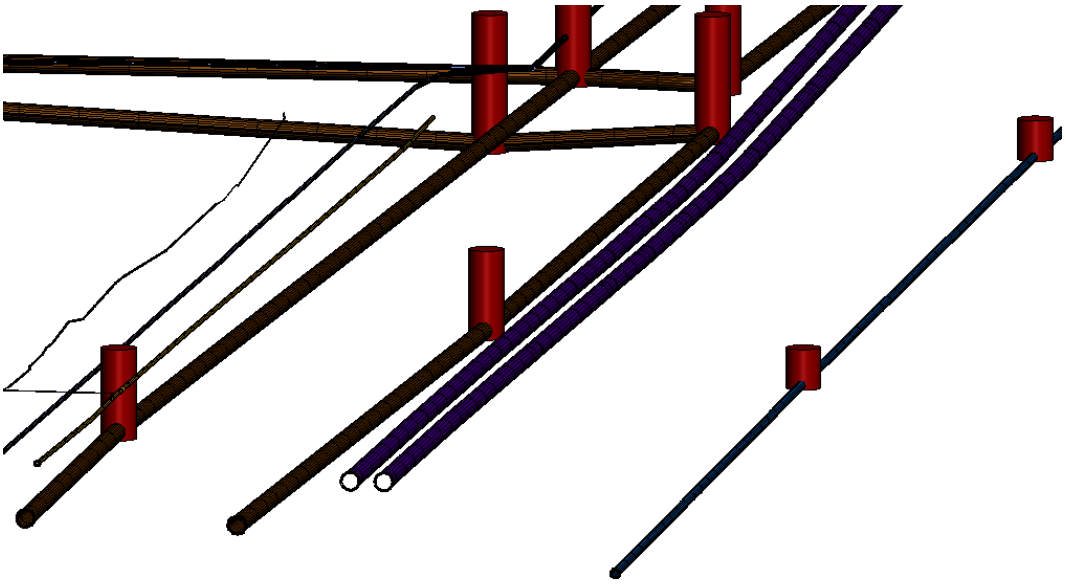

Figure 4.1.2.13-1 Existing utilities

4.1.2.14 Rainwater basins

Usage:

The models will be used to define the shape, volume and placement of the basins during the design. The models are to be used as setting-out data during the construction phase.

Description:
3D models of the rainwater basins have to include the basins as 3D surfaces including bottom, sides, boundary and connection to the existing terrain. The 3D models have to be delivered as mesh components including the breaklines and points used to generate the surfaces.

Detailing level:
The basic design has to include the concept for placement, dimensions, volume and design of the rainwater basins as 3D models corresponding to information level 3.

The models at detailed design have to include the final shape and design of the basins based on final agreements with municipalities and respective authorities corresponding to information level 4.

As-built models have to correspond to information level 6.

Formats:
Depending on the chosen application the 3D models have to be delivered in DTM/DGN or LandXML/DWG format as mesh components.

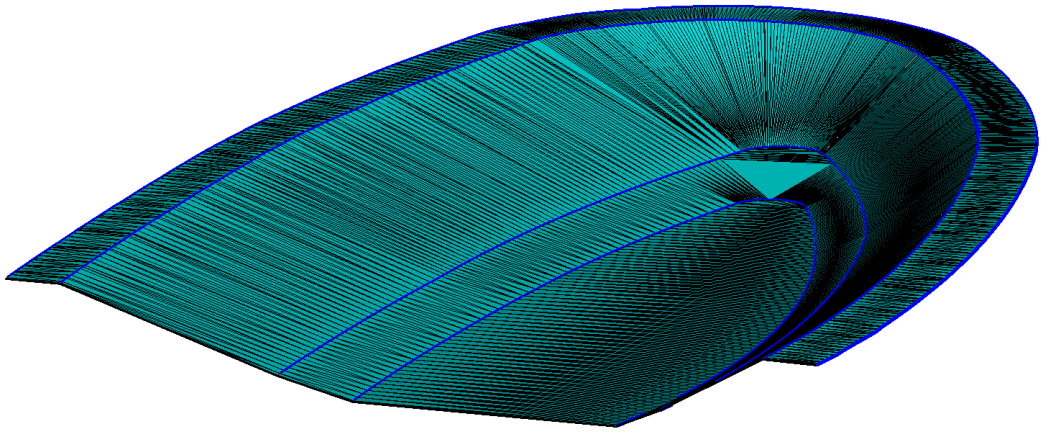

Figure 4.1.2.14-1 Rainwater basins

4.1.2.15 Drainage

Usage:
The models will be used to design and build the drainage system. The models are to be used as setting-out data during the construction phase.

Description:
Drainage models are to be modelled for different parts of the project: railway, roads and bridges/tunnels.

A part of the drainage system will be ditches included in the corridor models. The drainage models have to contain all objects included in design e.g.:

- Pipes
- Manholes
- Inlets
- Outlets
- Related constructions
- Pumping stations
- Culverts

Every object has to be modelled as whole elements/components in their actual shape and dimensions, and connections to the existing drainage system have to be clarified. Following the standard for drainage systems, the reference lines for the pipes and reference points for connections e.g. top and bottom of the wells, inlets and outlets must be included in the models.

Annotation must either be placed in the 3D file, on a certain elevation (e.g. 0), and separate layers or in a separate 2D file in association with the 3D model.

Discipline data for the drainage system have to be available for exchange with other parties as well as delivered to Banedanmark.

Detailing level:
At basic design the design can be delivered as calculations and description of the concept for the drainage system as well as 2D drawings documenting the chosen solution.

Detailed design has to include 3D models for the chosen system based on calculations indicating the final dimension of the drainage system and associated constructions.

As-built models have to be delivered corresponding to information level 6. The models have to include information about type, dimension and owner of the utilities as tags or items. As-built data for state road drainage system have to be delivered to Vejdirektoratet and follow their requirements.

Formats:
Depending on the chosen application the 3D models have to be exchanged and delivered in DTM/DGN or DWG/LandXML format. The drainage system related to the railway has to be delivered as GIS Esri data as well. Further details concerning delivery formats have to be agreed on with Banedanmark before design start-up.

Data for drainage system for state roads have to be delivered to Vejdirektoratet, so the documentation and file formats have to follow their requirements.

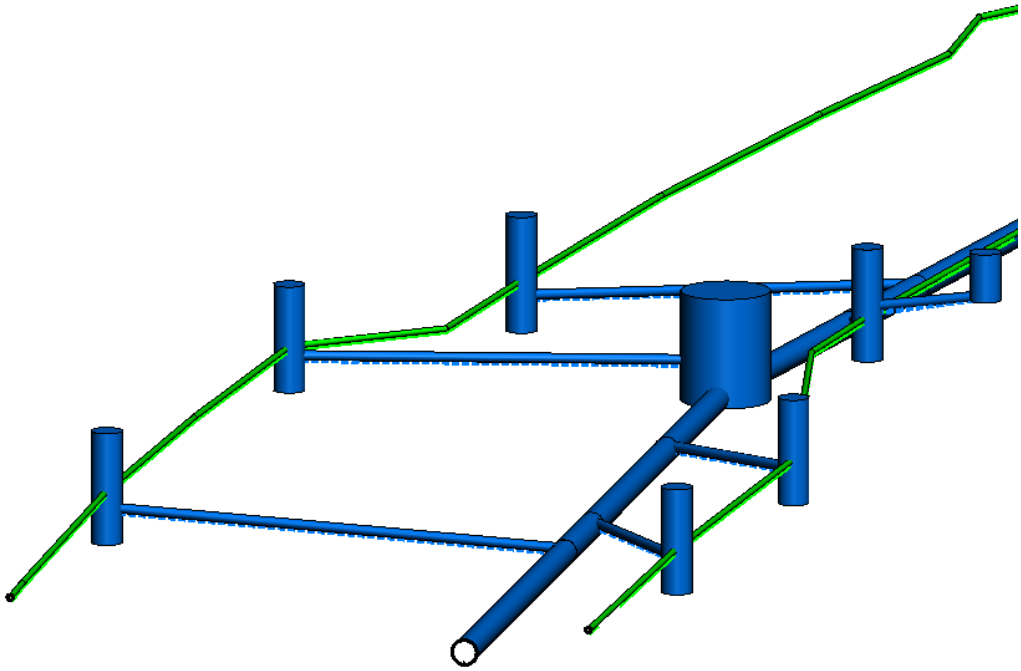

Figure 4.1.2.15-1 Drainage

4.1.2.16 Spoil areas

Usage:
Models for the spoil areas will be used for authority approvals as well as planning the earth logistics during design and construction. The models are to be used as setting-out data during the construction phase.

Description:
The placement, shape and available volume of the spoil areas have to be calculated and designed in 3D models as surfaces. The models have to include the surface as mesh components and the connection to the existing terrain as breaklines. The excavation residues must be placed within the defined area and must respect the limitations. Leaving the site, the contractor has to deliver a measurement of the areas as a 3D surface model, even if the entire area is not used.

Detailing level:
The models for spoil areas have to be delivered based on estimates in basic design for authority approvals. In this phase the models have to correspond to information level 3.

Detailed design models have to include the final geometry for the spoils, both the temporary and permanent areas based on detailed design of the whole earth works and authority approvals. The models have to correspond to information level 4 at this phase.

The spoil areas have to be delivered corresponding to information level 6 for as-built documentation. The models have to be based on surveys or laser scanning. The area may be included in the final terrain model, when this is delivered as as-built documentation.

Formats:

Depending on the chosen application the 3D models have to be delivered as mesh components in DTM/DGN or LandXML/DWG format. The necessary formats for setting out have to be agreed between the parties as soon as the contractor is appointed. If laser scanning data is delivered, the file formats and point resolution have to be agreed on with Banedanmark.

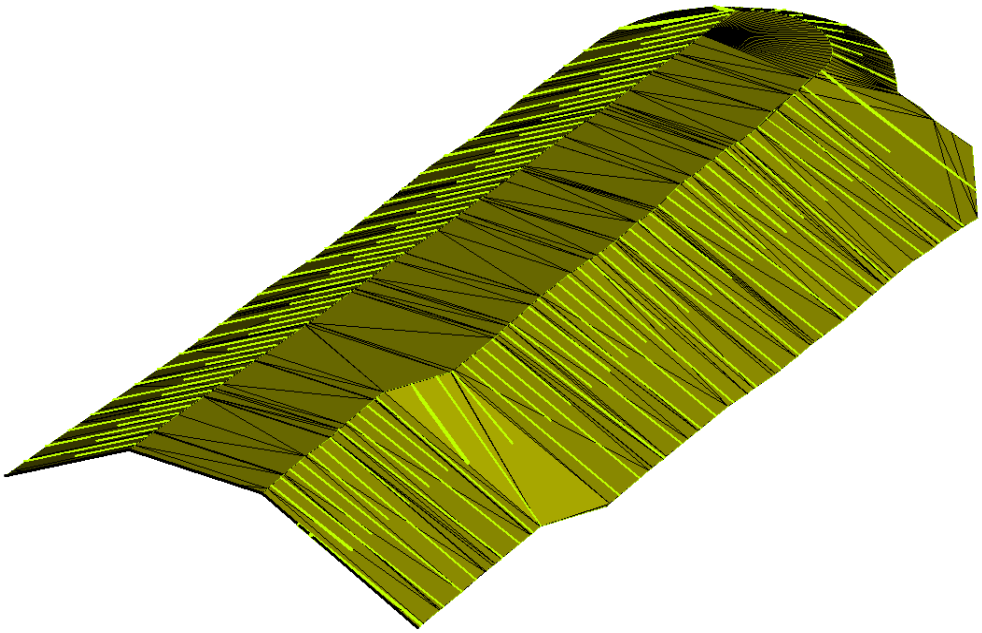

Figure 4.1.2.16-1 Spoil area

4.1.2.17 Terrain model

Usage:
By the end of the construction works the new situation has to be registered and delivered as a 3D model within the contract area.

Description:
The terrain model has to be described by points, breaklines and mesh components. Breaklines have to be measured and registered as continuous 3D lines/line-strings. The layer/level structure in the CAD files has to follow the relevant standards and different feature types have to be placed on correct layers/levels. If laser scanning is used as the basis for the final terrain model, the model has to be supplied with breaklines from as-built models.

The terrain model combined with as-built models for the other disciplines have to define the complete geometry of the works performed by the contractor.

Discipline data that has been generated when creating the as-built terrain model, must be available for exchange with other parties and delivered to Banedanmark.

Detailing level:
The terrain model is required only at the end of construction works corresponding to information level 6.

Formats:

Depending on the chosen application the 3D models have to be delivered as mesh components in DTM/DGN or LandXML/DWG format.

4.2 Drawing production

Data used in drawing production must derive directly from the 3D models, supplied with necessary 2D information in all phases of the project as well as in the as-built documentation.

General requirements for content and layout of drawings are described in section 3.2.5.

4.3 Simulation

Simulations can be performed based on both 2D and 3D models within one or more disciplines.

For simulation purposes, each individual party can create its own simulation models, if necessary supplemented by input from other relevant disciplines.

Each party is responsible for implementing amendments, demonstrated in simulation tests. Amendments outside the discipline of the party performing the simulation must be coordinated with the relevant parties.

4.4 Consistency control

Consistency control must ensure that the content of different model files agree with each other.

Each party must carry out consistency control on an on-going basis between its own model files and in relation to other parties' model files.

A final interdisciplinary consistency control must be carried out on model files by completion of each phase or milestone.

If a collision occurs, the relevant parties must take action.

The working procedure for consistency control means that:

- Consistency control can advantageously be carried out on the principle of self-checking followed by interdisciplinary checks.
- Each party checks that its own model files are consistent with each other and between different disciplines.
- The parties jointly check that all models files across the project are consistent.
- The Banedanmark CAD coordinator makes consistency controls based on the delivered models.

The responsibility for finding clashes or inconsistency between the models is always placed at the designers.

4.5 Visualization

Visualization is used in both technical and communicational contexts.

Visualizations can be prepared on the basis of model files, or by producing special visualization models according to the purpose.

Valid data for construction must only be found in the models described in section 4.1. If new model files containing special or modified geometry have to be created in order to perform the visualization (e.g. aesthetic modifications of 3D models), then it is not permitted to use these model files in other contexts.

4.6 Data extracts

Data extracts can be used for several purposes, like:

- Quantities
- Setting out data and machine control
- Schedule simulation

4.6.1 Quantities

Data extracts used for quantities must derive from the 2D or 3D models wherever possible. Where that is not possible, it must be clearly stated and documented where the quantities derive from, and which assumptions and estimations are used.

Major items/posts/tasks need to be divided into minor items. The source of the minor items has to be clearly defined so the connection between the items and the design data is completely traceable within the whole project.

The documentation for quantities based on data extracts must include the relevant information regarding:

- Name
- Location coordinate x,y,z
- Length
- Width
- Height
- Amount
- Area, gross and net
- Circumference
- Radius
- Volume

4.6.2 Setting out data

Setting out data must be generated either from discipline data, 2D models or 3D models and delivered either as geometry in a model file or as coordinate lists or a combination of both. The formats and setup of the setting out data have to be agreed between the parties as soon as the contractor is appointed.

4.6.2.1 Machine control

Machine control is generally used for earthworks. Where the technology is applicable, the necessary data must be generated from the models and discipline data. The exchange format and necessary information have to be agreed between the parties at project upstart.

When using machine control, the as-built data must be collected by the machine while working in site as documentation for the final as-built model. The interval, format and content for data deliveries must be agreed on before the site works begin.

4.6.3 Schedule simulation

A simulation of time can be made, combining the data from models and time schedules. If data exchange between the parties is necessary to make the simulation, the extent of the data and formats has to be agreed on between parties.

Data extracts from models, can be used to import in cyclogram software for planning and illustrate mass balance over time.

5 Documentation

5.1 Model file- and discipline data lists

Each party shall prepare a list of all model files. A template for this list is delivered by Banedanmark, and will be available for be downloaded from the Project's exchange server.

The relation (parent-child) between 3D/2D discipline data and model files must be part of the lists.

The model file list must be uploaded to the project's exchange server and updated at the time of exchange with information about date of revision corresponding to each model's model block. The model list has to indicate the overall delivery of models for each contract.

The model file list must be named as follows:

- ModelList_[*Contract*][Stage]_[*Locality (optional)*]

The list has to be updated for each upload. The changes have to be highlighted in the list.

5.2 Drawing lists

Each party shall prepare a drawing list of all digital plot files. A template delivered by Banedanmark will be available for downloaded from the Project's exchange server.

The drawing list must be named as follows:

- DrawingList_[*Contract*][Stage]_[*Locality (optional)*]

The list has to be updated for each upload. The changes have to be highlighted in the list.

Depending on the amount of data, the drawing list can be divided in several files - one for each location. The division must be agreed on with Banedanmark.

5.3 Traceability

In order to ensure traceability during the design and construction phases, it is important to prepare documentation showing the connection between 3D CAD models, 2D extractions, discipline data drawings, quantities and calculations.

A description of the chosen design system containing the following issues is required to be delivered by the designers:

- Description of the CAD and 3D environment
- The approach to use 3D modeling during the design and construction phase including different extractions from the models e.g. drawings and quantities
- The applications used to generate the 3D models.

The documentation must at any time be maintained and updated. The documentation shall keep track of relationship and on which changes are made. The documentation must be available for Banedanmark on demand.

6 Exchange

The following files can be exchanged:

- Model files
- Digital plots
- Archive files (on special occasions)
- Discipline data files
- Interdisciplinary files
- Assembly files

The formats for different file types are defined in section 6.2. Formats for each discipline are described further in section 4.1.

6.1 Purposes

Exchanging files can serve multiple purposes:

- As basis for the recipients model files
- As background for the recipients drawing production
- To handover model file to other parties
- As background for interdisciplinary consistency control
- To inform and coordinate with external parties

In general the sender is responsible for the content and structure of the exchanged files. In the event of amendments, the sender must submit new versions of models. The exchanged files have to respect the requirements mentioned for each file type. The elements in the model files should be divided onto levels in a manner that will allow the recipient to turn off – for the recipient - irrelevant elements.

6.1.1 Basis for the recipients model files

The recipient uses the models as a reference in order to design own models, which have dependencies to the received models.

The recipient may not modify the models received. The recipient is responsible for how other parties' models are used in own production.
Any amendments to the sender's models must be communicated to the sender, who subsequently makes the amendments.

6.1.2 Background for the recipients drawing production

The recipient uses the models as reference files in order to make own drawings.

The recipient may not modify the discipline models received. The recipient is responsible for generating drawings using the received models as references as well as for how external models are used in own drawing production.

Any amendments to the sender's models must be communicated to the sender, who subsequently makes the amendments.

6.1.3 Handing over model file to other parties

The models can be handed over to a recipient for further design/processing.

The sender is responsible for content and structure at the time of handover. The discipline code and any theme code in the filename must be changed by the recipient.

After handover, only the receiver's version of the model will be available. The senders model will be archived and removed from the list of model files and can only be used to control the further design of the model. The recipient is now responsible for all modifications and updates.

6.1.4 Background for interdisciplinary consistency control

In order to control the consistency, the relevant parties and disciplines may exchange models. Upon finding conflicts, the parties have to find a solution and agree which part must modify own model.

In the event of amendments to any model, the owner is responsible for submitting a new version.

The models delivered to Banedanmark are supposed to be the final version without inconsistency. Banedanmark's CAD coordinators make an overall control of the delivered material and prepare a report as response to the senders.

6.1.5 Information and coordination with external parties

It can be necessary to exchange drawings and models with utilities owners and authorities, during design and construction phases. The process, interval and formats have to be agreed on between the relevant parties.

In projects divided in different packages, designed or build by different contracts, it will be necessary to exchange data. In this case the parties have to clarify the extent of models and drawings which are to be exchanged as an interface agreement.

It is necessary that the contracts agree on interfaces regarding 3D modelling. Layers/Levels and feature names have to be coordinated. The agreements could be provided with sketches defining names of features, elements and layers/levels.

6.2 Formats

Each discipline can work in their preferred application and format, but the different disciplines must be able to exchange files with Banedanmark and each other in formats specified by Banedanmark.

The responsibility for any conversion between valid model file formats or discipline data lies with the recipient. The version of the software will be mentioned in the ICT contract. The use of any newer format must be agreed on with Banedanmark.

The responsibility for conversion between any valid discipline data – listed in the table below – lies with the sender. Valid formats have to be agreed on with Banedanmark and a test must be done.

File type	Exchange format
Model files	DGN or DWG format or i-models
Drawing files	Are not exchanged
Digital plots	PDF (as-built supplemented with TIFF format)
Archive files	DGN or DWG format
Discipline data files	Original format as well as LandXML format
Interdisciplinary files	DGN or DWG format
Assembly files	DGN or DWG format

Table 6.2-1 Exchange file formats

Different available formats for exchange will be used in the project for different purposes and/or programs, as shown in the table below.

Exchange file format	Description
LandXML*	For exchange of discipline data between incompatible applications. Also used for machine control, terrain models and alignments. The version has to be agreed.
ALG	Bentley format used for alignment design, both roads and rails.
DTM	Bentley format used for design of terrain models.
SHP	ArcGIS format, used for geographic overview, e.g. for the 'Map of The New Line'.
DGN	MicroStation (Bentley).
DWG	AutoCAD (Autodesk).
I.DGN	I-models for exchange of intelligent models and geometry in 3D models from different applications.

Table 6.2-2 Exchange file formats

*Some information might be missing when converted to LandXML, such as layer/level names and components, therefore LandXML have to be supplemented with CAD files, stake out data and geometry when necessary.

6.3 Procedures

6.3.1 Sender procedures

Prior to sending, the following must be done:

- The model file must be cleared of empty levels, unused complex geometric entities, etc.
- All levels are to be turned on
- Compliance with the drawing standard and level structure must be checked
- The geometry must be placed in the defined coordinate system
- The model- and drawing file list must be updated
- The model block, title block and revision log must be updated
- Checks must be conducted in accordance with section 8
- Regarding archive files: Any references in underlying levels/depths shall be merged to the top level

6.3.2 Receiver procedure

On reception the following shall be carried out:

- Registration of received files
- Check of received files
- Information to the sender of any errors in the received files.

6.3.3 External exchange procedure

Files must be exchanged according to interface agreements between parties. The interface agreement has to indicate the media for exchanging files, as well as exchange interval, data formats, coordinate systems and other relevant issues. The process for informing the relevant parties for data updates has to be indicated in the interface agreement as well. The agreements have to be available at the exchange server.

6.3.4 Recommended test of the exchange procedure

If compatible software is used across the different parties, the models and discipline data can be exchanged directly, without necessary test of exchange. If the parties use different software, it is necessary to make a test of exchanging the discipline data and 3D model files. The test must clarify the most optimal conversion method in order to include as much information as possible.

Testing of the exchange procedure for discipline data files involves:

- Preparation of a discipline data file that complies with the agreed use of setup. The data file must as minimum include the elements, which will be necessary to exchange during the design.
  For alignment data the file must include horizontal and vertical geometry, super elevation (roads), cant and turnovers (rail).
  For surfaces the data file must include features and mesh components.

- Translation of the discipline data model to the agreed exchange format.
- The agreed checking procedures must be followed.
- The extract of data in the agreed CAD file format must be sent with the test file.
- The discipline data transferred, must be checked for content as well as visually by displaying the imported data in a CAD file. Data extracts must be compared and checks made that all types of data structure have been preserved.
- The functionality of the transferred entities must be preserved.
- The process must be repeated the other way, to ensure the conversion is possible both ways.
- A documentation describing the process and a check list must be prepared, so it can be used at the next conversion.

7 Review

In quality assurance (QA), the main emphasis is put on matters that are shown by experience to involve the greatest risk of failure.

The quality assurance of the technical content is closely linked with the consistency control described in section 4.4The difference between consistency control and quality assurance is that quality assurance may not be performed by the person who created the building model or performed the data extracts.

Another important link within quality assurance of technical documentation is traceability between design data. Design data have to be linked to the 3D models or be direct products of them. The providers of data have to document their processes to fulfil these requirements in their QA documentation. As a part of approval process Banedanmark's CAD coordinators will make a random control of the deliveries to ensure the consistency and traceability within the design data. The responsibility always rests with the suppliers.

Contracts are responsible for internal control of all CAD material, according to this CAD manual, before exchanging with other parties and deliveries to Banedanmark.

It is recommended that all parties make their own check lists, which have to be used to ensure the quality of the deliveries.

8 Delivery

In order to manage the coordination of the disciplines, Banedanmark will establish milestones within each tender package, where all relevant disciplines deliver their 3D models. The models have to be controlled for consistency prior to delivering to Banedanmark.

8.1 Partial deliveries

8.1.1 Negotiation process

In a "Design & Build" type of contract it may be required to deliver 3D models for a chosen location of the project. In this case the models have to be delivered together with the other bidding documents. The requirements for deliveries at negotiation stages will be further described in the contract documents.

The delivered models at this stage will be used to ensure that the contractors are able to fulfil the requirements in the CAD manual.

8.1.2 Design Phase

3D models and drawings must be delivered at time intervals, defined in the time schedule for the Consultancy Contract or for Tender Packages. The models have to be delivered at Basic Design and Detailed Design Phases. In the Design & Build contracts delivery of the models have to be included in the contractor's time schedule and coordinated with Banedanmark's CAD coordinator. The extent of deliveries for each phase is described in section 4.1.2 and listed in appendix 1.

8.1.2.1 Preliminary Design

Models and drawings and data files for Preliminary Design have to be used for estimating of the price, simulations, visualizations, environment analyses and defining the boundaries for expropriations. The data have to be delivered at defined milestones and as basis for design in the next stages. Models in this phase have detailing level corresponding to information level 2.

8.1.2.2 Basic Design

Models and drawings for the Basic Design Phase have to be delivered together with the documents showing the authority's approval. Models in this phase have detailing level corresponding to information level 3.

Banedanmark's CAD coordinator will comment on the delivered material and make a report, comparing the delivered material towards the requirements in the CAD manual and ICT contract. Crucial comments are to be worked out by the designers at the next phase. For more information see appendix 2.

8.1.2.3 Detailed Design

Models and drawings and data files for the Detailed Design Phase have to be delivered for third part validation. The technical evaluation of the delivered material will be done by the validator while the CAD coordinator controls the delivered data towards the specifications in the CAD manual and ICT contract.

Banedanmark's CAD coordinator will comment on the delivered material and make a report. The designer has to update the material respecting the comments and deliver it as final design before the construction works begin in the field. The delivered materials at this phase have to correspond to information level 4. For more information see appendix 2.

Besides the defined milestones it might be necessary to deliver 3D models ad-hoc. The consultants and contractors must be prepared to deliver the 3D models, digital drawings or archive files with short notice during the design phase.

8.1.3 Construction Phase

During the Construction Phase the contractor must be prepared to deliver data at agreed milestones. The data, which registers the geometry of the construction will be used to follow the work in progress as well as preparing as-built models and drawings by comparing the QA measurements with detailed design. By end of the construction works, the as-built documentation has to be ready to deliver including the 3D models and drawings.

8.2 As-built

8.2.1 General

Generally it is required to deliver as-built documentation in accordance with "Krav til Teknisk documentation" and "Krav til Teknisk data".

Teknisk Drift is the operation and maintenance section of Banedanmark, to which the project will be handed over when completed.

Teknisk Drift is divided into several sections, each have specific demands to the as-built delivery. The as-built documentation for each section has to meet their requirements as well as the requirements in this CAD manual.

8.2.2 Model files

It is required that the contractor delivers as-built documentation in updated 3D model files according to the descriptions for each model in section 4.1.

The models must comply with the limit of tolerance described in the contract documents. If elements of the design model are within the tolerance, they get status of As-Built without updates. If the designed elements are not within the tolerances, they must be updated according to QA measurements.

The 3D models designed by the contractors, may contain significantly more data than the models being exchanged and delivered in the exchange format. In this case, the contractor must also deliver the models in the design software's original format.

Using machine control the extent and details about data collection by machines have to be agreed on with Banedanmark.

Data extraction from machine control must be encoded to make the sorting of the collected data possible, well-defined and relevant. The result has to be delivered in 3D models including the as-built surface as well as the breaklines and points used to generate the surface. The result will form the basis for the QA of the work performed.

The machine data must be supplemented with traditional survey of selected positions.

See also the table of model files in section 4.1 for required exchange formats.

8.2.3 Drawings

As-Built documentation as digital plots and archive files shall be delivered to Banedanmark in accordance with the provisions in "Krav til Teknisk dokumentation". The different sections in *Teknisk Drift* have specific requirements for the content of the drawings. The drawings must comply with the minimum requirements for the different sections.

It might be necessary to change the file names, when delivering As-Built drawings. "Krav til Teknisk dokumentation" and its appendixes defines the file names.

8.2.4 Discipline data

All discipline data used to generate the models must be updated during the Construction Phase and delivered in original format as well as LandXML format as as-built documentation.

8.2.5 GIS data

Prior to delivery, GIS data shall be converted to the UTM32 coordinate system. Data must be delivered in DGN and ESRI SHP format with the content sorted according to the following main construction elements:

- Horizontal alignment
- Noise and vibration
- Environment and planning data
- Bridge and road facilities
- Expropriations
- Railway stations and station facilities

8.2.6 Delivery to external stakeholders

State Roads (highways) are taken over by Vejdirektoratet (VD). VD is responsible for operation and maintenance of the road surface on bridges. Thus, the requirements for submission must follow their requirements:
http://ts.vejdirektoratet.dk/_layouts/Enabling.VD/NavigationLanding.aspx?term=15

Other roads are handled by municipalities. Thus, the requirements for submission must follow the standards defined by the municipalities.

9 References and glossary

9.1 Document references

1. Dansk Standard
   - DS/EN 15016-1:2004 Tekniske tegninger - Jernbaneudstyr - Del 1: Generelle principper.
   - DS/EN 15016-2:2004 Tekniske tegninger - Jernbaneudstyr - Del 2: Styklister.
   - DS/EN 15016-3:2004 Tekniske tegninger - Jernbaneudstyr - Del 3: Behandling af modifikationer af tekniske dokumenter.
   - DS/EN/ISO 128-20:2001 Teknisk tegning – almene tegneregler - Del 20: Grundlæggende regler for linjer.
   - DS/EN/ISO 128-21:2001 Teknisk tegning – almene tegneregler - Del 21: Tegning af linier ved hjælp af cad-systemer.
   - DS/ISO 128-22:2001 Teknisk tegning – almene tegneregler - Del 22: Grundlæggende principper og anvendelsesmuligheder for henvisningslinjer og referencelinjer.
   - DS/ISO 128-30:2002 Teknisk tegning – almene tegneregler - Del 30: Grundlæggende principper regler for afbildninger.
   - DS/ISO 128:1983 Teknisk tegning – almene tegneregler.

2. Banedanmark
   - Krav til Teknisk dokumentation
   - Krav til Teknisk data
   - Fritrumsprofiler
   - Banenorms and Tekniske Meddelelser
3. Det Digitale Anlæg
   - Level structure for infrastructure disciplines by Det Digitale Anlæg
4. bips
   - CAD manual 2008
   - C102, CAD manual 2008, instructions
   - C201, Layer structure 2005
   - C203, Drawing Standards Part 1-6

   In the event of discrepancies between Danish Standards and bips publications, the DS rules apply.

9.2 Glossary

Word	Explanation
A-frames	Drawing frames are multiples of A4 size. Each fold is 210 mm long and 297 mm high.
ALG	Bentley format used for design of alignments.
Archive files	Archive files are copies of drawing files except that all references are linked to/merged with the drawing. Archive files can be used internally in the company to document the drawing's content at a given time or to exchange with other parties or delivering of As-built documentation.
Assembly files	Empty DGN or DWG file including attachments to relevant references within the same discipline.
Bentleyuser.dk	User group for Bentley products, such as MicroStation, which publishes standards for construction projects.
bips	Member organisation that publishes standards primarily for the construction industry.
CAD Coordinator	The person responsible in each organisation for coordinating CAD tasks relating to a specific project.
DDA	"Det Digitale Anlæg" is the corporation of the main actors within the infrastructure branch in Denmark to define common standards for the whole branch. See www.digitaleanlaeg.dk
DGNLIB	Empty MicroStation file containing level names, colours, line widths and line types for one or more disciplines.
Discipline data	Data files (not CAD files) used by applications. With file formats as ALG and DTM.
Digital Plots	Digital documentation of drawings in formats as PDF, TIFF, etc. Used for exchanging the drawings between the parties and as a basis for paper prints.
Drawing files	Drawing files are used to create and maintain drawing layouts.
DTM	Bentley format for Digital Terrain Models.

Word	Explanation
GIS	Geographic Information System to capture, store, manipulate, analyze, manage, and present all types of geographical data.
I.DGN	Format for i-models.
i-model	Intelligent file format to convert data and 3D models from different CAD applications to Bentley software.
Interdisciplinary files	Empty DGN file with references to 3D models from different disciplines, used for e.g. clash detection, simulation or visualization.
LandXML	Neutral file format for exchange of discipline data between CAD systems, which are not compatible with each other. Used for machine control, terrain models and alignments.
Layer/level	CAD files use layers/levels to identify different elements. Using the functionalities in the layers/levels within the CAD files makes it possible to use the same model in different drawings. The information indicated in the layers makes it possible for the different parties to understand the content of the exchanged CAD files.
Live nesting	The functionality in MicroStation, which allows usage of multiple level of referencing..
Model files	The geometrical information that is used to create, process and store the project are stored in model files. The model file is executed in 1:1 in relation to the actual measurement. Each discipline prepares its own model files and is responsible for updating them.
Notation files	Notation files are CAD files which contain standard elements as cells/blocks e.g. drawing frames, folder markers, title blocks, notes, etc.
Object number	All bridges and structures owned by Banedanmark are registered in a register and assigned an object number.
CAD Exchange Server/Project Web	The portal for exchange of documents and CAD data between the project's partners. Using ProjectWise the server is common for all relevant parties, who have to work directly with the files stored at the server.
Resource file	File that contain definitions of line types, text fonts, etc.

Word	Explanation
Revision	Revision is used to manage changes in drawings between to major stages of design.
Revision log	Table for managing and providing information about changes to the document. Must include the date of the change, the sections that are modified and a brief description of the change at each posting.
Seed file	An empty MicroStation file with the project's setup. The file will be copied when new files are created.
Sketches	Sketches are temporary drawing files, which have a limited lifetime and should not be handed over to Banedanmark.
Symbol fonts	Special text fonts that use the letters' positions and give them in the form of symbols. If you have not installed the font, you will get letters instead. Symbol fonts have been widely used by surveyors and in the production of basic maps.
Terrain model	A digital model of the terrain. It may be shown as triangles, components, mesh, contours or feature lines and points.
Version	Versions are used to mark the drawings with final status and to manage changes from a final stage to another.
X-ref Overlay	AutoCad's answer to Live nesting. See "Live nesting".