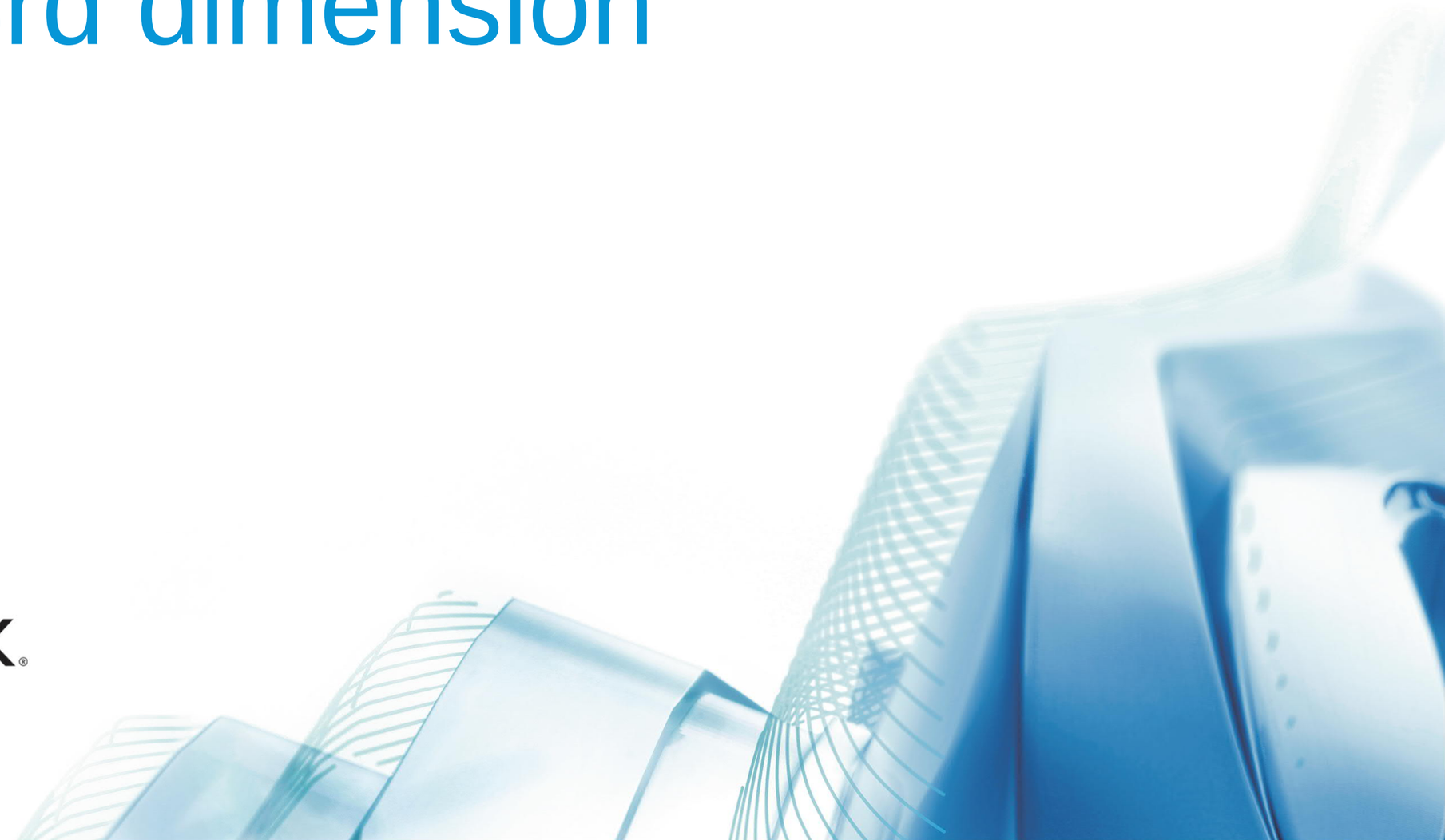
Getting railway signaling into the 3rd dimension



AUTODESK.
UNIVERSITY

About the speaker

DB Engineering & Consulting

Marcel Kintzel

Design Engineer for Control-Command and Signaling

DB Engineering & Consulting GmbH, Germany

- is working at the german railway company Deutsche Bahn since October 2001
- more than 15 years experience in creating plan documents in 2D using AutoCAD and AutoCAD based applications
- 3D-modelling is part of his current responsibilities
- member of the central workgroup Control-Command and Signaling at DB Engineering & Consulting GmbH

About the co-speaker

Matthias Kühn

DB Engineering & Consulting

BIM consultant, DB Engineering & Consulting GmbH, Germany

- background as a civil engineer for bridge design in railway infrastructure for almost 20 years
- extensive experience with Autodesk Revit since 5 years
- developing BIM content (Revit-families) and giving Revit user-support within the company
- creating uniform basic principles, templates, workflows and the like for 3D modeling and BIM in our company

About the speaker

Jens Luetzelberger

I am part of the Global Consulting Delivery (GCD) team of Autodesk since November 2016.

Our group

Deutsche Bahn

On 33,300 kilometers more than
25,000 bridges and 740 tunnels
in the railway network of the DB

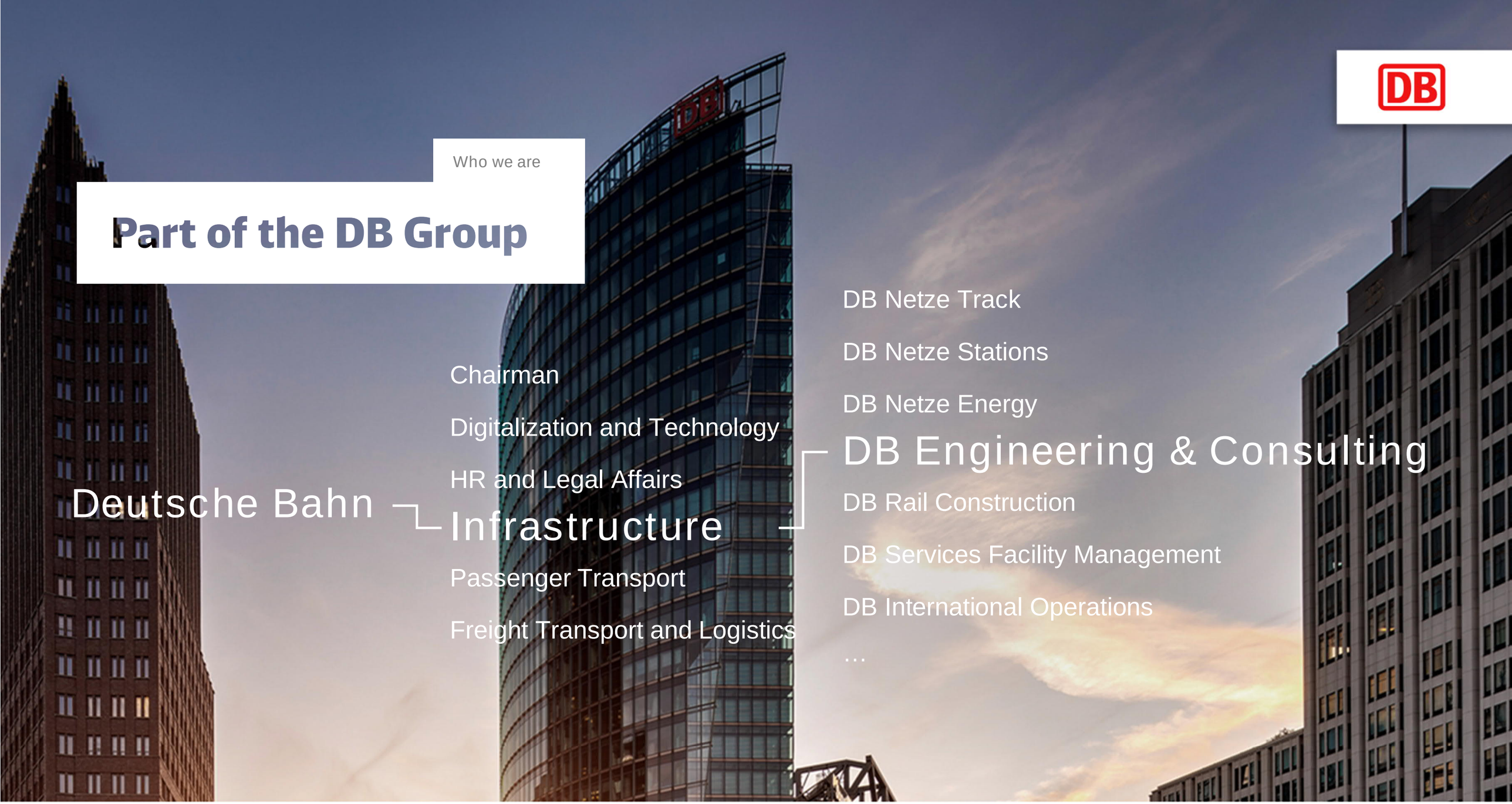
Around 7.3 million passengers
a day on trains and buses in Germany

5,700 stations
in Germany

On weekdays over 1 million metric tons
of goods by rail in Germany and Europe

Data as of March 2019

Photography: Deutsche Bahn AG/Barteld Redaktion



Who we are

Part of the DB Group

Deutsche Bahn

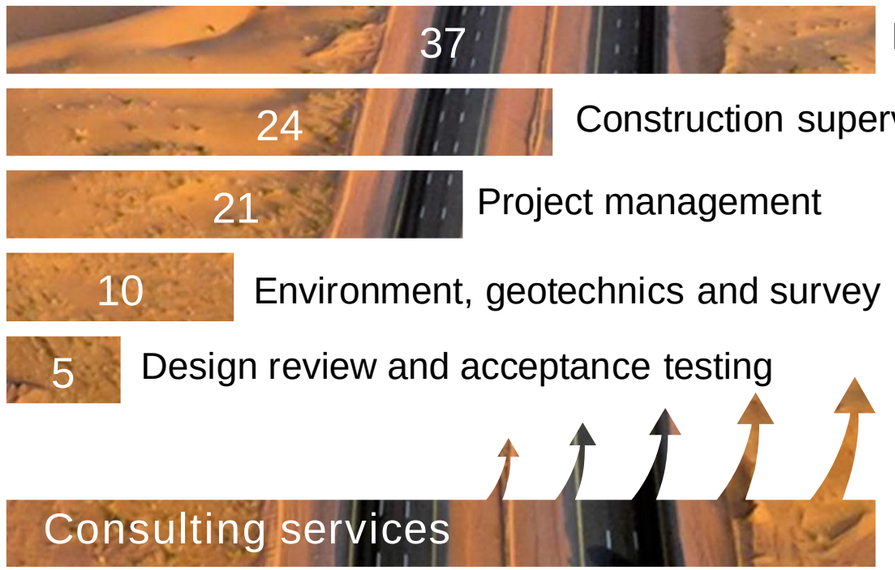
- Chairman
- Digitalization and Technology
- HR and Legal Affairs
- **Infrastructure**
- Passenger Transport
- Freight Transport and Logistics

DB Engineering & Consulting

- DB Netze Track
- DB Netze Stations
- DB Netze Energy
- DB Rail Construction
- DB Services Facility Management
- DB International Operations
- …

4,800 employees from 77 countries for all technical disciplines

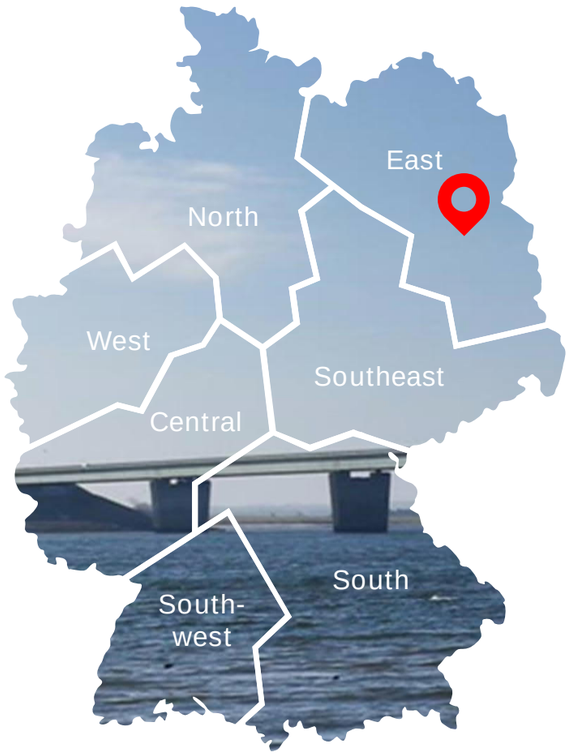
Our specialists



Functional percentage of production staff, 3 % other (as of June 2019)

Who we are

In Germany



7 regions with more than 80 locations

Headquarters Berlin

Photography: Lothar Mantel

Represented on every
continent

Projects in over
100 countries

since 1966

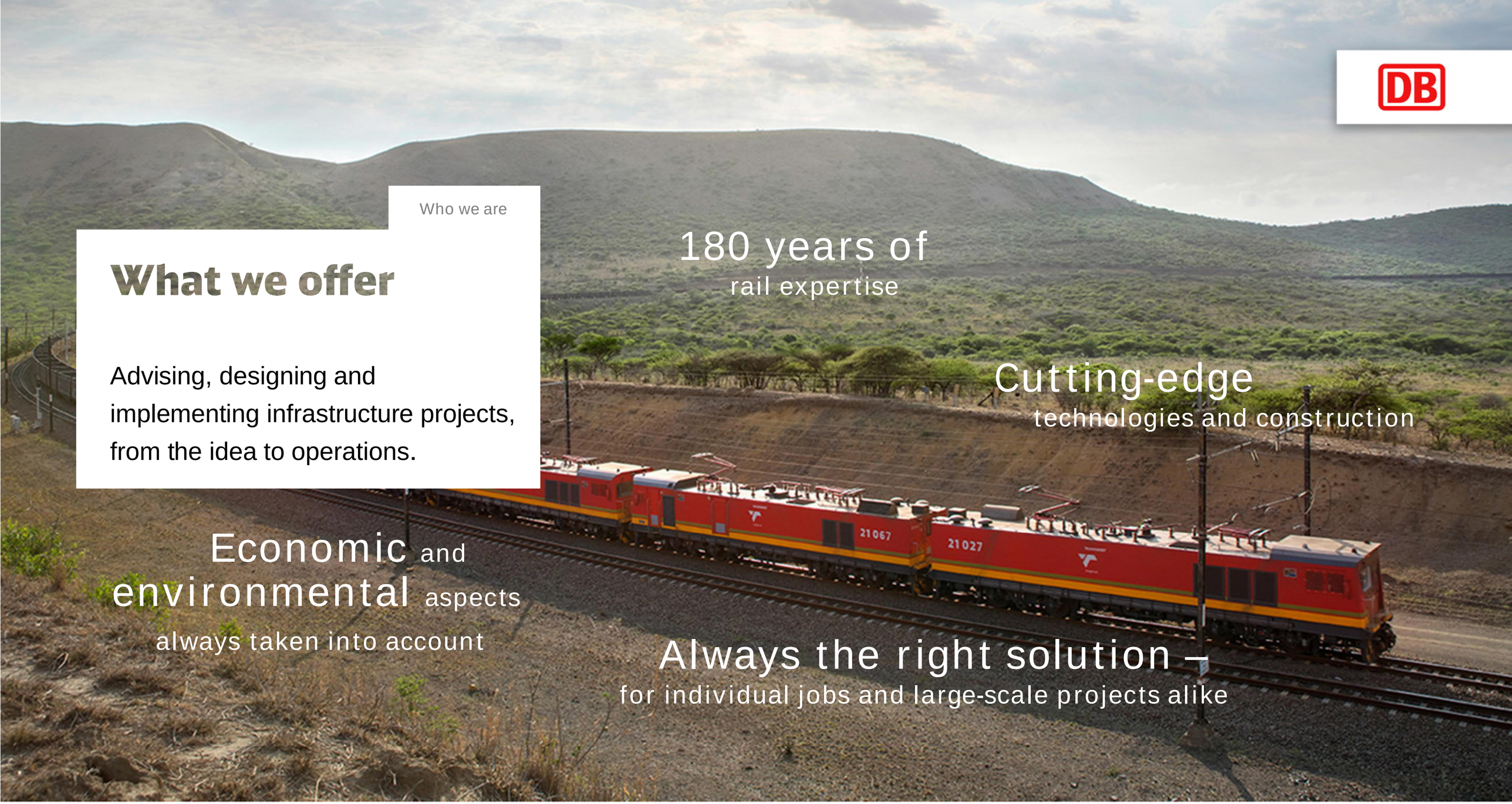
Worldwide

Photography: Lothar Mantel

Our mission

As one of the world’s leading engineering and consulting firms, we shape the world of tomorrow – with customized and sustainable mobility and transport solutions.

Photography: Torsten Spiller



Who we are

What we offer

Advising, designing and implementing infrastructure projects, from the idea to operations.

180 years of
rail expertise

Cutting-edge
technologies and construction

Economic and environmental aspects
always taken into account

Always the right solution –
for individual jobs and large-scale projects alike

Photography: Ben Bergh

Agenda

- Why 3D model for railway signaling?
- Create parameterized Revit families
- Create a 3D-model by using origin data base and Dynamo
- Sight distance check
- Looking forward

Why 3D model for railway signaling?

Classic workflow

1. Planning railway signaling

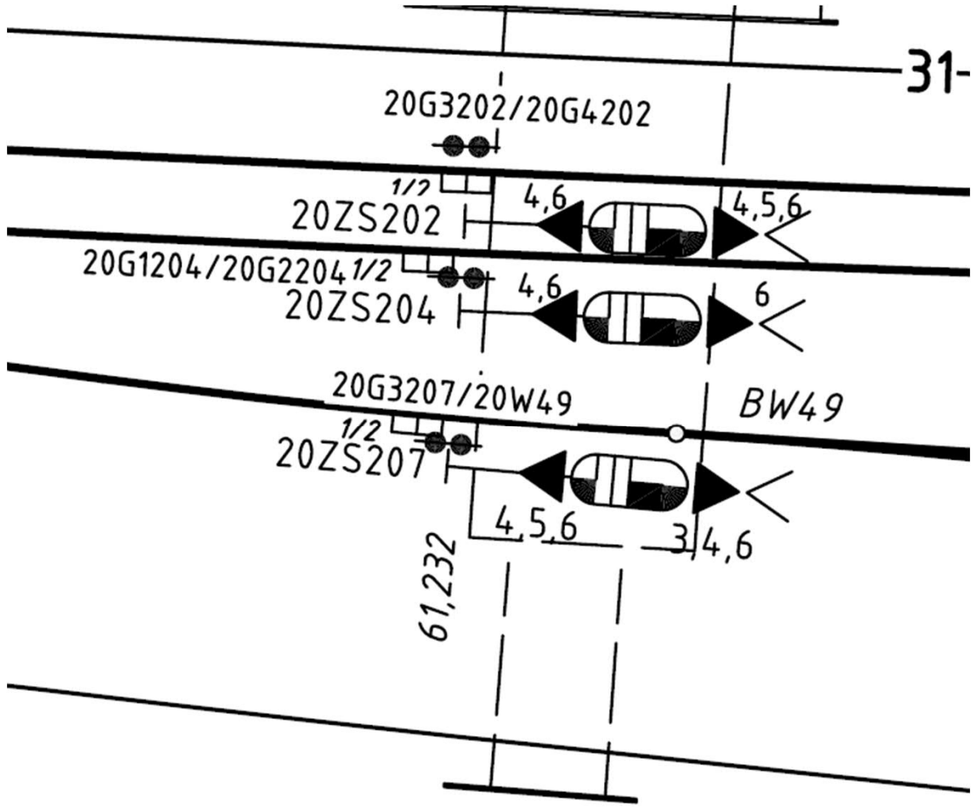
2. Producer

3. Construction work

4. Operate and maintain

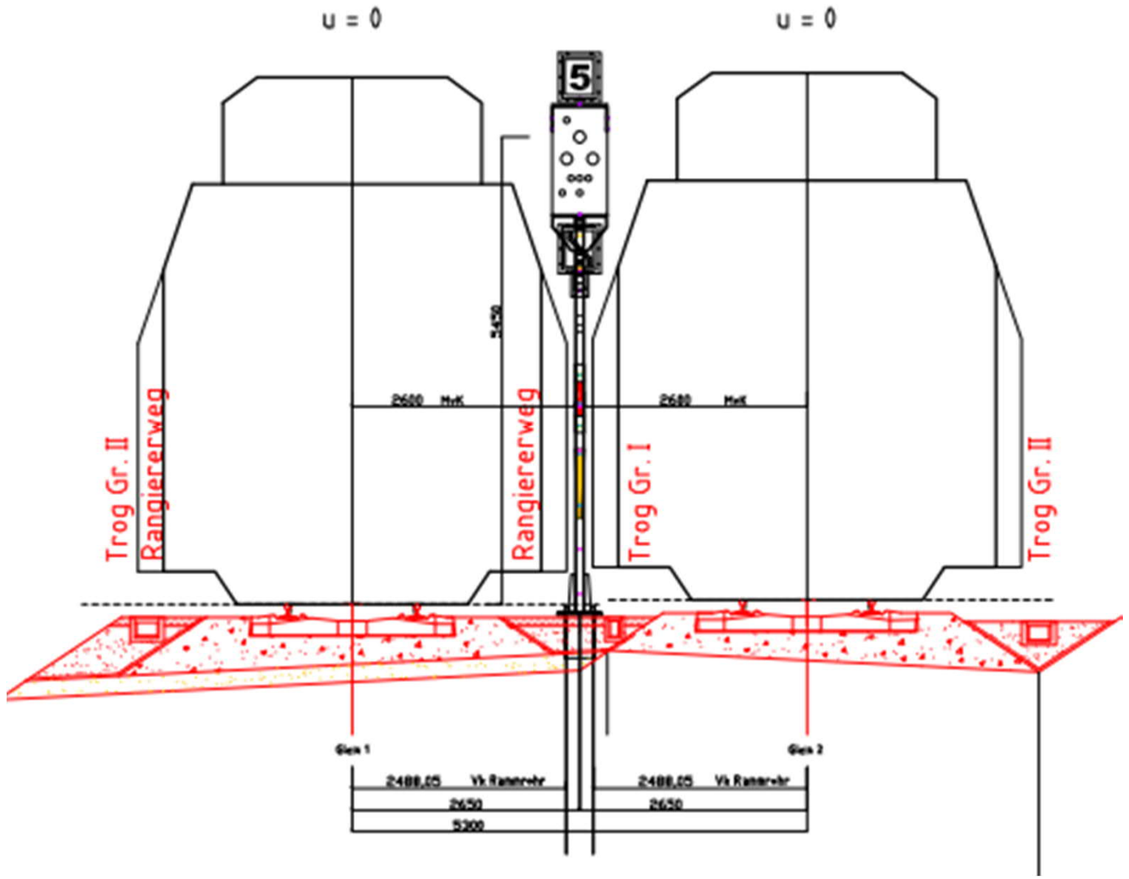
Planning railway signaling

- drawings for railway signaling are created in 2D
  - Views from top - using symbols



Planning railway signaling

- drawings for railway signaling are created in 2D
  - Views from top - using symbols
  - Using clearance gauge in cross sections



Planning railway signaling

- drawings for railway signaling are created in 2D
  - Views from top - using symbols
  - Using clearance gauge in cross sections
- Data from primary planning software printed in form of tables

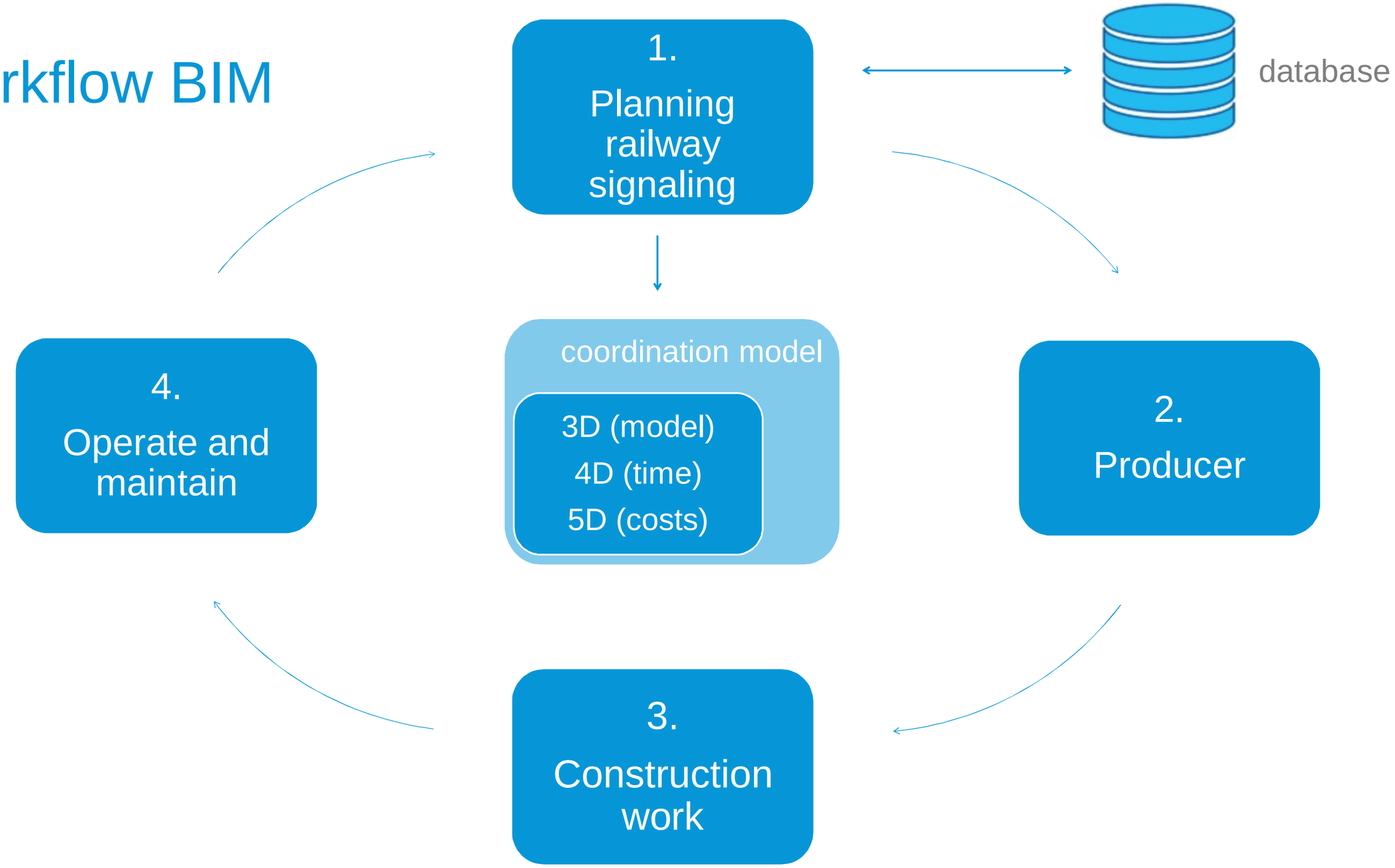
	Bezeichnung Haupt- u. Vorsignale			20P101		20P2	
	Bezeichnung Rangiersignale / Schutzsignale						
	Bezeichnung Signale						
1	Standort [km] / Strecke			62,271 / 5900		62,234 / 5900	6
2	sonstige zulässige Anordnung	1)					
3	obere Lichtpunkthöhe [mm]			5400		6000	
4	Rz S8000.5.x Bild Nr.			1		8	
5	Rz S6250/2440 Blatt 15 Bild Nr.	5)					
6	Ls nach Rz S8000.7.1 Bild Nr.						
7	Signalsicht (Soll-/Mindestsignalsicht) [m]			400 / 225		400 / 225	
8	Richtpunktentfernung [m]						
9	Streuscheibe / Betriebsstellung						
10	Fundament Art / Höhe [mm]	2)					
11	Sonderkonstruktion						
12	Sonderanordnung	4)					
13	Rz Anordnung an Signalausleger, Brücke, Tunnel						
14	Richtungsanzeiger						
15	Richtungsvoranzeiger						
16	Geschwindigkeitsanzeiger	6)		6F		6F	
17	Geschwindigkeitsvoranzeiger	6)					
18	Signalbegriff Hp			0		0	
19	Signalbegriff Ks			1		1	
20	Signalbegriff Ra / Sh			Sh 1		Sh 1	
21	ETCS-Halttafel Ne14 nach Rz S541.1 Bild Nr.						
22	Kenn - / Zusatzlicht						
23	Signalbegriffe Zs (im Schirm)			1		1	
24	Zs am Signalmast			6		6	
25	Zs am Betonpfosten/Rohrmast (separat)						
26	Zp am Signalmast						
27	Zp am Betonpfosten/Rohrmast (separat)						
28	Kombination Zp-Zs / Zs-Zs						
29	Signal zugbedient / wärterbedient			z / w		z / w	
30	Mastschild			H		H	
31	Vorsignaltafel Rz S525.4.x Bild Nr.						
32	Vorsignalbaken: Anzahl / Rz S526.2.x Bild Nr.						
33	Bü-Anlage (HP abhängig)	im Abstand [m]	Soll				
34			Ist				
35	Abstände zu Gleismitte von Fvk [mm]	2)	links				
36			rechts				
37	Abstände in Längsrichtung [m]		Signal				
38			Länge				
39	Schaltkasten außerhalb der Gleise		3)				
40	Dunkelschaltung						
41	Fahrtanzeiger auf Bahnsteig						

Why 3D model for railway signaling?

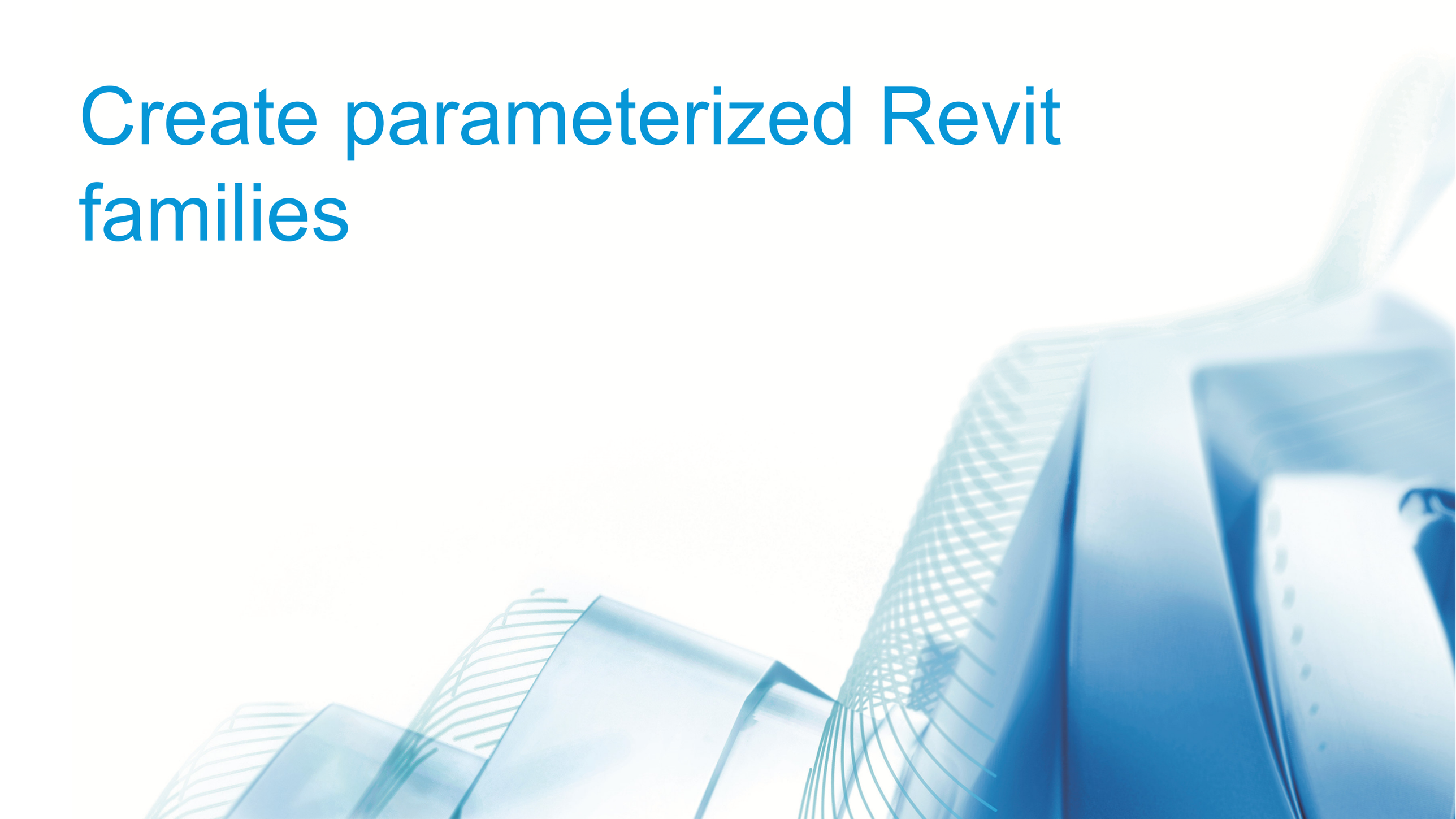
Railway signaling components are required for several BIM use cases:

- 3D modeling / visualisation
- Clash detection
- Simulation of construction sequences
- Sight distance check

Workflow BIM



Create parameterized Revit families



The initial situation

- DB rules and standards:
  - one drawing (S 8000 5.7) … **20** different figures of one signal
  - one signal … ca. **10** different elements

figure no. 9

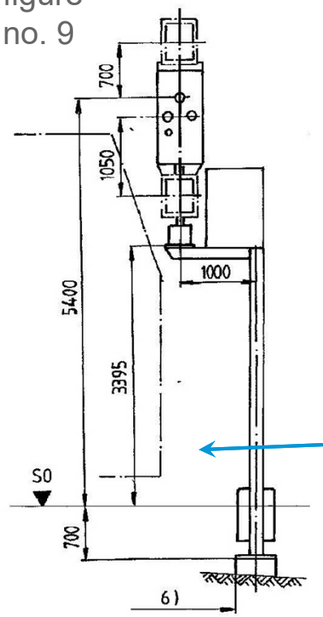


figure no. 2

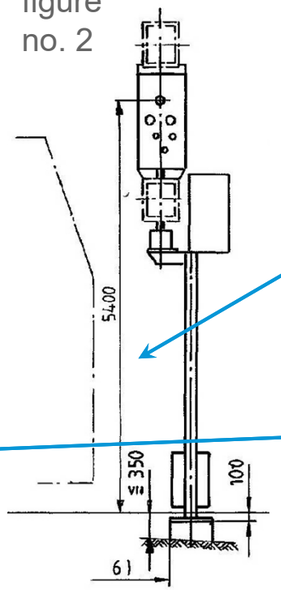


figure no. 7

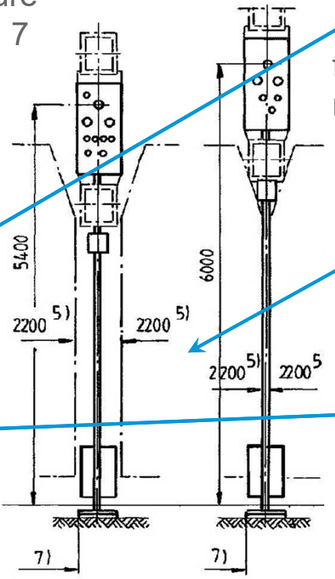
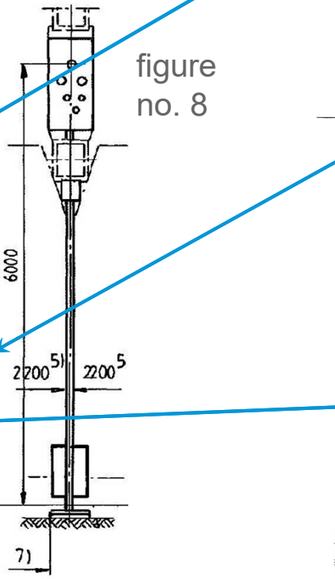
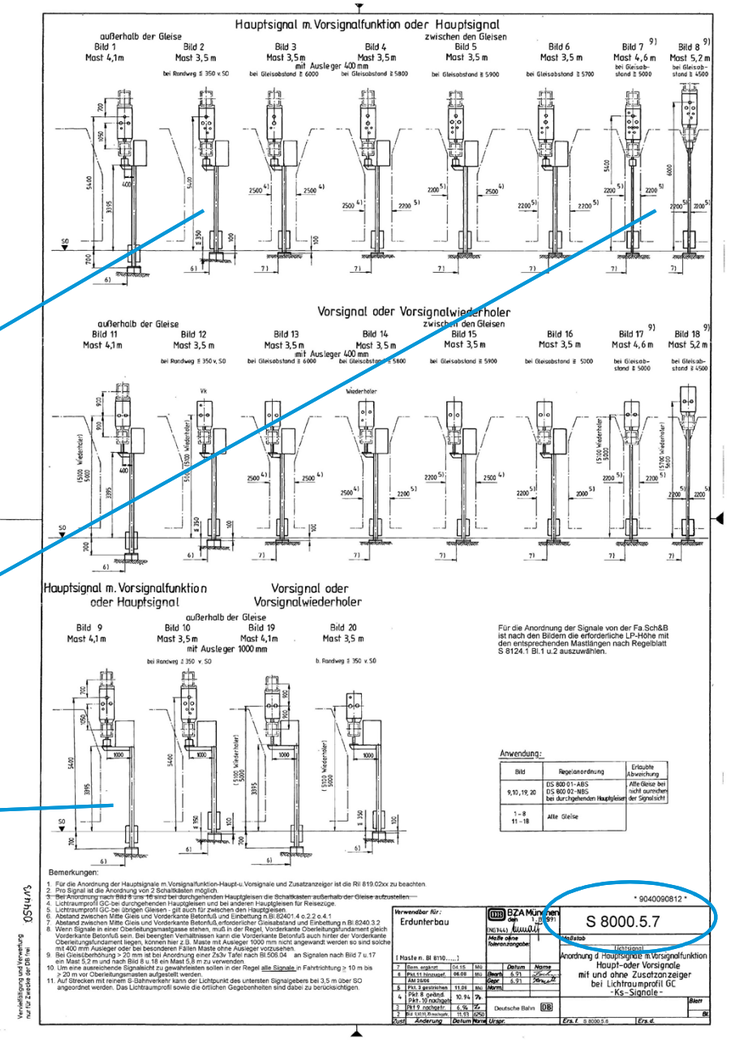


figure no. 8





- many more standard drawings included

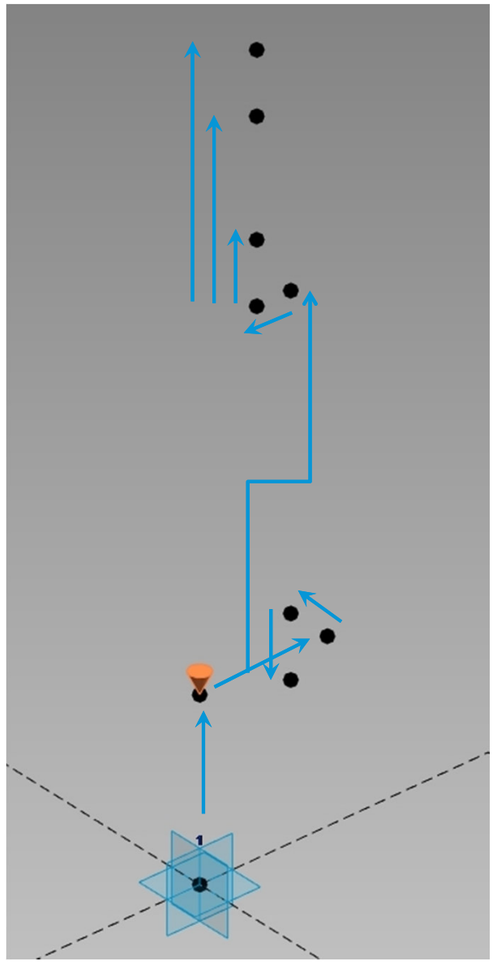
The idea

- creating **one nested family** with **20 types** and ca. **10 sub families**
- using existing geometries, already drawn in **Inventor**
- placing the signal (= main family) in a project
  - **by hand** (small projects)
  - with an **automated process** / using **dynamo** (large projects)
- giving as much **flexibility** as possible to adjust the model following to the automatic placement

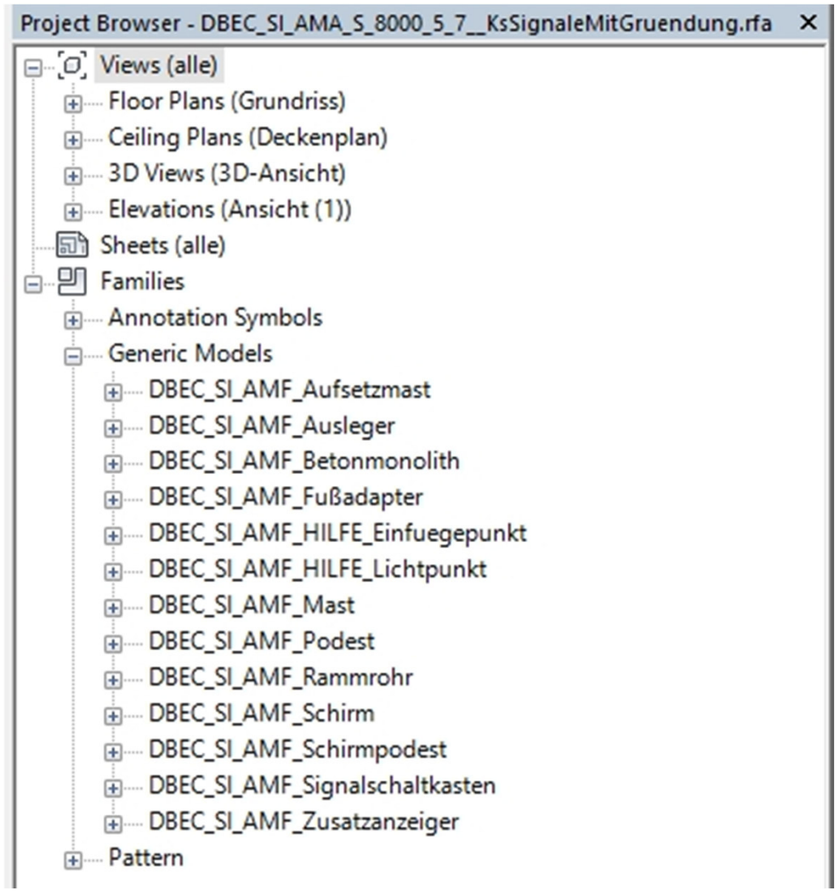
  > parameters for geometry, position and information

The concept

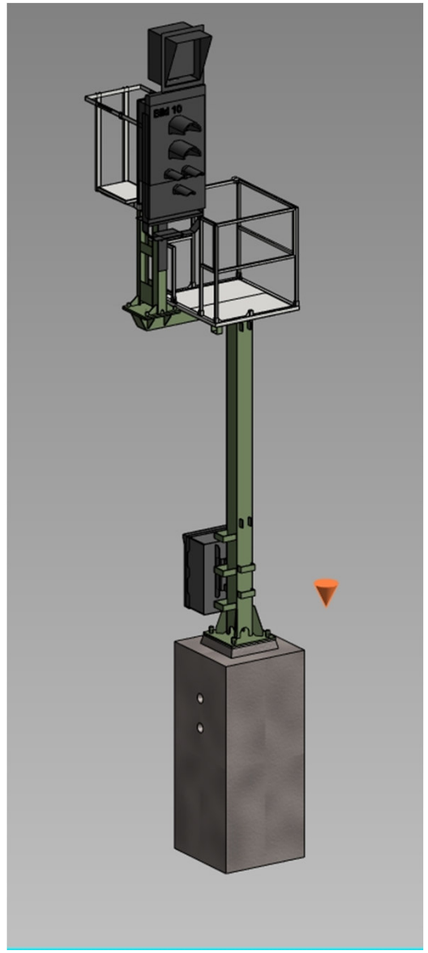
- **main family** (based on template Metric Generic Model Adaptive.rft)
  - one adaptive point (= placement point)
  - 3 reference points > fixed on the adaptive point respectively on each other
    > allow rotation around x-, y- and z-axis
    > allow offset in x-, y- and z-direction
  - 6 reference points > fixed on the 3rd reference point respectively on each other
    > representing the host / plane for the sub families
- **sub families** (based on template Metric Generic Model face based.rft)
  - made from Inventor geometries
  - placed in main family by using reference points
  - controlled in position and geometry by parameters



The structure

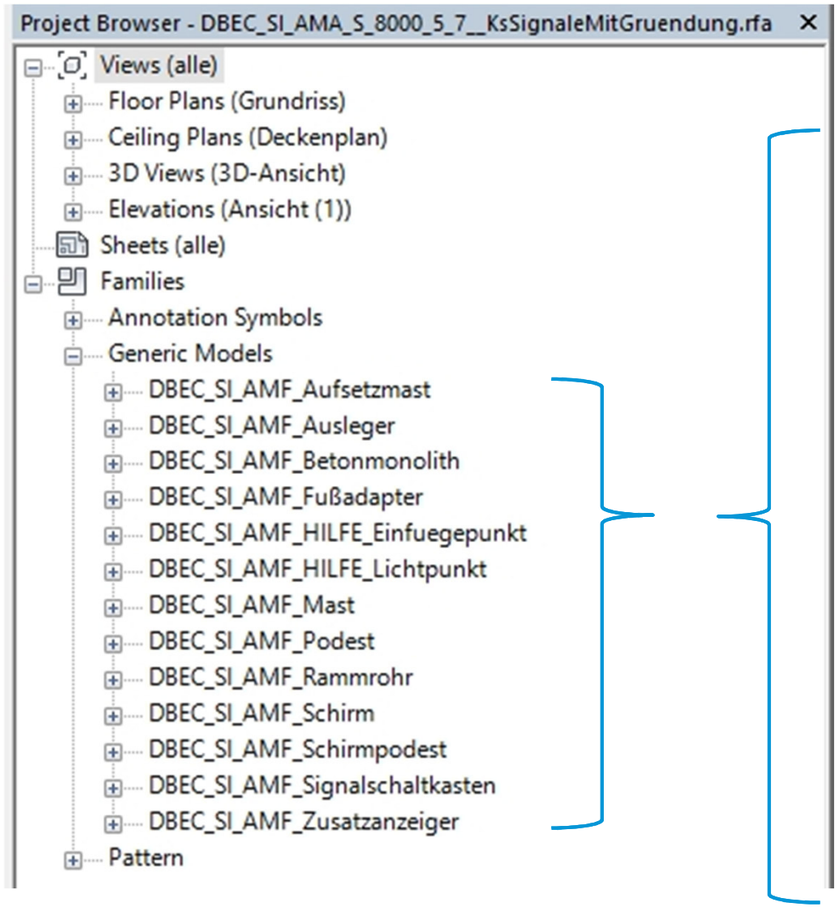


→ signal with foundation



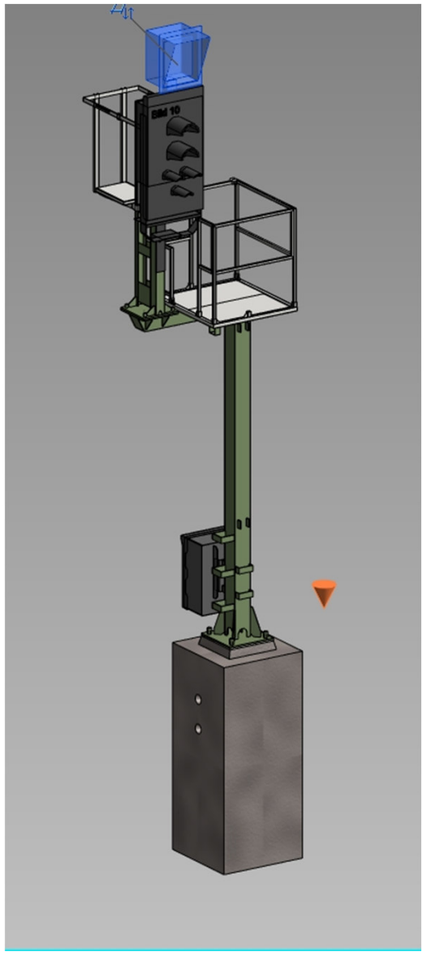
main family

The structure



signal with foundation

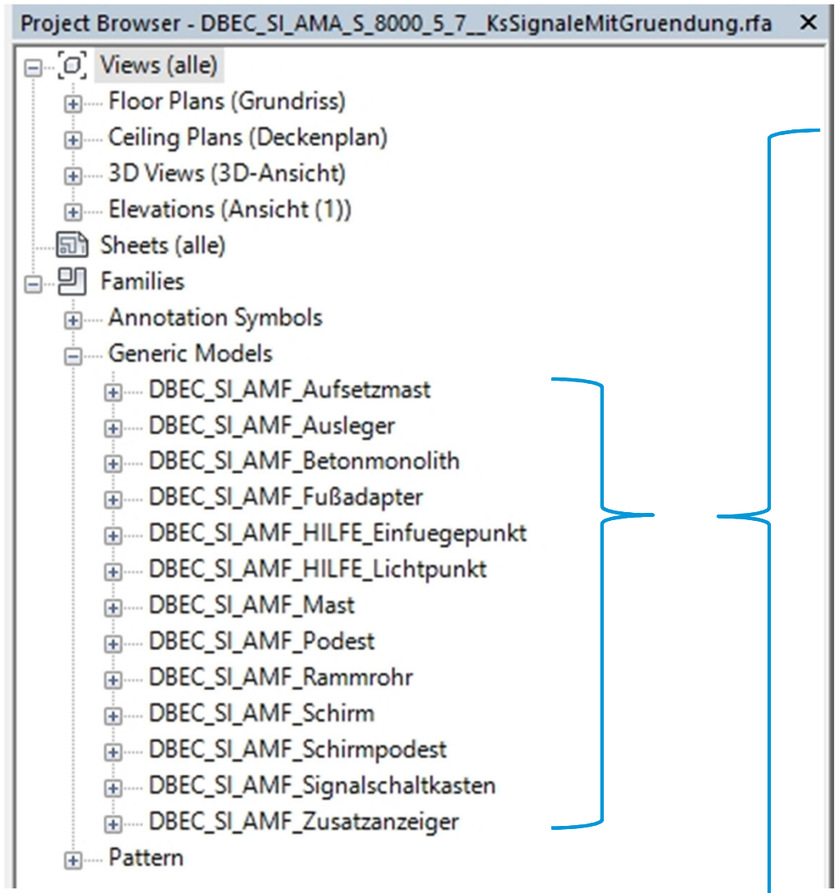
additional screen



main family

subfamilies

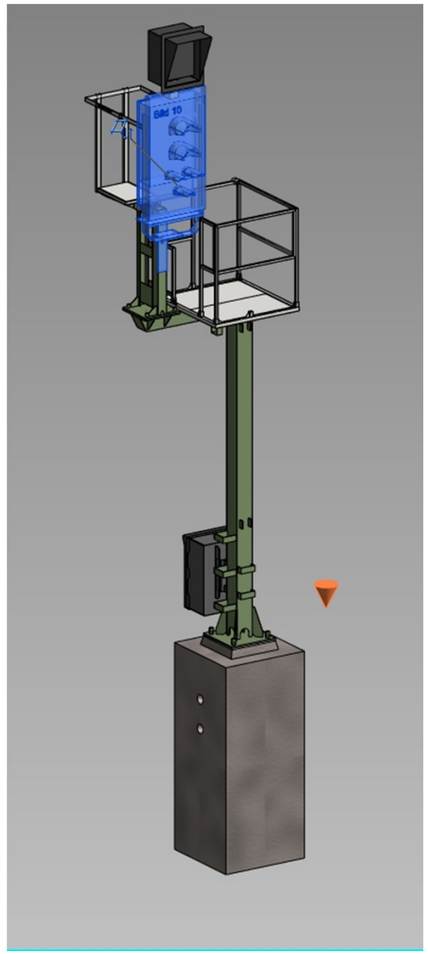
The structure



signal with foundation

screen

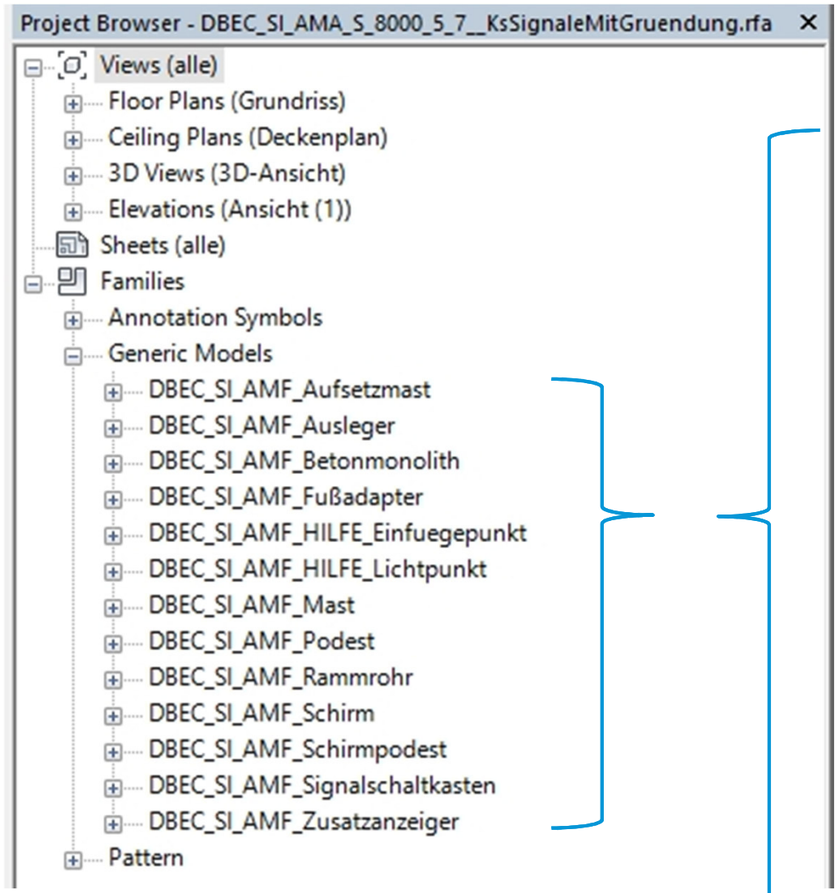
additional screen



main family

subfamilies

The structure

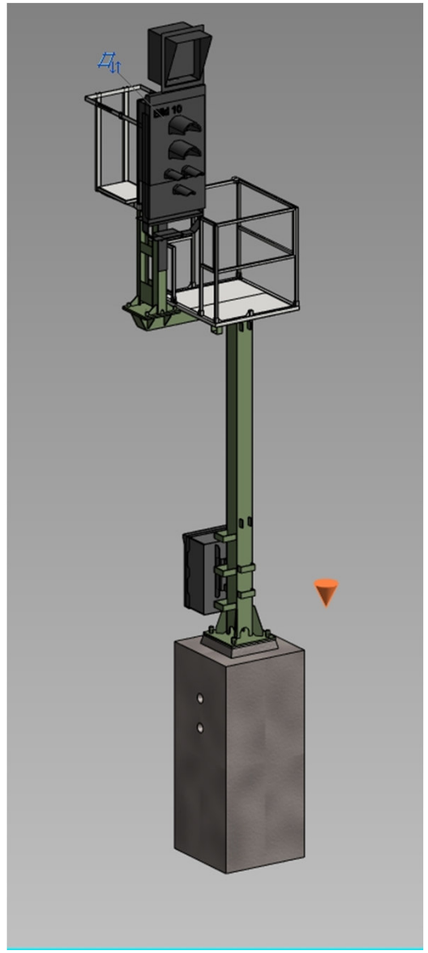


signal with foundation

light point

screen

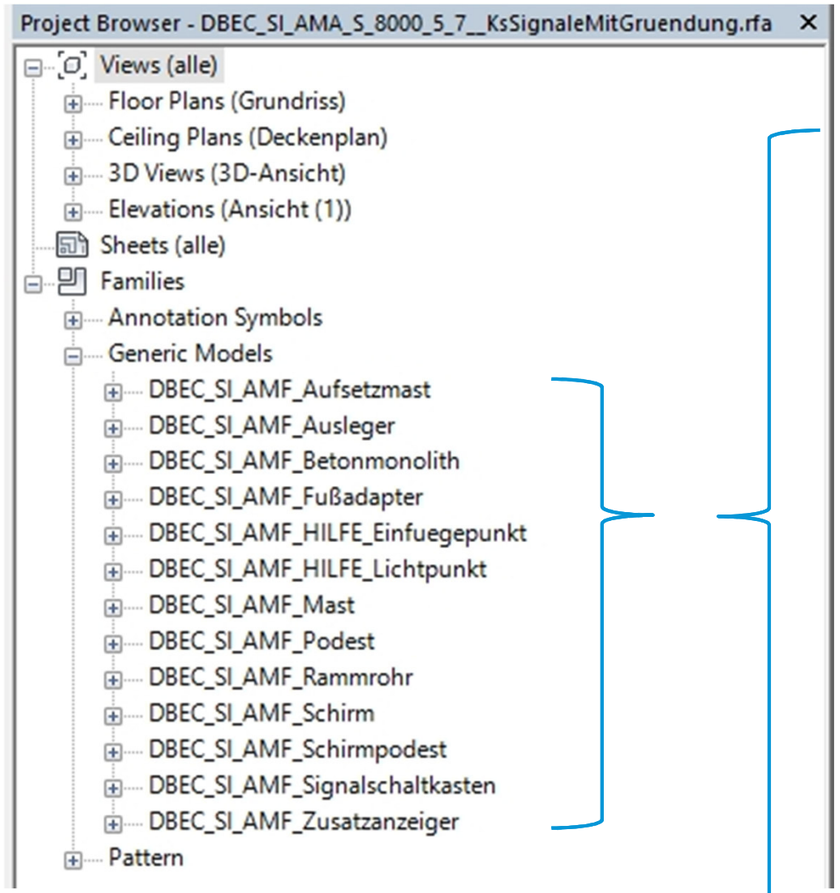
additional screen



main family

subfamilies

The structure



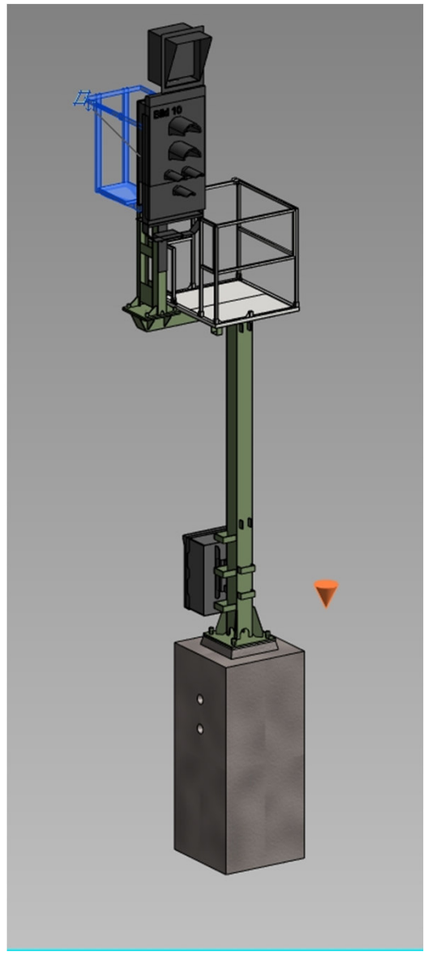
signal with foundation

light point

screen

platform behind screen

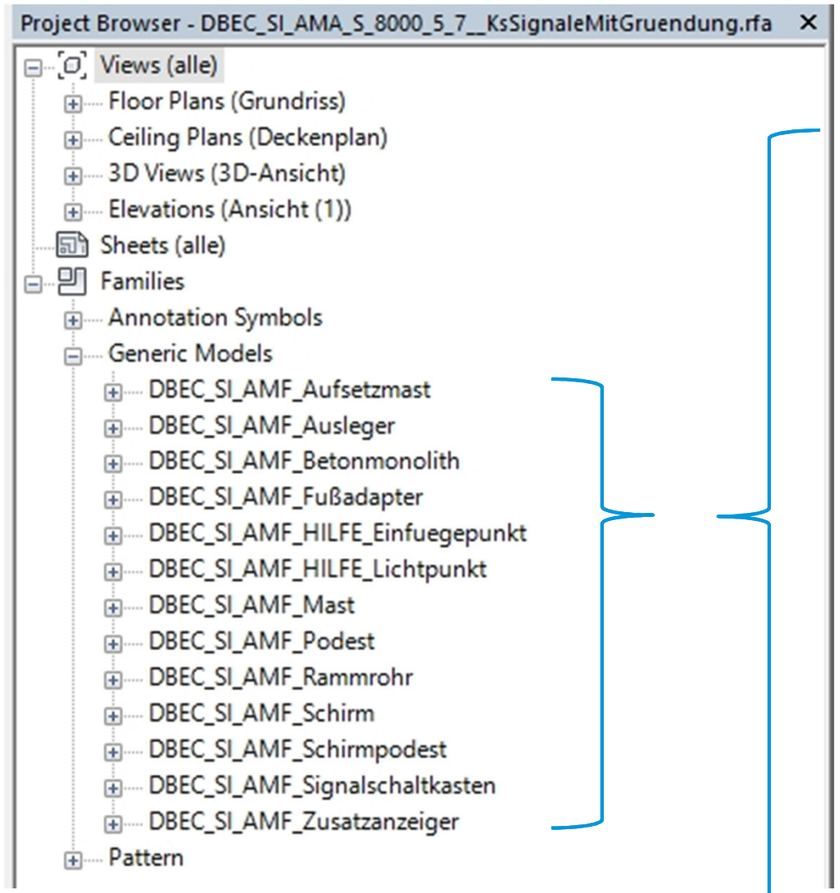
additional screen



main family

subfamilies

The structure



→ signal with foundation

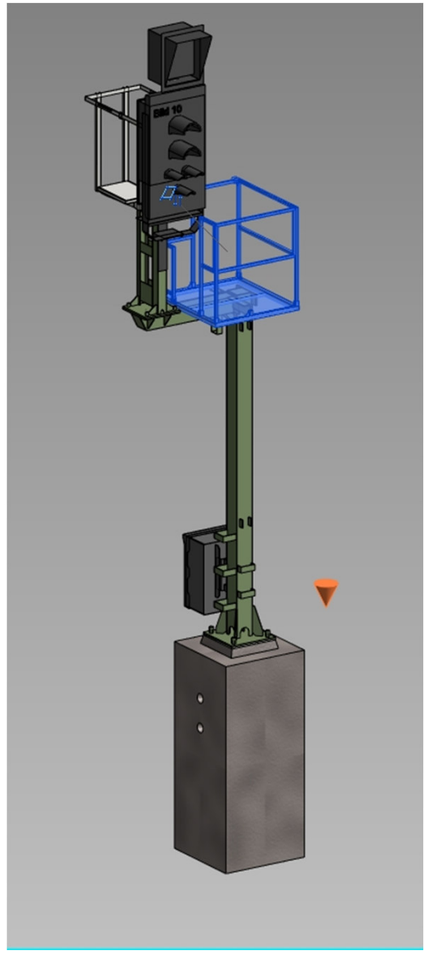
light point

platform

screen

platform behind screen

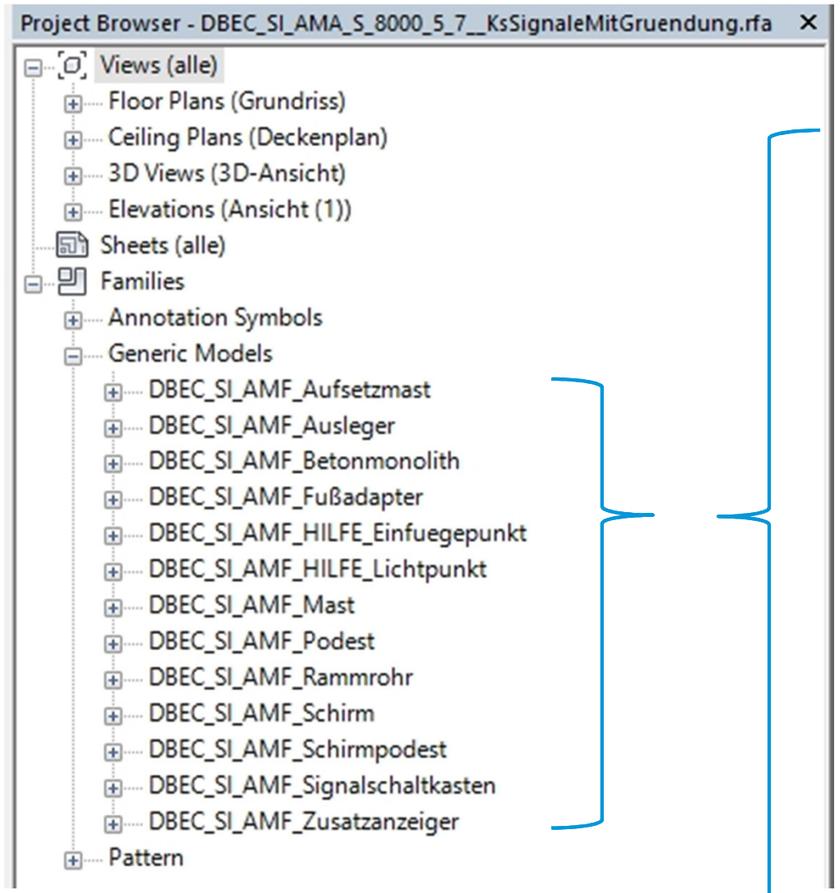
additional screen



main family

subfamilies

The structure



→ signal with foundation

extension pole

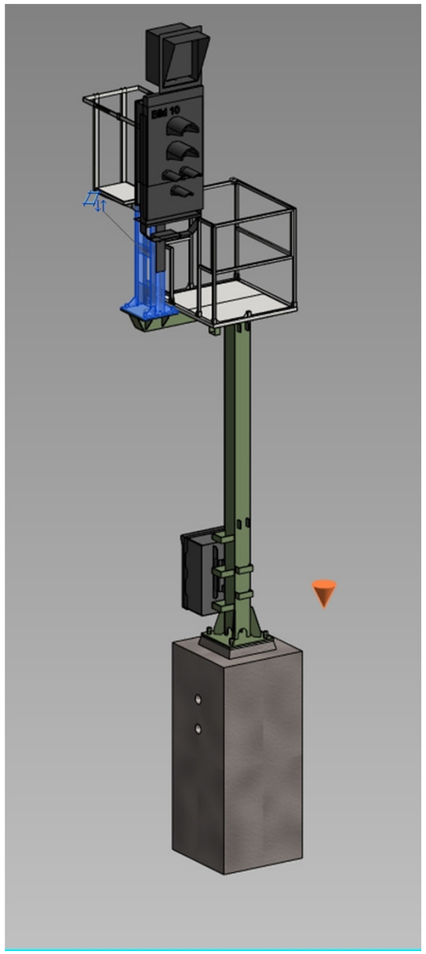
light point

platform

screen

platform behind screen

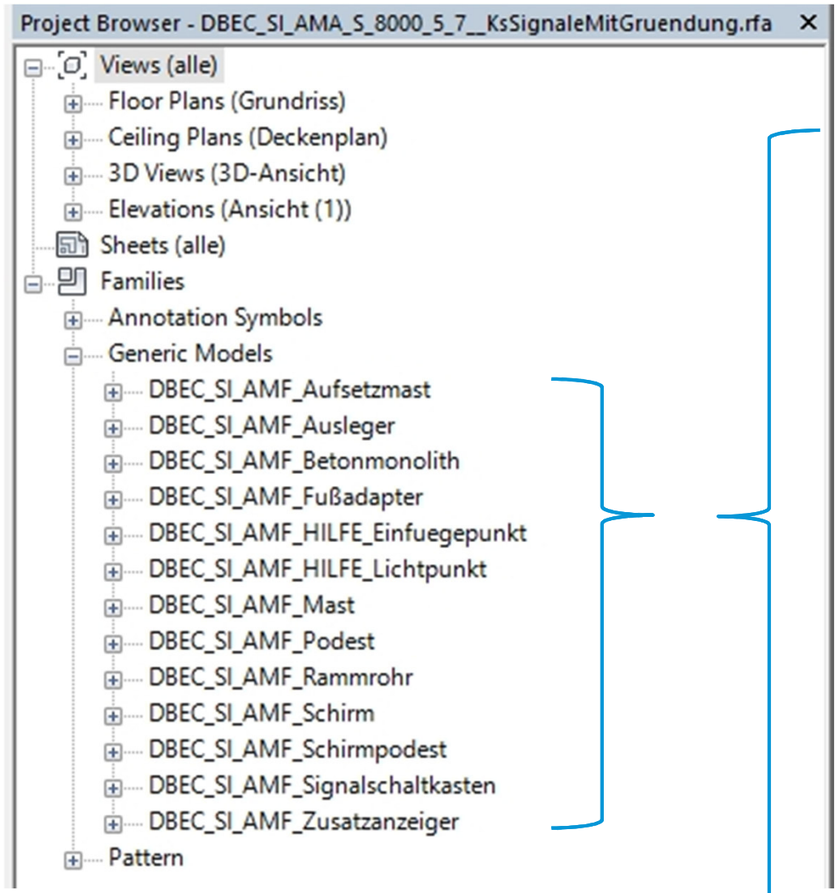
additional screen



main family

subfamilies

The structure



signal with foundation

extension pole

cantilever arm

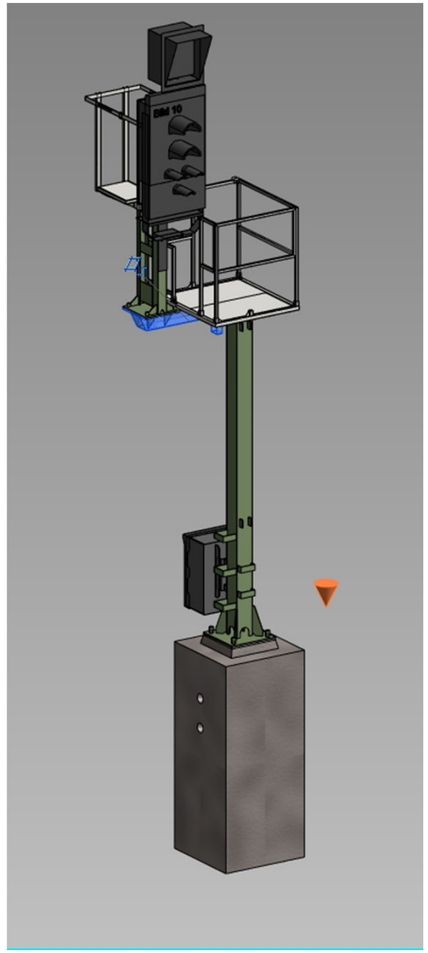
light point

platform

screen

platform behind screen

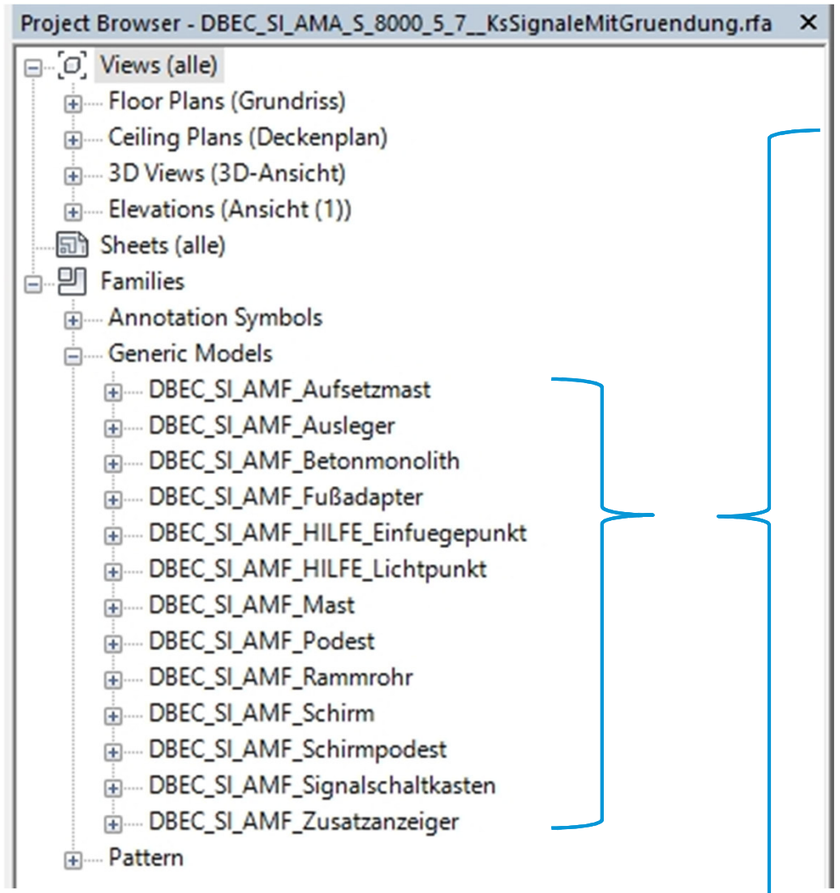
additional screen



main family

subfamilies

The structure



signal with foundation

main family

extension pole

cantilever arm

subfamilies

light point

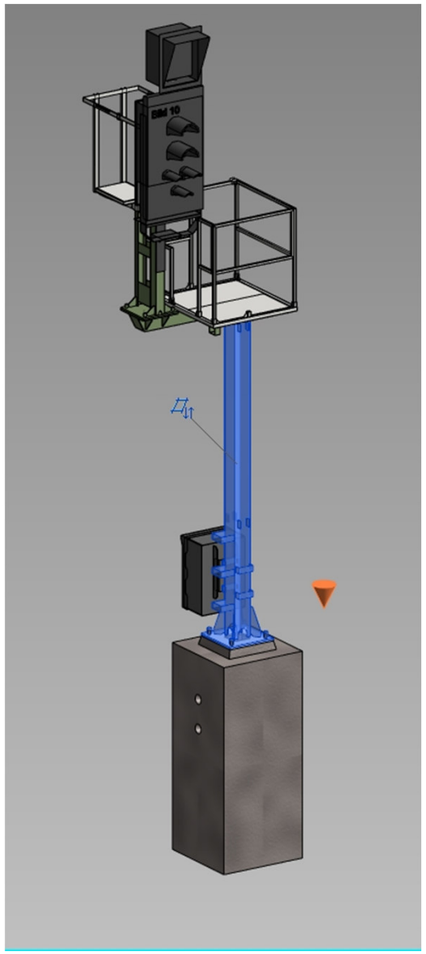
pole

platform

screen

platform behind screen

additional screen



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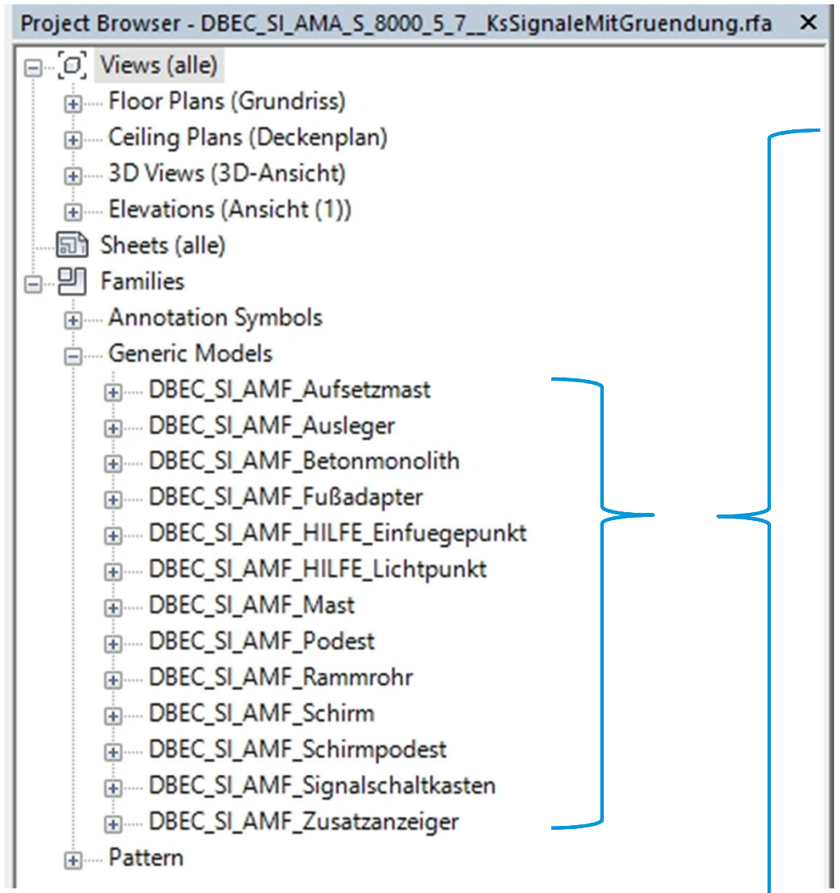


→ signal with foundation

main family

extension pole

cantilever arm

subfamilies

light point

pole

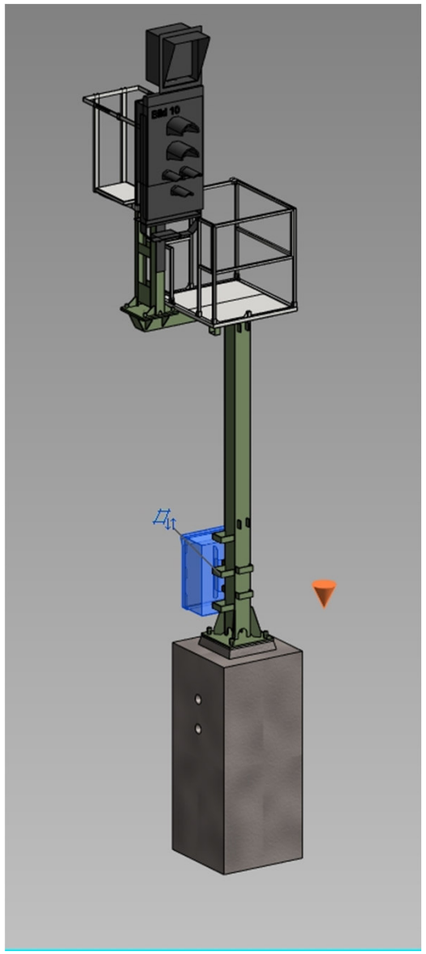
platform

screen

platform behind screen

switch box

additional screen



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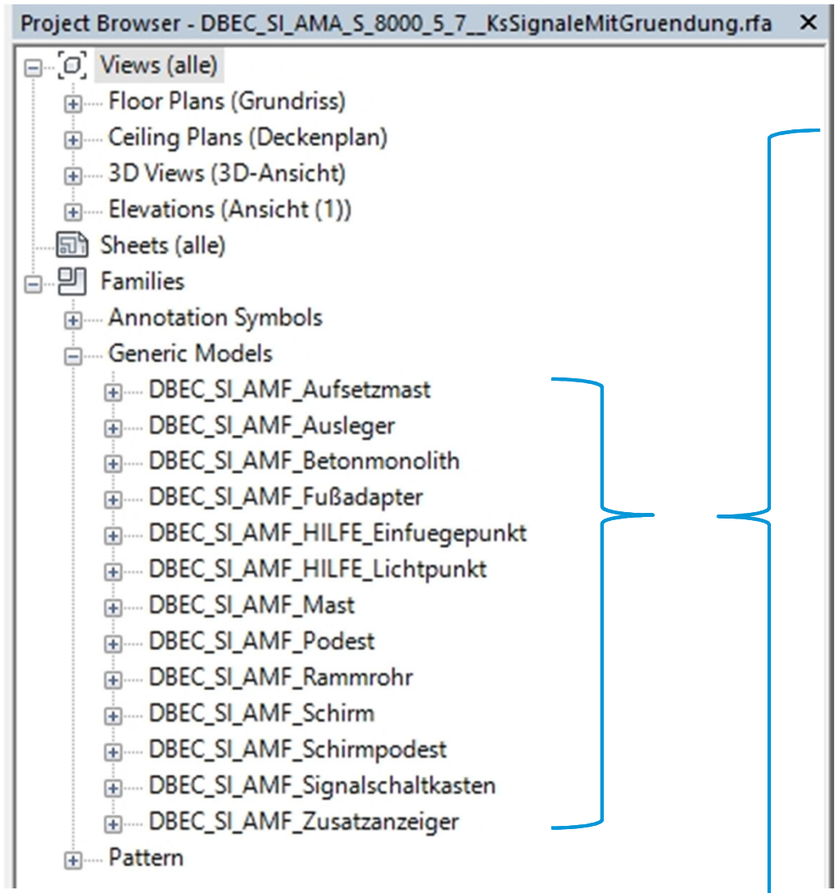


→ signal with foundation

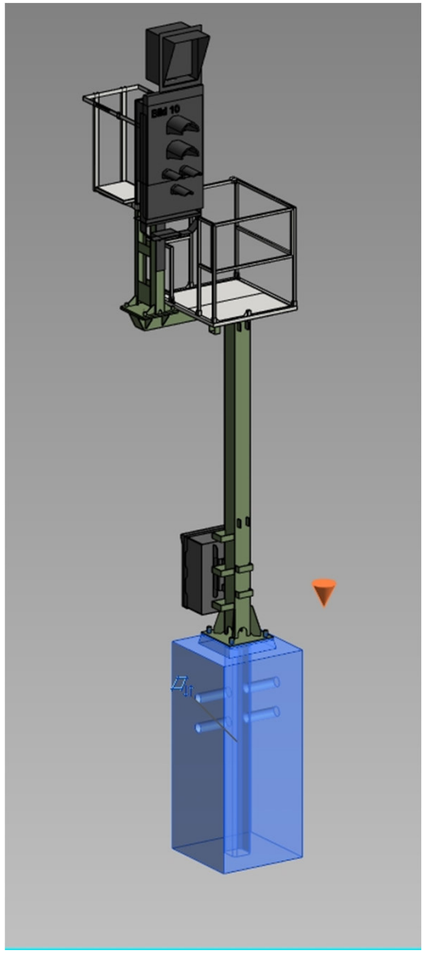
main family

extension pole
cantilever arm
concrete block foundation

subfamilies

light point
pole
platform

screen
platform behind screen
switch box
additional screen



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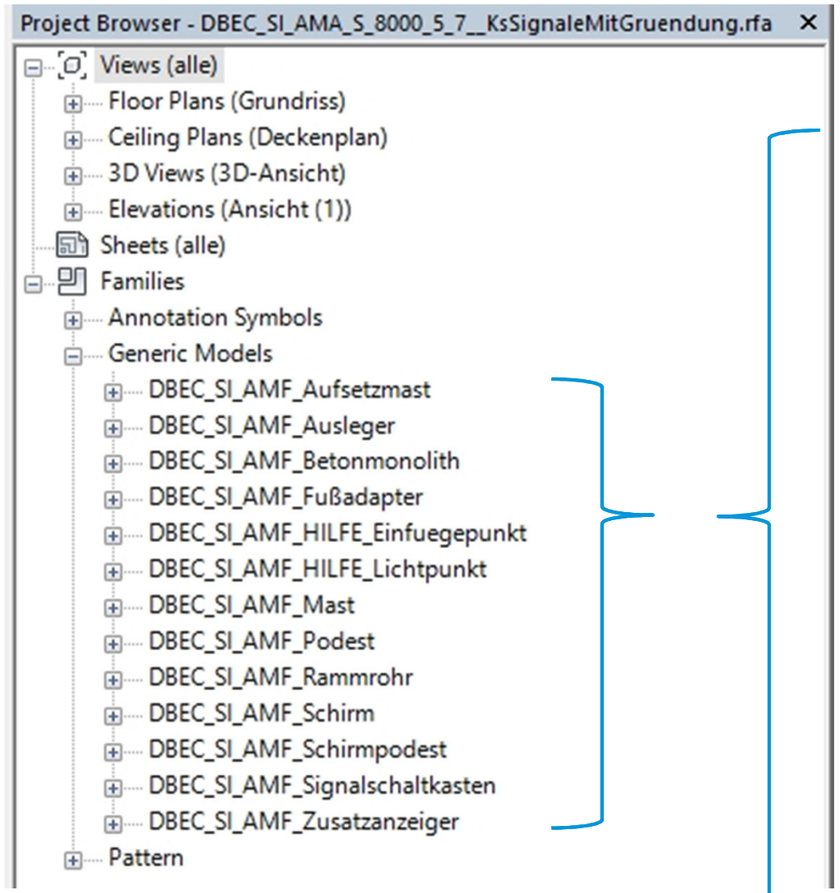


→ signal with foundation

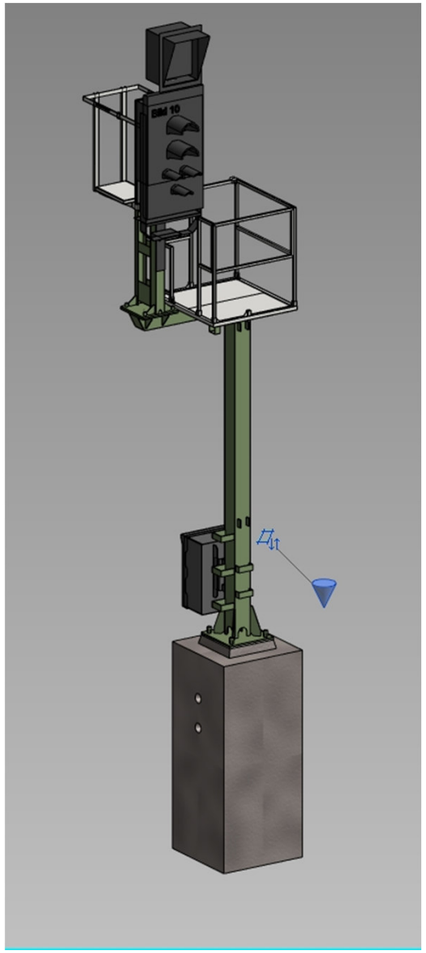
main family

extension pole
cantilever arm
concrete block foundation

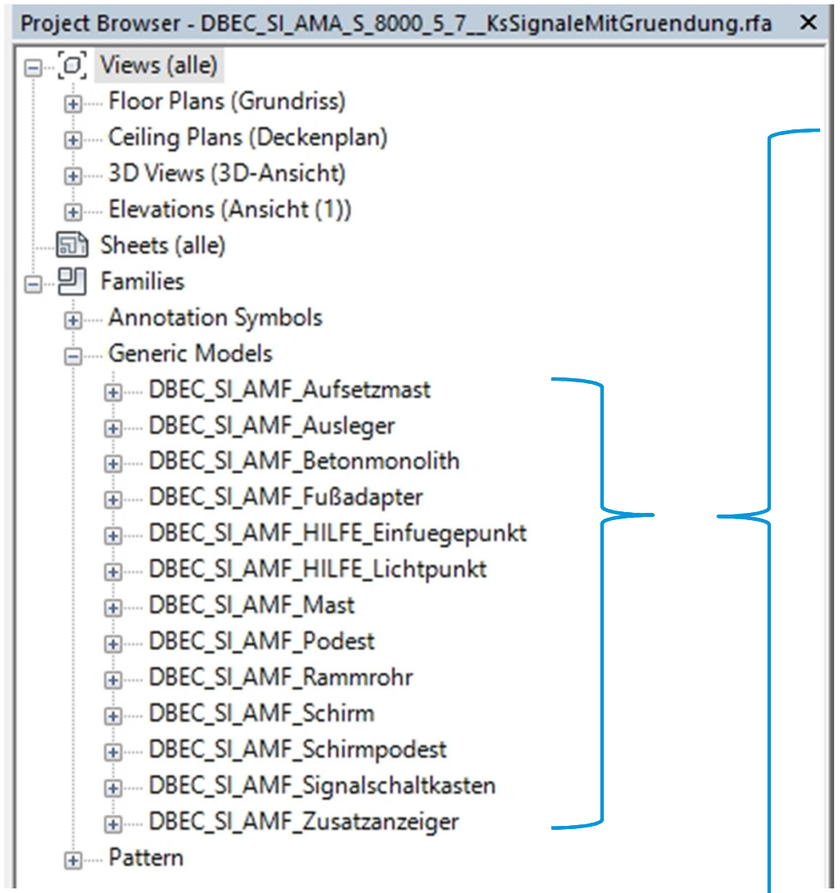
subfamilies

insertion point
light point
pole
platform

screen
platform behind screen
switch box
additional screen



The structure



signal with foundation

main family

subfamilies

extension pole

cantilever arm

concrete block foundation

base adapter

insertion point

light point

pole

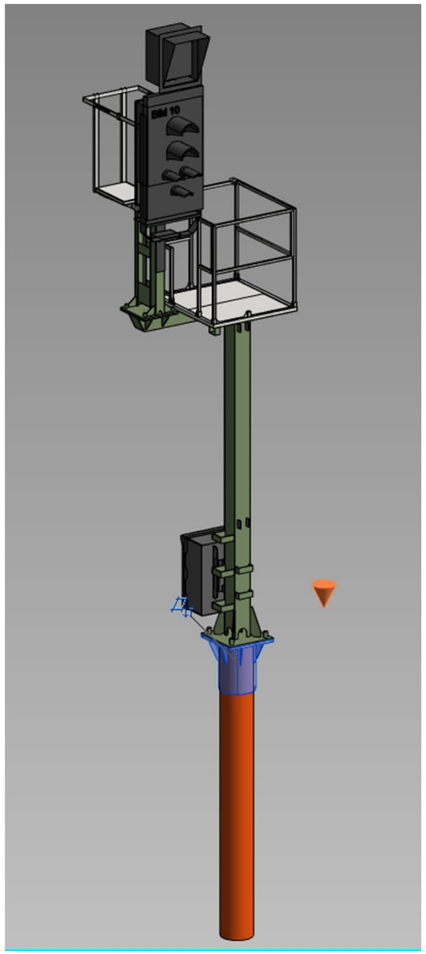
platform

screen

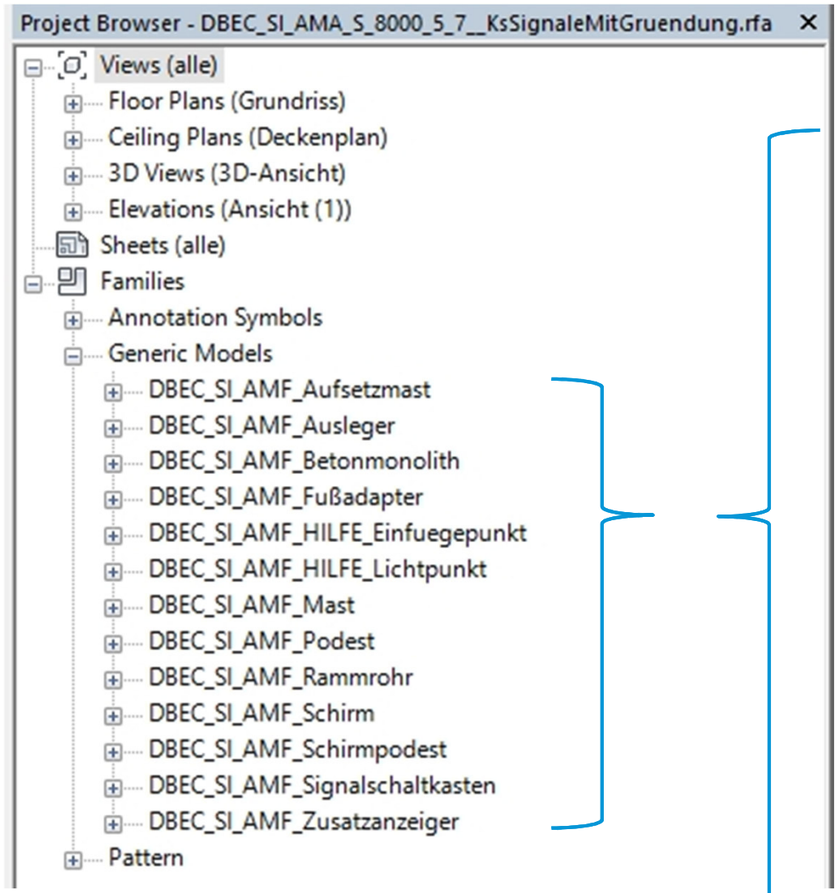
platform behind screen

switch box

additional screen



The structure

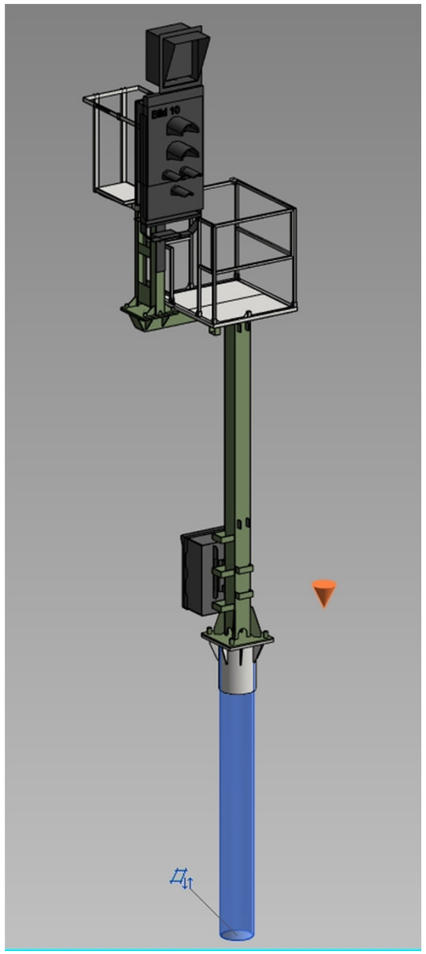


→ signal with foundation

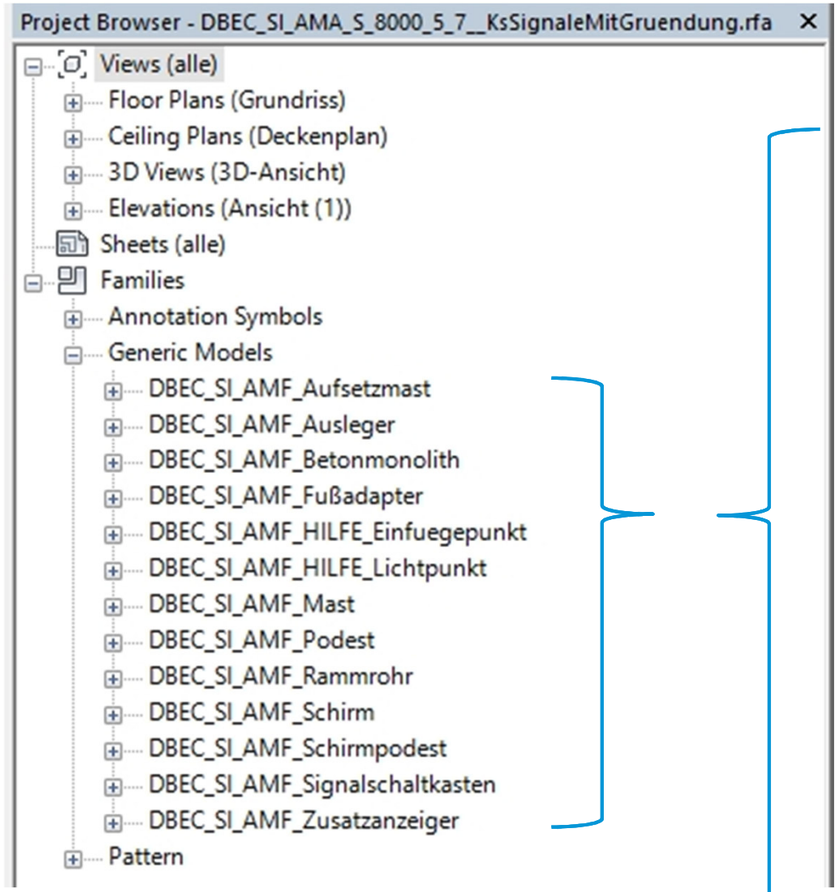
main family

subfamilies

- extension pole
- cantilever arm
- concrete block foundation
- base adapter
- insertion point
- light point
- pole
- platform
- ramming pipe
- screen
- platform behind screen
- switch box
- additional screen



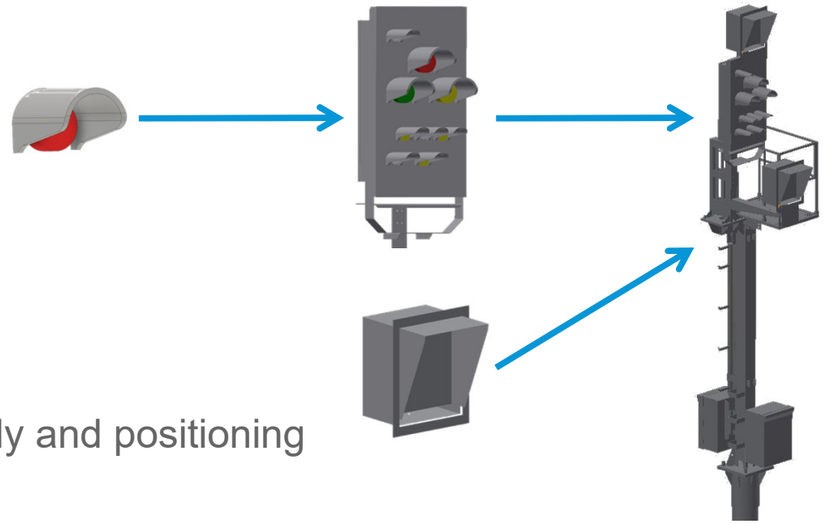
The structure



signal with foundation … 20 types (20 figures) **main family**

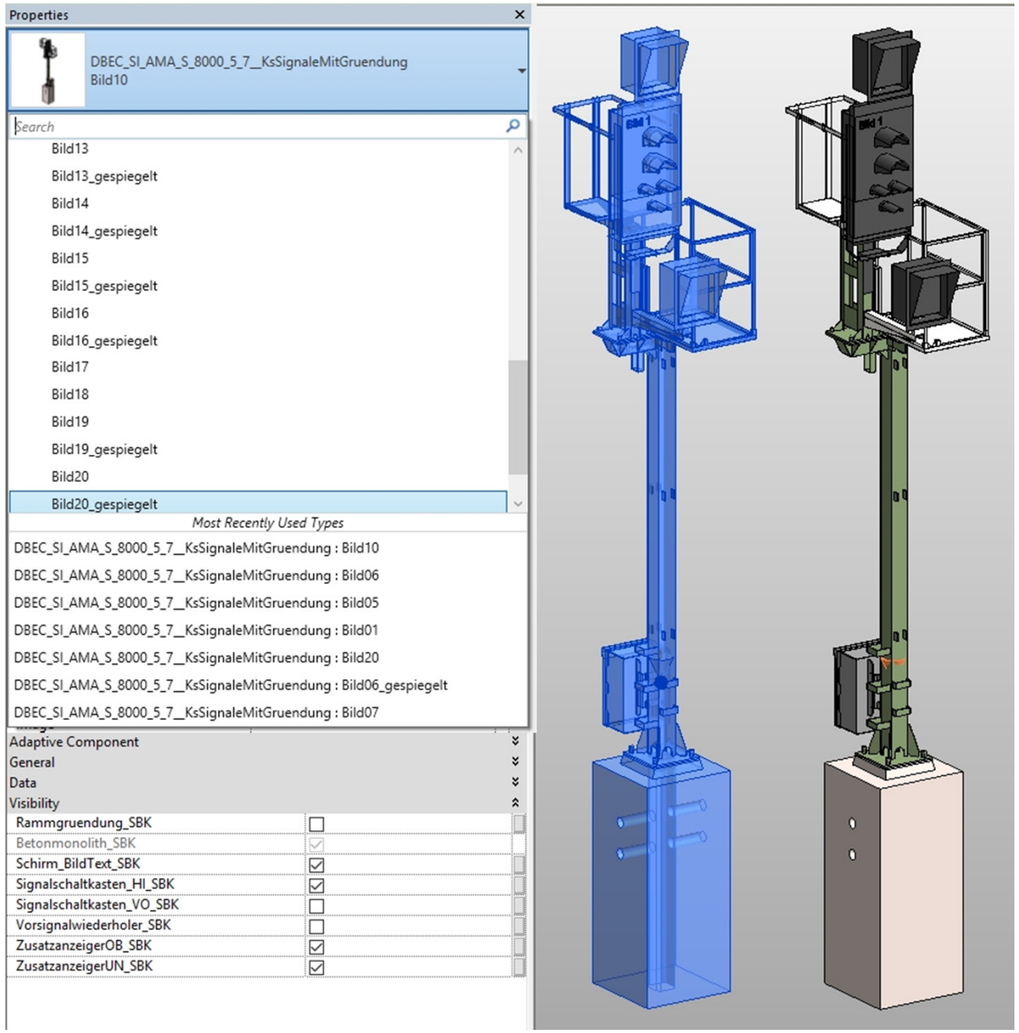
extension pole	… 3 types (1x empty + 2 lengthes)	**subfamilies**
cantilever arm	… 5 types (1x empty + 2 lengthes + left/right)	
concrete block foundation	… 5 types	
base adapter	… 2 types	
insertion point	… no types (auxiliary means)	
light point	… no types (auxiliary means)	
pole	… 4 types (4 lengthes)	
platform	… 5 types (1x empty + 2 dimensions + left/right)	
ramming pipe	… 16 types (8 lengthes + 2 profiles)	
screen	… 20 types (20 figures)	
platform behind screen	… 3 types (3 dimensions)	
switch box	… 2 types	
additional screen	… 2 types	

The work



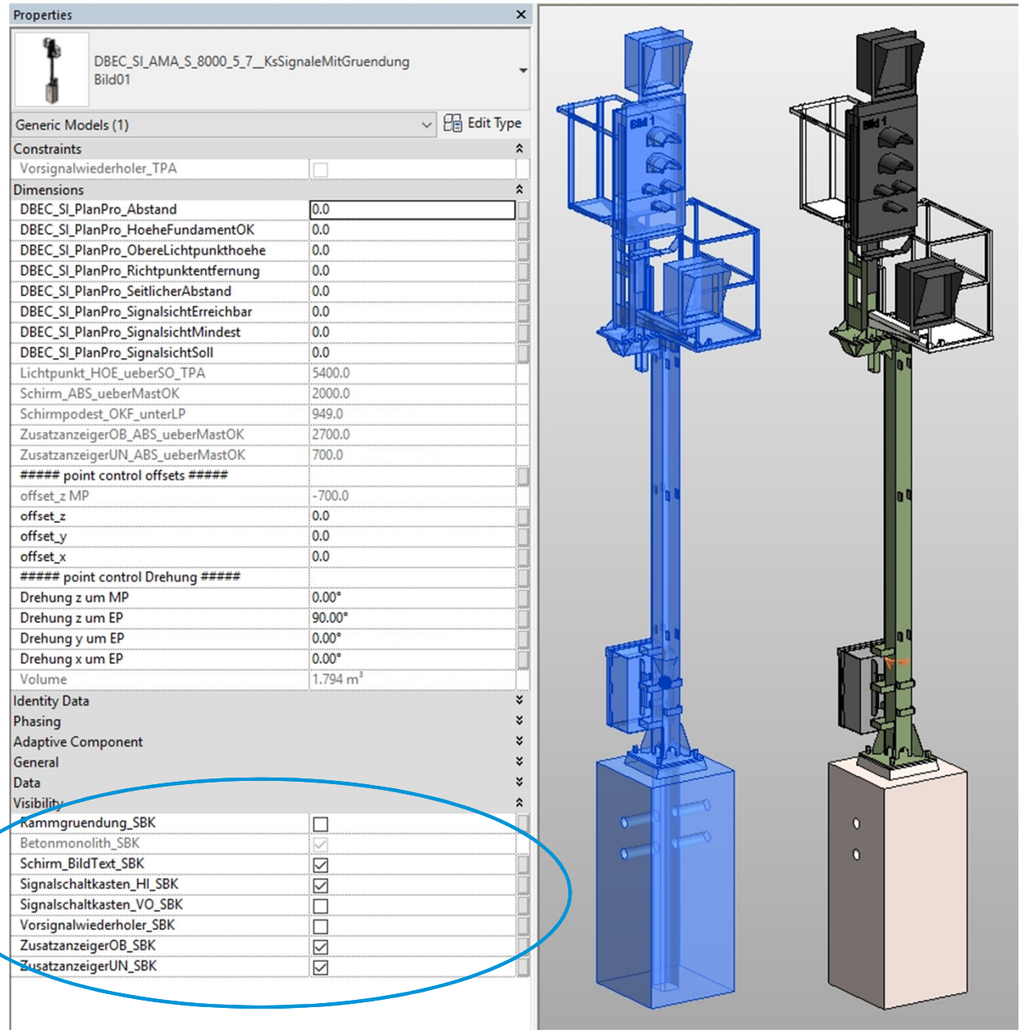
- step 1: creating Revit sub families out of Inventor geometries
  - merging Inventor parts to an Inventor assembly
  - using shrinkwrap command to simplify geometries
  - exporting assembly into ADSK file format
  - opening ADSK file in Revit, copy geometry in a new face based family and positioning
- step 2: creating Revit main family
  - creating 1-point adaptive family with interconnected reference points
  - placing sub families from step 1 and defining dependencies
- step 3: parameter setting
  - defining parameters for controlling geometry / position and holding information

The result



- one nested family
  - 36 types
  - 13 sub families with more than 60 types

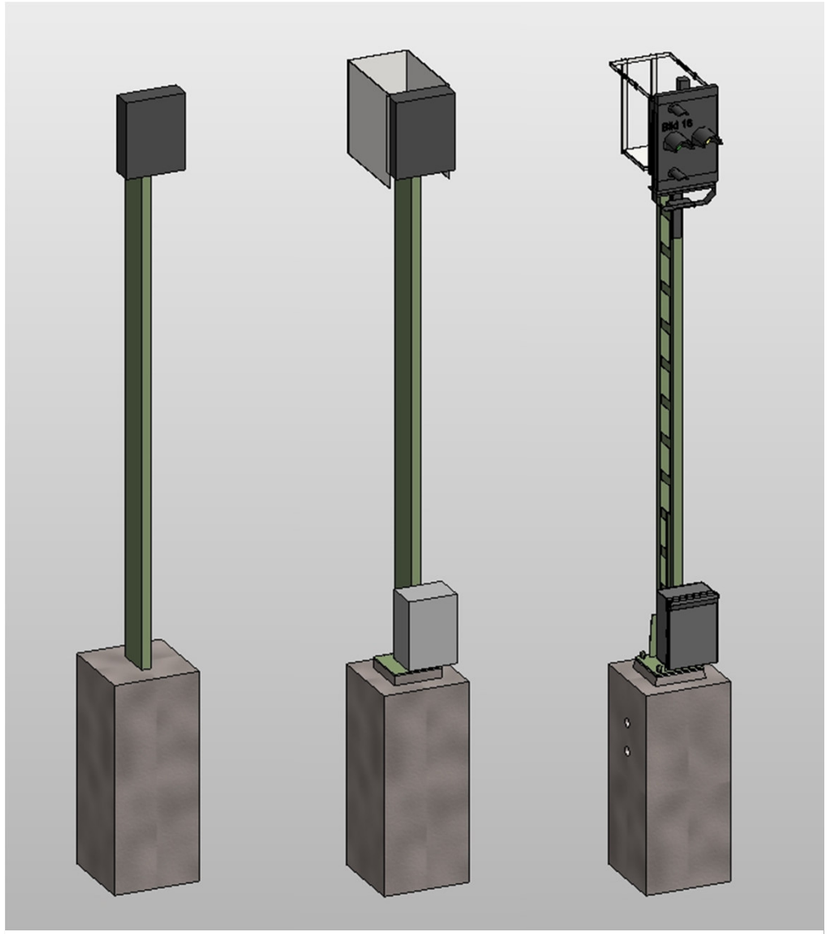
The result



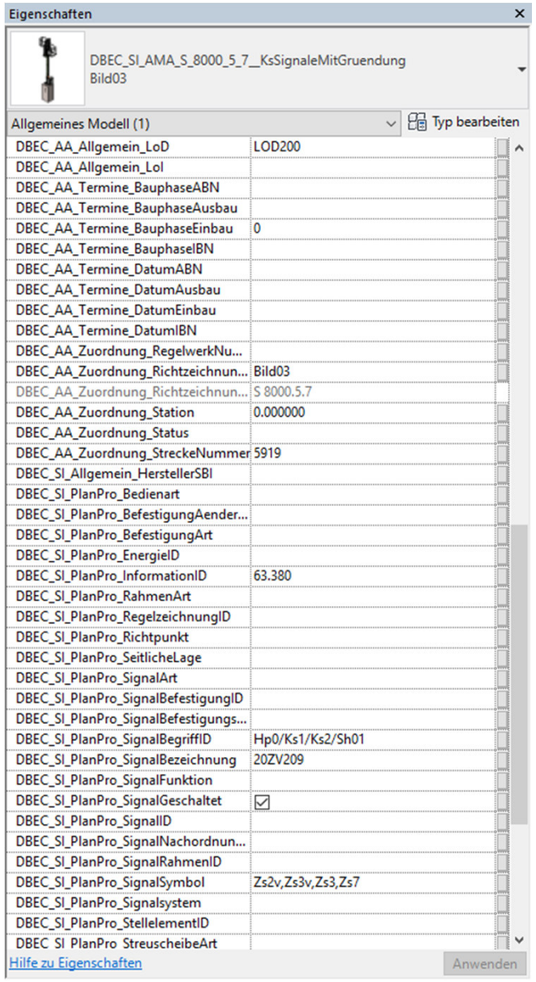
- one nested family
  - 36 types
  - 13 sub families with more than 60 types
  - many variation due to parameters for controlling the visibility of elements (e.g. deep or surface foundation, one or two additional screens, …)
  - filesize 15.7 MB

The result

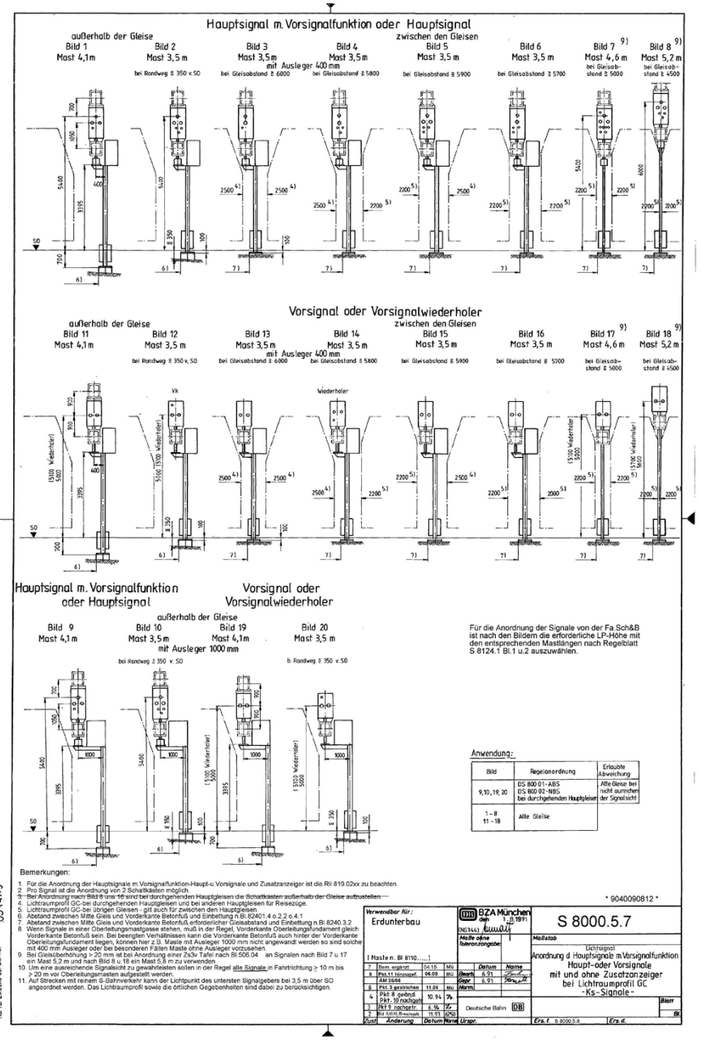
- one nested family
  - 3 detail levels
  - all information from primary planning software

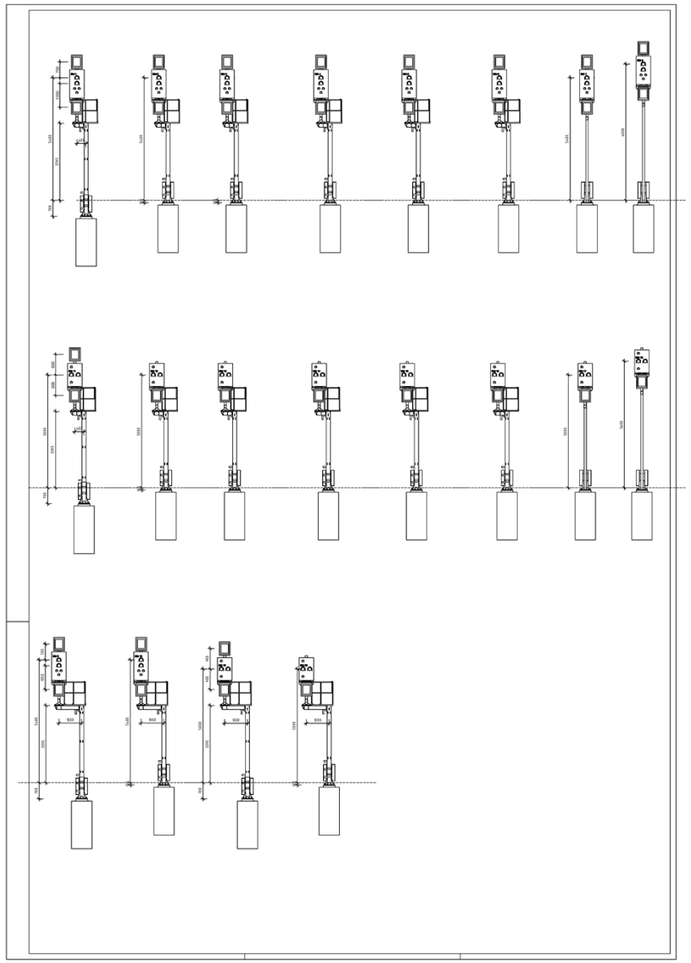


coarse medium fine



The result


Hauptsignal m. Vorsignalfunktion oder Hauptsignal
außerhalb der Gleise
zwischen den Gleisen
Bild 1 Mast 4,1 m
Bild 2 Mast 3,5 m
Bild 3 Mast 3,5 m mit Ausleger 400 mm
Bild 4 Mast 3,5 m
Bild 5 Mast 3,5 m
Bild 6 Mast 3,5 m
Bild 7 Mast 4,6 m
Bild 8 Mast 5,2 m
Vorsignal oder Vorsignalwiederholer
Bild 11 Mast 4,1 m
Bild 12 Mast 3,5 m
Bild 13 Mast 3,5 m mit Ausleger 400 mm
Bild 14 Mast 3,5 m
Bild 15 Mast 3,5 m
Bild 16 Mast 3,5 m
Bild 17 Mast 4,6 m
Bild 18 Mast 5,2 m
Hauptsignal m. Vorsignalfunktion oder Hauptsignal
Vorsignal oder Vorsignalwiederholer
außerhalb der Gleise
Bild 9 Mast 4,1 m
Bild 10 Mast 3,5 m mit Ausleger 1000 mm
Bild 19 Mast 4,1 m
Bild 20 Mast 3,5 m
Für die Anordnung der Signale von der Fa Sch&B ist nach den Bildern die erforderliche LP-Höhe mit den entsprechenden Mastlängen nach Regelblatt S 8124.1 Bl.1 u.2 auszuwählen.
Anwendung:
Bemerkungen:
S 8000.5.7
Anordnung d. Hauptsignale m. Vorsignalfunktion
Haupt- oder Vorsignale
mit und ohne Zusatzanzeiger
bei Lichtraumprofil GC
- Ks - Signale -



The result

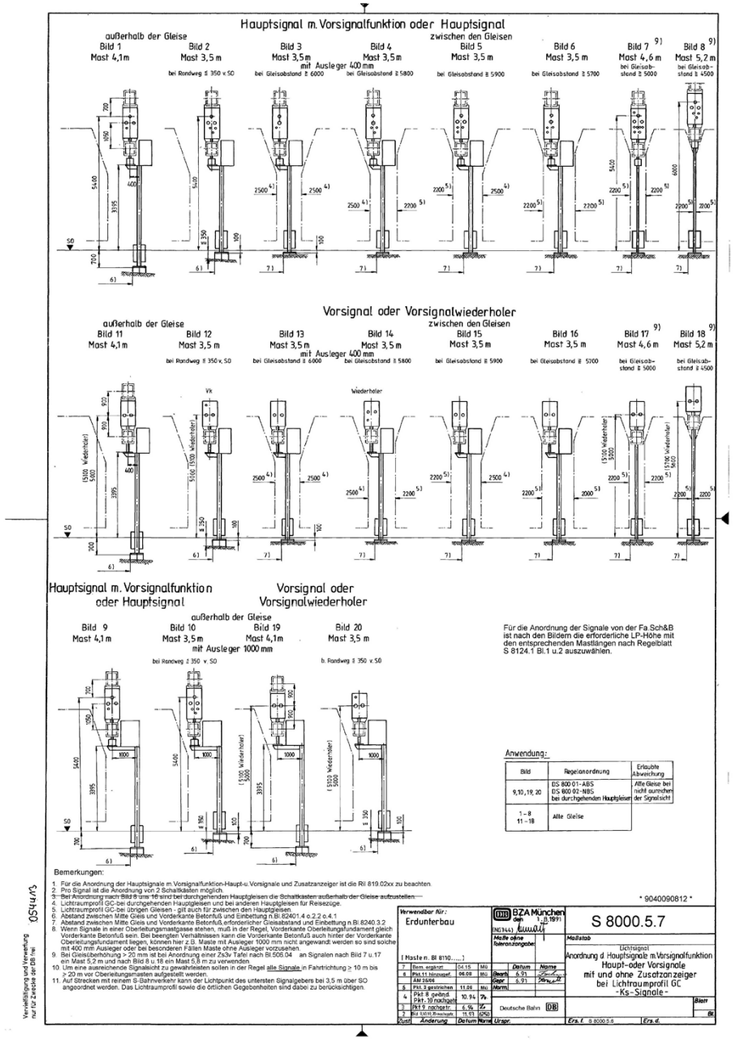

Hauptsignal m. Vorsignalfunktion oder Hauptsignal
außerhalb der Gleise
zwischen den Gleisen
Bild 1 Mast 4,1 m
Bild 2 Mast 3,5 m
Bild 3 Mast 3,5 m mit Ausleger 400 mm
Bild 4 Mast 3,5 m
Bild 5 Mast 3,5 m
Bild 6 Mast 3,5 m
Bild 7 Mast 4,6 m
Bild 8 Mast 5,2 m
Vorsignal oder Vorsignalwiederholer
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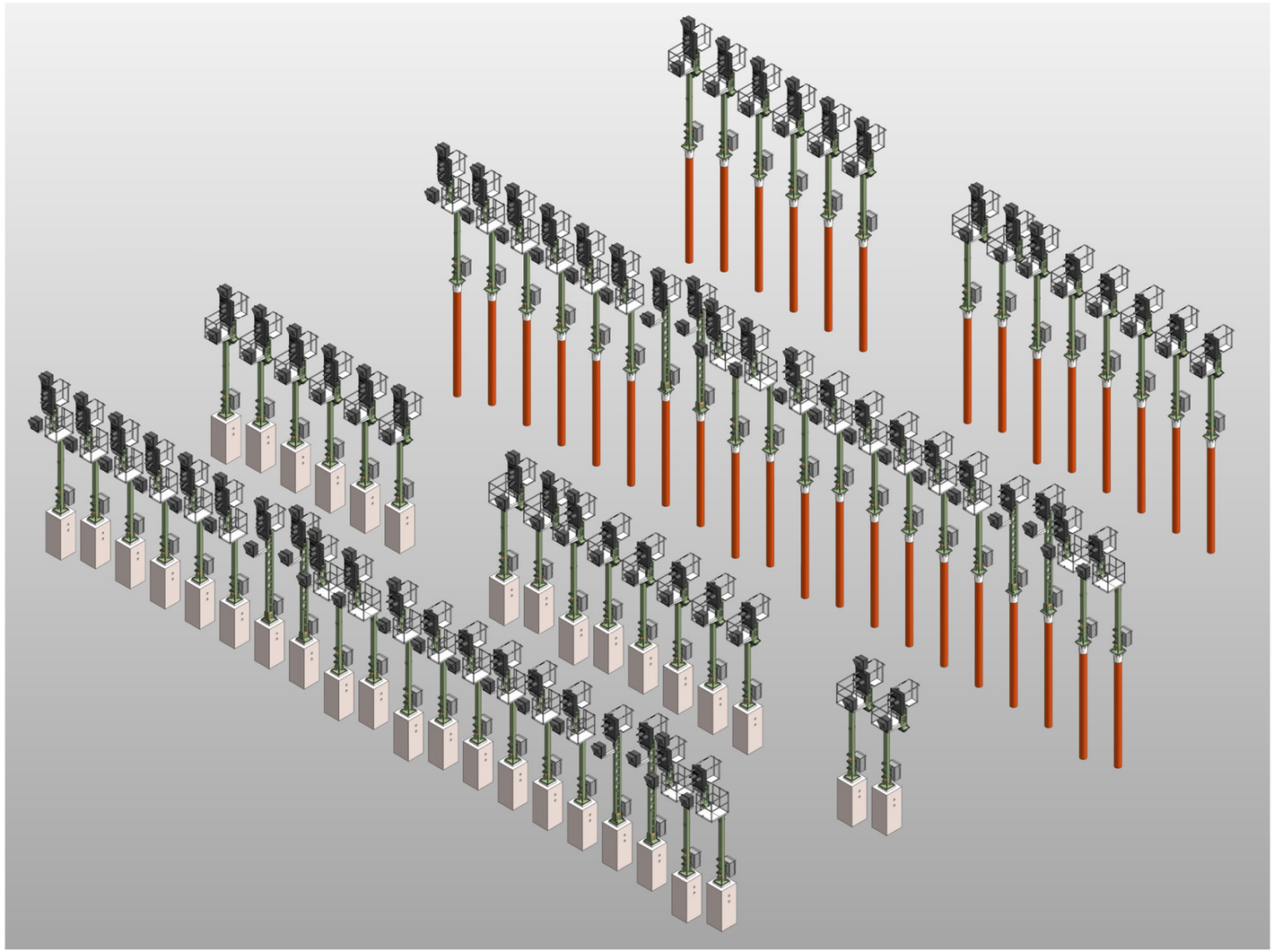
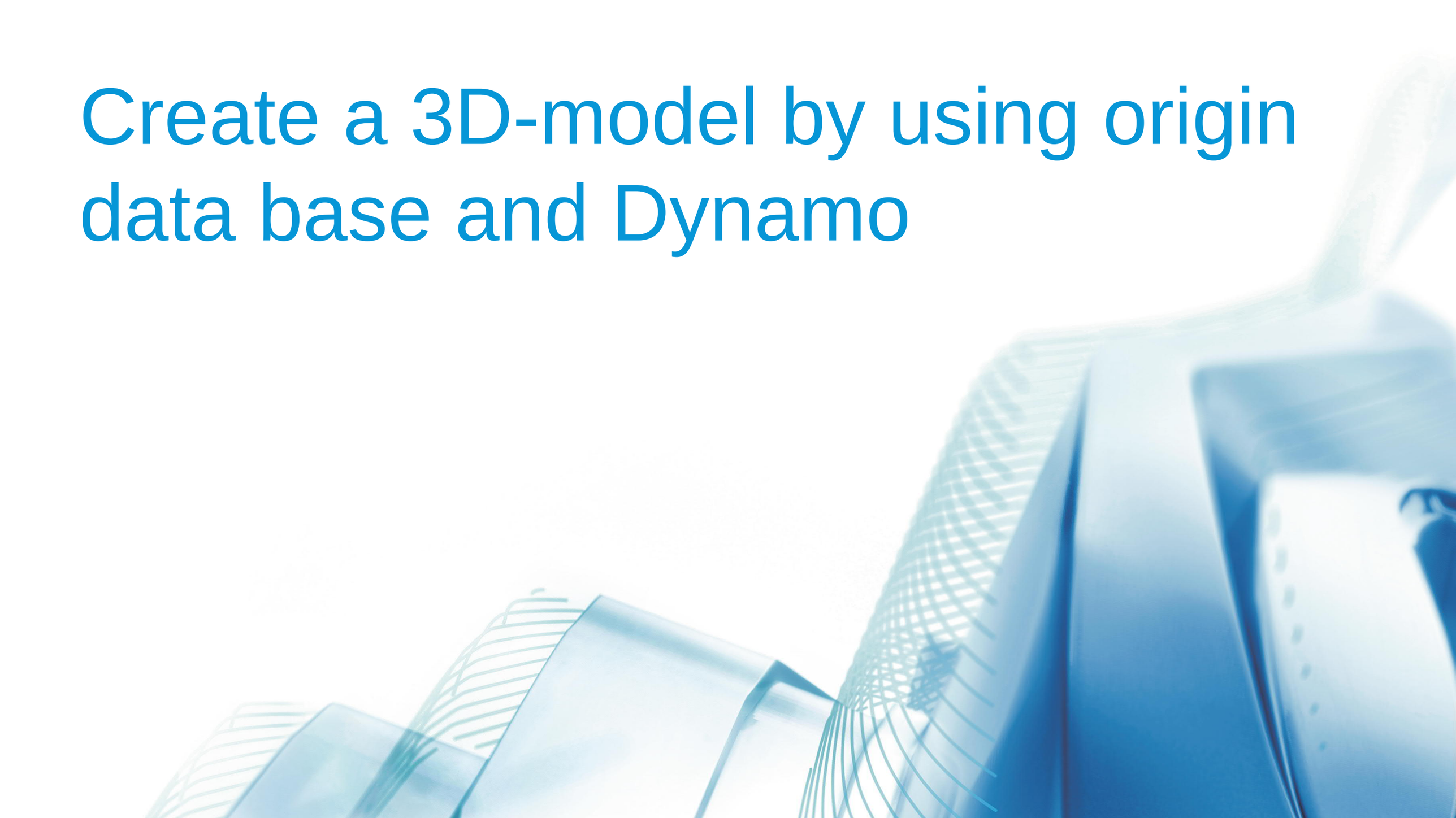
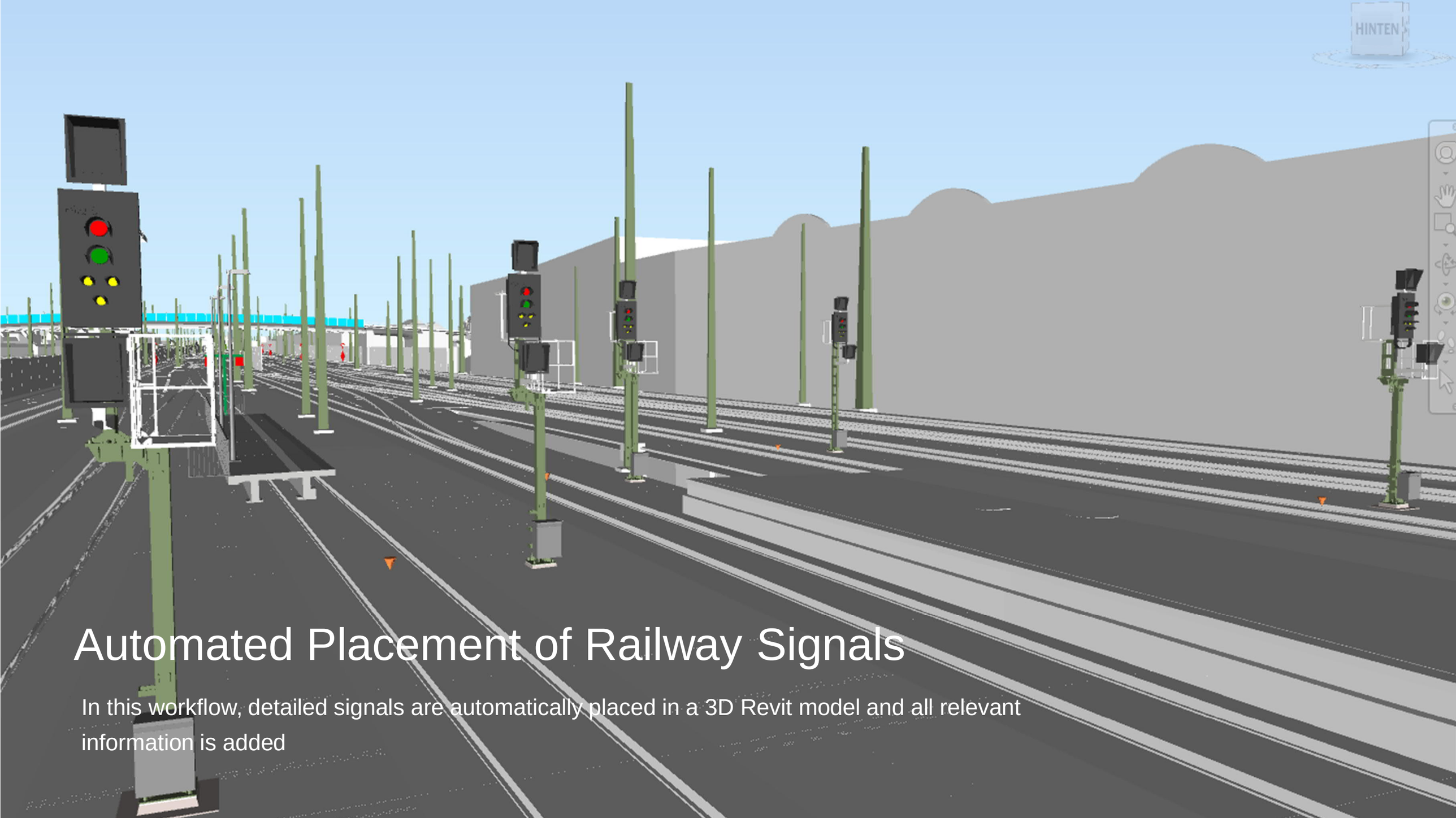
Bild 12 Mast 3,5 m
Bild 13 Mast 3,5 m mit Ausleger 400 mm
Bild 14 Mast 3,5 m
Bild 15 Mast 3,5 m
Bild 16 Mast 3,5 m
Bild 17 Mast 4,6 m
Bild 18 Mast 5,2 m
Hauptsignal m. Vorsignalfunktion oder Hauptsignal
Vorsignal oder Vorsignalwiederholer
außerhalb der Gleise
Bild 9 Mast 4,1 m
Bild 10 Mast 3,5 m mit Ausleger 1000 mm
Bild 19 Mast 4,1 m
Bild 20 Mast 3,5 m
Für die Anordnung der Signale von der Fa Sch&B ist nach den Bildern die erforderliche LP-Höhe mit den entsprechenden Mastlängen nach Regelblatt S 8124.1 Bl.1 u.2 auszuwählen.
Anwendung:
Bemerkungen:
S 8000.5.7
Anordnung d. Hauptsignale m. Vorsignalfunktion Haupt- oder Vorsignale mit und ohne Zusatzanzeiger bei Lichtraumprofil GC -Ks-Signale-
Deutsche Bahn



Create a 3D-model by using origin data base and Dynamo

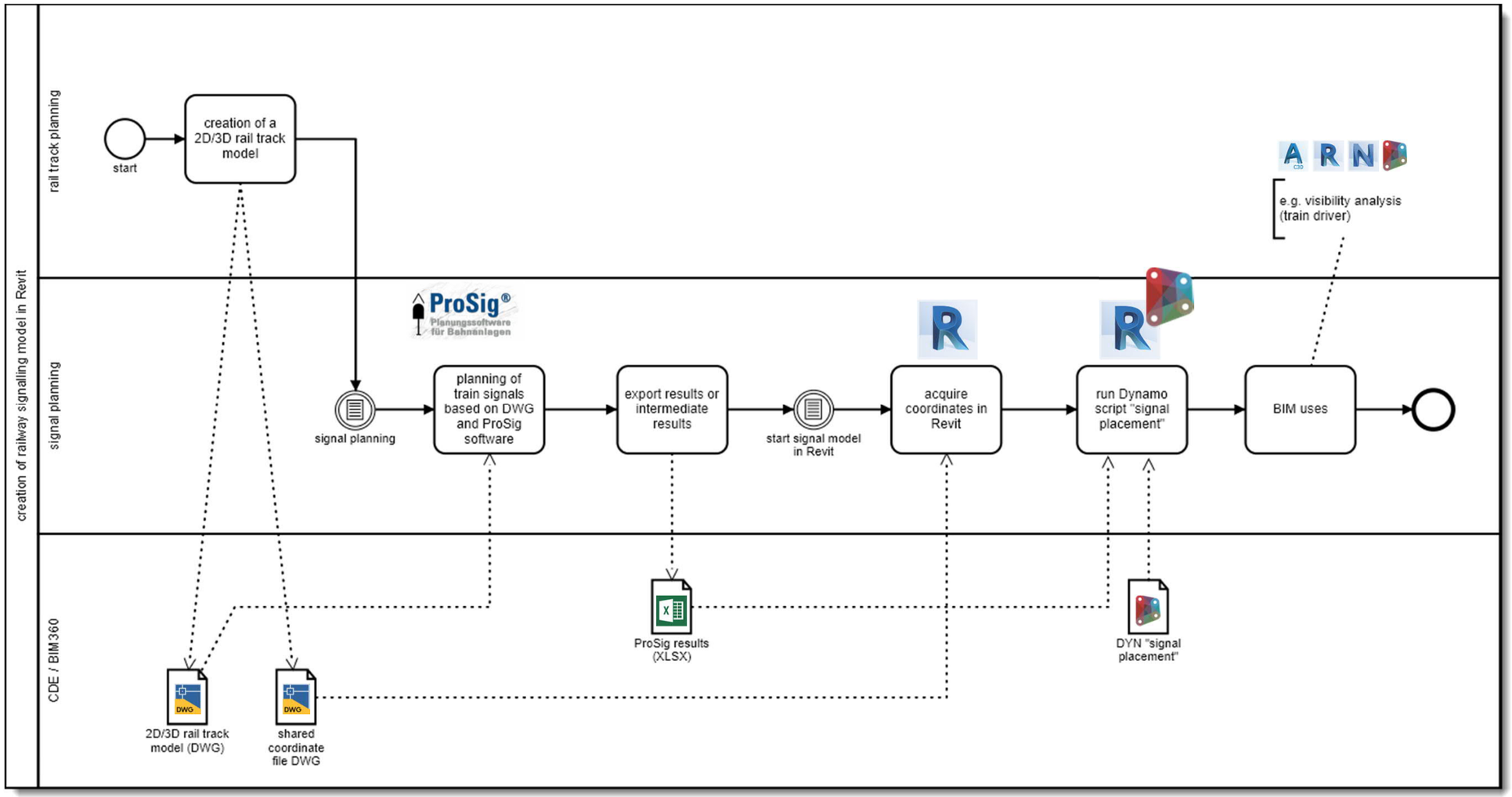




Automated Placement of Railway Signals

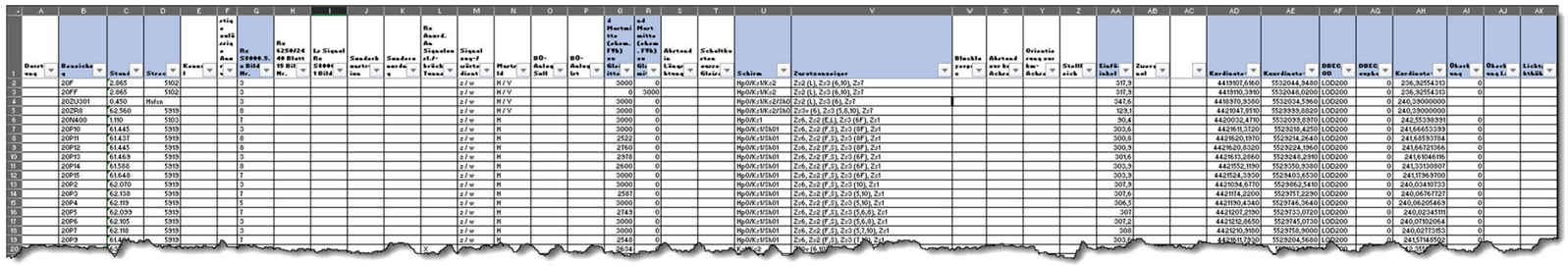
In this workflow, detailed signals are automatically placed in a 3D Revit model and all relevant information is added

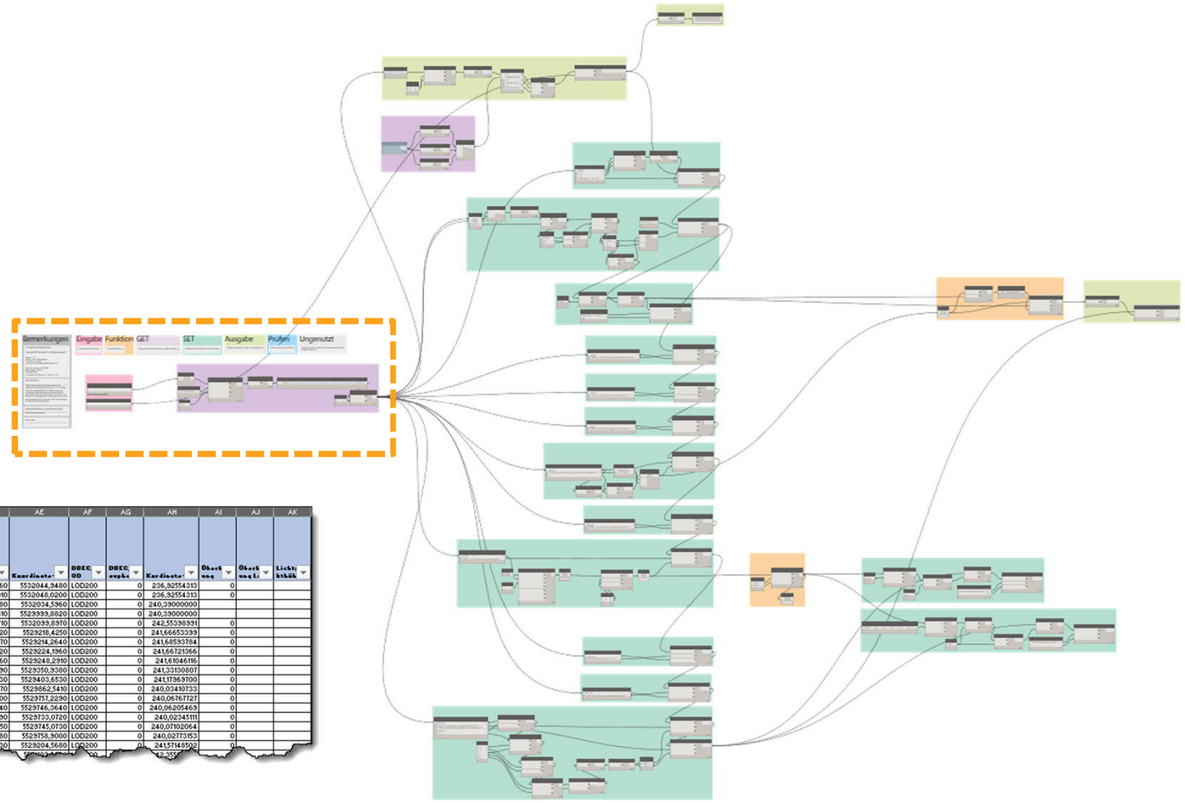
Automated Placement of Railway Signals



The Dynamo Script

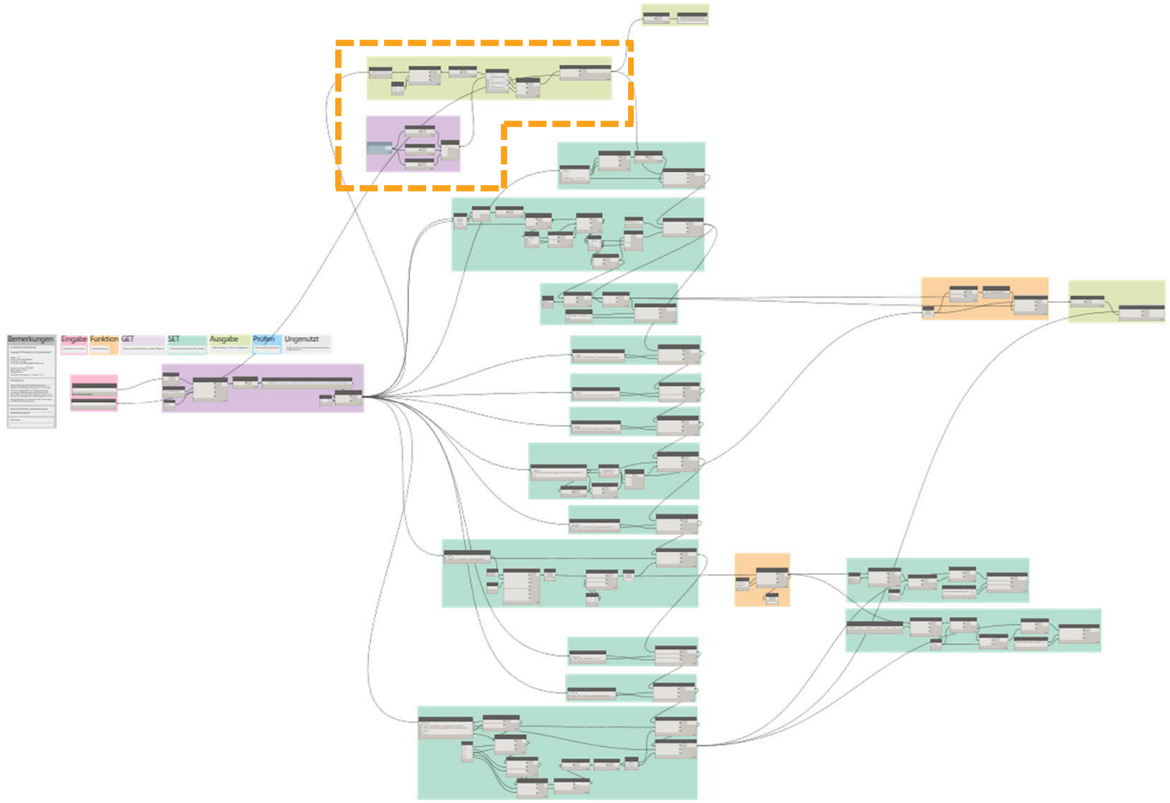
- Data import from Excel file (ProSig/ProCoPS export)





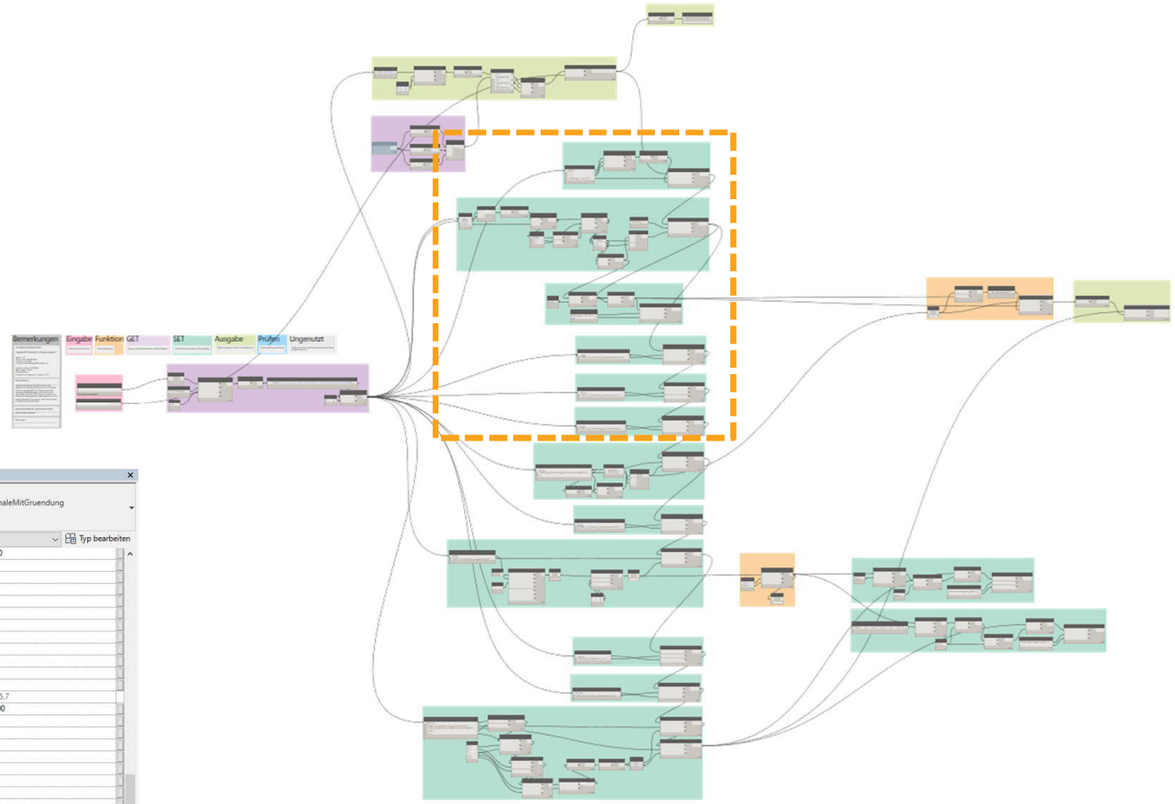
The Dynamo Script

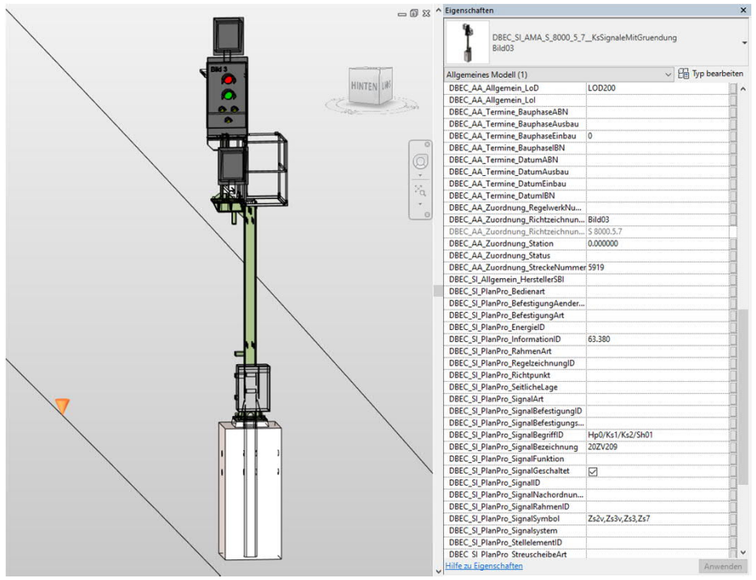
- Data import from Excel file (ProSig/ProCoPS export)
- Coordinate adjustments and placement of initial signal family type



The Dynamo Script

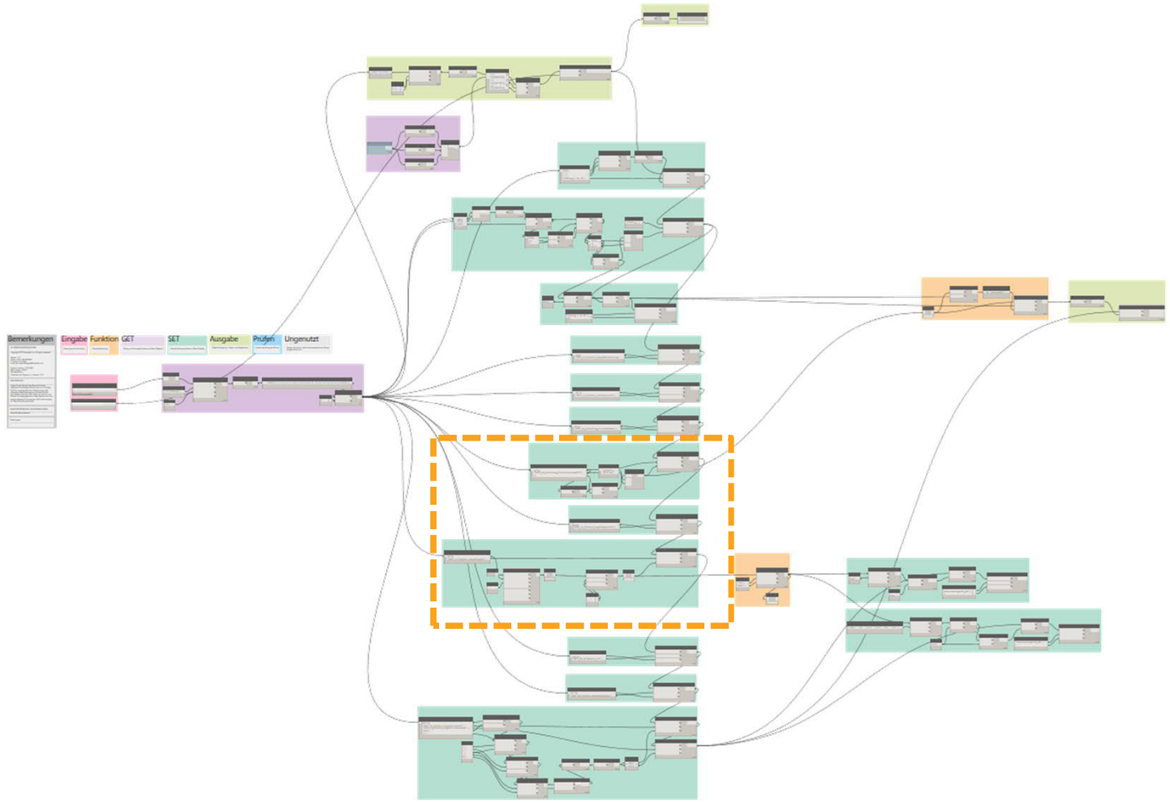
- Data import from Excel file (ProSig/ProCoPS export)
- Coordinate adjustments and placement of initial signal family type
- information settings
  - rotation about insertion point (track axis), offset from insertion point (track axis), mirrored y/n, signal mark, chainage, rail track number





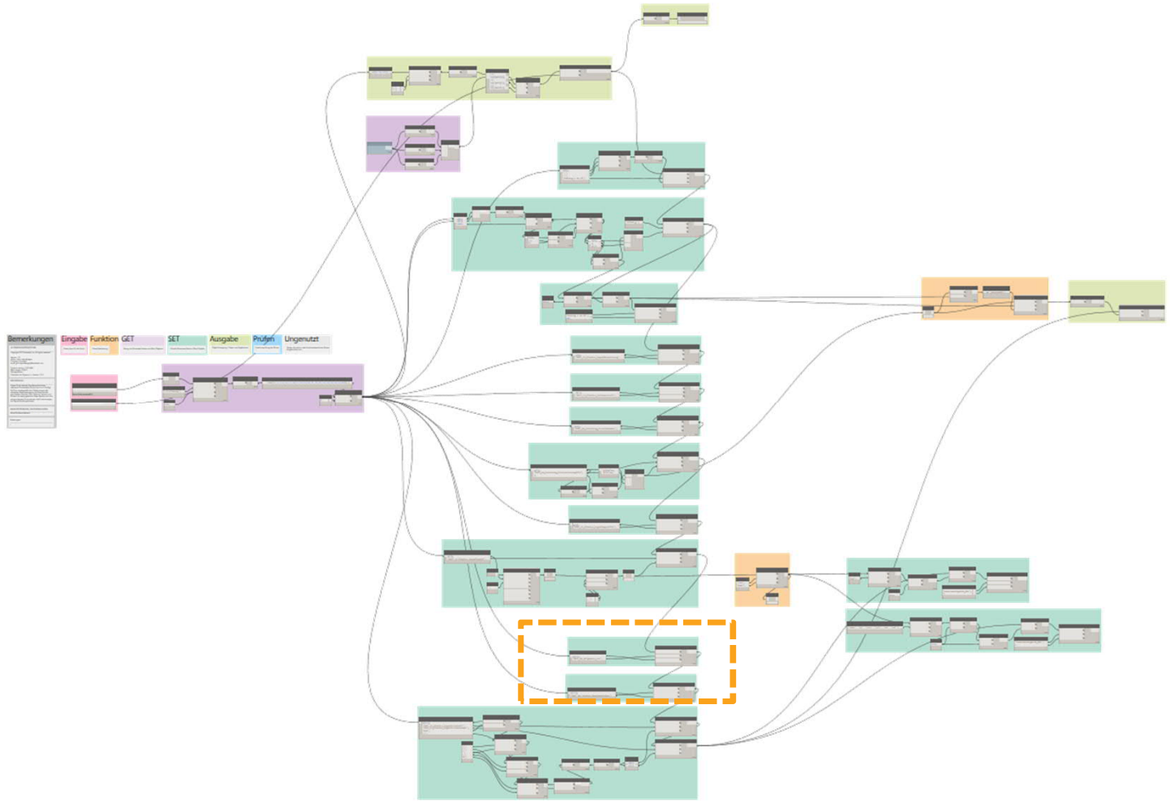
The Dynamo Script

- Data import from Excel file (ProSig/ProCoPS export)
- Coordinate adjustments and placement of initial signal family type
- information settings
  - rotation about insertion point (track axis), offset from insertion point (track axis), mirrored y/n, signal mark, chainage, rail track number
  - signal type, signal background, indicator above, indicator below



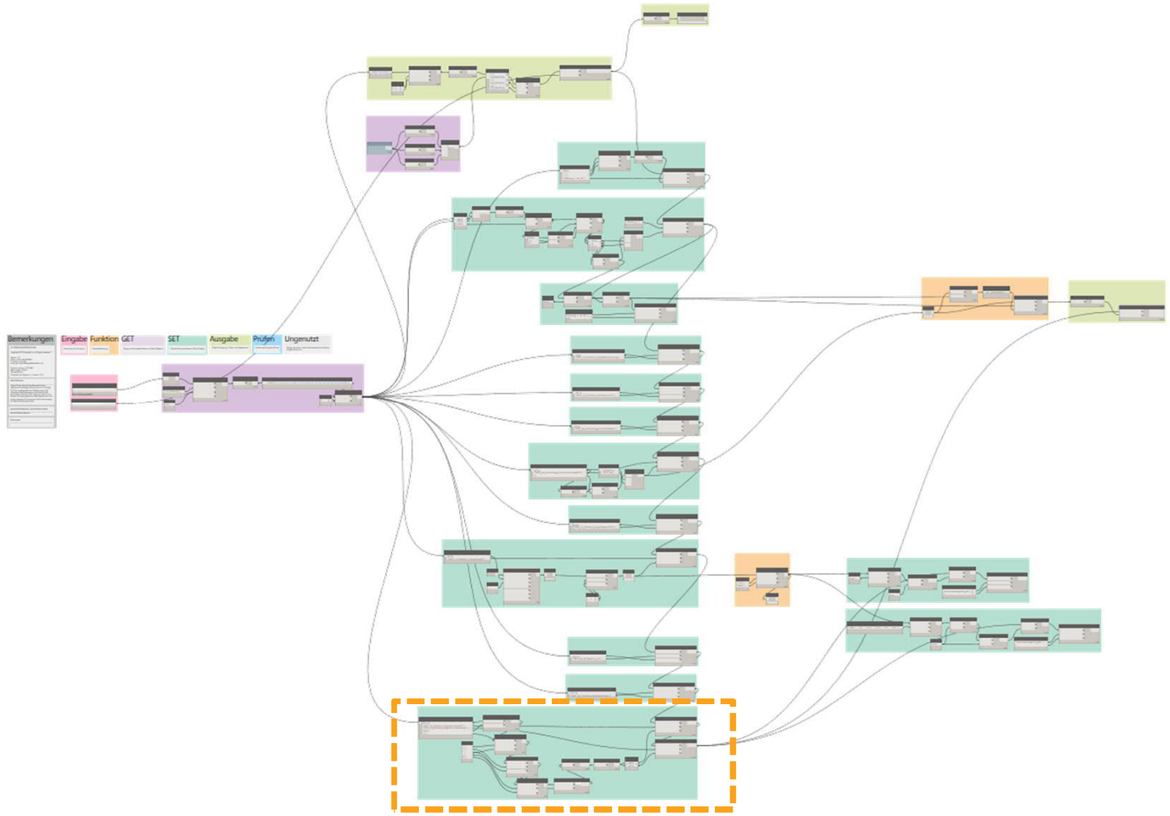
The Dynamo Script

- Data import from Excel file (ProSig/ProCoPS export)
- Coordinate adjustments and placement of initial signal family type
- information settings
  - rotation about insertion point (track axis), offset from insertion point (track axis), mirrored y/n, signal mark, chainage, rail track number
  - signal type, signal background, indicator above, indicator below
  - LOD, construction phase



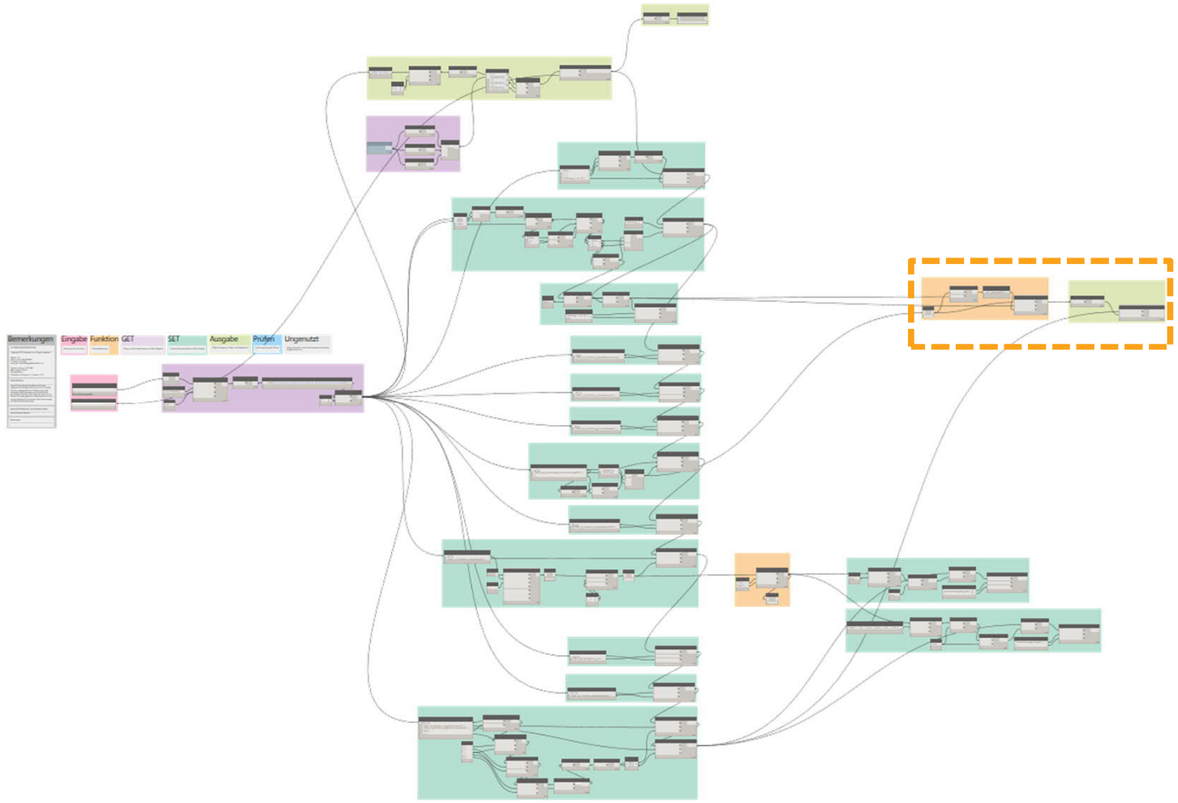
The Dynamo Script

- Data import from Excel file (ProSig/ProCoPS export)
- Coordinate adjustments and placement of initial signal family type
- information settings
  - rotation about insertion point (track axis), offset from insertion point (track axis), mirrored y/n, signal mark, chainage, rail track number
  - signal type, signal background, indicator above, indicator below
  - LOD, construction phase
  - visibility target/minimum



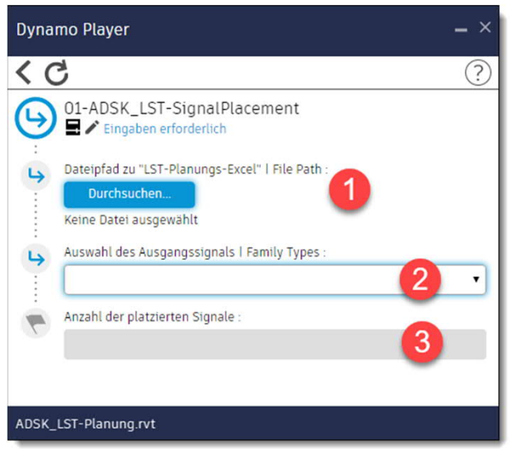
The Dynamo Script

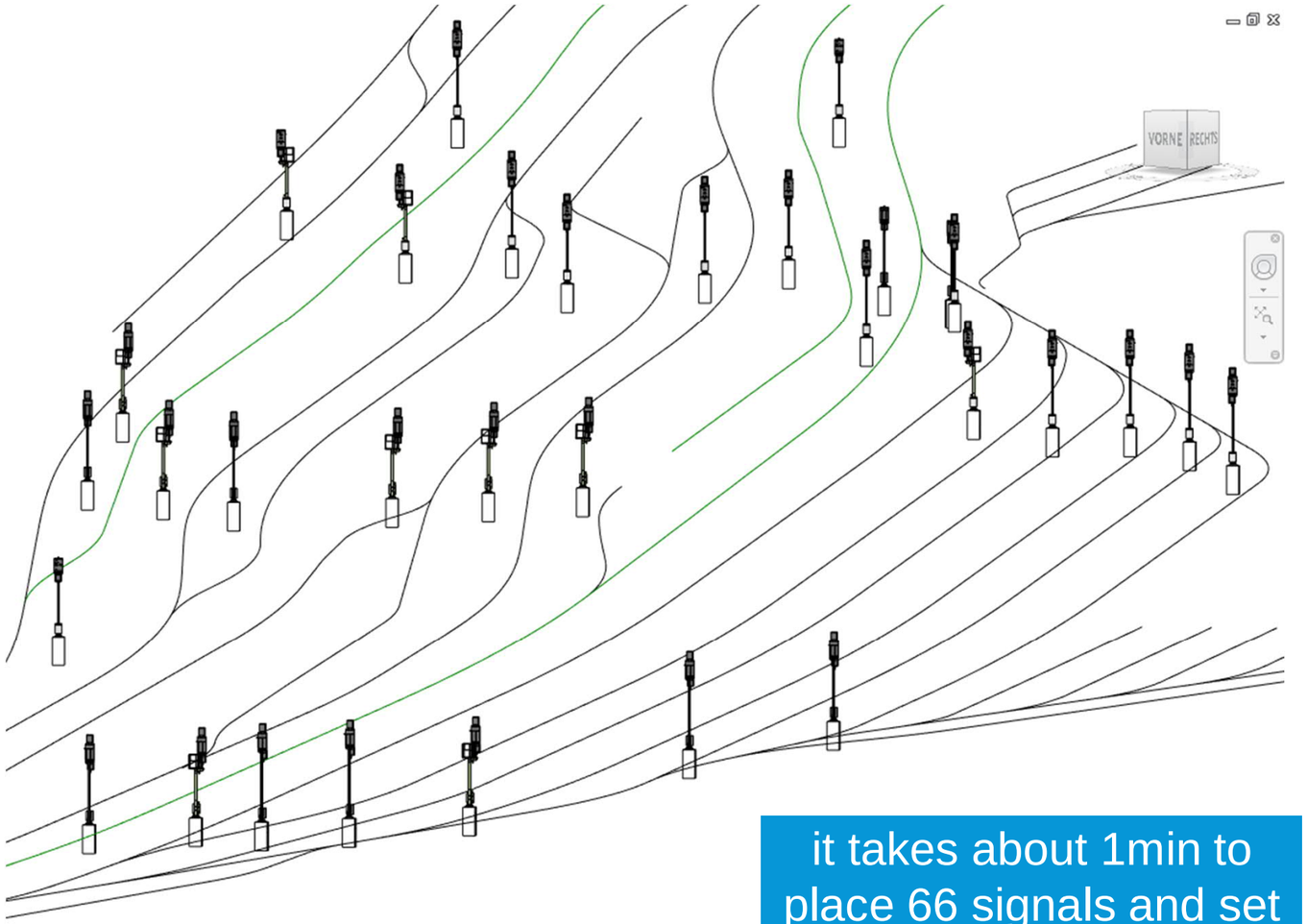
- Data import from Excel file (ProSig/ProCoPS export)
- Coordinate adjustments and placement of initial signal family type
- information settings
  - rotation about insertion point (track axis), offset from insertion point (track axis), mirrored y/n, signal mark, chainage, rail track number
  - signal type, signal background, indicator above, indicator below
  - LOD, construction phase
  - visibility target/minimum
- setting of the correct family type according to “signal type”



User Interface & Results

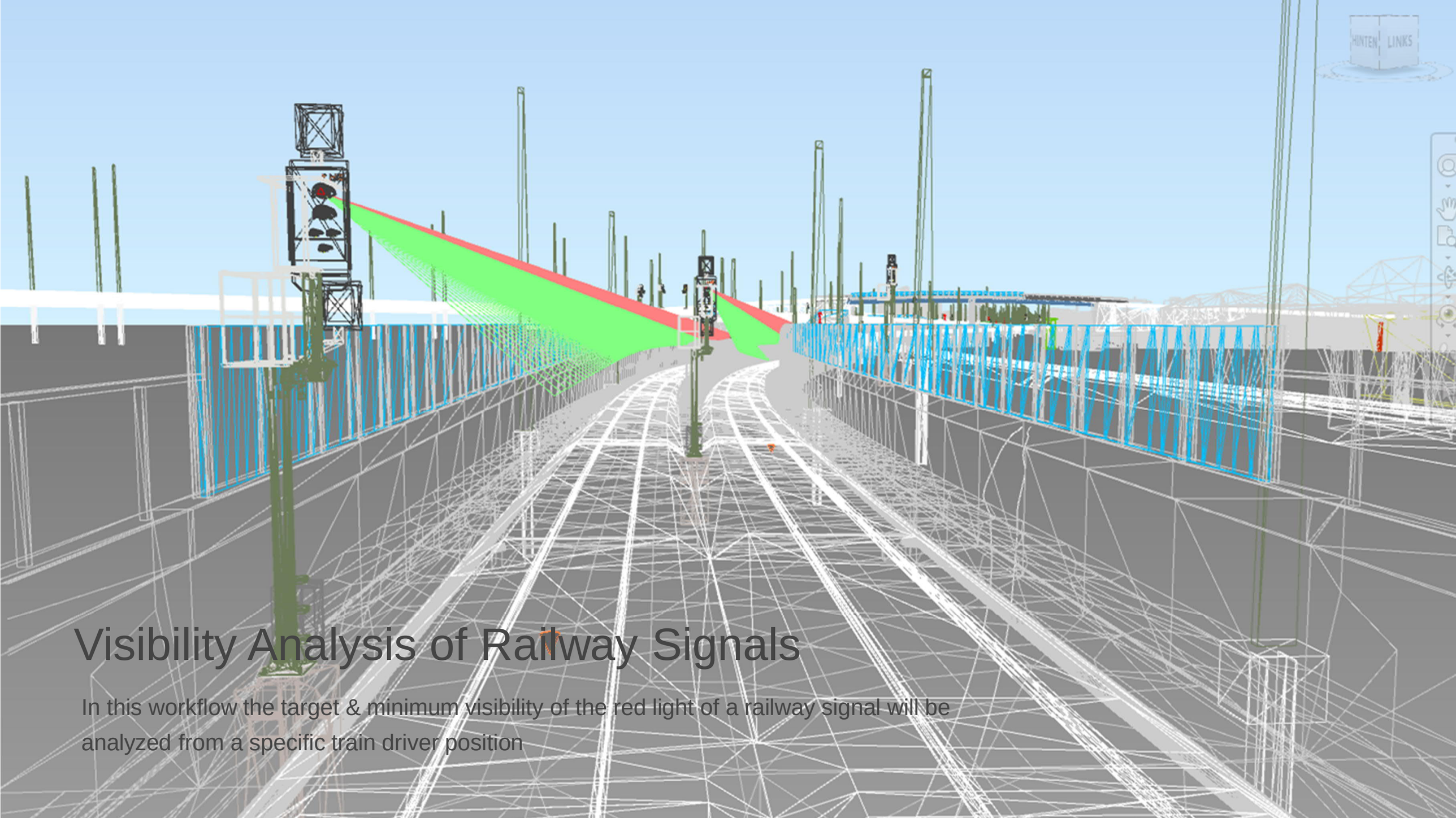
- User Interface: Dynamo Player
  - (1) file path ProSig/ProCoPS Excel file
  - (2) initial signal family type
  - (3) result of how many signals were placed





it takes about 1min to place 66 signals and set all their information

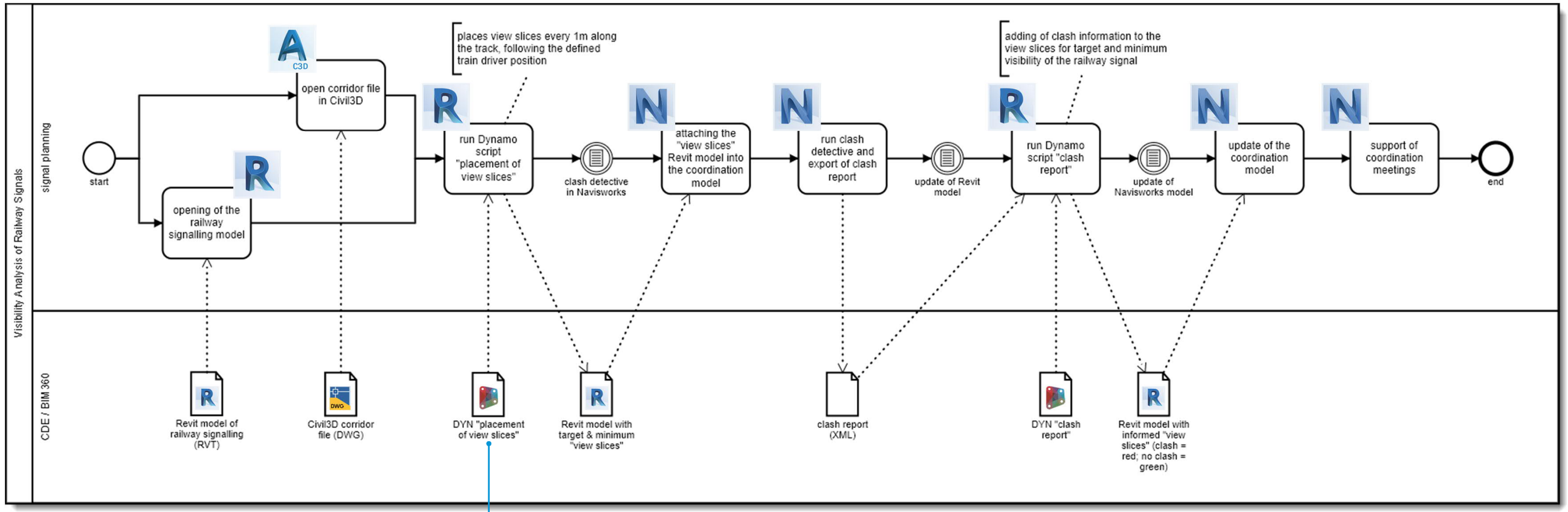
Sight distance check



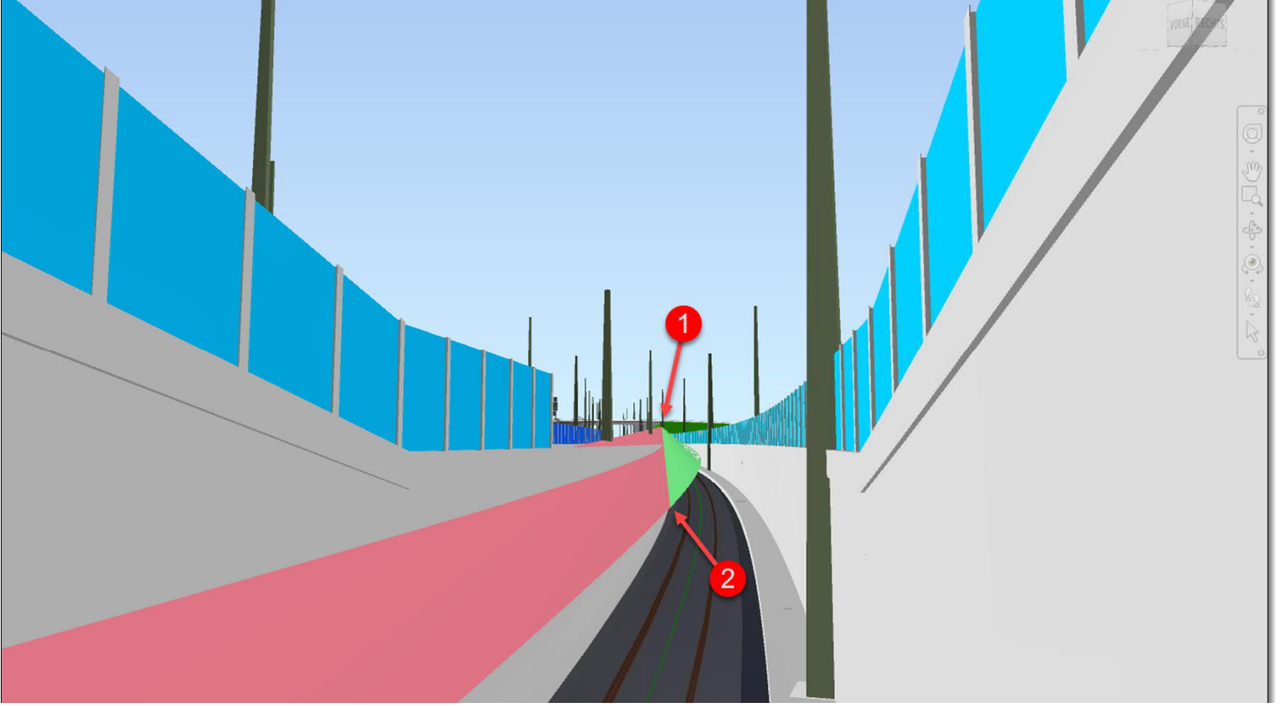
Visibility Analysis of Railway Signals

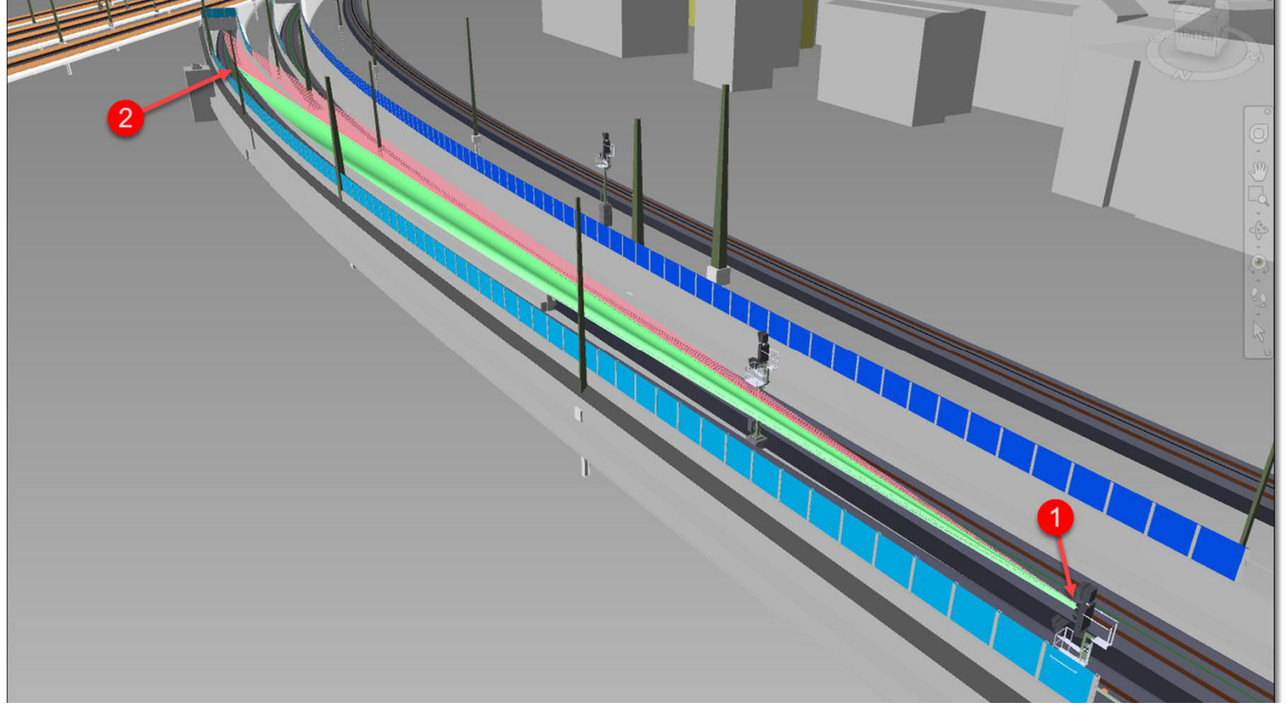
In this workflow the target & minimum visibility of the red light of a railway signal will be analyzed from a specific train driver position

Visibility Analysis of Railway Signals



Note: includes nodes from the CivilConnection package!



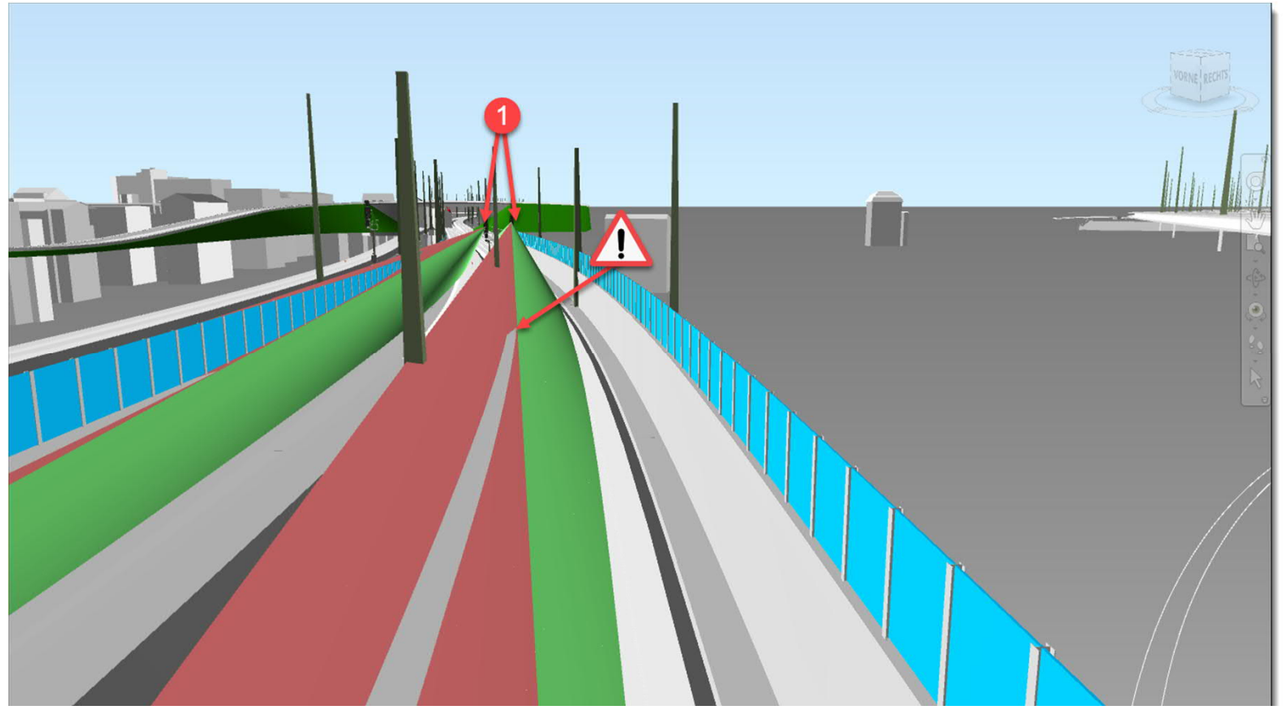


Results in Navisworks

The updated Revit model of the view slices in Navisworks, can now support coordination meetings to find the best location to place the analyzed railway signal.

1) the signal (red light)

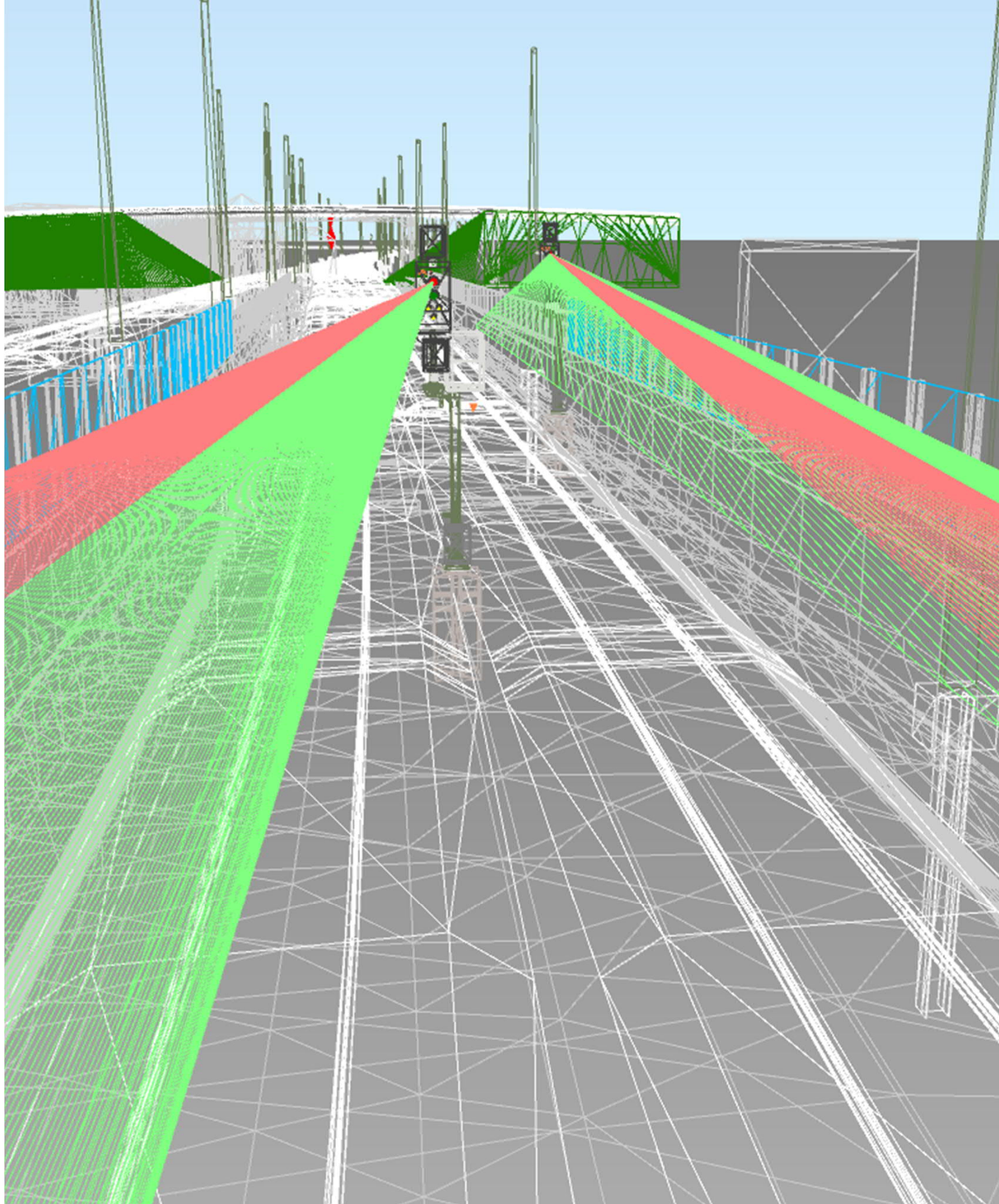
2) Start of the visibility of the signal for the train driver (position: 3,0m above track center)



Result of Visibility Analysis

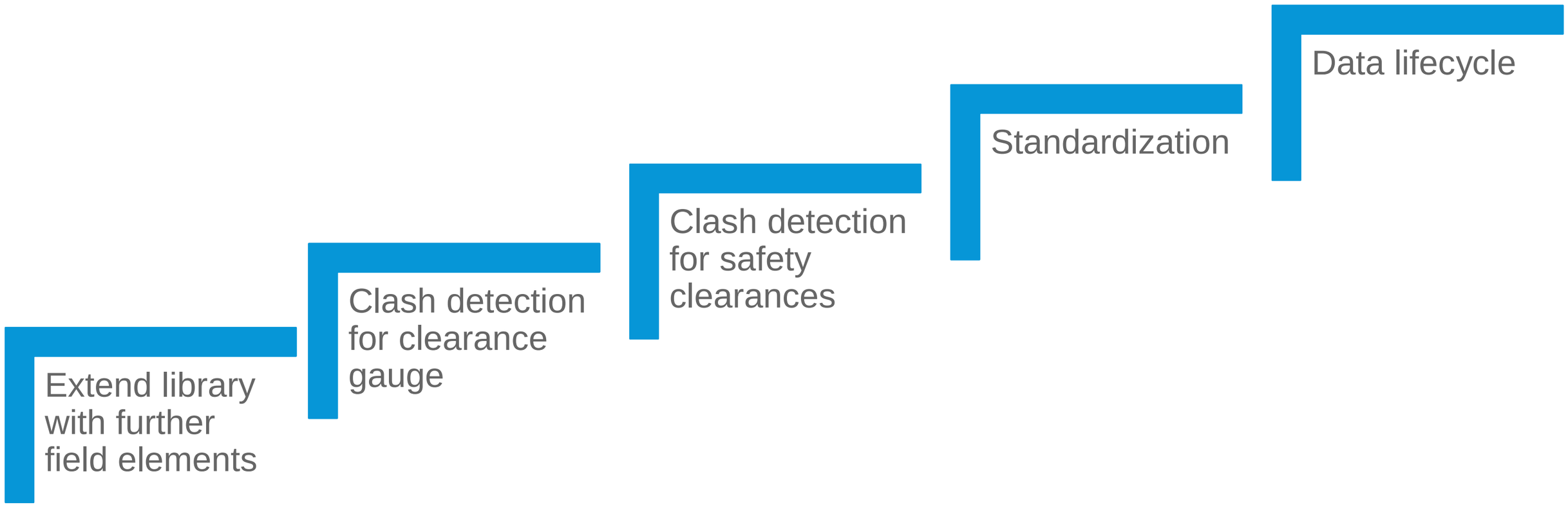
- Prerequisites
  - DWG with “train driver position corridor”
  - Revit model of railway signals
  - focus on the red light of the railway signal
  - train driver position 3,0m above track center line
    - all other train driver positions, 8x in total, are prepared in the Civil3D corridor (sub-assembly) and can be addressed in this process

- Result for a train speed of 120 km/h
  - right signal:
    red light is visible for 5,1 sec (170m); minimum 6,75 sec (225m)
  - left signal:
    red light is visible for more than 6,75 sec (225m)

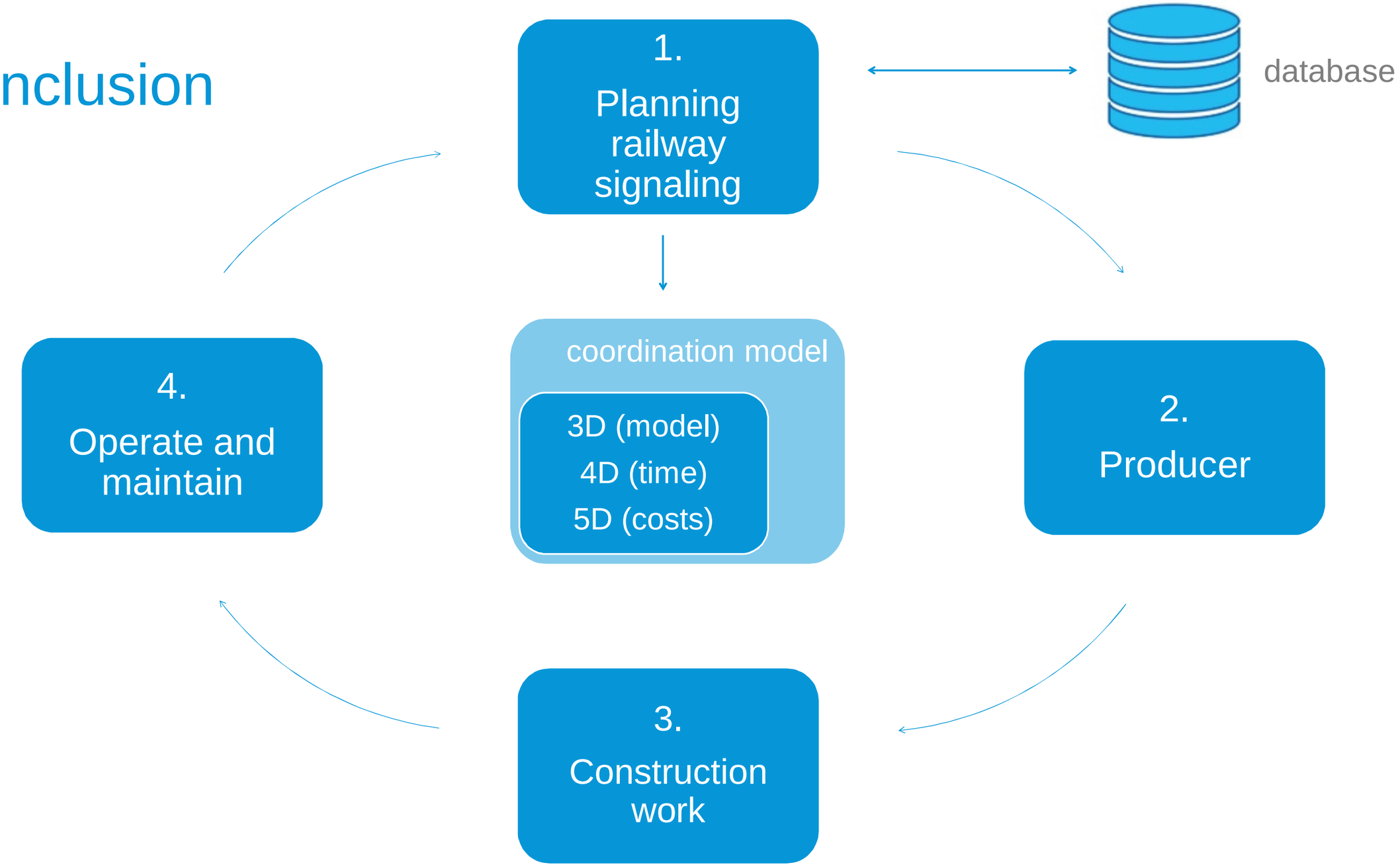


Looking forward

Next steps


Extend library with further field elements
Clash detection for clearance gauge
Clash detection for safety clearances
Standardization
Data lifecycle

Conclusion


1.
Planning railway signaling
database
coordination model
3D (model)
4D (time)
5D (costs)
2.
Producer
3.
Construction work
4.
Operate and maintain

Conclusion

database

1.
Planning railway signaling

4.
Operate and maintain

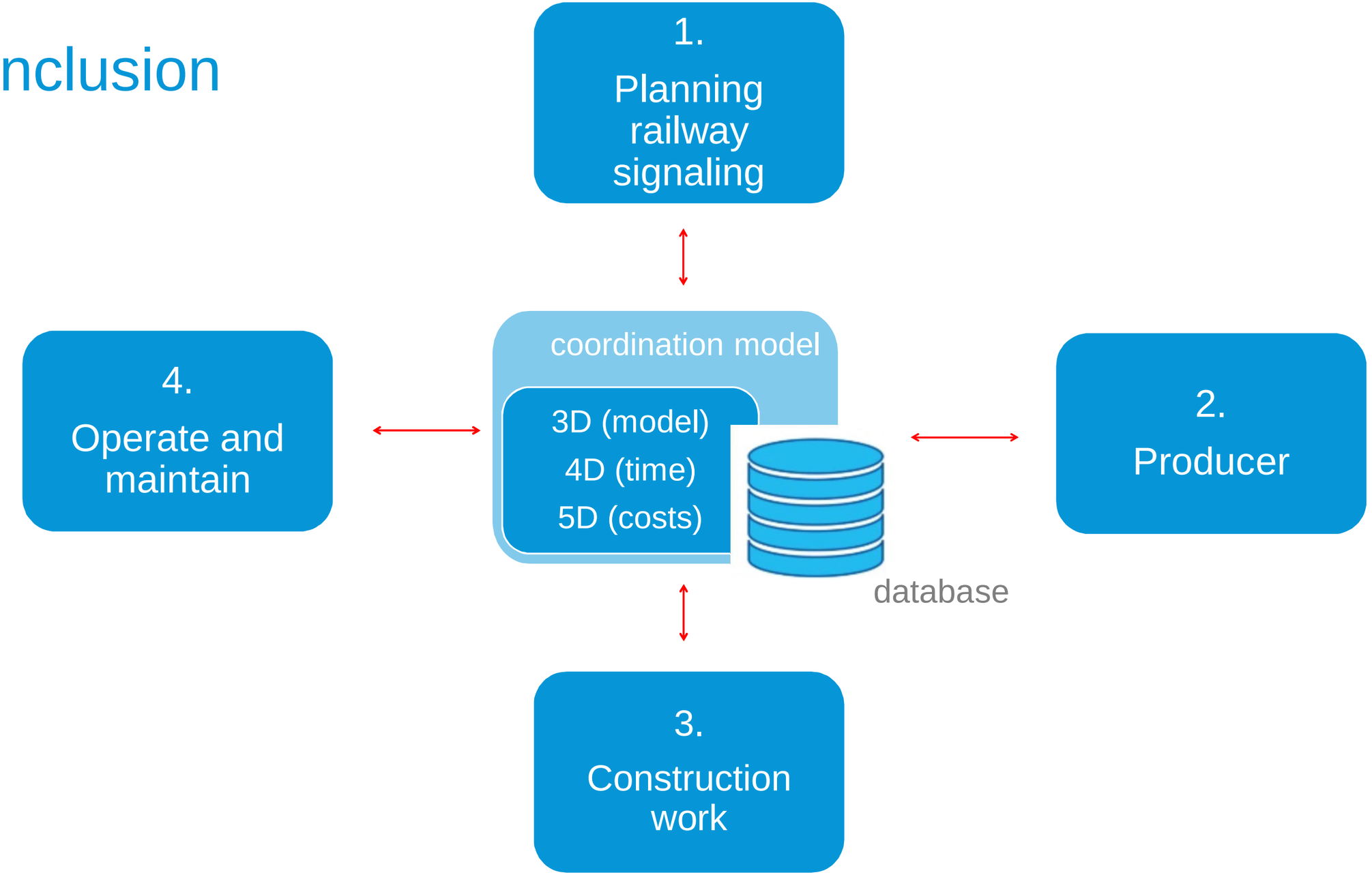
coordination model

3D (model)
4D (time)
5D (costs)

2.
Producer

3.
Construction work

Conclusion


1.
Planning railway signaling
coordination model
3D (model)
4D (time)
5D (costs)
database
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Producer
3.
Construction work
4.
Operate and maintain

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