Advanced BIM Workflows for Linear Infrastructure Modelling

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Modeling Concepts
Dynamo Basics

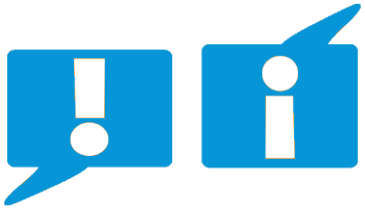
Intro

What is perfection?

"Perfection is finally attained not when there is no longer anything to add, but when there is no longer anything to take away"

Antoine de Saint-Exupéry, french writer and aviator

3 key-experiences I had to make



No.1 **Data: When in doubt, leave it out**

Sufficient data for main purpose

No.2 **Minimizing staff means neglecting roles**

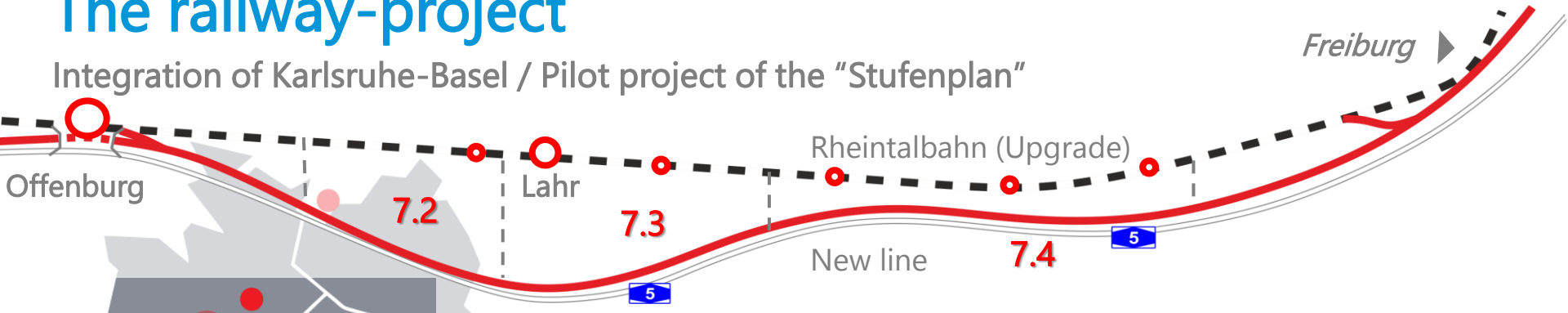
BIM isn`t just about technic

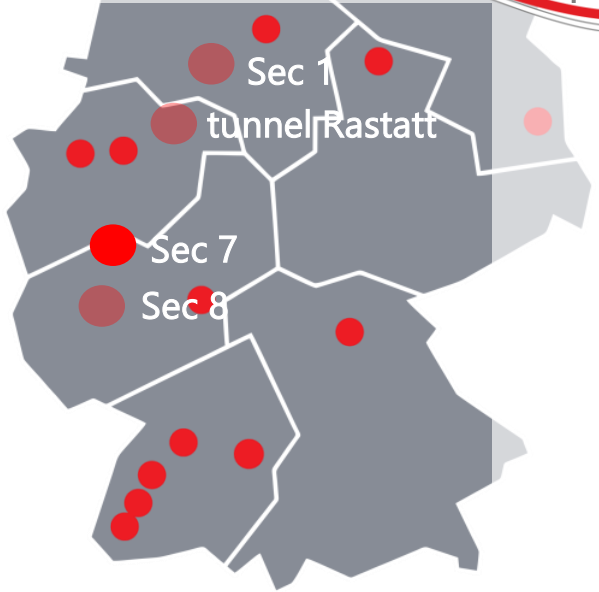
No.3 **Throw away existing work**

Model concept Revit-Dynamo in practical use

The railway-project

Integration of Karlsruhe-Basel / Pilot project of the “Stufenplan”





Extent

- Ca. 83 km line (Upgrade + New line)
- 6 stations and 2 stop points
- 61 existing buildings

Main use cases

- Existing conditions modeling
- Comparison of alignment and routing variations

No.1: Data – When in doubt, leave it out

Sufficient data for main purpose

Specification of the EIR

- Modeling without planning
  - Lack of coordination
- Modeling of the existing conditions
  - 61 bridges
  - LOG of 1cm
  - Minimum 75% demolition

→ Level of accuracy

→ Time needed

5 month completion

→ Motivation of team

Much work, no real benefit

No.1: Data – When in doubt, leave it out

Sufficient data for main purpose

Specification of the EIR

- Modeling without planning
- Modeling of the existing conditions
- Irregular scan with 2cm distance
  - Use heliscan
  - Combine with stationary scan
  - No minimizing

  → No experience in offending

  → Overload for later models

No.1: Data – When in doubt, leave it out

Sufficient data for main purpose

Specification of the EIR

- Modeling without planning
  → Status: Pilot project
- Modeling of the existing conditions
  → LOD follows purpose
- Irregular scan with 2cm distance
  →set a well performing base instead of useless details

GAINED EXPERIENCE
GIVES SELF-CONFIDENCE
FOR FUTURE CONSULTING

No. 2 Neglecting roles

Unite roles means increases role conflicts

LESSONS LEARNED

- Who is in charge of providing a model-structure?
- Who defines sprint-backlog?
- Who collects user stories for the the next sprint ?
- When is the right time to confirm the model?

Unexperienced teams = Concentrated method

No. 3 Throw away existing work

Unite roles means increases role conflicts

Start

5 Month — Existing conditions LOD 100

3 Month — Version modeling LOD 200

Alignment choice

5 Month — Modeling team 1 — M.+

2 M. — Modeling team 2

Development

1
- Lack of fundamental specifications

2
- Mature planning base to model it

3
- Well-rehearsed team modeling with interacting software

Facing technical challenges

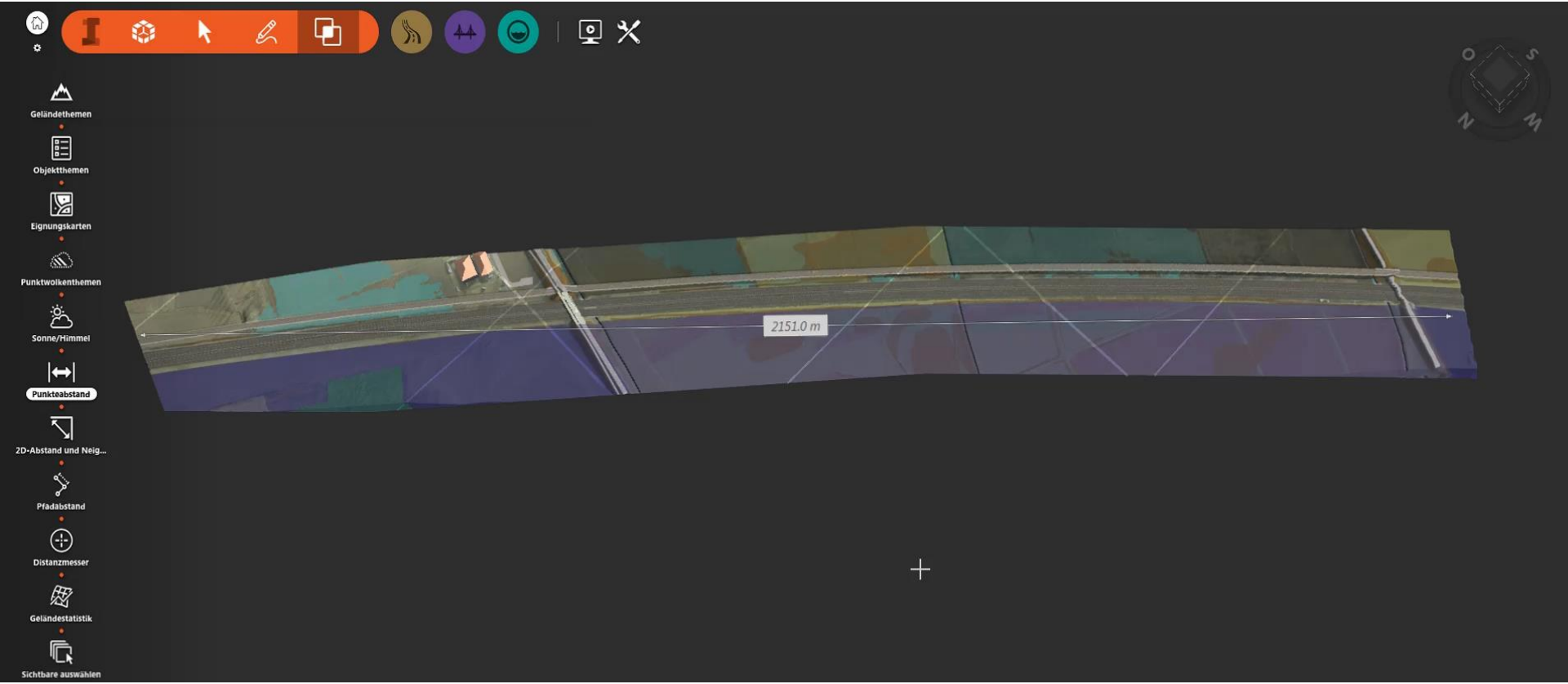
Tool set for main benefit

		Revit	Navisworks	Infraworks
		▪ Modeling existing bridges/under-pass based on point cloud	▪ Assembley of coordination model	▪ Model LOD 100 for support of the alignment choice (conventional process)
		▪ Modeling new alignment	▪ Clash detection	
		▪ Inspection of the existing buildings compared wirt point cloud		

CDE of the employer: At frist EPLASS project collaboration (Adv. processing)

Infraworks

Generating a new LOD



InfraWorks for trendsetting decision

Requirement fulfillment

1

- Bridges constructed by Infraworks / dimension from point cloud
- Digital terrain model included (only helicopter)
- Main buildings included
- Surface use included (e.g. protective areas)
- Alignment included

Main use:

- Mass calculation +/- 10%
- Visual clash detection

Facing technical challenges

Tool set for main benefit

ProVI	Dynamo	Revit	Navisworks	Infraworks
▪ Conversion & editing Alignement data	▪ Visual script of the Revit workflow	▪ Modeling existing bridges/under-pass based on point cloud	▪ Assembley of coordination model	▪ Model LOD 100 for support of the alignement choice (conventional process)
▪ Output of listed points extracted from cross sections		▪ Modeling new alignement	▪ Clash detection	
		▪ Inspection of the existing buildings compared wirt point cloud		

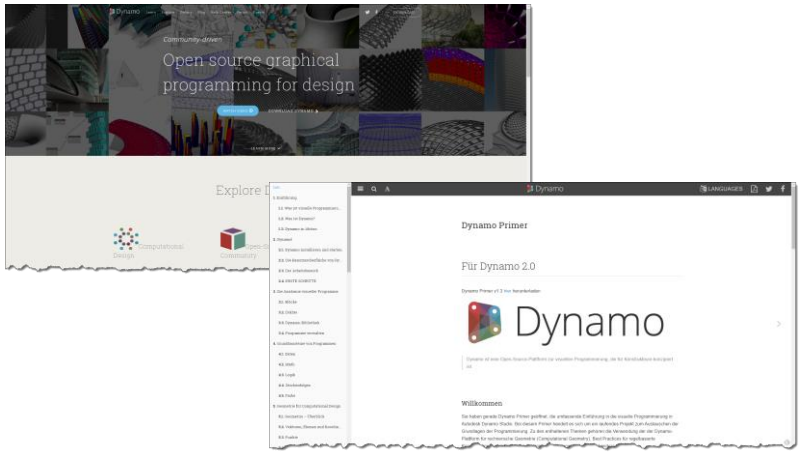
CDE of the employer: At frist EPLASS project collaboration (Adv. processing), at last BIM 360 (Adv. AD compatibility)

Dynamo basics and why it is used

Modeling Concepts

- What is Dynamo?
  - Open-source platform
  - Visual interface to construct logic routines
  - Geometry creation
  - Workflow automation
  - Interface for multiple software tools

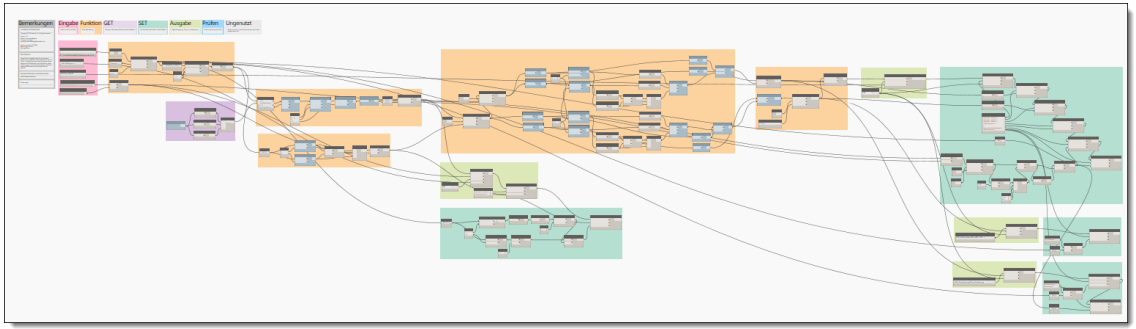
- Resources
  - http://dynamobim.org/
    (Download, Blog, Forum…)
  - http://primer.dynamobim.org/de/
    (Online-Manual in different languages)

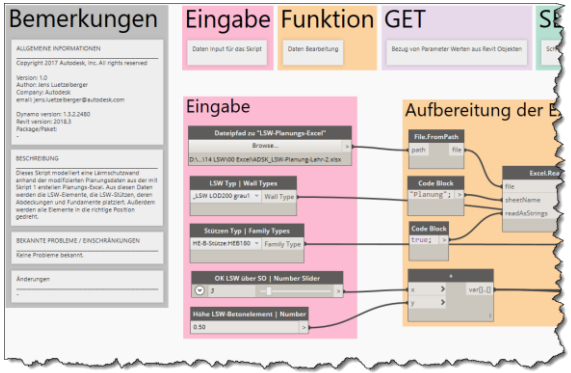


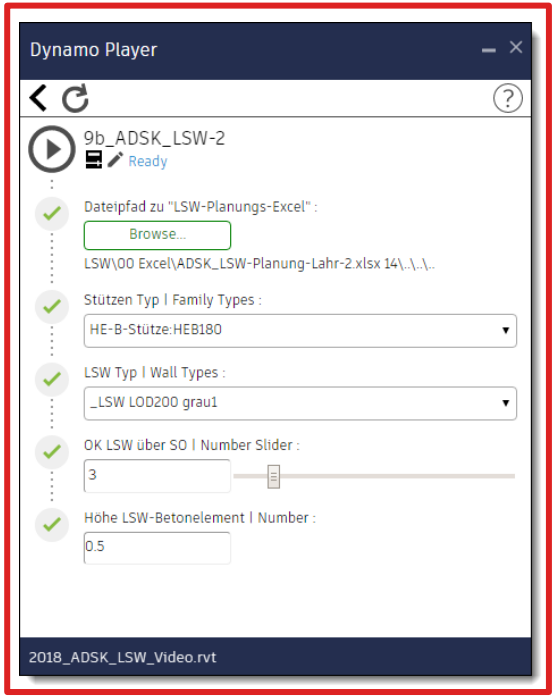
Do I have to watch all the „spaghettis“?

Dynamo Basic

A Dynamo script can be viewed and used directly, but also via the Dynamo Player. The Dynamo Player automatically generates an input mask based on the structure of the Dynamo script.



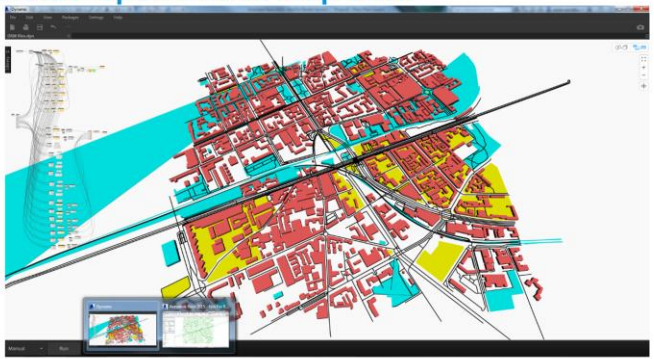




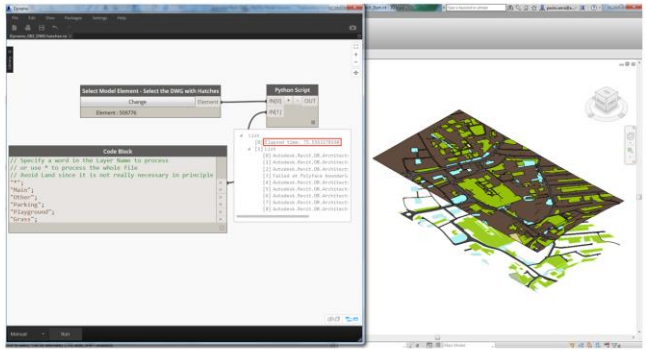
Applications / Use Cases

Modeling Concepts

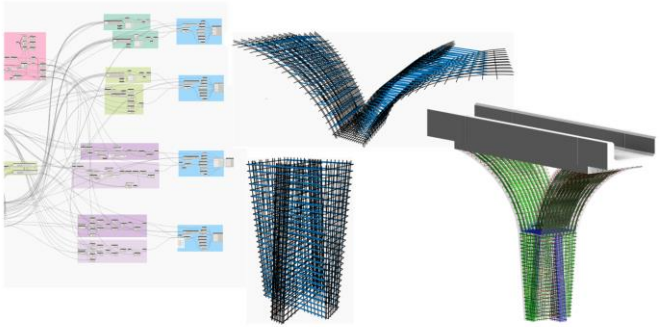
Access Open Street Map Data



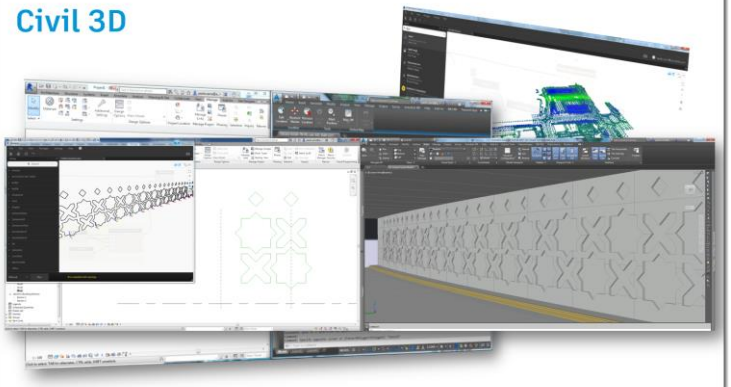
AutoCAD-Revit



Revit – Rebar (2016+)

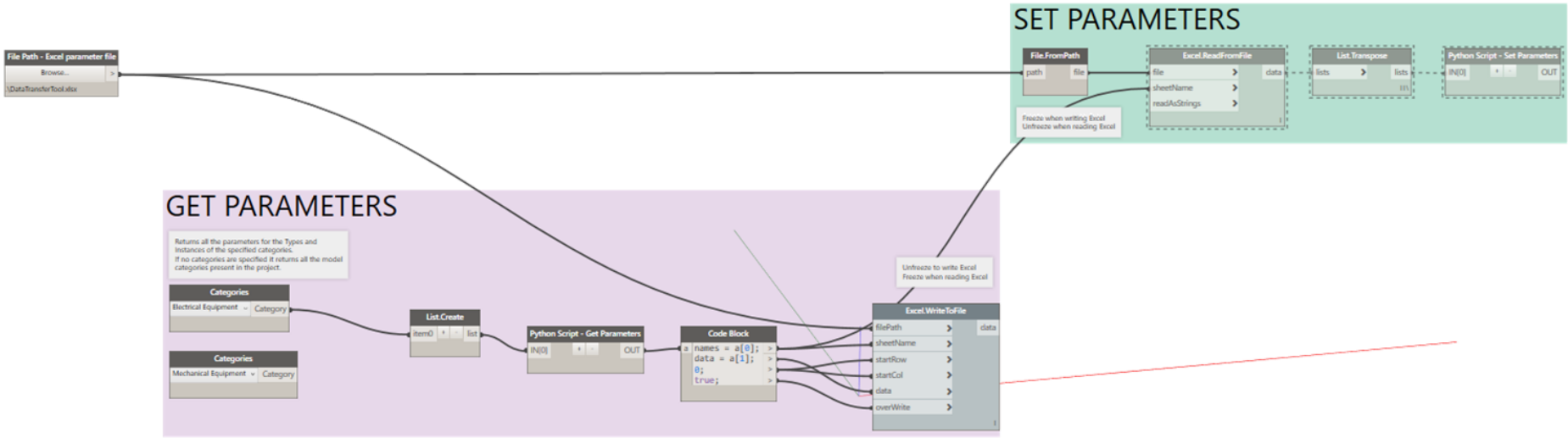


Civil 3D



Excel Interoperability

Modeling Concepts



Task	Software Sequence
Modeling of Signals (existing)	

Overview of the Modeling Concepts

Workflow Overview

Pilot project „Karlsruhe – Basel“

Task	Revit Families	Dynamo script	Note
rail track	• 2x rail profiles • 2x sleepers	• rail track solid geometry, placement of sleepers	existing and new rail track modelling purposes
	• bedding • subgrade	• placing of bedding and subgrade families along the rail track	deviations in input make it necessary to revise the script for rail tracks next to train stations
equipment	• 1x power pole U140 with 29x Types • cantilever • overhead lines	• placement of power poles, cantilever and overhead lines according defined rules	existing conditions modeling; new in preparation
		• automated creation of Revit family types by using Excel input data (steel power pole types)	-
	• KS-Signal	• placement of existing signals • placement of new signals	existing conditions modeling; new in preparation
train platform (existing conditions; LOD100)	• precast concrete element BSK55 • foundation	• placement of BSK55 & foundation • solid from boundary (DWG)	existing conditions modeling LOD100; new currently not in focus
noise barrier (existing conditions)	• noise protection elements • joint-forming profile family • precast concrete base element • column cap • foundation	• noise barrier script 1 (calculation of top of nb and Excel export) • noise barrier script 2 (automated modeling based on Excel import) • noise barrier script 3 (replacement of base element(s))	existing conditions modeling; new in preparation
drainage culvert	• round profile • rectangular profile	• placement according rail track axis	parameter for rotation in Revit family included

General

Workflows

There are different workflows for existing conditions modeling and the modeling of a newly planned track section. The major difference is the structure of the input data for automated and semi-automated processes provided by the main authoring tool(s).

- Existing Conditions Modelling
  (e.g. overhead lines)
  - track data per track and per IVL-section (1 km section of whole track)
  - pylon data read from existing DWG or PDF files
    - no automatic assignment to rail track available (rotation)
    - no z-height, no pylon-height, no pylon type etc.
  - point clouds are used to detail and verify the Revit model
    - manual task

- New
  - track data per track and per IVL-section existing
  - spreadsheets of all relevant information for new pylons available
    - automated control of parameters such as e-value and others possible

Task	Software Sequence
Modeling of power pole, cantilever and overhead lines (existing)	

Task	Software Sequence
Modeling of Signals (existing)	

Mastnummer	Position	Mittelpunkt Mastsymbol	Column1
		x	y
183-21	ldB	3407943,475	5337553,452
183-22	rdB	3407932,772	5337553,527
183-23	ldB	3407943,206	5337494,091
183-24	rdB		
183-25	ldB		
183-26	rdB		
183-26	rdB		
183-27	ldB		
183-28	rdB		

Station	Beschreibung	Hohe	Rechtswert	Hochwert
154520	Plan,Kante re,	152,5311	3417623,054	5364776,404
154520	Schiene li,	153,4468	3417627,174	5364774,463
154520	Schiene re,	153,4468	3417625,81	5364775,105
154520	Bettung	153,0494	3417628,301	5364773,931
154520	Bettung	153,2688	3417628,003	5364774,072
154520	Bettung	153,2688	3417624,98	5364775,496
154520	Bettung	152,5864	3417624,054	5364775,933
154520	Planum	152,8211	3417628,301	5364773,931
154520	Planum	152,7211	3417626,492	5364774,784
154520	Planum	152,5311	3417623,054	5364776,404
154520	PSS	152,5207	3417628,301	5364773,931
154520	PSS	152,4207	3417626,492	5364774,784
154520	PSS	152,2064	3417622,614	5364776,611
154530	Plan,Kante re,	152,557	3417618,792	5364767,358
154530	Schiene li,	153,4726	3417622,911	5364765,417
154530	Schiene re,	153,4726	3417621,547	5364766,059

General

Workflows

Station	Beschreibung	Höhe	Rechtswert	Hochwert
154520	Plan,Kante re,	152,5311	3417623,054	5364776,404
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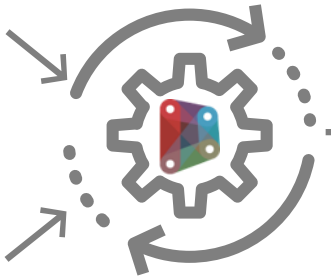
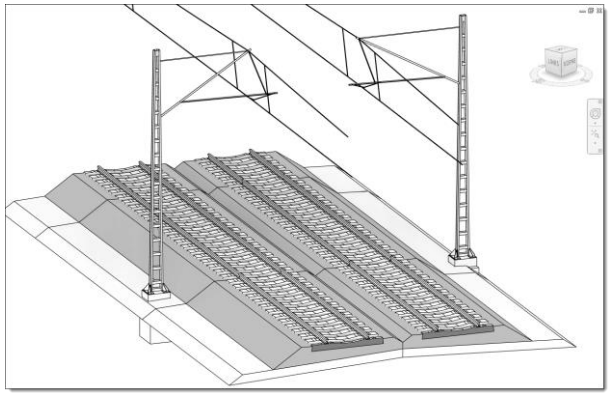
183-24	rdB	3407932,754	5337494,239
183-25	ldB	3407944,084	5337444,042
183-26	rdB	3407823,066	5337457,193
183-26	rdB	3407933,477	5337443,864
183-27	ldB	3407946,552	5337379,22
183-28	rdB	3407935,793	5337378,9

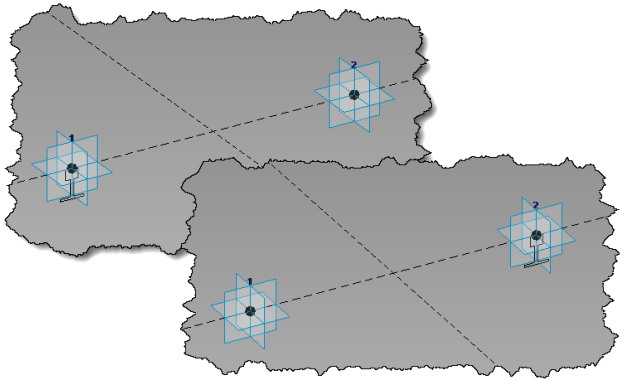


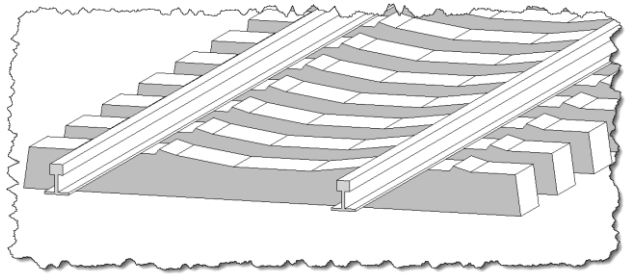


Rail Track Components

Rail Profile

- RFA Template
  - Generic model adaptive
- Structure of the RFA
  - two adaptive points are placed in a side view at a distance of 1500 mm
  - the rail profile is placed under one of these points
  - rail profile with reduced detailing
- Idea / Concept
  - to make rotation easy, you have to work with one RFA for SO left and one for SO right (SO = top of rail)
  - placement of 2-point AC takes care of the cant
- Level of automation
  - 100% - placement of the profiles and rail solids which are created by Dynamo
  - Dynamo script to be used in project environment of Revit

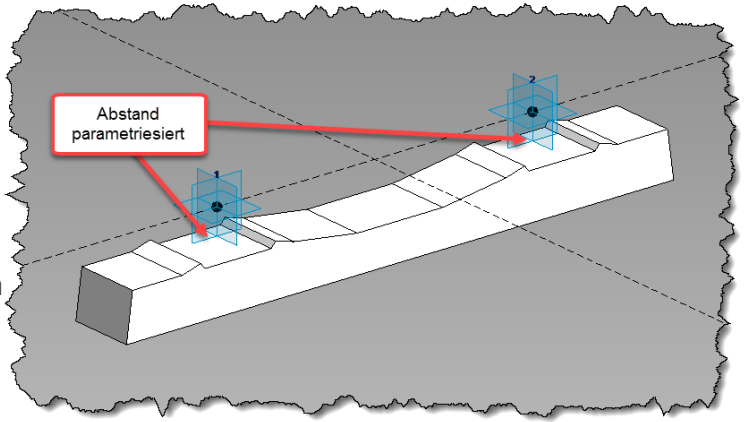


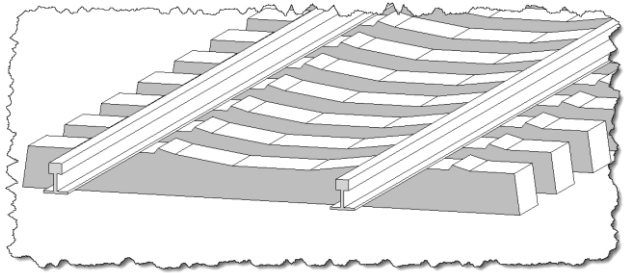


Rail Track Components

Sleeper

- RFA Template
  - Generic model adaptive
- Structure of RFA
  - two adaptive points are placed in a side view at a distance of 1500 mm
  - depending on the adaptive points, the shape of the sleeper is modeled including a parameter to control the distance to the SO
- Idea/ Concept
  - placement of 2-point AC takes care of the cant
  - the parameter controlling the distance from SO to sleeper ensures usability with different rail profiles (different heights)
- Level of automation
  - 100% - placement of the sleepers
  - Dynamo script to be used in project environment of Revit

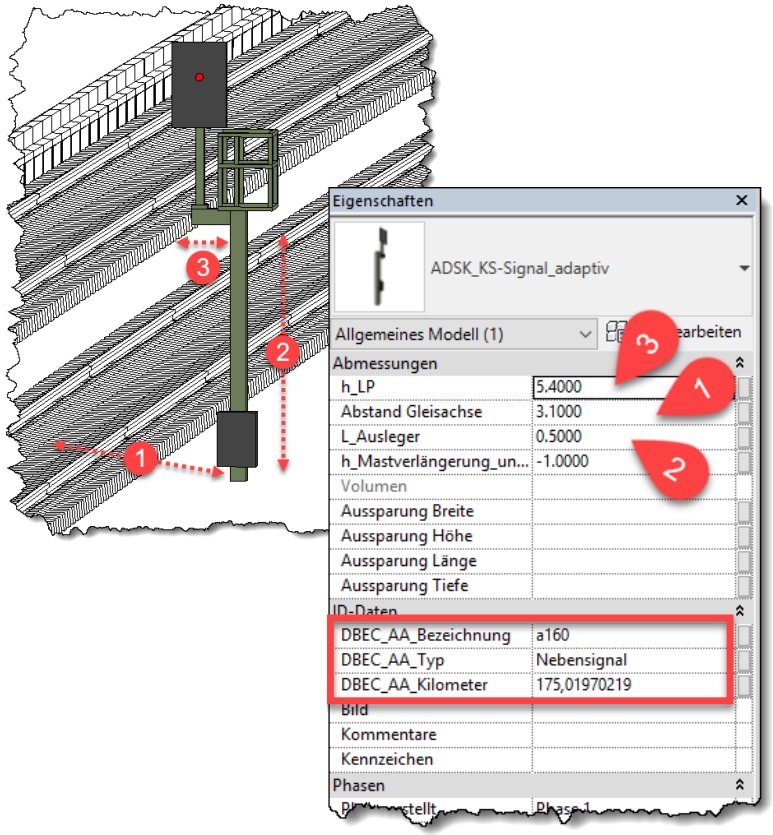




Rail Track Equipment

Signal existing conditions

- RFA Template
  - Generic model adaptive
- Structure of RFA
  - 2x adaptive points ensure coordinate-correct placement and rotation to the track
  - Parameters control the position of the light spot to the track axis, the extension of the mast to the ground and the length of the arm
- Idea / Concept
  - Signaling is required both in inventory and in planning, so two placement methods are needed
  - the signal is placed over a coordinate list and automatically rotated to the track axis
- Level of automation
  - 90-100% - placement and rotation are automated, the extension to the ground is partially manual to solve

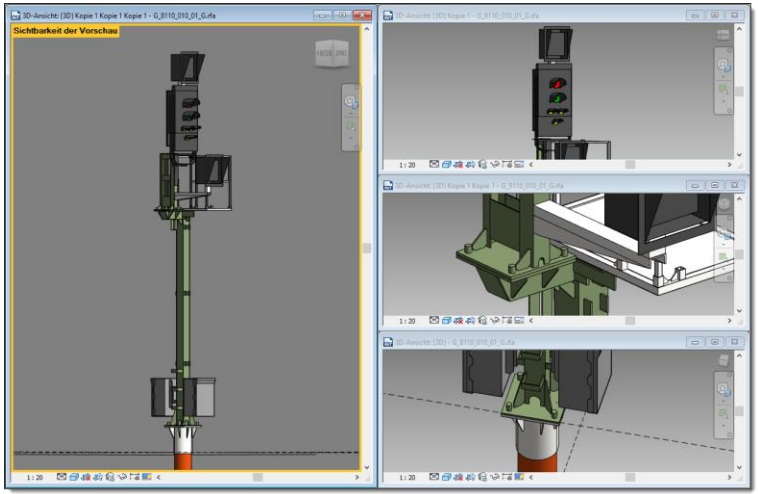


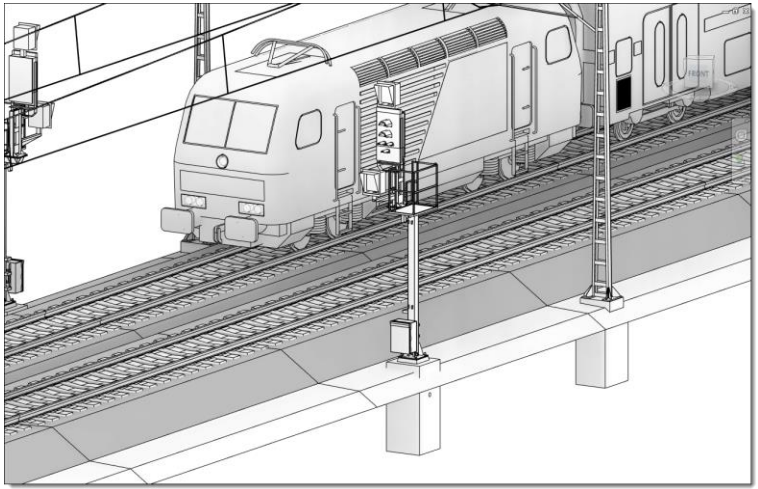
Jens Luetzelberger

Rail Track Equipment

Signal 2.0 - detailed

- RFA Template
  - Generic model adaptive (1-Point)
    - face-based Revit families included, carrying the shrink-wrap geometry from inventor files
- Structure of RFA
  - **1x adaptive point** ensure coordinate-correct placement on the rail track axis; rotation provided from authoring tool (parameter driven)
  - all standardized signal types are provided by Revit families
- Idea / Concept
  - the signal is placed over a coordinate list and automatically rotated to the track axis
  - relevant signal types are provided by the authoring tool (ProSig)
  - exported FBX files of the RFAs can be reused as InfraWorks content
- Level of automation
  - 100% - placement, rotation and type selection are automated





Signal Placement 2.0

Highly flexible Revit-Family

Signal Family 2.0

- 1-point adaptive
- offset and rotation all axis
- made out of Inventor files with a minimum of effort

Documentation of the Workflows

Insight into the Documents

Documentation of the Workflows

1 **Kurzbeschreibung**

Die Gleismodellierung umfasst Schienen, Schwellen, Bettung, Planum/PSS und Equipment entlang der Strecke. Da es sich hierbei um einzelne Fachmodelle handeln kann, ist der Themenblock der Gleismodellierung unterteilt in einzelne Teilbereiche.

In dieser Anleitung wird beschrieben, wie Schienen und Schwellen automatisch platziert werden.

Basierend auf einer strukturierten Exceldatei, die den Datenexport aus ProVi enthält, werden Schienenprofile und Schwellen entlang der Strecke in Revit platziert. Zusätzlich werden die gewählten Schienenprofile in ein 3D-Schienenobjekt umgewandelt.

Dieser Workflow kann sowohl mit Bestandsdaten, als auch mit Daten von Neubauprojekten genutzt werden.

Der Modellierungsprozess ist abgestimmt auf die Anforderungen im Projekt „Karlsruhe-Basel".

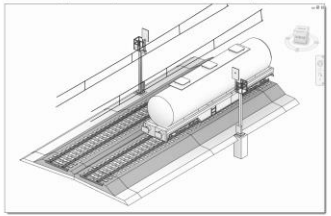


Abbildung 1 - Übersicht

3.1.3 **Die Revit Familien**

Die Basis für das automatische Platzieren der Revit Familien (Schienenprofile und Schwellen) bildet eine strukturierte Excel-Liste, das entsprechende Dynamo-Skript und die parametrischen, adaptiven Revit Familien.

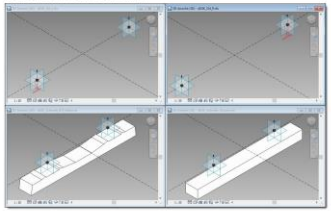


Abbildung 2 - Übersicht der adaptiven Familien

Die Revit Familien sind 2-Punkt adaptive Familien, deren Parametrik über das Dynamo-Skript angesteuert wird.

Bei dem Aufbau der Familien wurde berücksichtigt, dass diese Art der Struktur für weitere Anwendungsfälle genutzt werden kann, da er automatisch die Drehung der Elemente zur Gleislage erzeugt. Dieser Ansatz ist leicht zu verstehen und kann beispielsweise noch um die Platzierung von Lichtraumprofilen erweitert werden.

Eine Besonderheit der Profilfamilien ist, dass die Profile einer eigenen Unterkategorie im Revit zugewiesen sind, über die sich später die Sichtbarkeit steuern lässt. Das ist wichtig für visuelle Kontrollen, als auch für Visualisierungen, Planableitungen uvm.

3.1.5 **Das Dynamo-Skript**

Das Dynamo-Skript lädt die Daten der Schienenoberkanten und prozessiert diese, wie unten dargestellt. Es platziert ausgewählte Schienenprofile am angegebenen Stationspunkt (Rechts-/Hochwert/Z-Höhe). Aus den platzierten Profilen wird im weiteren Ablauf des Skripts automatisch die entsprechende Schienengeometrie erstellt und das Objekt im Revit-Modell platziert.

Parallel wird aus den SO-Punkten eine 3D-Kurve je Schiene in Dynamo erstellt, auf der dann alle 61,5cm eine der ausgewählten Schwellen-Familien abgesetzt wird. Die Darstellung der Schwellen hat nicht den Anspruch, exakt mit der Wirklichkeit in Einklang zu stehen, sondern für Visualisierungen den entsprechenden Kontext zu liefern.

Das Layout der Dynamo-Skripte ist standardisiert. Es folgt einem vorgegebenen Farblayout für Gruppen von Nodes, um deren Funktion darzustellen.

Außerdem gibt es immer eine Legende zum Layout und einen Beschreibungsblock, der die Funktion und vor allem die Versionen und ggf. genutzte Packages/Pakete darstellt, die der Anwender installiert haben muss.

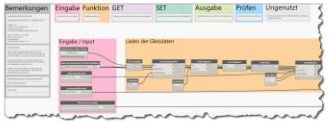


Abbildung 4 - Übersicht Dynamo-Skript

Nachfolgend eine Prozessübersicht des Dynamo-Skripts. Alle gelisteten Tasks finden sich im Skript als Gruppentitel wieder. Das Männchen symbolisiert, dass dieser Task vom Anwender ausgeführt werden muss, das Skript-Symbol zeigt, dass dieser Task automatisch abläuft.

Abbildung 5 - Übersicht Dynamo-Skript

3.1.7 **Modellierungsanleitung**

Im Folgenden wird Schritt für Schritt beschrieben, wie die automatisierte Modellierung von Schienen und Schwellen mit dem Dynamo Player durchgeführt wird.

Beschreibung	Screenshots
Zunächst wird ein Fachmodell (RVT), basierend auf einer Projektvorlage (RTE) angelegt. Sollte der Modellierungsprozess vorsehen, dass die Schienen und Schwellen in ein Projektmodell hinzugeladen werden, dann wird dieses geöffnet (RVT). In diesem Beispiel wird ein Revit-Modell eines bestimmten IVL-Bereichs geöffnet und die Schienen und Schwellen darin platziert.	
Über den Tab „Verwalten" öffnet der Model Autor nun den Dynamo-Player.	
Der Model Autor kontrolliert zunächst, ob der Dynamo Player die Skripte anzeigt, die für dieses Projekt vorgesehen sind. Sollte dies nicht der Fall sein, ändert er den Ordner (1), aus dem der Dynamo Player die Skripte auflistet. Dann sucht er das Skript zur Erstellung der Schienen und Platzieren der Schwellen aus der Liste heraus (2). Die Benennung kann abweichen. Jetzt wird mit einem Klick auf das kleine Symbol „Eingaben bearbeiten" (3) die Eingabemaske zum ausgewählten Dynamo Skript aufgerufen.	

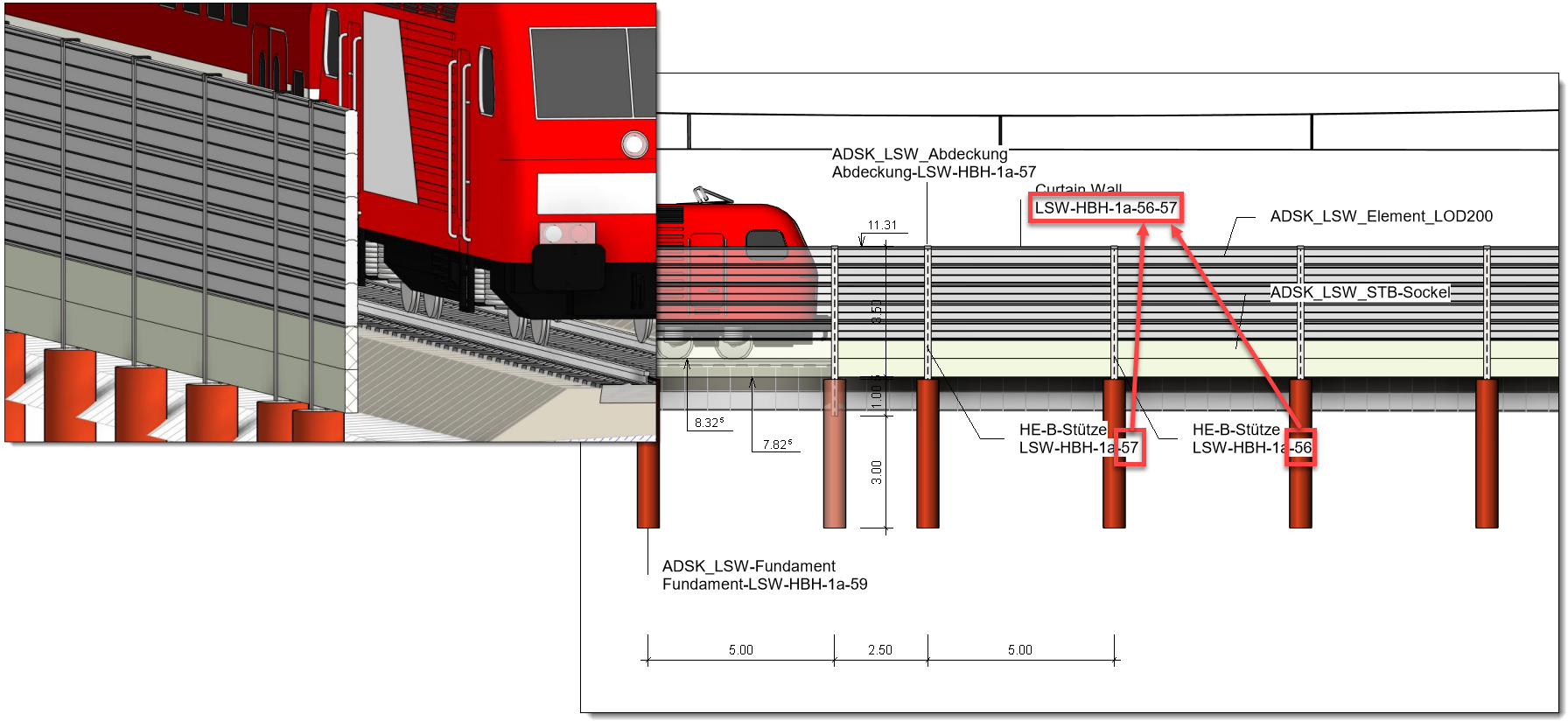
Practical Example: Noise Barrier „Herbolzheim“

Modeling of a Noise Barrier

Practical Example

Modeling of a Noise Barrier - Drawings

Practical Example



Modeling of a Noise Barrier - BOM

Practical Example

<LSW Stützen>

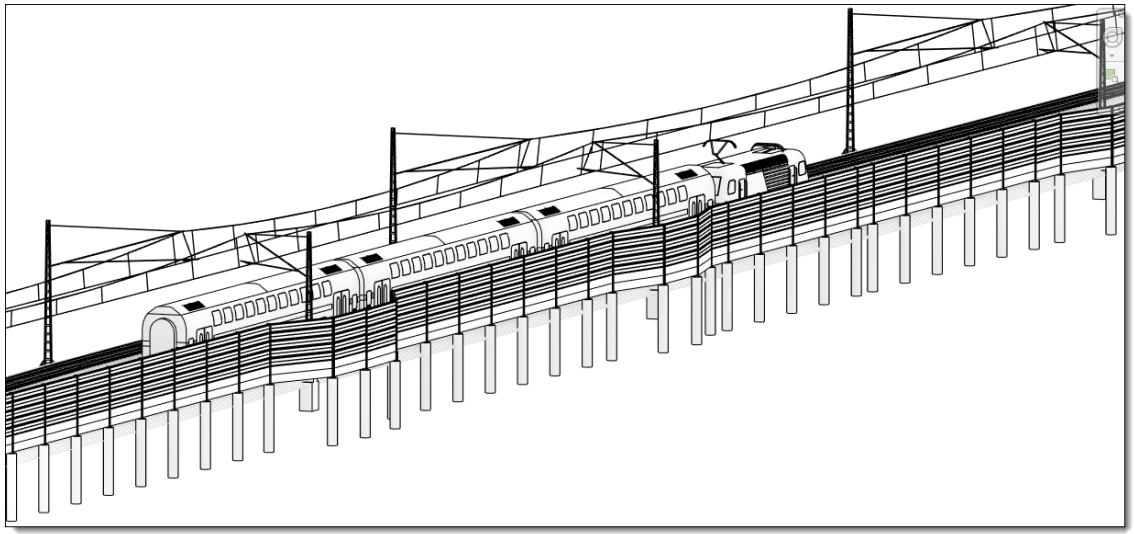
A	B	C	D
Count	Type	Mark	Length
HEB180			
1	HEB180	LSW-HBH-1a-1	4.550
1	HEB180	LSW-HBH-1a-2	4.550
1	HEB180	LSW-HBH-1a-3	4.550
1	HEB180	LSW-HBH-1a-4	4.550
1	HEB180	LSW-HBH-1a-5	4.600
1	HEB180	LSW-HBH-1a-6	4.550
1	HEB180	LSW-HBH-1a-7	4.550
1	HEB180	LSW-HBH-1a-8	4.550
1	HEB180	LSW-HBH-1a-9	4.600
1	HEB180	LSW-HBH-1a-129	4.550
1	HEB180	LSW-HBH-1a-130	4.550
1	HEB180	LSW-HBH-1a-131	4.550
1	HEB180	LSW-HBH-1a-132	4.550
1	HEB180	LSW-HBH-1a-133	4.550
1	HEB180	LSW-HBH-1a-134	4.550
1	HEB180	LSW-HBH-1a-135	4.550
1	HEB180	LSW-HBH-1a-136	4.550
HEB180: 136			
Grand total: 136			

<LSW Panels>

A	B	C
Count	Type	Height
Grau 1		
675	Grau 1	0.500
Grau 1: 675		
STB		
270	STB	0.500
STB: 270		
Grand total: 945		

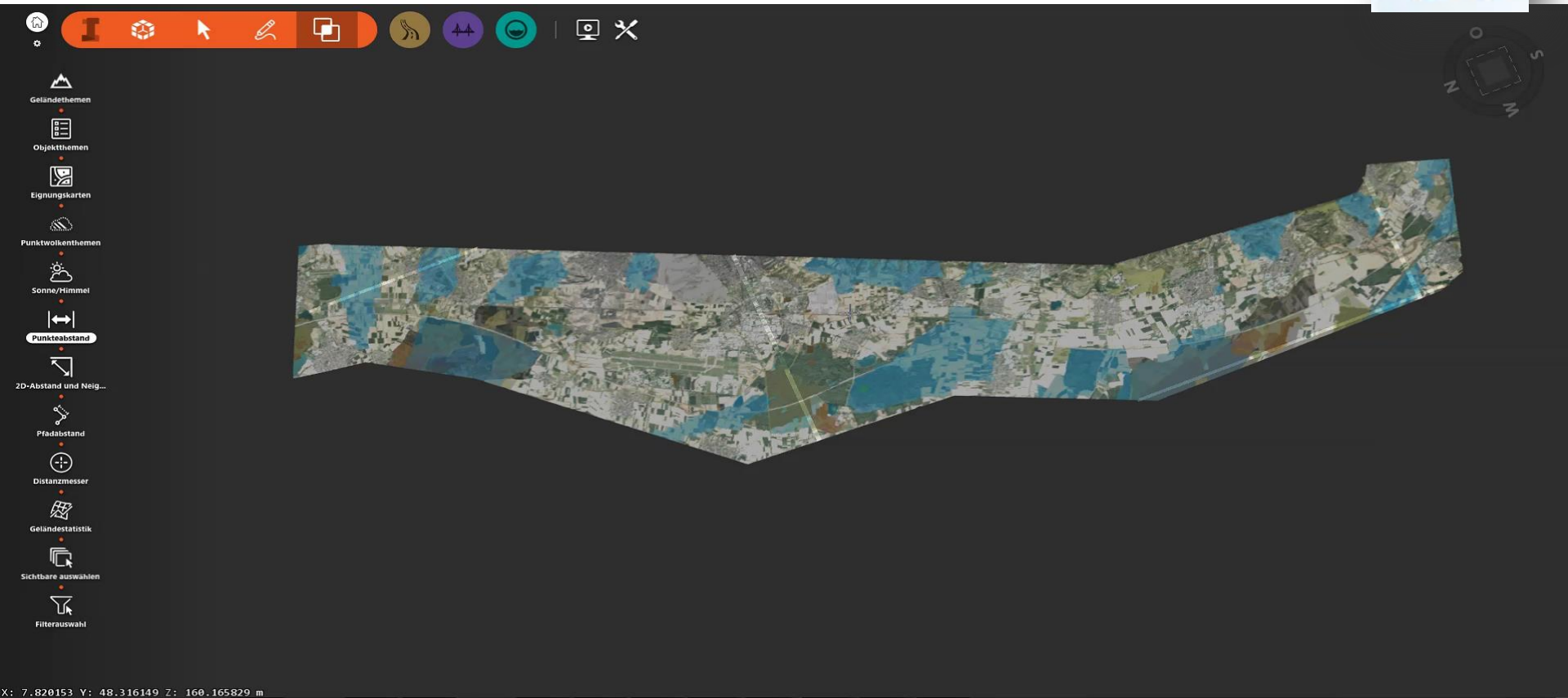
<Gemischt>

A	B
Count	Family
ADSK_LSW-Fundament	
136	ADSK_LSW-Fundament
ADSK_LSW-Fundament: 136	
ADSK_LSW_Abdeckung	
136	ADSK_LSW_Abdeckung
ADSK_LSW_Abdeckung: 136	
Grand total: 272	



Emergency solution to first choice

Using Infraworks



Q&A

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