EUTF EUROPEAN UNDERGROUND & TUNNEL FORUM

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Deutscher Ausschuss für
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German Tunnelling Committee

BIM in Tunnelling

Webinar – March 18, 2021

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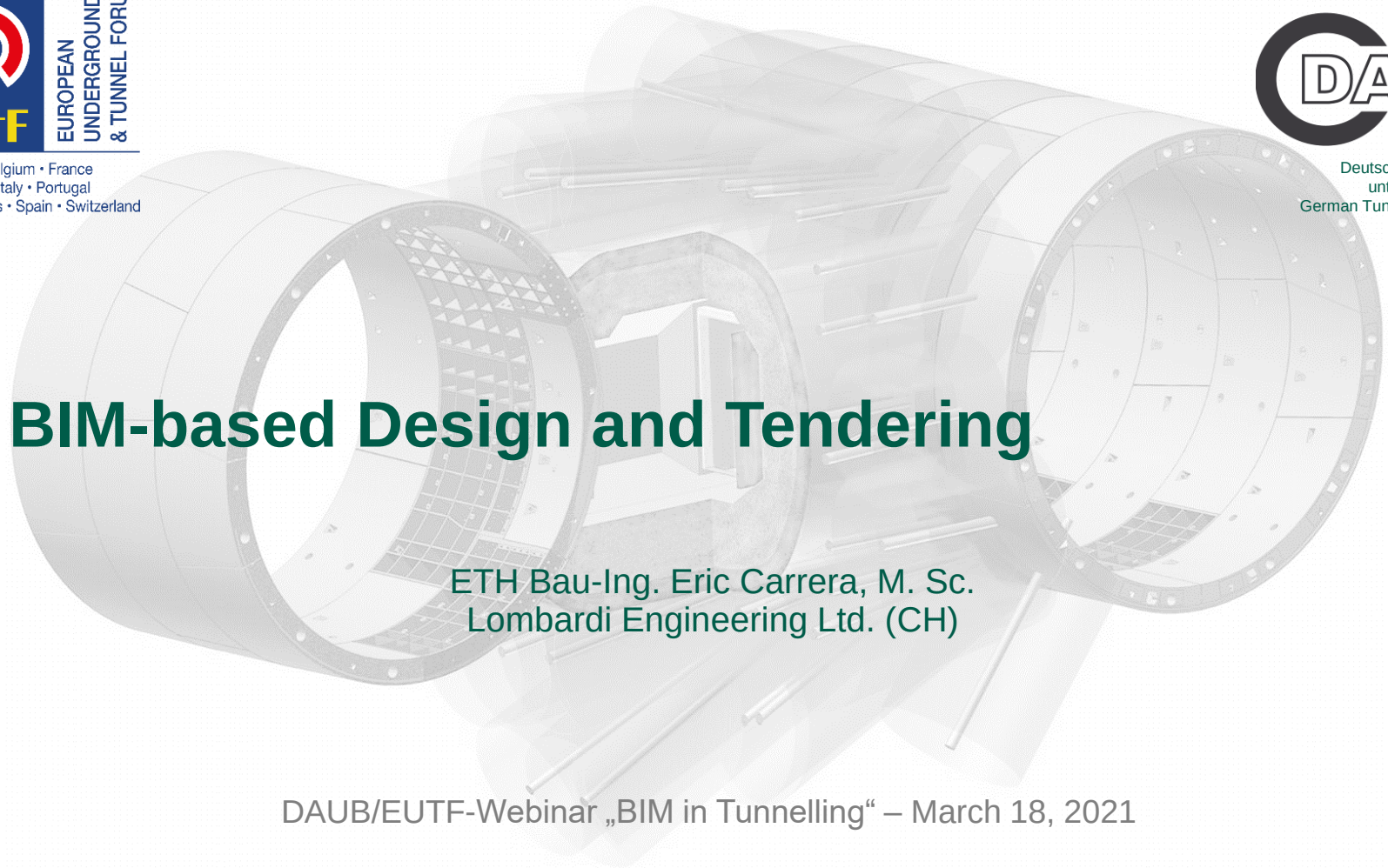
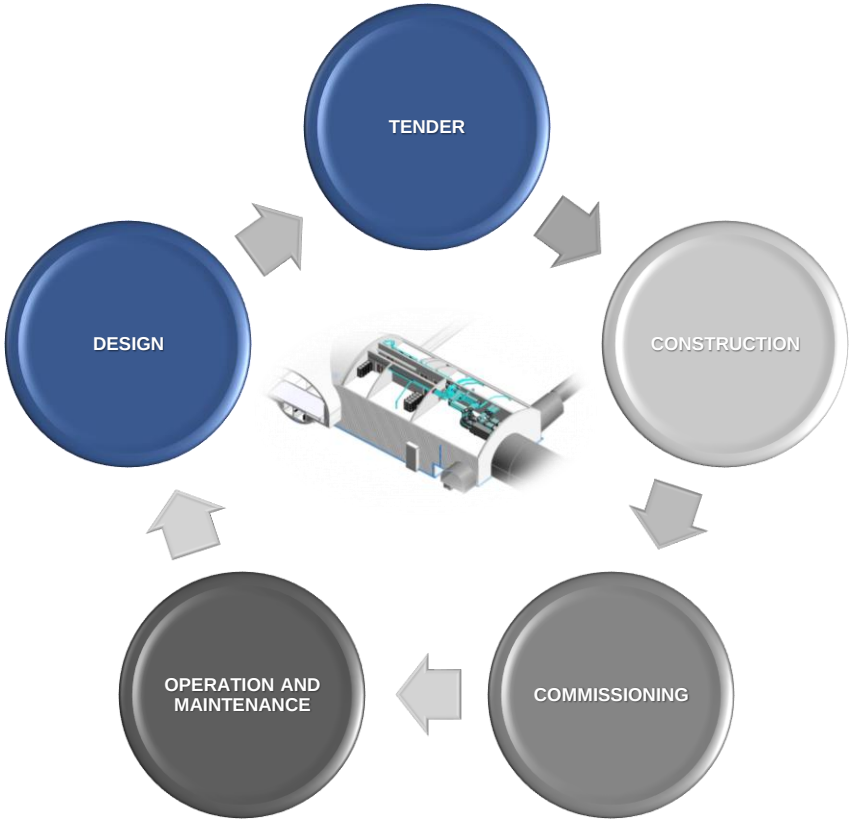


BIM-based Design and Tendering

ETH Bau-Ing. Eric Carrera, M. Sc.
Lombardi Engineering Ltd. (CH)

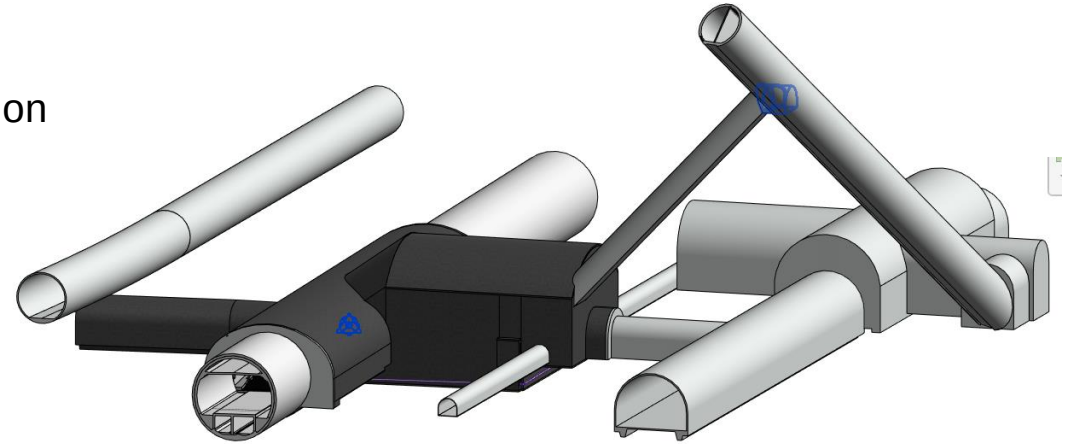
DAUB/EUTF-Webinar „BIM in Tunnelling“ – March 18, 2021

CONTEXT OF TODAYS PRESENTATION



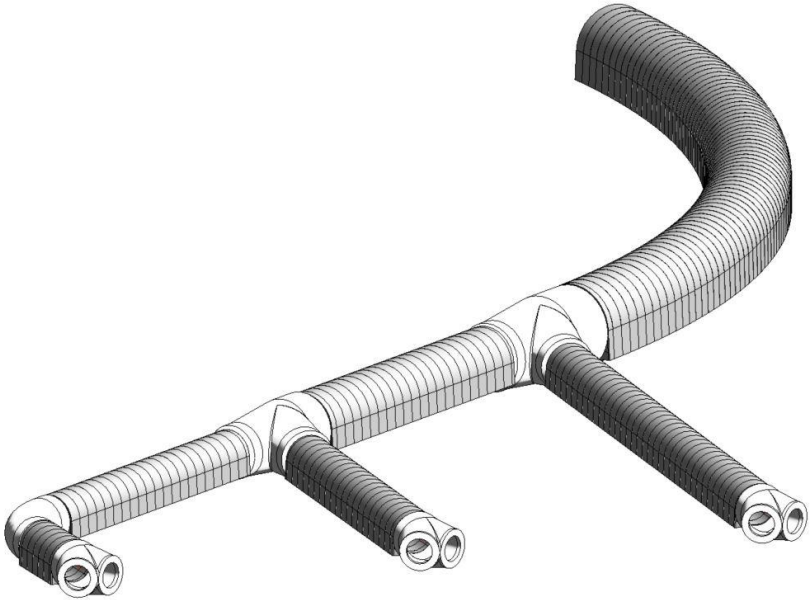
CONTENT

- Model-based design
  - BIM Goals, BIM use cases
  - BIM Execution Plan
  - Model-based coordination
  - Quantity take-off and cost estimation
  - Extraction of drawings
- Model-based tendering
  - Bill of quantities
  - Tender award
  - Model handover to contractor and construction preparation



2. tube Gotthard-Roadtunnel, Visualization

Model-based design



BIM Modell HPP, Visualization

Model-based design – BIM Goals and BIM use cases

Definition of BIM Goals and BIM Use cases

- Definition of BIM goals by the **client** during the tendering phase→ **EIR / PIR**
- Definition of BIM use cases by the **client** during the tendering phase→ **EIR / PIR**
- Extension and specification of the BIM use cases by the **client** together with the **designer** → **BEP**
- Definition of precise and clear BIM use cases for your project.

BIM Goals	BIM Use cases	Requirements
Improvement of the design quality	*Model-based coordination*	*Creation of discipline models (format .ifc and native), Coordination-model in CDE (BCF)*
	Model-based quantity take-off	*Direct extraction of quantities from native software to excel*
Use BIM model for operation and maintenance	*Model-based maintenance*	*Update model to an «as-built» model and implement maintenance plan / define maintenance related attributes*
	Model-based trainings and simulations for rescue forces	*Update model to an «as-built» model and export to VR/AR application*

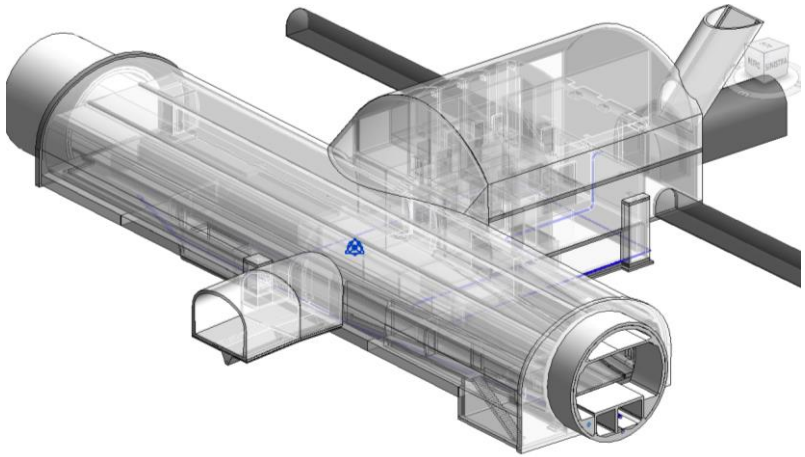
Examples of BIM goals and uses cases

Model-based design – BIM Execution Plan BEP

BIM Execution Plan - BEP

– The importance of the BEP → **designers Roadmap for every BIM-Project**

– BIM-Goals and BIM use cases
– BIM Organization
– BIM-Process plan
– Information requirements
– Coordination and collaboration rules
– Model requirements
– ICT (Software, CDE, etc.)
– Quality Management



2. tube Gotthard-Roadtunnel, Visualization

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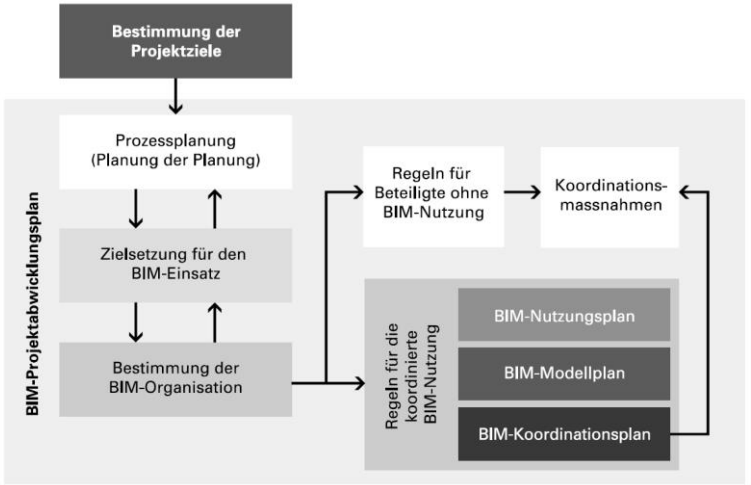

Extract of SIA D2051, content BEP

Model-based design – BIM Execution Plan BEP

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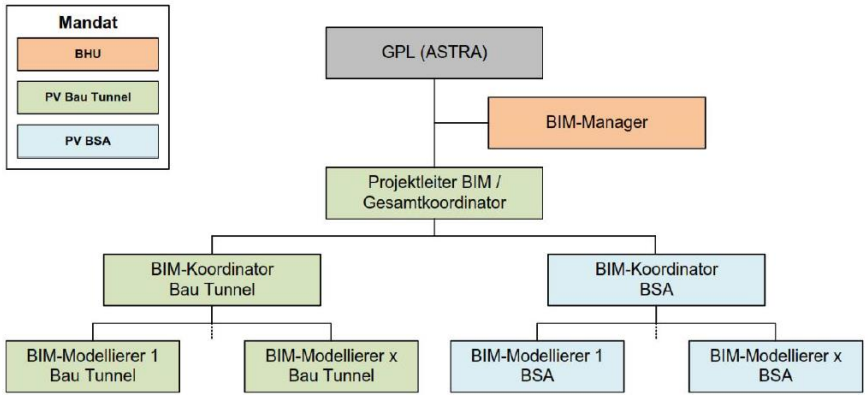

Example of BIM Organization, Project: 2. tube Gotthard-Roadtunnel

Model-based design – BIM Execution Plan BEP

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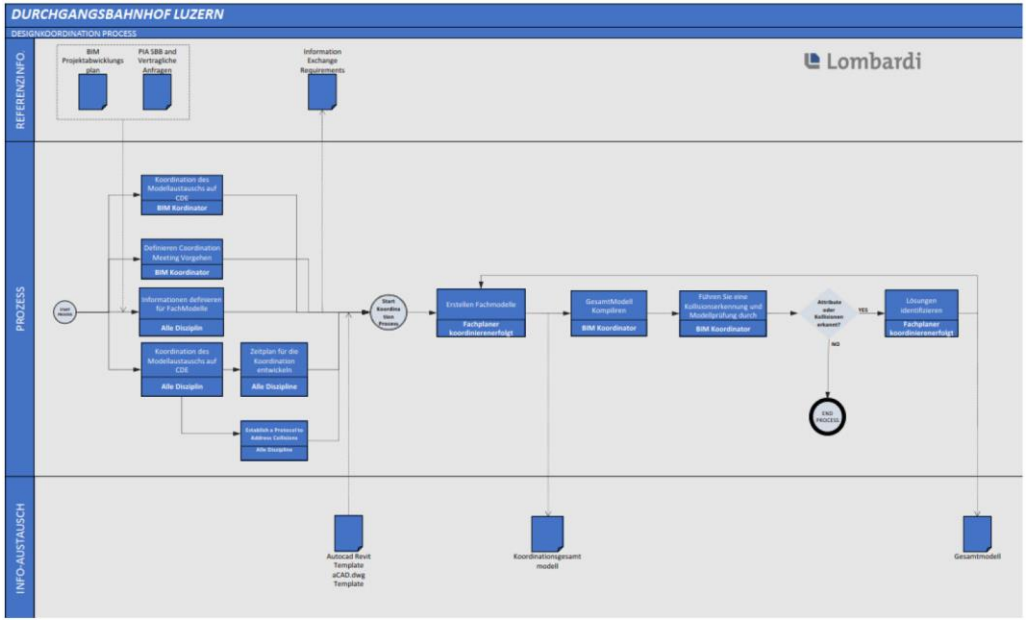

Example of BIM-Process Plan

Model-based design – BIM Execution Plan BEP

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- Coordination and collaboration rules
- Model requirements
- ICT (Software, CDE, etc.)
- Quality Management

Modell		Verantwortlicher	Elemente		Attribute		Detaillierungsgrad LOG/LOI			
							DP	Ausschreibung	Ausführung	Betrieb
Achse	AX	ILF	Polylinie	XX	Geometrie	Gm	300	300	300	300
SiSto	SI	ILF	Innenschale	In	Geometrie	Gm	300	300	300	300
Geologie	GE	ILF	Litologie	Au	Geometrie	Gm	300	300	300	300
					Geologie	Ge				
					e-BKP	KP				
					Bauphase	Ph				
Rohbau Haupttunnel	TU	ILF	Ausbruch	Ta	Geometrie	Gm	300	N.N	N.N	N.N
					Typ	Tü				
					e-BKP	Kp				
			Ausbruchssicherung	Tü	Geometrie	Gm	300	N.N	N.N	N.N
					Beton	Be				
					Typ	Tü				
					e-BKP	KP				
			Innengewölbe	In	Geometrie	Gm	300	N.N	N.N	N.N
					Aussparungen	Au				
					Schalungstyp	St				
					Beton	Be				
					Bewehrung	Bw				
					e-BKP	KP				
			Sohlgewölbe	Sg	Geometrie	Gm	300	N.N	N.N	N.N
					Aussparungen	Au				
					Schalungstyp	St				
					Beton	Be				
					Bewehrung	Bw				
					e-BKP	KP				
			WELK	Wk	Geometrie	Gm	300	N.N	N.N	N.N
					Aussparungen	Au				
					Schalungstyp	St				
					Beton	Be				
					Bewehrung	Bw				
					e-BKP	KP				
			Zwischendecke	Zw	Geometrie	Gm	300	N.N	N.N	N.N
					Aussparungen	Au				
					Schalungstyp	St				
					Beton	Be				
					Bewehrung	Bw				
					e-BKP	KP				
			SOS-Nische	So	Geometrie	Gm	300	N.N	N.N	N.N
					Aussparungen	Au				
					Schalungstyp	St				
					Beton	Be				
					Bewehrung	Bw				
					e-BKP	KP				
			Kappenbahn	Nb	Geometrie	Gm	300	N.N	N.N	N.N
					Material	Ma				
					e-BKP	KP				
			Abdichtung	Ab	Geometrie	Gm	300	N.N	N.N	N.N
					Material	Ma				

Example LoD-Matrix and attributes, Project 2TG

Model-based design – BIM Execution Plan BEP

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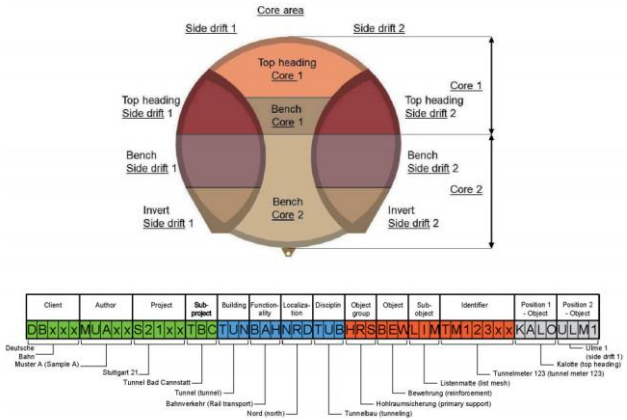
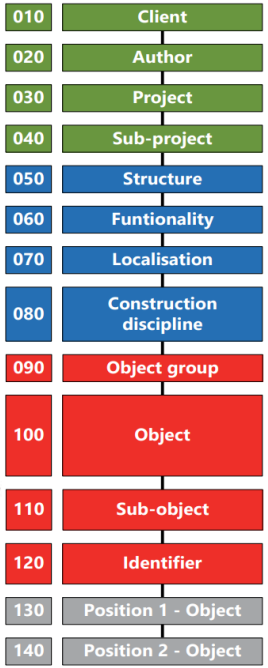
– **Model requirements**
– ICT (Software, CDE, etc.)
– Quality Management





Object coding acc. to DAUB, «Model requirements – Part 1»

Model-based design – BIM Execution Plan BEP

BIM Execution Plan - BEP

– The importance of the BEP → **designers Roadmap for every BIM-Project**

– BIM-Goals and BIM use cases
– BIM Organization
– BIM-Process plan
– Information requirements
– Coordination and Collaboration rules
– Modelling requirements
– **ICT (Software, CDE, etc.)**
– Modell Definition
– Quality Management

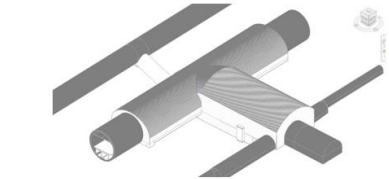
Funktion/Fachbereich	Disziplin	Lieferant	Software	Version	Format
Punktewolke für Landschaftsmodelle (bestehender Bahnhof)	Landschaft	Autodesk	ReCaP + Point Layout	2020	.shp .ifc .dwg
Georeferenzierte Lage bestehender Bauwerke	Landschaft	ArcGIS	ArcGIS	2020	.gdb
Architektonisches Modell	Architektur	Graphisoft	ArchiCAD	2020/2021	.ifc
Konstr. Ingenieurbau und Spezialtiefbau	Konstr. Ingenieurbau, Spezialtiefbau	Autodesk	Revit +Civil 3D	2021	.rvt &ifc
Fahrbahn	Bahnbau	Autodesk	Civil 3D	2021	.dwg .xlsx .ifc
Elektromechanik	Elektro-mechanik	Autodesk	Civil 3D + Dynamo	2021	.dwg .xlsx .ifc
Positionierung von Ringen und Halterungen	Rohbau	Autodesk	Civil 3D + Dynamo	2021	.dwg .xlsx .ifc
Statische und geotechnische Berechnungen	konstr. Ingenieurbau, Spezialtiefbau	SOFICAD	SOFiSTiK	2020	.SOFISTIK
Positionierung geognostischer Vermessungen mit Lithographie	Geologie	Seequiring	Leapfrog WORK	2020	.aproj .ifdata
Modellierung von elektrischen, mechanischen und hydraulischen Systemen	Elektro-mechanik	Autodesk	Revit Inventor	2021	.rvt &ifc

Example required software for each discipline model and exchange-format

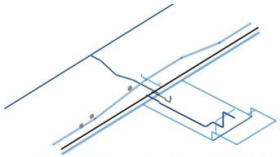
Model-based design – Model-based coordination

Model-based coordination and collaboration

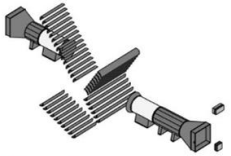
- Definition of project and model structure and structure of discipline models;
- Definition of units (m, mm, m^2, etc.) and other geometrical constraints (i.e. coordinate system, zero point, etc.);
- Definition of codification an colours;
- Definition of collaboration systems and coordination workflows and meetings (ICE Sessions, etc.).



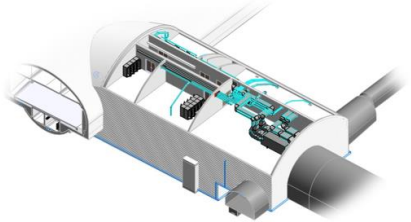
Discipline model civil and structural works



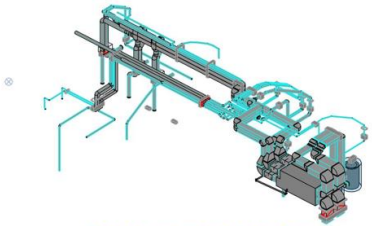
Discipline model plumbing



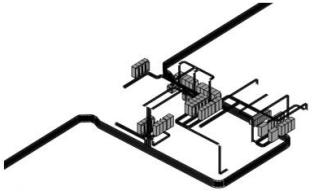
Discipline model ventilation



Coordination model



Discipline model cooling



Discipline model cables and equipments

Example coordination model and discipline models, Project: 2. tube Gotthard-Roadtunnel

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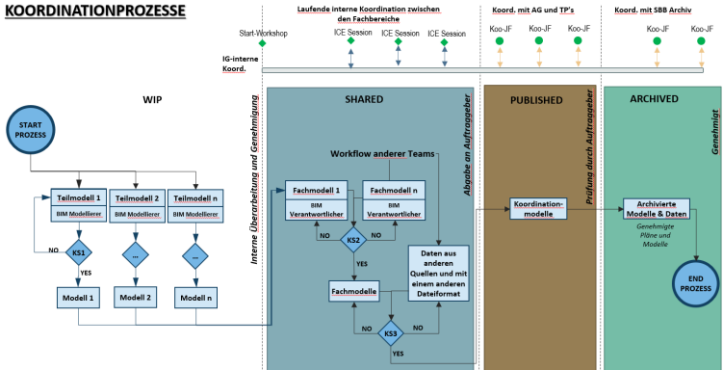
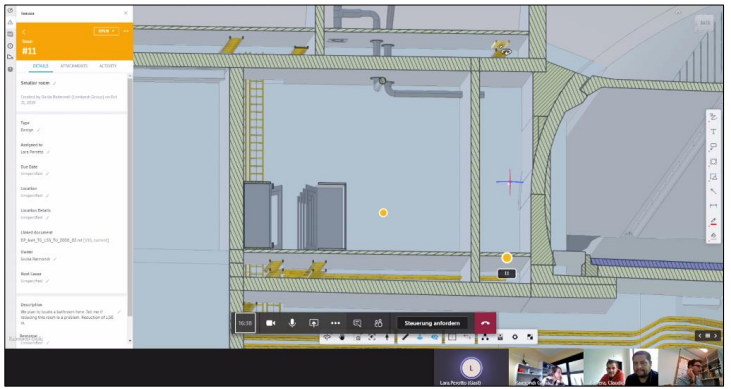


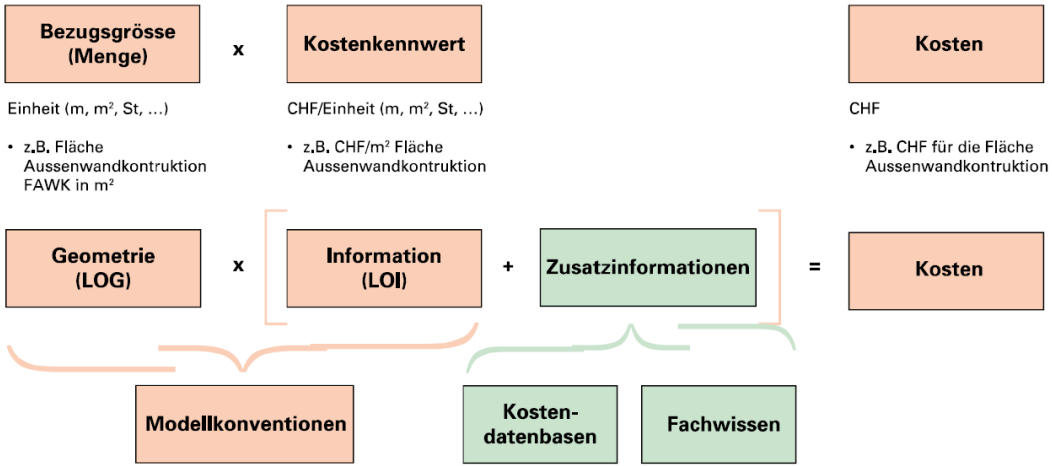


Example coordination workflow and ICE-Session, Project 2TG

Model-based design – Quantity take-off and cost estimation

Cost estimation (BIM 5D), principles

- Direct quantity take-off from BIM-Modell;
- Link model with unit prices.

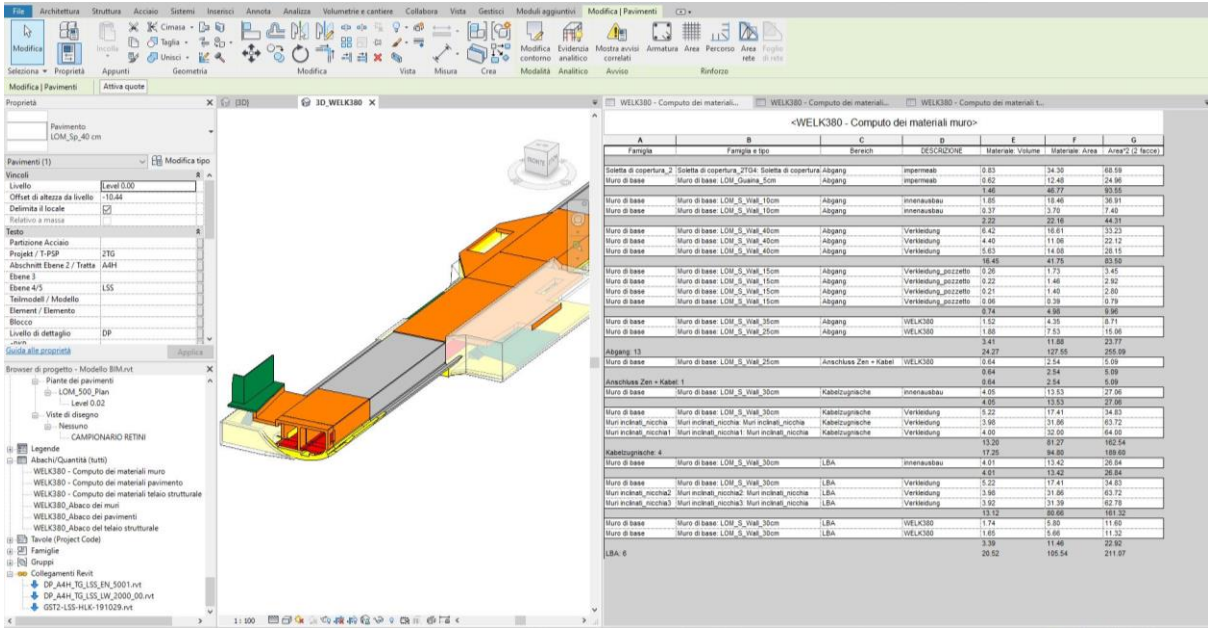


Principles of cost estimation, extract of SIA D0271

Model-based design – Quantity take-off and cost estimation

Cost estimation (BIM 5D), based on level «NPK» or «eBKP» (Switzerland)

- **Direct quantity take-off from BIM-Modell;**
- **Definition of «NPK»-Structure as Attribute in the Modell;**
- Unit prices list for every calculated «NPK»;
- Linking unit prices list with extracted quantities of the BIM-Modell;
- Further cost estimations methods (eBKP, see following slides).



Example of model-based cost estimation, quantities

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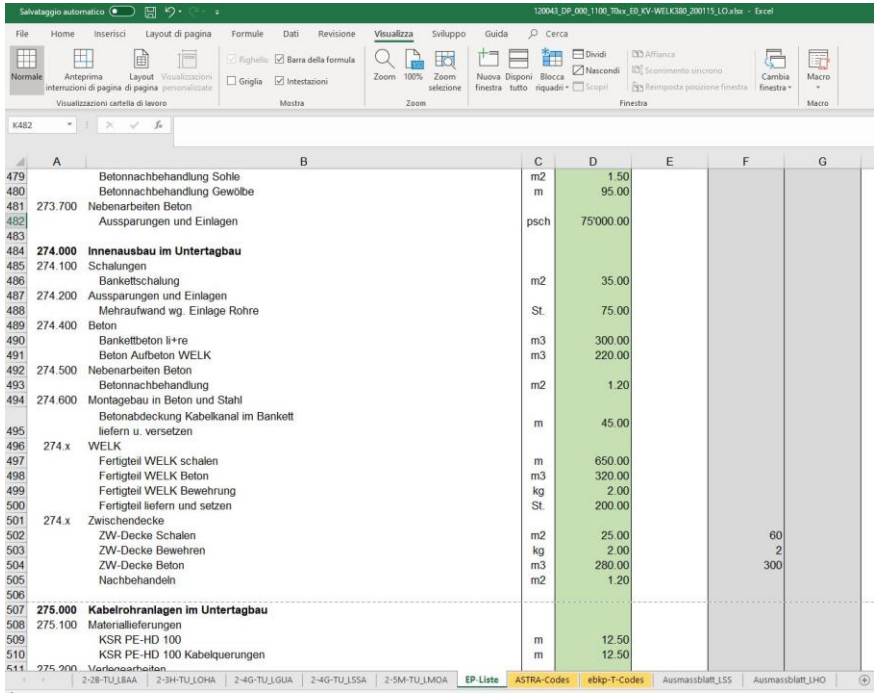

	A	B	C	D	E	F	G
479		Betonnachbehandlung Sohle	m2	1.50			
480		Betonnachbehandlung Gewölbe	m	95.00			
481	273.700	Nebenarbeiten Beton					
482		Aussparungen und Einlagen	psch	75'000.00			
483							
484	**274.000**	**Innenausbau im Untertagbau**					
485	274.100	Schalungen					
486		Bankettschalung	m2	35.00			
487	274.200	Aussparungen und Einlagen					
488		Mehraufwand wg. Einlage Rohre	St.	75.00			
489	274.400	Beton					
490		Bankettbeton li+re	m3	300.00			
491		Beton Aufbeton WELK	m3	220.00			
492	274.500	Nebenarbeiten Beton					
493		Betonnachbehandlung	m2	1.20			
494	274.600	Montagebau in Beton und Stahl					
495		Betonabdeckung Kabelkanal im Bankett liefern u. versetzen	m	45.00			
496	274.x	WELK					
497		Fertigteil WELK schalen	m	650.00			
498		Fertigteil WELK Beton	m3	320.00			
499		Fertigteil WELK Bewehrung	kg	2.00			
500		Fertigteil liefern und setzen	St.	200.00			
501	274.x	Zwischendecke					
502		ZW-Decke Schalen	m2	25.00		60	
503		ZW-Decke Bewehren	kg	2.00		2	
504		ZW-Decke Beton	m3	280.00		300	
505		Nachbehandeln	m2	1.20			
506							
507	**275.000**	**Kabelrohranlagen im Untertagbau**					
508	275.100	Materiallieferungen					
509		KSR PE-HD 100	m	12.50			
510		KSR PE-HD 100 Kabelquerungen	m	12.50			
511	275.200	Verlegearbeiten					

Example of model-based cost estimation, Unit prices list

Model-based design – Quantity take-off and cost estimation

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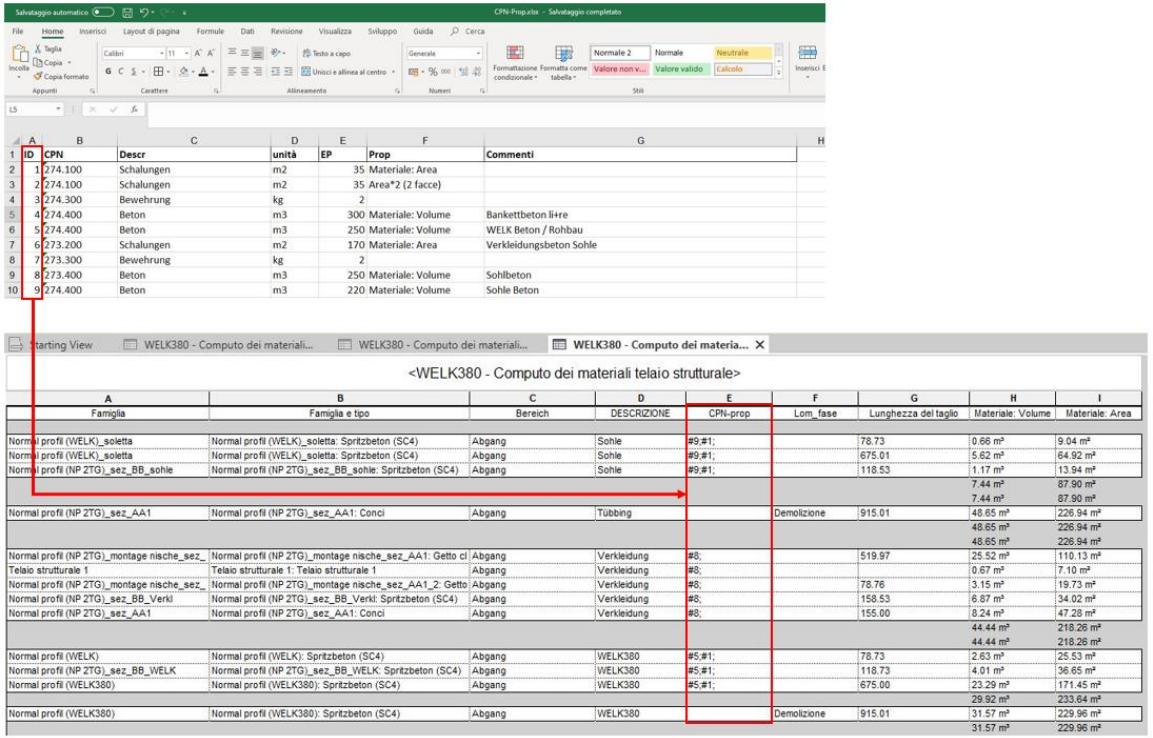


ID	CPN	Descr	unità	EP	Prop	Commenti
1	274.100	Schalungen	m2	35	Materiale: Area	
2	274.100	Schalungen	m2	35	Area*2 (2 facce)	
3	274.300	Bewehrung	kg	2		
4	274.400	Beton	m3	300	Materiale: Volume	Bankettbeton li+re
5	274.400	Beton	m3	250	Materiale: Volume	WELK Beton / Rohbau
6	273.200	Schalungen	m2	170	Materiale: Area	Verkleidungsbeton Sohle
7	273.300	Bewehrung	kg	2		
8	273.400	Beton	m3	250	Materiale: Volume	Sohlbeton
9	274.400	Beton	m3	220	Materiale: Volume	Sohle Beton

<WELK380 - Computo dei materiali telaio strutturale>

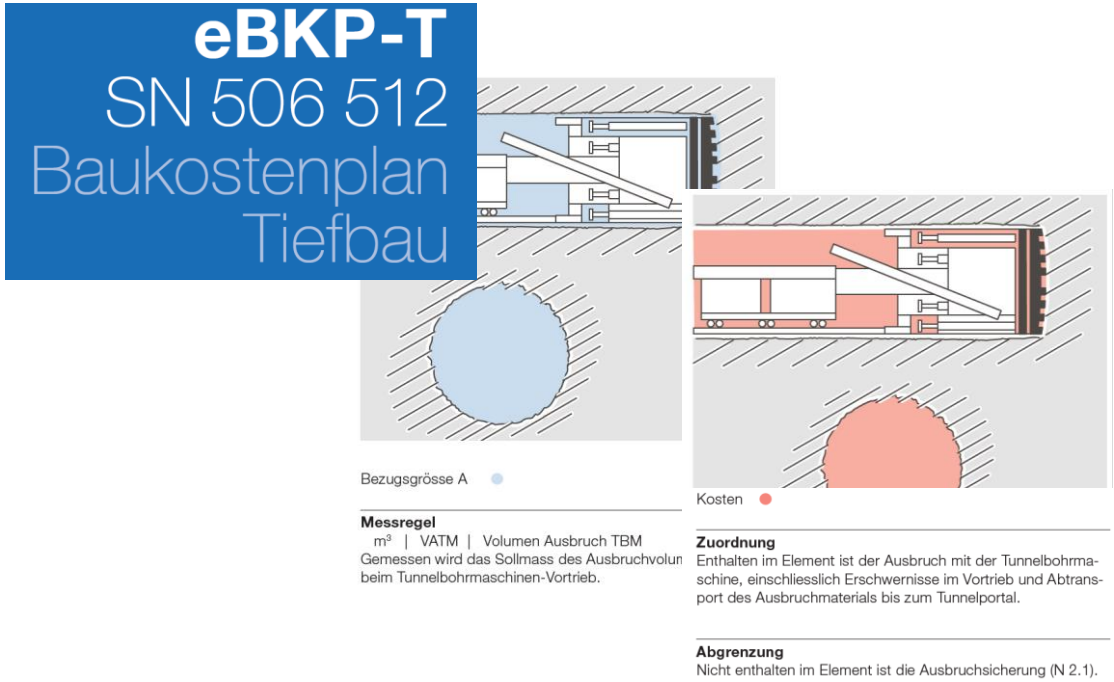
Famiglia	Famiglia e tipo	Bereich	DESCRIZIONE	CPN-prop	Lom_fase	Lunghezza del taglio	Materiale: Volume	Materiale: Area
Normal profil (WELK)_soletta	Normal profil (WELK)_soletta: Spritzbeton (SC4)	Abgang	Sohle	#9;#1;		78.73	0.66 m²	9.04 m²
Normal profil (WELK)_soletta	Normal profil (WELK)_soletta: Spritzbeton (SC4)	Abgang	Sohle	#9;#1;		675.01	5.62 m²	64.92 m²
Normal profil (NP 2TG)_sez_BB_sohle	Normal profil (NP 2TG)_sez_BB_sohle: Spritzbeton (SC4)	Abgang	Sohle	#9;#1;		118.53	1.17 m²	13.94 m²
							7.44 m²	87.90 m²
							7.44 m²	87.90 m²
Normal profil (NP 2TG)_sez_AA1	Normal profil (NP 2TG)_sez_AA1: Conci	Abgang	Tübbing		Demolizione	915.01	48.65 m³	226.94 m²
							48.65 m³	226.94 m²
							48.65 m³	226.94 m²
Normal profil (NP 2TG)_montage nische_sez_	Normal profil (NP 2TG)_montage nische_sez_AA1: Getto cl	Abgang	Verkleidung	#8;		519.97	25.52 m³	110.13 m²
Telaio strutturale 1	Telaio strutturale 1: Telaio strutturale 1	Abgang	Verkleidung	#8;			0.67 m³	7.10 m²
Normal profil (NP 2TG)_montage nische_sez_	Normal profil (NP 2TG)_montage nische_sez_AA1_2: Getto	Abgang	Verkleidung	#8;		78.76	3.15 m³	19.73 m²
Normal profil (NP 2TG)_sez_BB_Verkl	Normal profil (NP 2TG)_sez_BB_Verkl: Spritzbeton (SC4)	Abgang	Verkleidung	#8;		158.53	6.87 m³	34.02 m²
Normal profil (NP 2TG)_sez_AA1	Normal profil (NP 2TG)_sez_AA1: Conci	Abgang	Verkleidung	#8;		155.00	8.24 m³	47.28 m²
							44.44 m³	218.26 m²
							44.44 m³	218.26 m²
Normal profil (WELK)	Normal profil (WELK): Spritzbeton (SC4)	Abgang	WELK380	#5;#1;		78.73	2.63 m³	25.53 m²
Normal profil (NP 2TG)_sez_BB_WELK	Normal profil (NP 2TG)_sez_BB_WELK: Spritzbeton (SC4)	Abgang	WELK380	#5;#1;		118.73	4.01 m³	36.65 m²
Normal profil (WELK380)	Normal profil (WELK380): Spritzbeton (SC4)	Abgang	WELK380	#5;#1;		675.00	23.29 m³	171.45 m²
							29.92 m³	233.64 m²
Normal profil (WELK380)	Normal profil (WELK380): Spritzbeton (SC4)	Abgang	WELK380		Demolizione	915.01	31.57 m³	229.96 m²
							31.57 m³	229.96 m²

Example of model-based cost estimation, linking unit prices with «NPK» positions

Model-based design – Quantity take-off and cost estimation

Cost estimation (BIM 5D), based on level «NPK» or «eBKP» (Switzerland)

- Direct quantity take-off from BIM-Modell;
- Definition of «NPK»-Structure as Attribute in the Modell;
- Unit prices list for every calculated «NPK»;
- Linking unit prices list with extracted quantities of the BIM-Modell;
- **Further cost estimations methods (eBKP).**

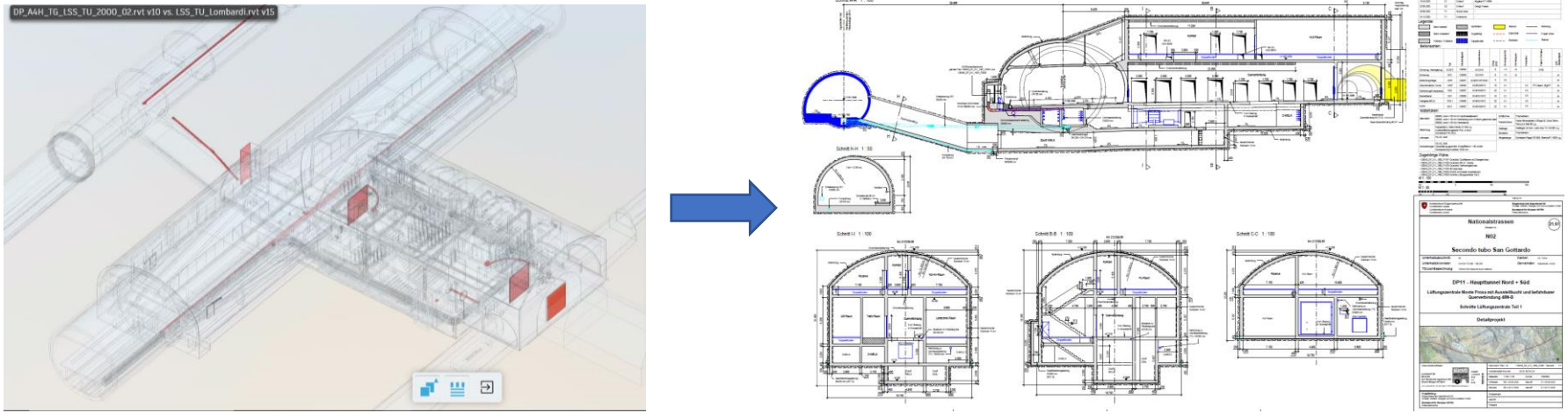


Extract «Anwenderhandbuch Baukostenplan Tiefbau»

Model-based design – Drawing extraction

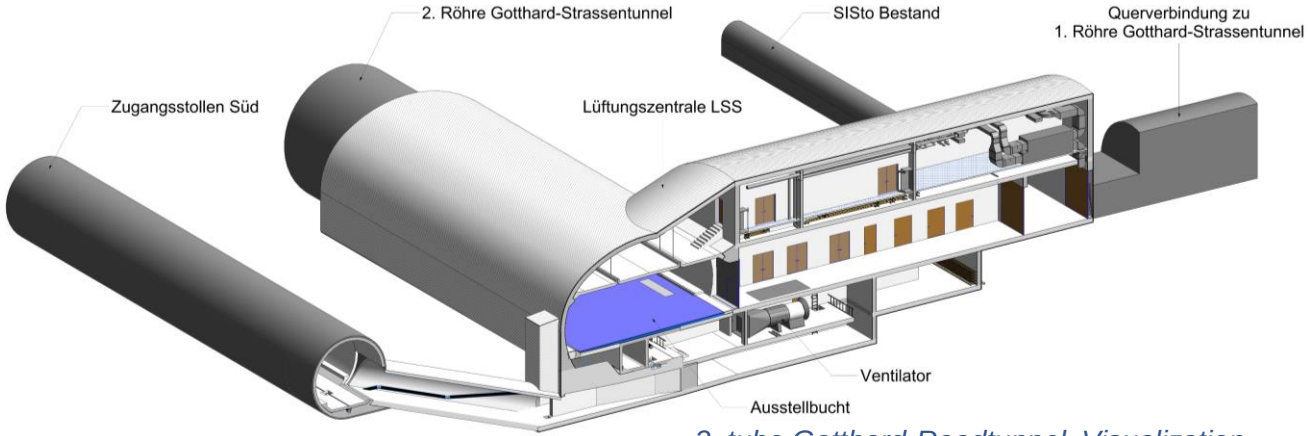
Drawing extraction

– Currently clients are still requiring «classic» 2D-drawings together with the BIM-models;
– Definition of clear and automatized template in order to optimize extraction process;
– Difficult to achieve the same quality as «classic» 2D-drawings



Example of 2D drawing extraction from a native Software

Model-based tendering

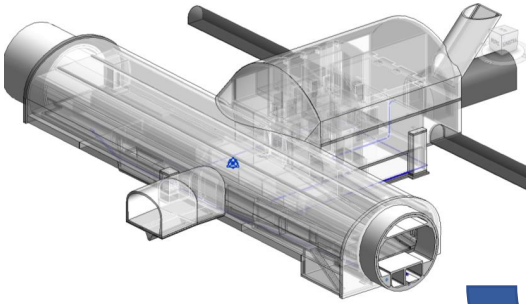


2. tube Gotthard-Roadtunnel, Visualization

Model-based tendering – Bill of quantities and tender award

Transforming a BIM Model into a tender documentation

Design → **Tendering** → **Construction contract**



?

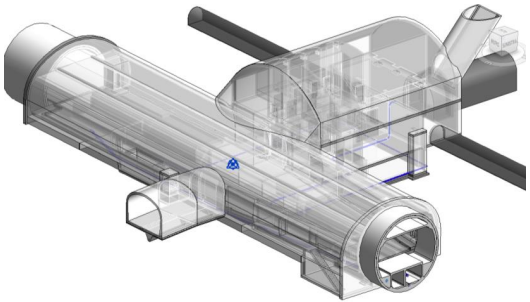
- Contract
- Technical specifications and constraints
- **Construction schedule**
- **BoQ**
- **Drawings**
- Technical descriptions (**Geology**, project, etc.)

Tendering documents
+
offer documents from the contractor

?

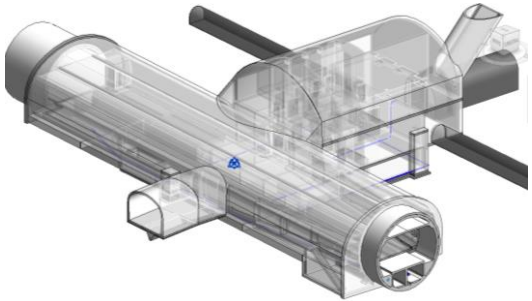
Model-based tendering – Bill of quantities and tender award

Transforming a BIM Model into a tender documentation



✓

- **Construction schedule (BIM 4D)**
- **BoQ** (building materials associated with quantities, formwork, prefabricated elements, etc.)
- **Drawings**
- **Technical descriptions** (Geology)



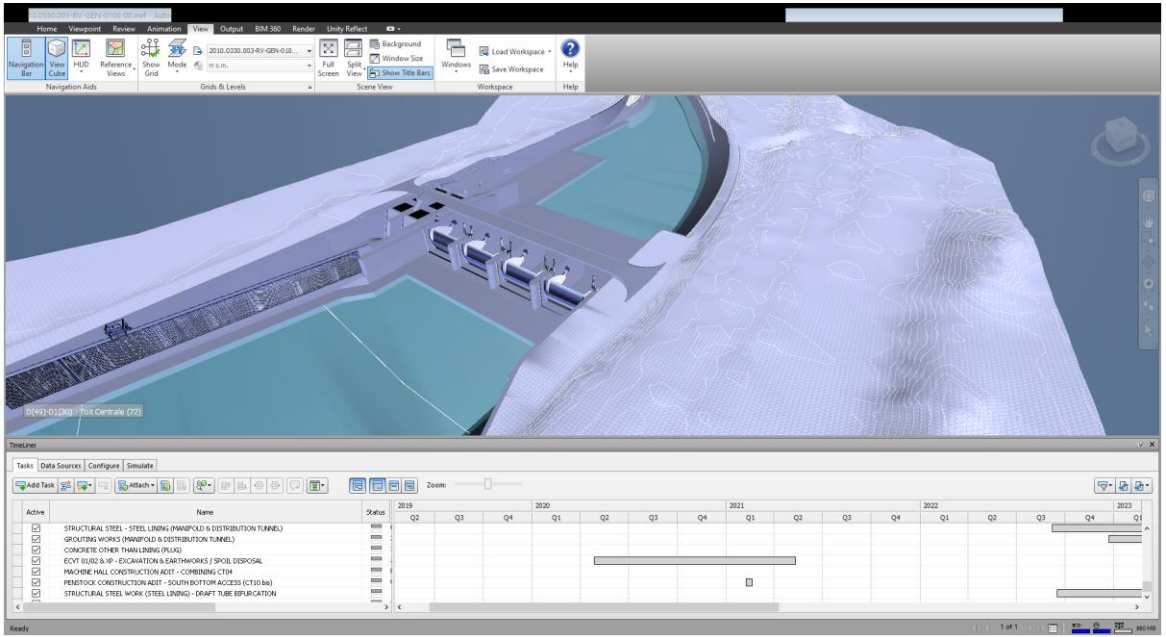
?

- Contract
- Technical specifications and constraints
- BoQ (installations, construction equipment's, work-by-force account, time dependent costs)
- Technical descriptions (project, etc.)

Model-based tendering – Model handover to contractor

Model handover to the contractor and construction preparation

- Construction site preparation;
- Simulation of construction logistics;
- Detailed construction scheduling.



Example 4D simulation for construction logistics

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German Tunnelling Committee

Thank you very much for your attention

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