IFC-BRIDGE

ÜBERBLICK ZUR ENTWICKLUNG

IFC-Bridge Project Team

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Projektablauf

1. Scope-Definition & Anforderungsanalyse

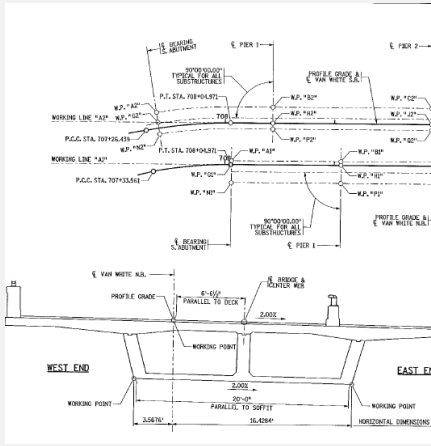
2. Identifikation semantischer Elemente und Eigenschaften
   → Taxonomie
   → basierend auf Input von ASB-ING, MiND, FHWA, KICT, CRBIM

3. Konzeptionelles Modell (UML)
   → Entities, Beziehungen, Eigenschaften
   → basierend auf IFC

4. Definition der Schema-Erweiterung

5. Validierung des Schemas durch Beispielmodelle

6. Erzeugung der Schemaerweiterung

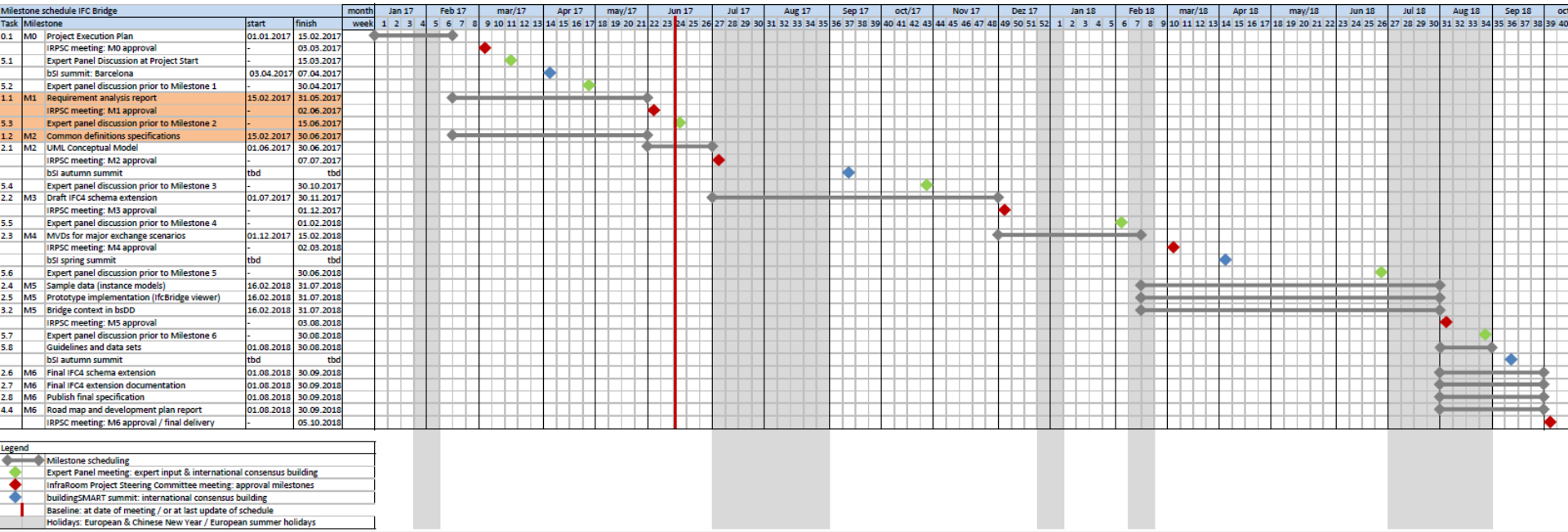




11 Expert Panel Meetings (8 online)

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Zeitplan



Milestone schedule IFC Bridge				month
Task	Milestone	start	finish	week
0.1	M0	Project Execution Plan	01.01.2017	15.02.2017
		IRPSC meeting: M0 approval	-	03.03.2017
5.1		Expert Panel Discussion at Project Start	-	15.03.2017
		bSI summit: Barcelona	03.04.2017	07.04.2017
5.2		Expert panel discussion prior to Milestone 1	-	30.04.2017
1.1	M1	Requirement analysis report	15.02.2017	31.05.2017
		IRPSC meeting: M1 approval	-	02.06.2017
5.3		Expert panel discussion prior to Milestone 2	-	15.06.2017
1.2	M2	Common definitions specifications	15.02.2017	30.06.2017
2.1	M2	UML Conceptual Model	01.06.2017	30.06.2017
		IRPSC meeting: M2 approval	-	07.07.2017
		bSI autumn summit	tbd	tbd
5.4		Expert panel discussion prior to Milestone 3	-	30.10.2017
2.2	M3	Draft IFC4 schema extension	01.07.2017	30.11.2017
		IRPSC meeting: M3 approval	-	01.12.2017
5.5		Expert panel discussion prior to Milestone 4	-	01.02.2018
2.3	M4	MVDs for major exchange scenarios	01.12.2017	15.02.2018
		IRPSC meeting: M4 approval	-	02.03.2018
		bSI spring summit	tbd	tbd
5.6		Expert panel discussion prior to Milestone 5	-	30.06.2018
2.4	M5	Sample data (instance models)	16.02.2018	31.07.2018
2.5	M5	Prototype implementation (IfcBridge viewer)	16.02.2018	31.07.2018
3.2	M5	Bridge context in bsDD	16.02.2018	31.07.2018
		IRPSC meeting: M5 approval	-	03.08.2018
5.7		Expert panel discussion prior to Milestone 6	-	30.08.2018
5.8		Guidelines and data sets	01.08.2018	30.08.2018
		bSI autumn summit	tbd	tbd
2.6	M6	Final IFC4 schema extension	01.08.2018	30.09.2018
2.7	M6	Final IFC4 extension documentation	01.08.2018	30.09.2018
2.8	M6	Publish final specification	01.08.2018	30.09.2018
4.4	M6	Road map and development plan report	01.08.2018	30.09.2018
		IRPSC meeting: M6 approval / final delivery	-	05.10.2018

Legend	
	Milestone scheduling
	Expert Panel meeting: expert input & international consensus building
	InfraRoom Project Steering Committee meeting: approval milestones
	buildingSMART summit: international consensus building
	Baseline: at date of meeting / or at last update of schedule
	Holidays: European & Chinese New Year / European summer holidays

- started Jan 2017, completed **March 2019**

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Scope: Abgedeckte Brückentypen

BRIDGE TYPES

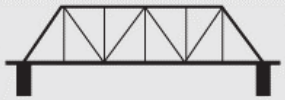
The I-35W bridge that collapsed Wednesday in Minneapolis was designed as a "non-redundant" truss structure. Non-redundant bridges require less material and are cheaper to build but have no other pathways for loads to be disbursed in the event of a failure. That design has caused problems with some other bridges, including the Silver Bridge that collapsed into the Ohio River in 1967 at the height of rush hour, carrying 31 vehicles and 46 people with it. Experts says greater redundancy could prevent a progressive collapse of a bridge.



GIRDER BRIDGE

A girder or beam bridge is arguably the most basic bridge. A log across a creek is an example of a girder bridge in its simplest form. Modern steel girder bridges often use I-beams or box girders in their construction.

EXAMPLE: The 2,165 foot Poplar Streeet Bridge.



TRUSS BRIDGE

The truss is a simple skeletal structure. In theory, the individual parts of a simple truss are only subject to tension and compression forces but not bending forces. Trusses are made up of small beams that when put together can support large amounts of weight and also span great distances.

EXAMPLE: The Old Chain of Rocks Bridge is a one-mile-long truss bridge with a dramatic joint in the center.



ARCH BRIDGE

The second oldest bridge type, the arch doesn't require piers in the center. Arches use a curved structure. This provides high resistance to bending forces. Arches can only be used where the ground or foundation is solid and stable.

EXAMPLE: The Eads Bridge has a three-arch span that totals 1,647 feet.



CANTILEVER BRIDGE

A cantilever bridge is a modified form of beam bridge. The support is in the middle of a span, not the end. The advantage to a cantilever bridge is its ability to span wide spaces without the need of extensive and expensive support while under constuction.

EXAMPLE: The Greater New Orleans Bridge over the Mississippi River.



CABLE-STAYED BRIDGE

A typical cable-stayed bridge is a continuous girder with one or more towers erected above piers in the middle of the span. Cables stretch down diagonally (usually to both sides) and support the girder from the towers.

EXAMPLE: The Clark Bridge crossing the Mississippi going to Alton.



SUSPENSION BRIDGE

The suspension bridge allows for the longest spans. A typical suspension bridge is a continuous girder with one or more towers erected above piers in the middle of the span.

EXAMPLE: The Golden Gate bridge in San Francisco.

SOURCES: Matsuo Bridge Co., Ltd., www.riverwebmuseums.org

Research by Mark Learman
Graphic by John D. Telford | Post-Dispatch

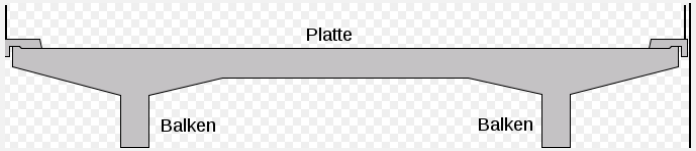
Balkenbrücken | Fachwerkbrücken | Bogenbrücken | Auslegerbrücken | Schrägseilbrücken | Hängebrücken

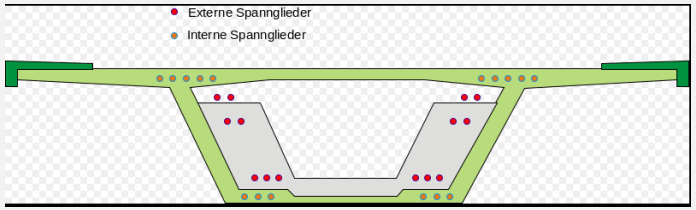
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Scope: Abgedeckte Brückentypen

Überbau:

- Balken
- Plattenbalken
- Hohlkasten





Geometrie des Überbaus

- gerade
- gevoutet
- In curve



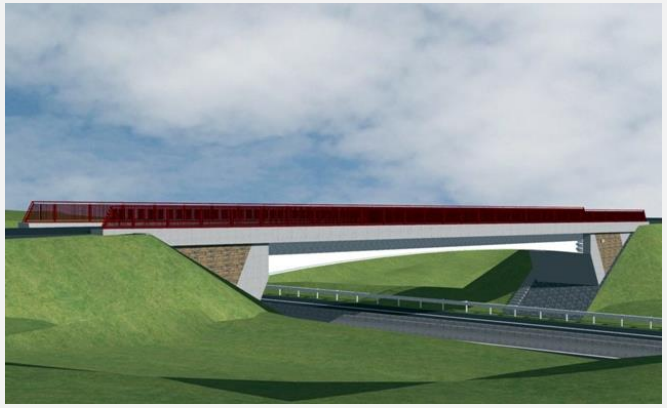


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Scope: Abgedeckte Brückentypen

Material

- Stahlbeton
- Spannbeton
- Stahlverbundbrücke
- Stahlträgerbrücken
- Stahlbrücken









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Anwendungsfälle

No	Use case	Description	Purpose	IFC exchange scenario	Required geometry representation	Required semantic information	Priority	Complexity	MVD
1	Initial State Modeling	initial data (terrain, soil, existing structures etc.) from various sources (including GIS) are brought into BIM space and exchanged using IFC	GIS (and other) data provides the basis for the design task	GIS & other sources to design application	Faceted BRep, Sweep Geometry where suitable (Deck, Rebar, Boring Piles etc), potentially based on alignment	Major design parameters, Material (soil classification), accuracy and reliability of initial data	high	low	Bridge Reference View
2	Import of alignment and major road / railway parameters	alignment information is imported from roadway/railway design tool into bridge modeler	Alignment provides the basis for bridge design	From roadway / railway design system into bridge modeling system	Faceted BRep, Sweep Geometry where suitable (Deck, Rebar, Boring Piles etc), potentially based on alignment	Maximum Speeds, Loads etc.	high	low	Bridge Reference View
3	Technical Visualization	3D technical visualization of the bridge project	Communication of design solutions to third parties, including the public	Design application to Visualization app.	Triangulated Face Sets	Bridge Breakdown Structure Object Types Material (opt) Colors (opt) Relationships between entities (IfcRelConnects...)	high	low	Bridge Reference View
4	Coordination / Collision detection	Coordination of domain-specific sub-models	Transfer and combine models to detect interferences (clashes)	Design application to Design application	Faceted BRep, Sweep Geometry where suitable (Deck, Rebar, Boring Piles etc) , potentially based on alignment	Component types Classification Relationships between entities (IfcRelConnects...)	high	low	Bridge Reference View

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Anwendungsfälle

No	Use case	Description	Purpose	IFC exchange scenario	Required geometry representation	Required semantic information	Priority	Complexity	MVD
5	4D Construction Sequence Modeling	4D technical visualization of the construction phases	Organization of construction site and construction activities	Design application to 4D scheduling application	Faceted BRep, Sweep Geometry where suitable (Deck, Rebar, Boring Piles etc) , potentially based on alignment	Temporal information	high	low	Bridge Reference View
6	Quantity Take-Off	Determine quantities (volumes and surfaces) from the model	Basis for cost estimation and cost calculation	Design application to QTO application	Faceted BRep, Sweep Geometry where suitable (Deck, Rebar, Boring Piles etc) , potentially based on alignment	Material, Classifications Relationships between entities (IfcRelConnects...)	high	low	Bridge Reference View
7	Progress Monitoring	Transfer information about the progress of the construction project	Track and document the progress of the construction project	Surveying application to visualization application	Faceted BRep, Sweep Geometry where suitable (Deck, Rebar, Boring Piles etc) , potentially based on alignment	Temporal information	high	low	Bridge Reference View
8	As-built vs. as-planned comparison	Compare the built structure against the as-planned model (Geometric Control)	Check the quality of the construction (on site)	Design application to field application	Faceted BRep, Sweep Geometry where suitable (Deck, Rebar, Boring Piles etc) , potentially based on alignment	Classification Tolerance values Relationships between entities (IfcRelConnects...)	high	low	Bridge Reference View
9	Handover to asset management	use the model to support operation and maintenance of the bridge,	use the model for inspection, damage detection, condition rating, condition prediction,	Design application to asset management system	Faceted BRep, Sweep Geometry where suitable (Deck, Rebar, Boring Piles etc) , potentially based on alignment	Classification Material Maintenance information	high	medium	Bridge Asset Management View

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Anwendungsfälle

No	Use case	Description	Purpose	IFC exchange scenario	Required geometry representation	Required semantic information	Priority	Complexity	MVD
			maintenance planning						
10	Handover to GIS for spatial analysis	Handover the bridge design to GIS for environmental analysis and/or asset mgmt.	GIS systems provide functionality for environmental analysis and can be used for asset management	Design application to GIS system	Faceted BRep, Sweep Geometry where suitable (Deck, Rebar, Boring Piles etc), potentially based on alignment	Major design attributes	high	low	Bridge Reference View
11	Design to Design (reference model)	Use bridge model from early design phase as a reference for creating a more detailed bridge model in the detailed design ohase, limited modifiability required	Models are exchanged across different design phases, model from earlier phase is used us background / reference model for next phase	Design application to design application	Faceted BRep, Sweep Geometry where suitable (Deck, Rebar, Boring Piles etc), potentially based on alignment S	Classification Material Component types Relationships between entities (IfcRelConnects...)	high	medium	Bridge Reference View
12	Design-to-Design (full model logic)	Exchange of fully parametric description of bridge between two distinct design applications	within the same design phase, design models are exchanged between different design applications, model remains fully modifiable,	Design application to design application	Fully parametric model information containing model logic, constraints and dependencies	All information entered in the design application	medium	high	Bridge Design Transfer View

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Anwendungsfälle

No	Use case	Description	Purpose	IFC exchange scenario	Required geometry representation	Required semantic information	Priority	Complexity	MVD
			all model logic is transferred						
13	Design-to-Construction	Handover from Design Phase to Construction Phase	Bridge Model is handed over from designer to Contractor for bidding and for actual construction	Design application to Tendering application and/or Review application	Faceted BRep, Sweep Geometry where suitable (Deck, Rebar, Boring Piles etc), potentially based on alignment	Material information Product information etc.	high	medium	Bridge Reference View
14	Structural Analysis incl. Structural Dynamics, Fluid-Structure Interaction, etc.	Structural analysis of bridges, tunnels, retaining walls	Ensure stability of the structures	Design application to structural analysis application	Procedural Description (Sweep and CSG) and/or Analytical Model	Loads, Material properties	medium	medium - high	Bridge Structural View
15	Code Compliance Checking	Check design of bridge for compliance with local codes and regulations	Compliance checking conducted by regulation authorities	Design application to checking application	Procedural description (Alignment, Sweep Geometry, CSG, BRep)	Information regarding the applying regulations (dimensions, distances, materials, etc.)	medium	high	?
16	Drawing generation and exchange	Exchange technical drawings derived from the model	Submission to owner / regulation authorities	Design application to Submission	2D representation	All information relevant for drawing representation (line styles, symbolic representations, etc.)	low	high	?

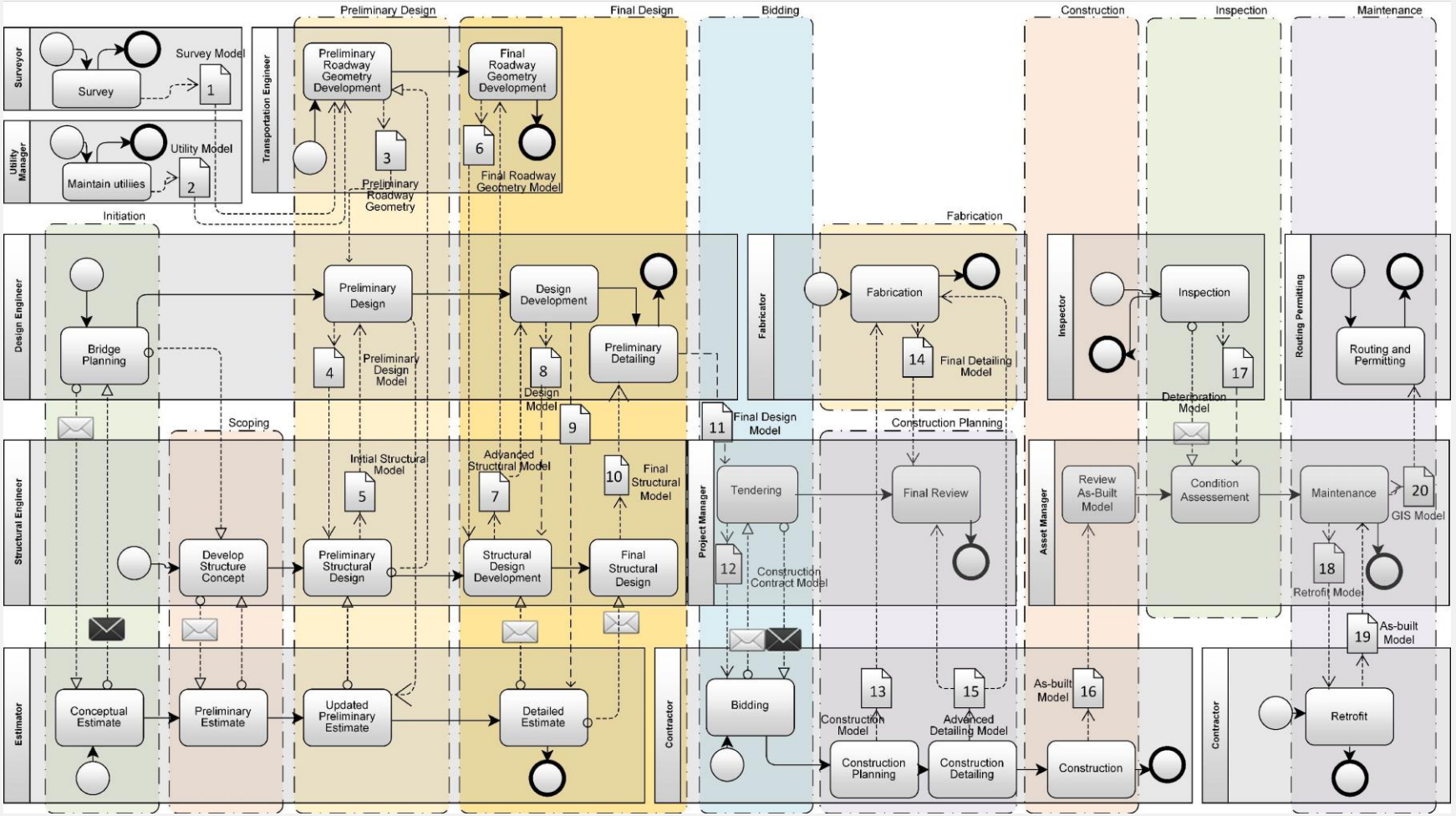
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Anwendungsfälle

No	Use case	Description	Purpose	IFC exchange scenario	Required geometry representation	Required semantic information	Priority	Complexity	MVD
17	Prefabrication and manufacturing	Usage of model information for control / steering of prefabrication machines.	Partially automated construction of bridge components	Design application to machine	Procedural description (Alignment, Sweep Geometry, CSG, Advanced BRep)	(specific)	low	medium	?

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Reference Process Map (Prozesslandkarte)

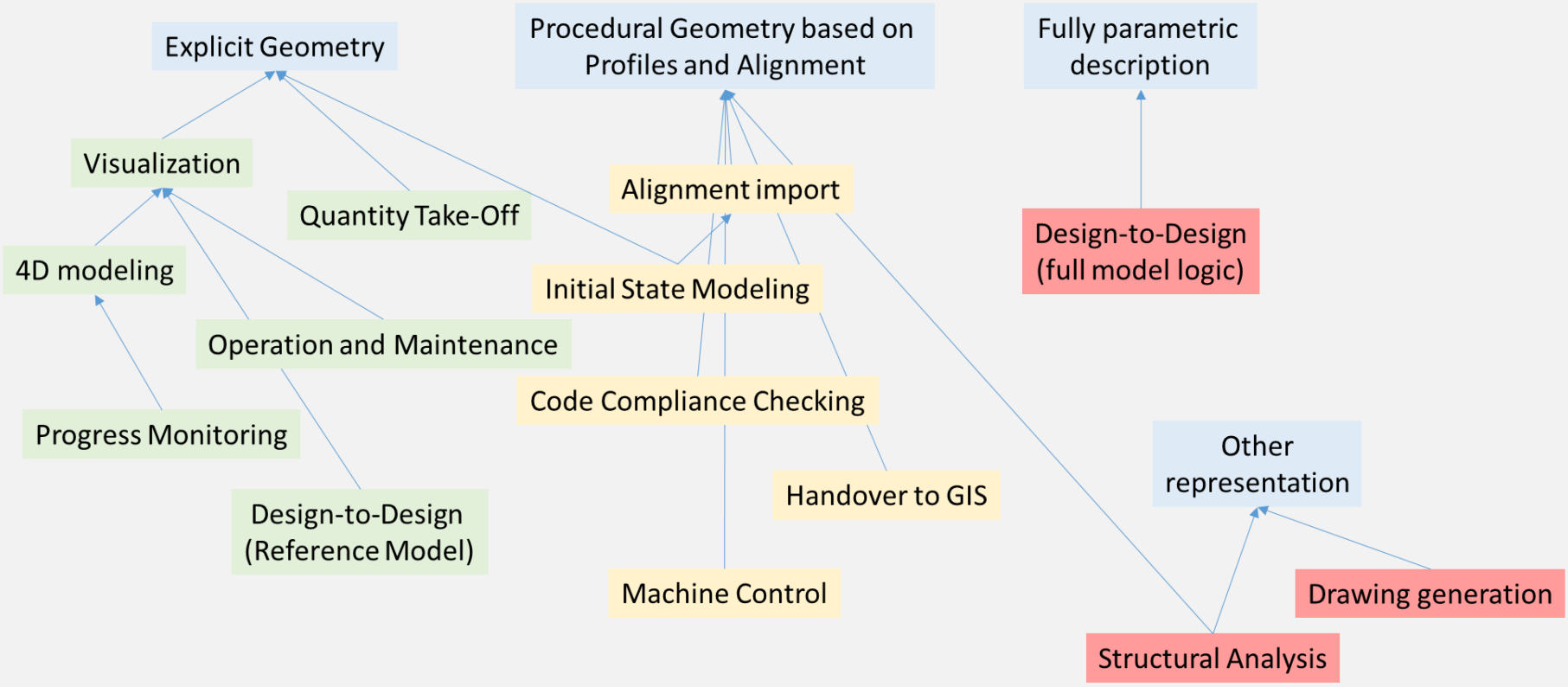


based on work by FHWA

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Anforderungsanalyse

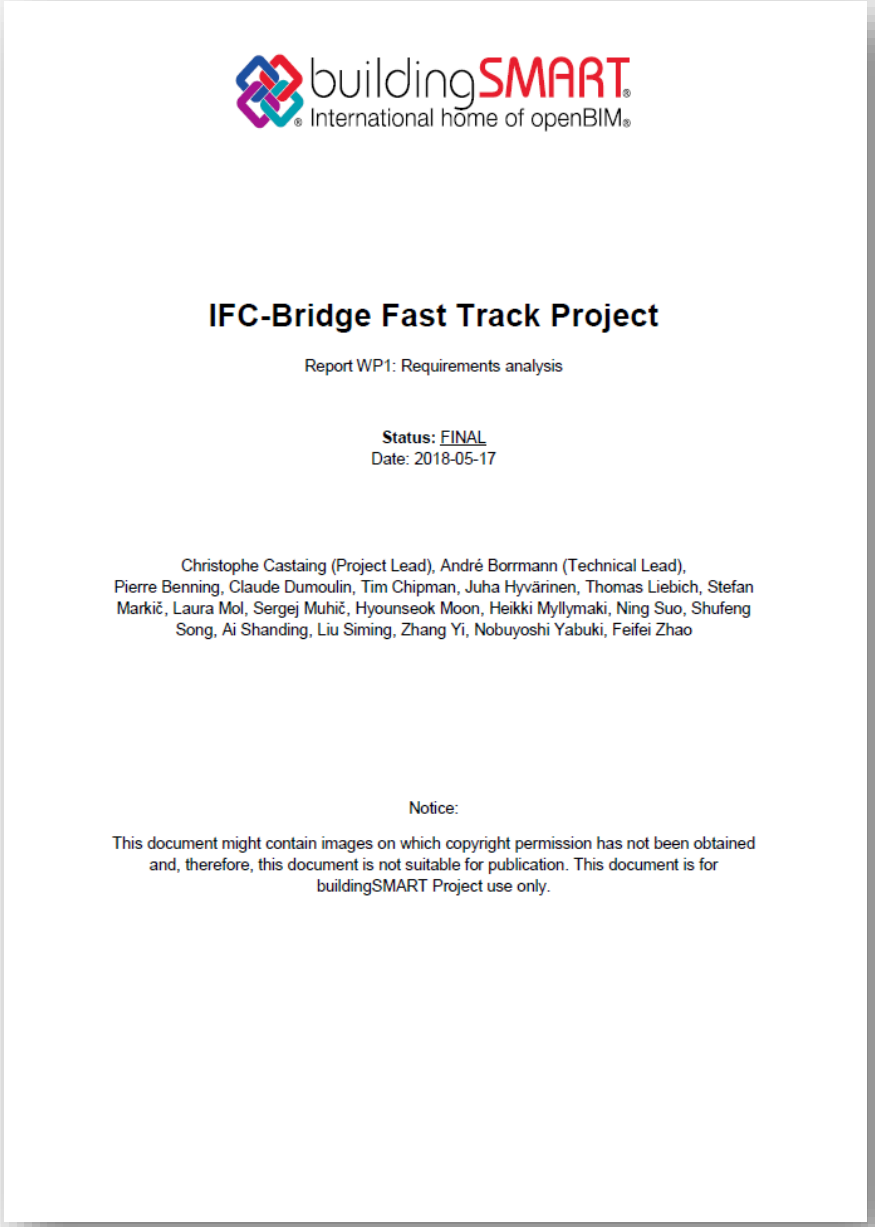
Geometrierepräsentationen für einzelne Anwendungsfälle



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Anforderungsanalyse

Final Report veröffentlicht in 05/2018



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IFC-Bridge Fast Track Project

Report WP1: Requirements analysis

Status: FINAL
Date: 2018-05-17

Christophe Castaing (Project Lead), André Borrmann (Technical Lead),
Pierre Benning, Claude Dumoulin, Tim Chipman, Juha Hyvärinen, Thomas Liebich, Stefan Markič, Laura Mol, Sergej Muhič, Hyounseok Moon, Heikki Myllymaki, Ning Suo, Shufeng Song, Ai Shanding, Liu Siming, Zhang Yi, Nobuyoshi Yabuki, Feifei Zhao

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https://buildingsmart.sharefile.com/d-s94ad76cdb564b73a

Taxonomie

Gemeinsames Vokabular für Brückenelemente

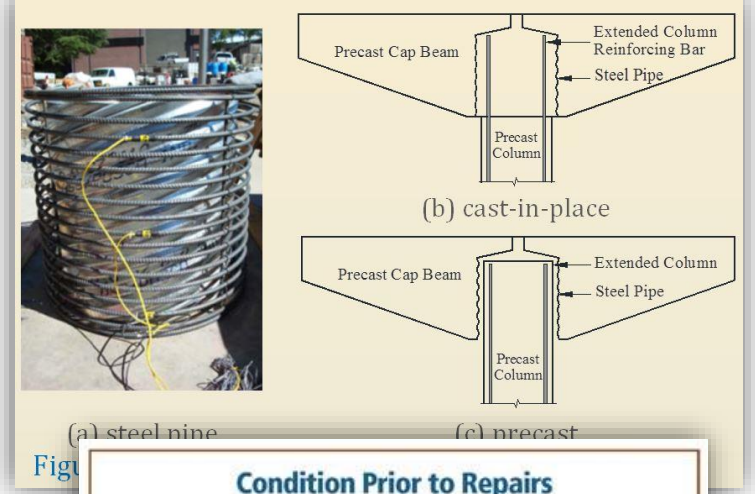
Bridge System Breakdown Structure

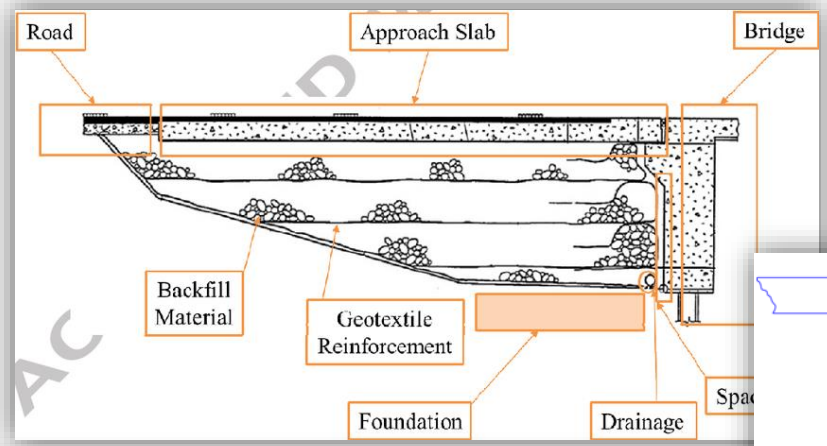
					Origin / Modeled in						
Level 1	Level 2	Level 3	Level 4	IfcBridge	MinND	FHWA	US-BrIM	CRBIM	Comments	Existing IFC Entity	New IFC Entity
Bridge											
	Roadway										
		Approach Slab								IfcSlab	
	Superstructure										
		Barrier									
		Bearing								IfcMechanicalFastener	
		Cross frame								IfcPlate	
		Deck							SM: Also called slab; Should come from IfcRoad/IfcRail	IfcSlab	
		Diaphragm							AB: Not sure; SM: About the name - it is correct (see p. 46/160).		
		Girder								IfcBeam	
			Steel Grider								
			Concrete Girder								
			Wood Girder								
			Truss						SM: with chords, stiffeners etc.		
			Combination						SM: with shear studs etc?		
		Haunch							AB: Not sure if this is an element		
		Median									
		Parapet							SM: also called apron	IfcWall.PARAPET	
		Pavement									
		Railing								IfcRailing	
		Sidewalk									
	Substructure										
		Abutment								IfcWall	
			Wing Wall						SM: can come with stairs		
			Head Wall								

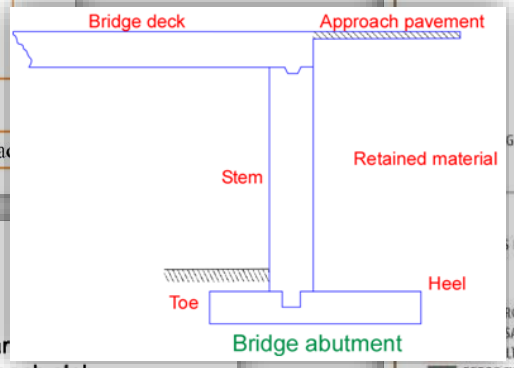
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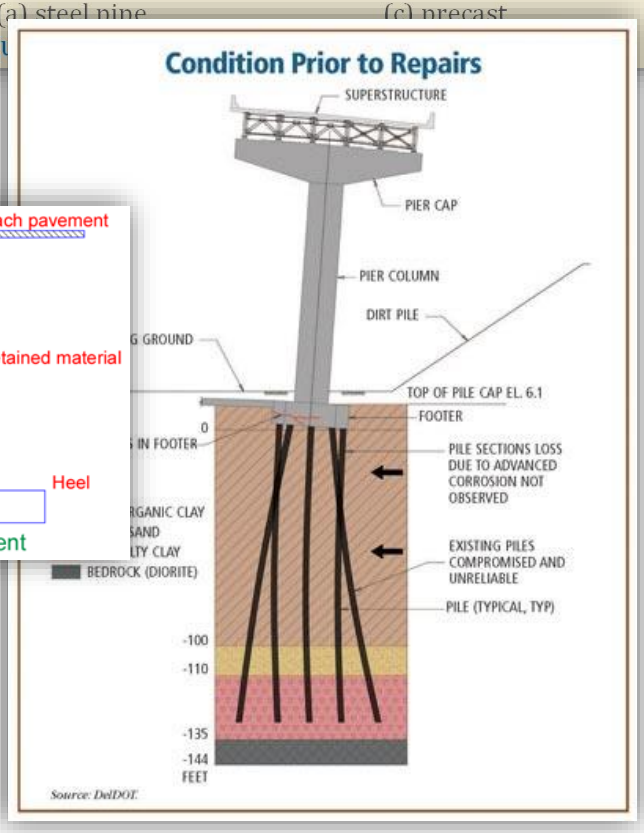
Taxonomie

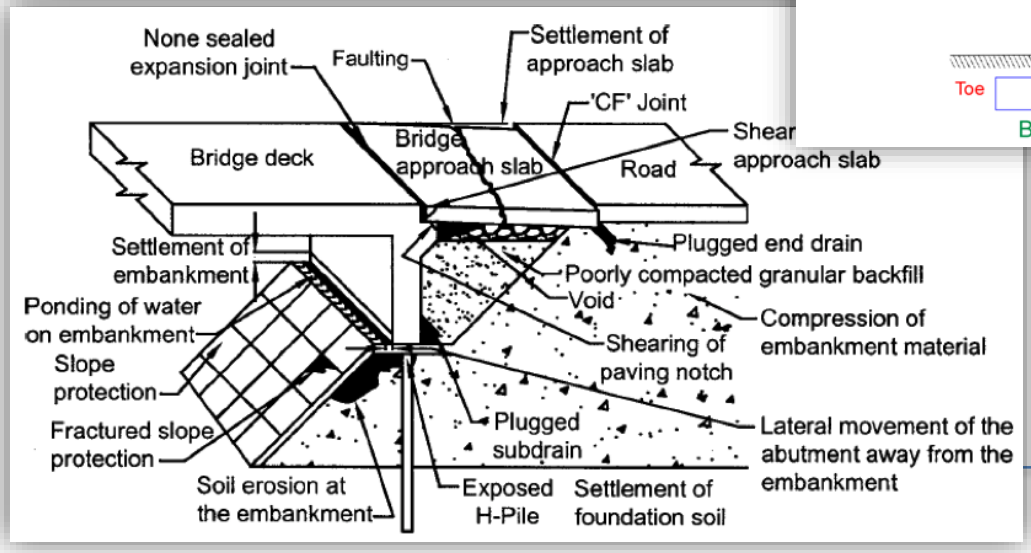
Nutzung von Fachbüchern, Abbildungen, Fotos





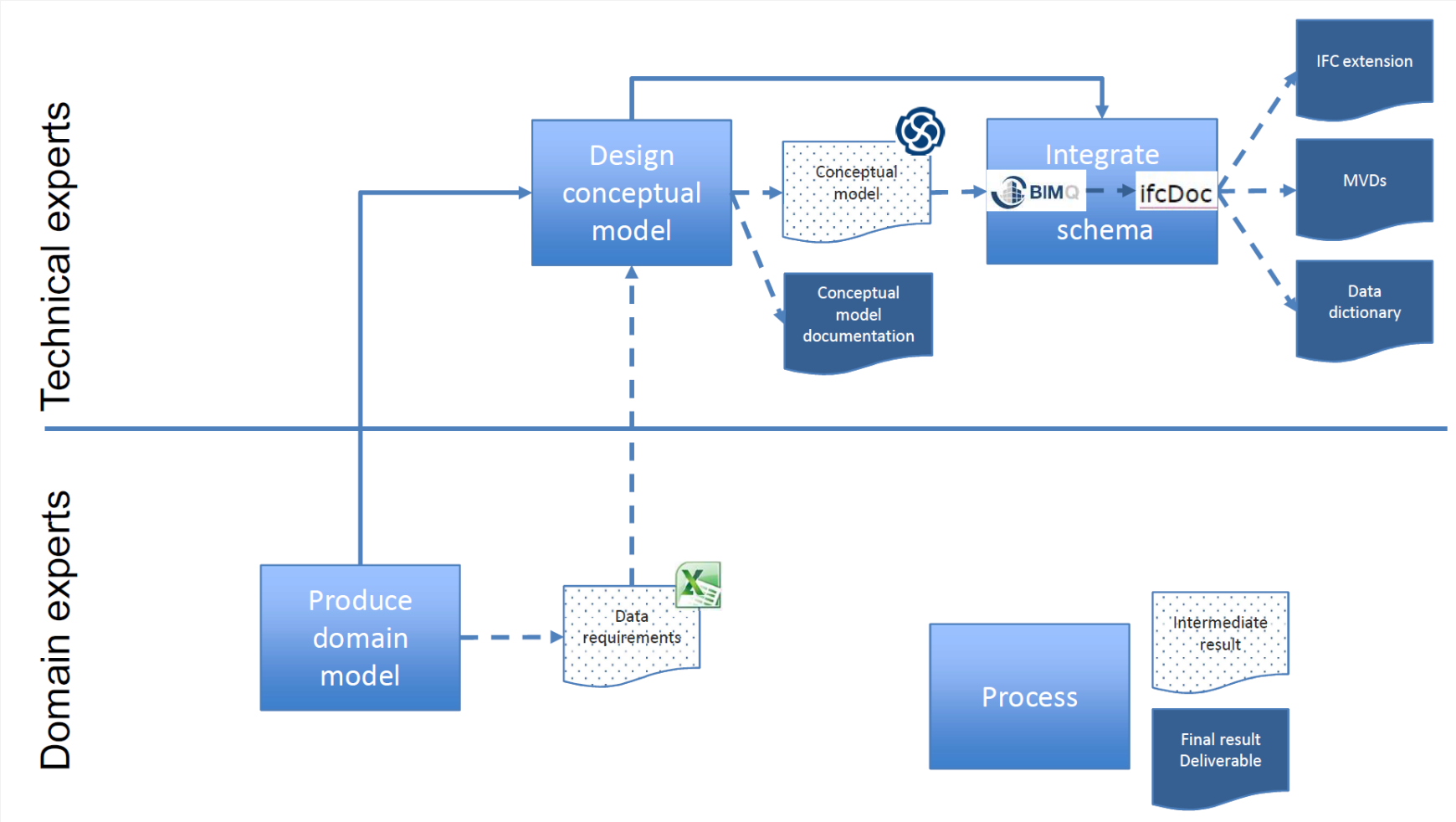






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Prozess



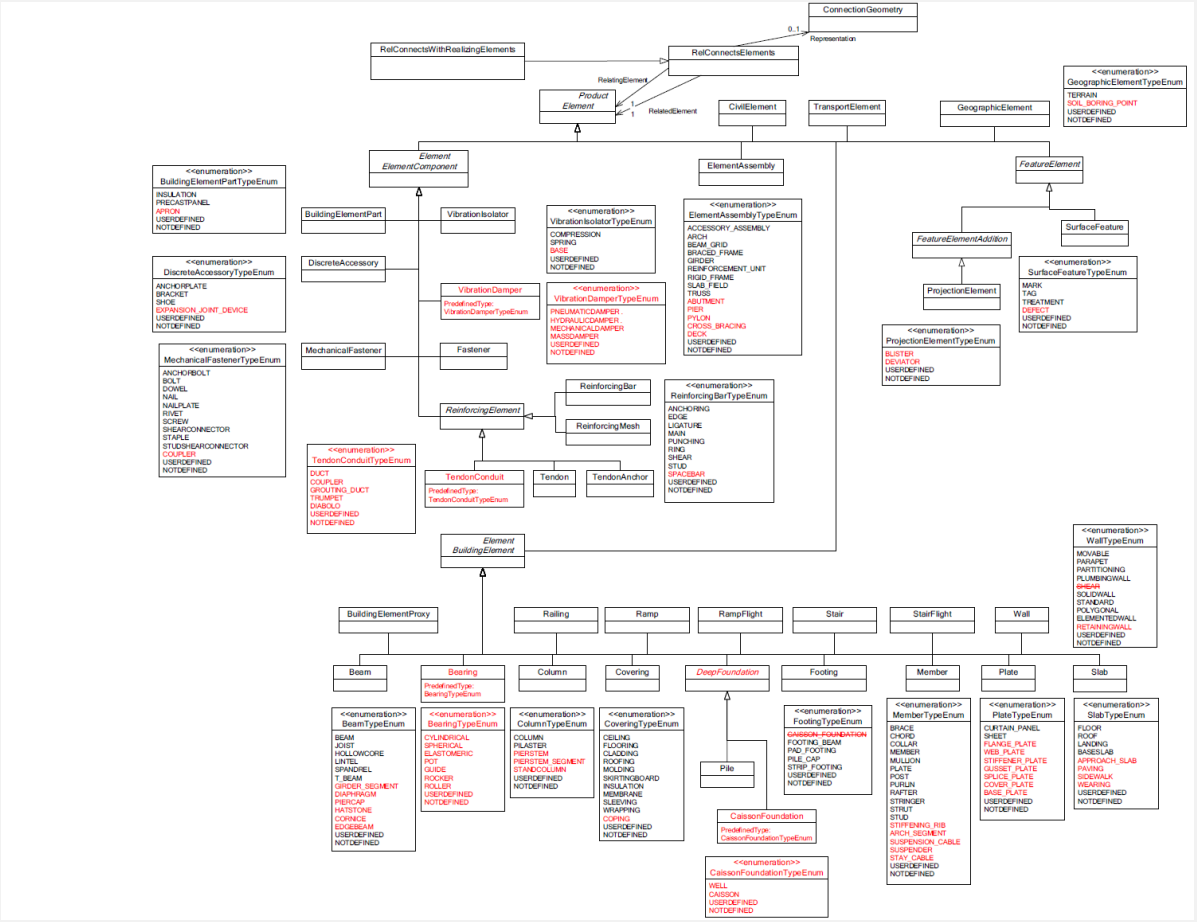
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Konzeptionelles Modell

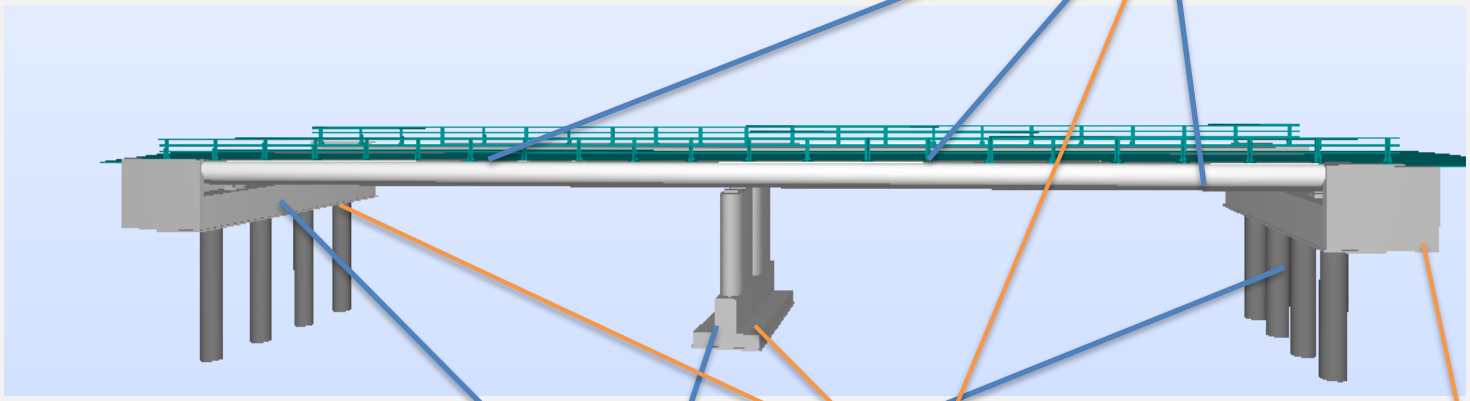
Modellierung der vorgeschlagenen IFC-Erweiterung in graphischer Notation

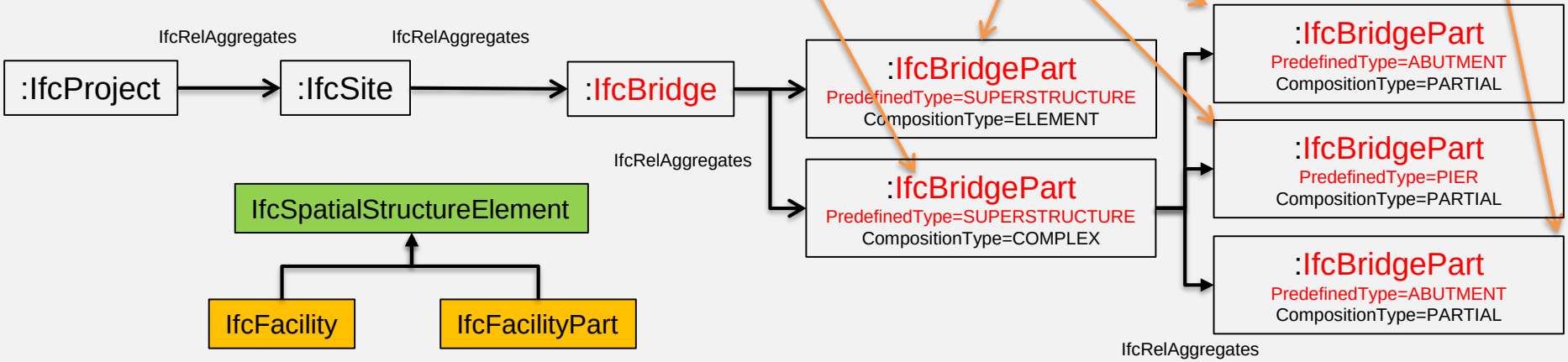
- in Übereinstimmung mit **IFC-Infra extension guidelines**
- nur wenige neue Klassen
- Erweiterung bestehender Klassen um neue vordefinierte Klassen



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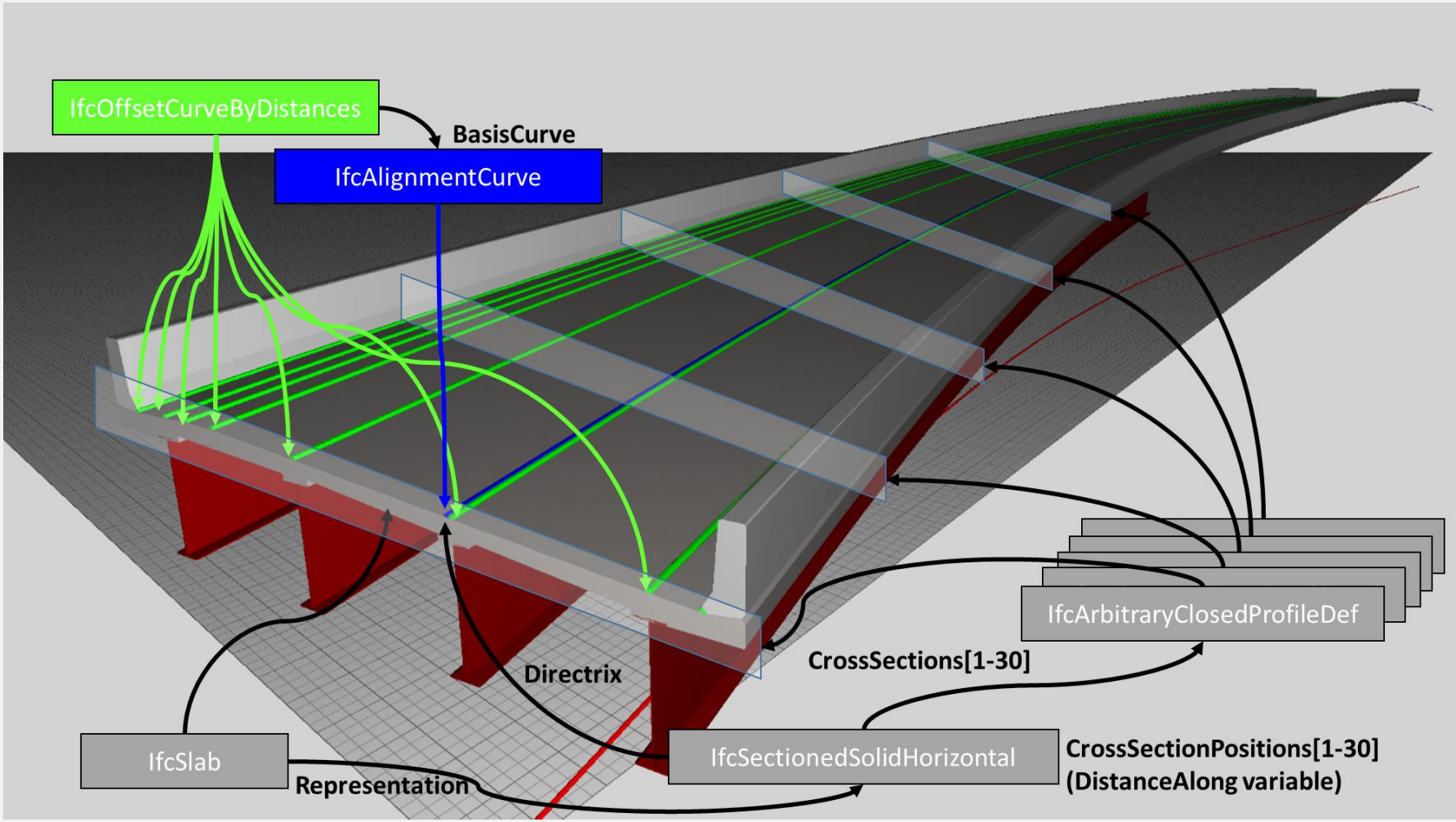
Konzeptionelles Modell: Räumliche Struktur





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Neue geometrische Repräsentation

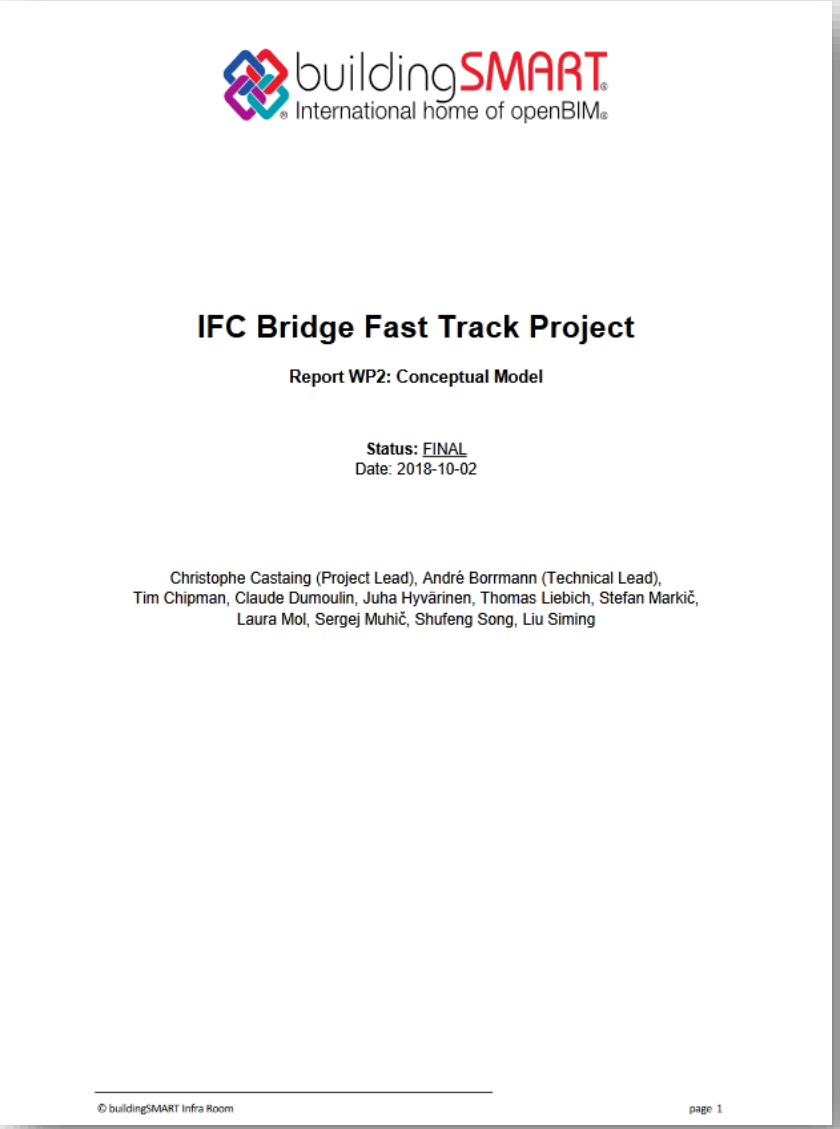


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Konzeptionelles Modell

Final Report

- veröffentlicht am 02.10.2018



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IFC Bridge Fast Track Project

Report WP2: Conceptual Model

Status: FINAL
Date: 2018-10-02

Christophe Castaing (Project Lead), André Borrmann (Technical Lead),
Tim Chipman, Claude Dumoulin, Juha Hyvärinen, Thomas Liebich, Stefan Markič,
Laura Mol, Sergej Muhič, Shufeng Song, Liu Siming

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Schema Erweiterung und Dokumentation

IFC 4x2 Draft 1 (30.10.2018) → Draft 2 (30.01.2019) → Final Draft (25.03.2019)

```
    PredefinedType : OPTIONAL IfcBeamTypeEnum;
 WHERE
    CorrectPredefinedType : NOT(EXISTS(PredefinedType)) OR
 (PredefinedType <> IfcBeamTypeEnum.USERDEFINED) OR
 ((PredefinedType = IfcBeamTypeEnum.USERDEFINED) AND EXISTS (SELF\IfcObject.ObjectType));
    CorrectTypeAssigned : (SIZEOF(IsTypedBy) = 0) OR
  ('IFC4X2 DRAFT 1.IFCBEAMTYPE' IN TYPEOF(SELF\IfcObject.IsTypedBy[1].RelatingType));
END_ENTITY;

ENTITY IfcBeamStandardCase
 SUBTYPE OF (IfcBeam);
 WHERE
    HasMaterialProfileSetUsage : SIZEOF (QUERY(temp <* USEDIN(SELF, 'IFC4X2 DRAFT 1.IFCRELASSOCIATES.RELATEDOBJECTS') |
              ('IFC4X2 DRAFT 1.IFCRELASSOCIATESMATERIAL' IN TYPEOF(temp)) AND
              ('IFC4X2 DRAFT 1.IFCMATERIALPROFILESETUSAGE' IN TYPEOF(temp.RelatingMaterial))
              )) = 1;
END_ENTITY;

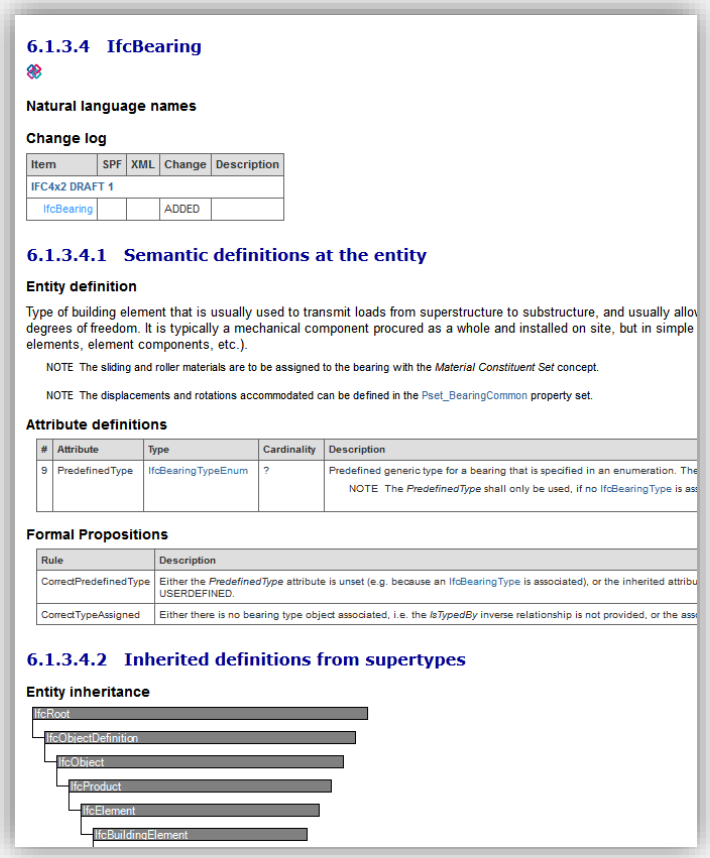
ENTITY IfcBeamType
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 WHERE
    CorrectPredefinedType : (PredefinedType <> IfcBeamTypeEnum.USERDEFINED) OR
((PredefinedType = IfcBeamTypeEnum.USERDEFINED) AND EXISTS(SELF\IfcElementType.ElementType));
END_ENTITY;

ENTITY IfcBearing
 SUBTYPE OF (IfcBuildingElement);
    PredefinedType : OPTIONAL IfcBearingTypeEnum;
 WHERE
    CorrectPredefinedType : NOT(EXISTS(PredefinedType)) OR
 (PredefinedType <> IfcBearingTypeEnum.USERDEFINED) OR
 ((PredefinedType = IfcBearingTypeEnum.USERDEFINED) AND EXISTS (SELF\IfcObject.ObjectType));
    CorrectTypeAssigned : (SIZEOF(IsTypedBy) = 0) OR
  ('IFC4X2 DRAFT 1.IFCBEARINGTYPE' IN TYPEOF(SELF\IfcObject.IsTypedBy[1].RelatingType));
END_ENTITY;

ENTITY IfcBearingType
 SUBTYPE OF (IfcBuildingElementType);
    PredefinedType : IfcBearingTypeEnum;
 WHERE
    CorrectPredefinedType : (PredefinedType <> IfcBearingTypeEnum.USERDEFINED) OR
((PredefinedType = IfcBearingTypeEnum.USERDEFINED) AND EXISTS(SELF\IfcElementType.ElementType));
END_ENTITY;

ENTITY IfcBlobTexture
 SUBTYPE OF (IfcSurfaceTexture);
    RasterFormat : IfcIdentifier;
    RasterCode : IfcBinary;
 WHERE
    SupportedRasterFormat : SELF.RasterFormat IN ['BMP', 'JPG', 'GIF', 'PNG'];
    RasterCodeByteStream : BLENGTH(RasterCode) MOD 8 = 0;
END_ENTITY;

ENTITY IfcBlock
 SUBTYPE OF (IfcCsgPrimitive3D);
    XLength : IfcPositiveLengthMeasure;
    YLength : IfcPositiveLengthMeasure;
    ZLength : IfcPositiveLengthMeasure;
END_ENTITY;
```



6.1.3.4 IfcBearing

Natural language names

Change log

Item	SPF	XML	Change	Description
IFC4x2 DRAFT 1				
IfcBearing			ADDED	

6.1.3.4.1 Semantic definitions at the entity

Entity definition

Type of building element that is usually used to transmit loads from superstructure to substructure, and usually allo
degrees of freedom. It is typically a mechanical component procured as a whole and installed on site, but in simple
elements, element components, etc.).

NOTE The sliding and roller materials are to be assigned to the bearing with the *Material Constituent Set* concept.

NOTE The displacements and rotations accommodated can be defined in the Pset_BearingCommon property set.

Attribute definitions

#	Attribute	Type	Cardinality	Description
9	PredefinedType	IfcBearingTypeEnum	?	Predefined generic type for a bearing that is specified in an enumeration. The NOTE The *PredefinedType* shall only be used, if no IfcBearingType is as

Formal Propositions

Rule	Description
CorrectPredefinedType	Either the *PredefinedType* attribute is unset (e.g. because an IfcBearingType is associated), or the inherited attribu USERDEFINED.
CorrectTypeAssigned	Either there is no bearing type object associated, i.e. the *IsTypedBy* inverse relationship is not provided, or the ass

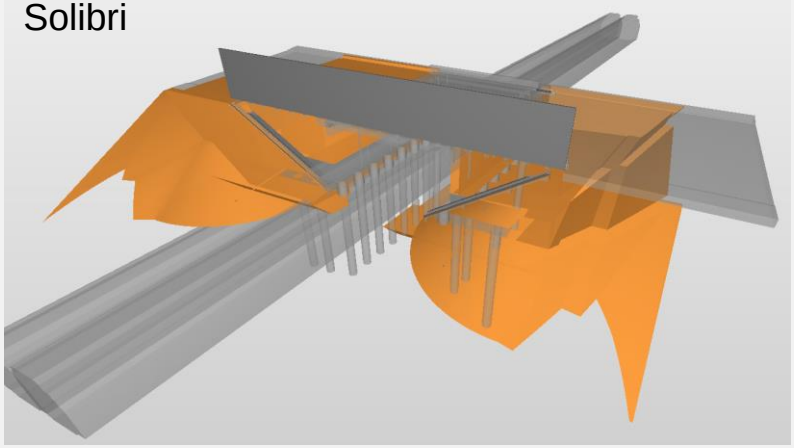
6.1.3.4.2 Inherited definitions from supertypes

Entity inheritance

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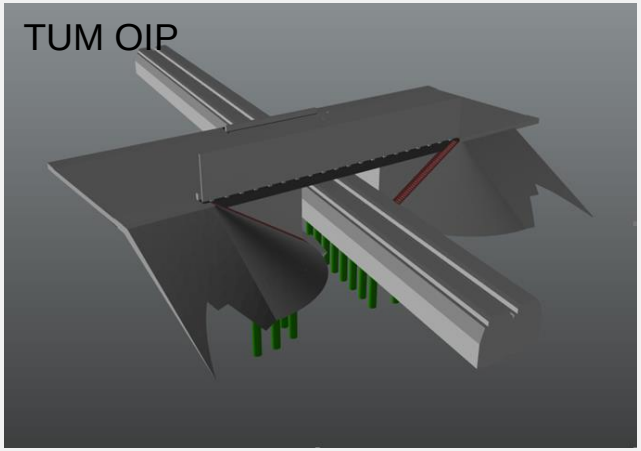
Beispieldateien

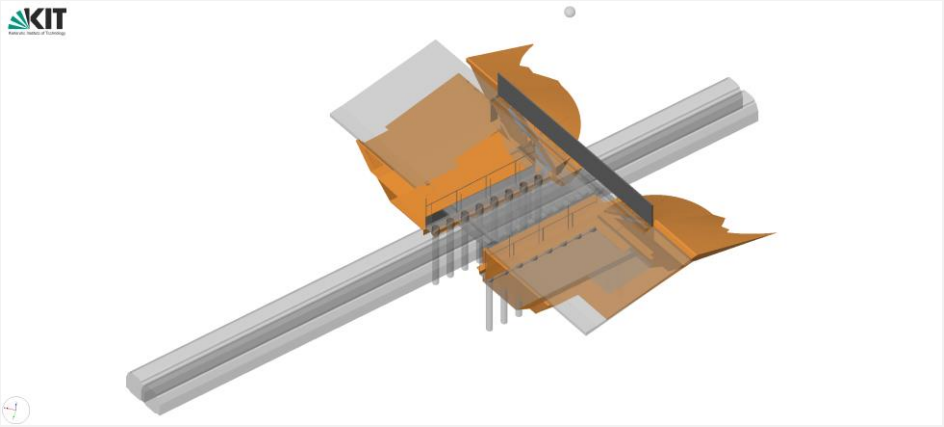
Solibri



- Spatial Structure: IfcFacility / IfcBridge
- Predefined Types
- Brep geometry

TUM OIP

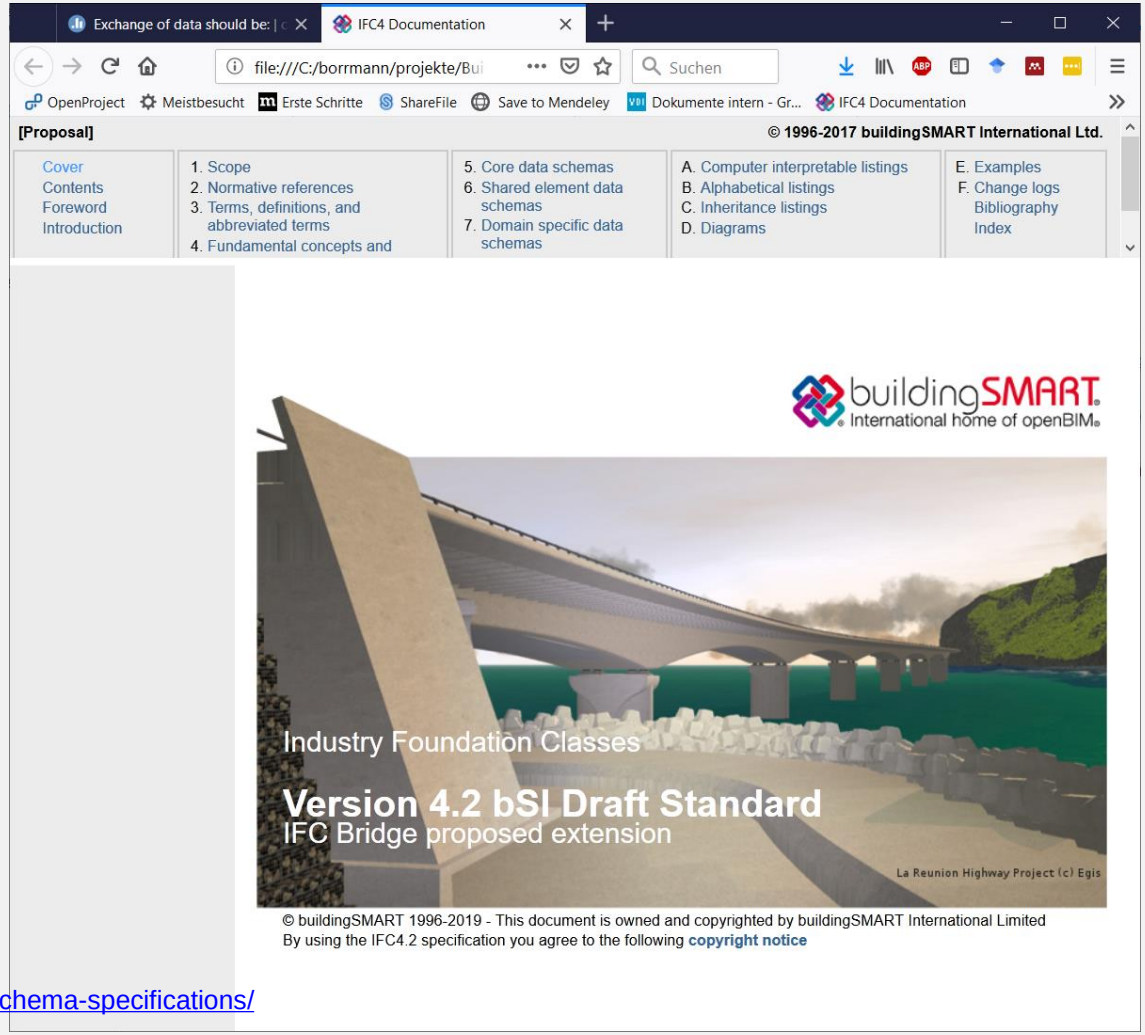




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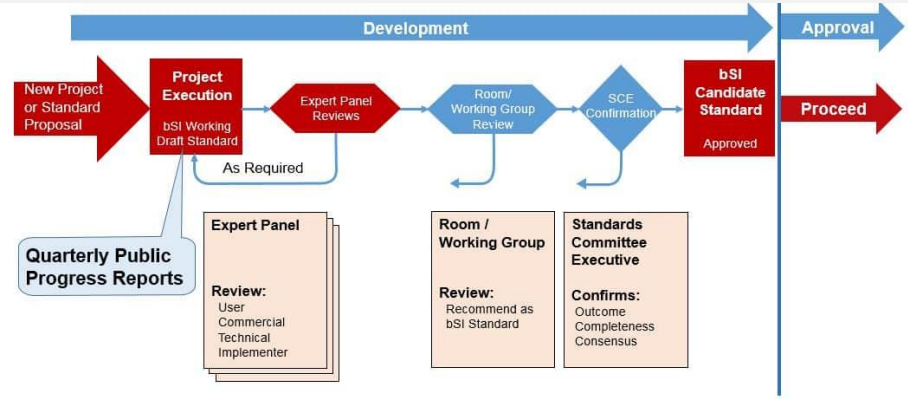
bSI Draft Standard IFC 4.2

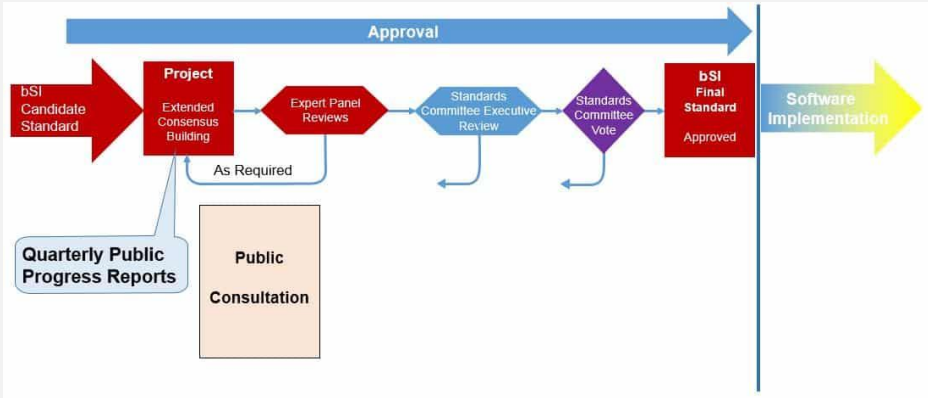
technical.buildingsmart.org



https://technical.buildingsmart.org/standards/ifc/ifc-schema-specifications/

Standard Adoption Process



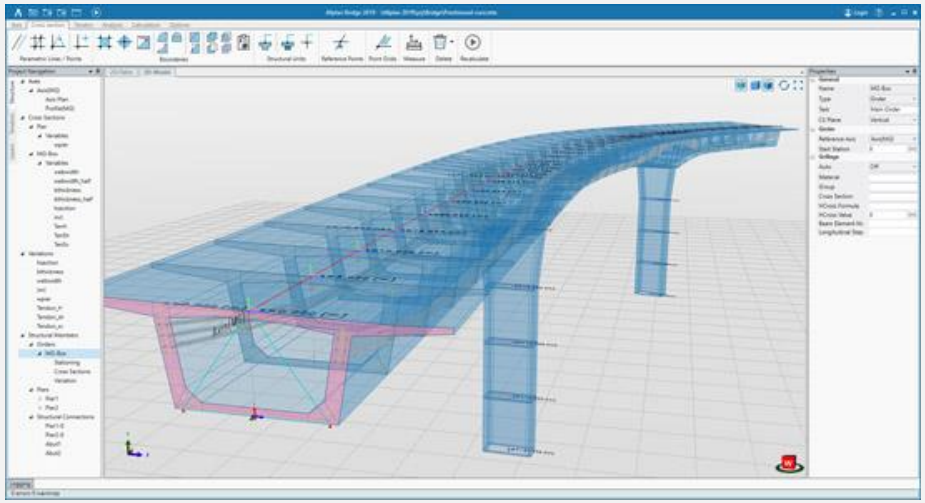


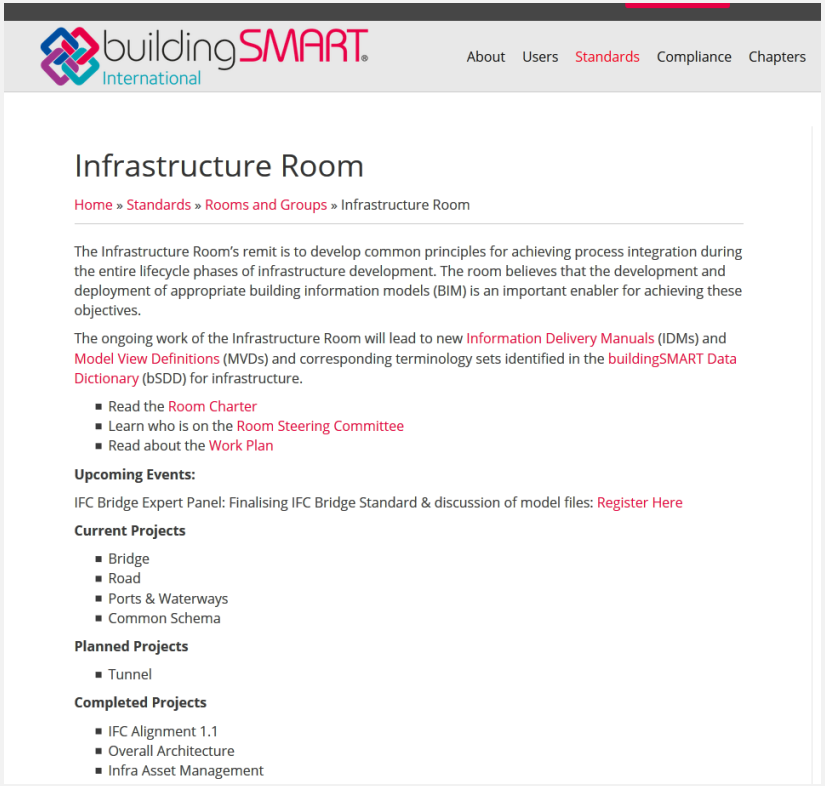
From	To	Voting & Notification
bSI Standards Proposal	bSI Working Draft Standard	SCE supports proposal. Simple majority of SC members and at least three Chapters or Members commit to take part and nominate experts.
bSI Working Draft Standard	bSI Draft Standard	Project consortia agree that the project's work plan is complete and that the consensus requirements have been met. No SC or SCE vote required.
bSI Draft Standard	bSI Candidate Standard	Consensus requirement for stage 2 demonstrated. SCE in favour. No serious opposition if it's going to be a final product for test implementation.
bSI Candidate Standard	bSI Final Standard	Consensus requirements for stage 3 demonstrated. Majority in SCE will forward it to SC. Circulation to SC 8 weeks. 65% of SC members in favor. Not more than 10% of total votes cast are negative.

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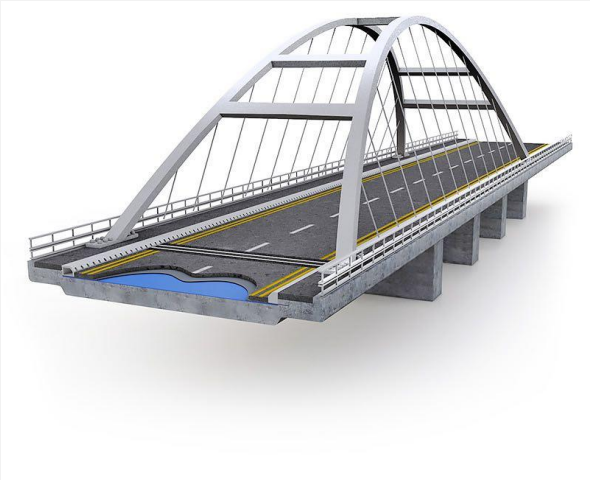
Nächste Schritte

- Implementierung durch die Softwarehersteller
- Zertifizierung durch buildingSMART



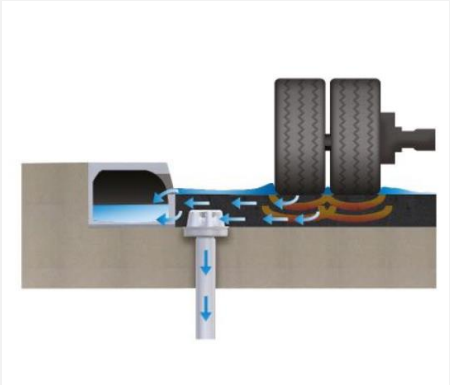


Noch nicht abgedeckt



Elemente

- Entwässerung
- Erdbau / Geotechnik
- Ausstattung
- (Schäden)



Anwendungsfälle

- Strukturanalyse
- Design-to-Design, etc.

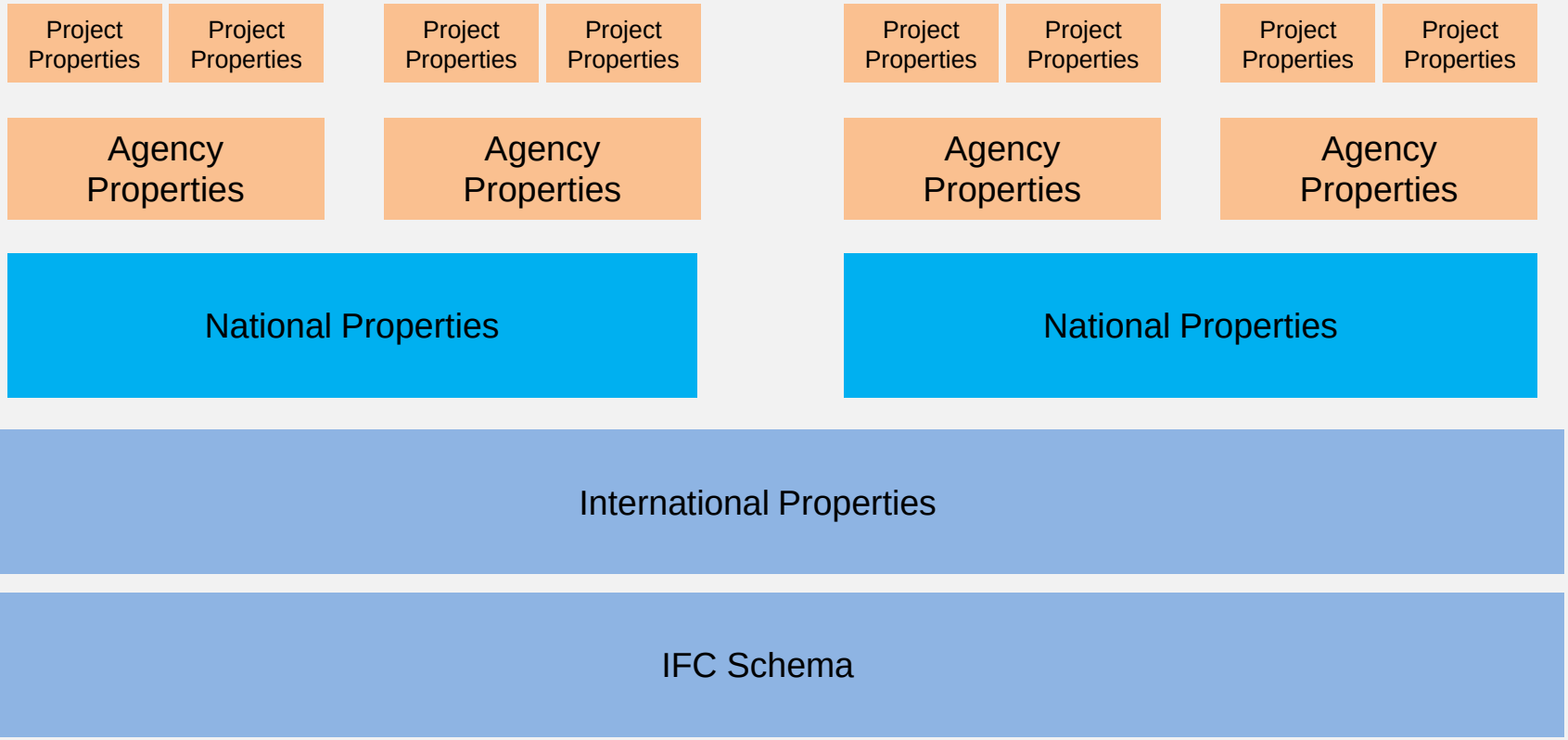


Bridge types

- Komplexere Brückentypen
- Holzbrücken, etc.

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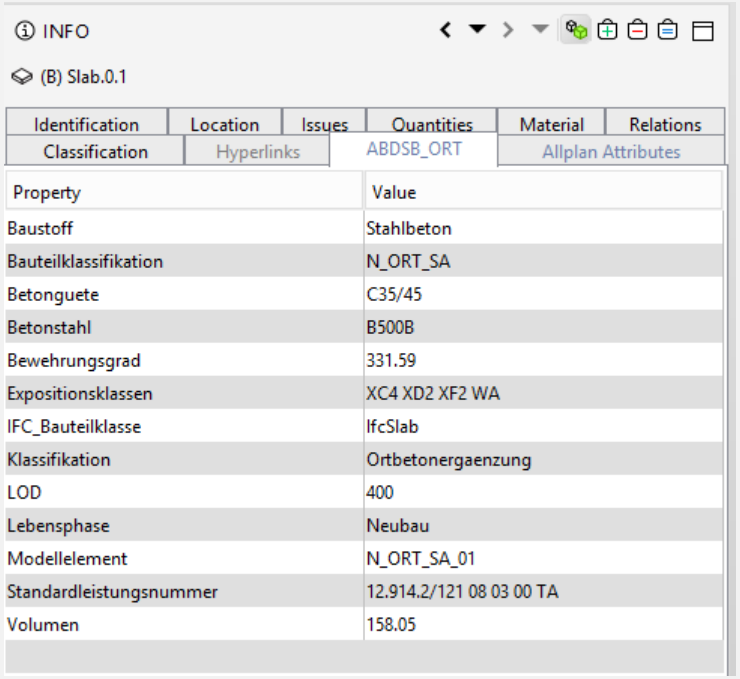
Properties



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Nächste Schritte auf nationaler Ebene

- Festlegung von Eigenschaftssätzen auf nationaler Ebene (oder Länderebene, oder AG-Ebene)
  - Vereinheitlichung wünschenswert
  - Berücksichtigung der ASB-ING
  - Zuordnung zu Leistungsphasen



Property	Value
Baustoff	Stahlbeton
Bauteilklassifikation	N_ORT_SA
Betonguete	C35/45
Betonstahl	B500B
Bewehrungsgrad	331.59
Expositionsklassen	XC4 XD2 XF2 WA
IFC_Bauteilklasse	IfcSlab
Klassifikation	Ortbetonergaenzung
LOD	400
Lebensphase	Neubau
Modellelement	N_ORT_SA_01
Standardleistungsnummer	12.914.2/121 08 03 00 TA
Volumen	158.05

- Vorschriften zu korrekten Nutzung der IFC-Erweiterung
  - Beispiel:
    Übergangskonstruktion → IfcDiscreteAccessory.EXPANSION_JOINT_DEVICE

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