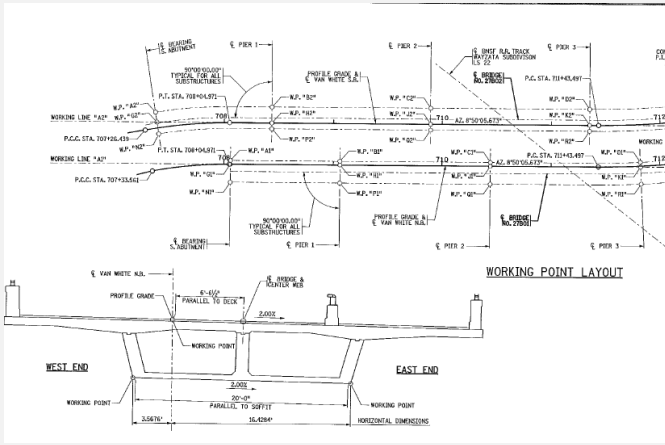
IFC-BRIDGE

PROJECT STATUS OVERVIEW

IFC-Bridge Project Team

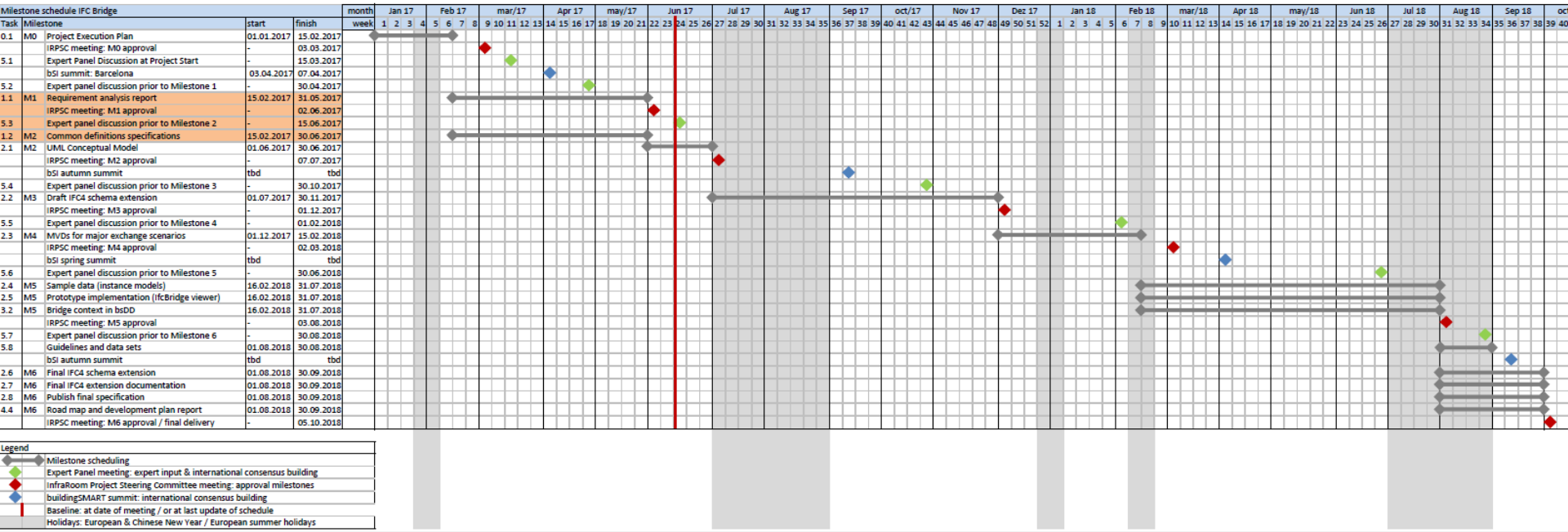
Project outline

1. Requirements analysis & scope definitions
2. Identify semantic elements and properties
   → Taxonomy
   → based on input from MiND, FHWA, KICT, CRBIM
3. Conceptual model
   → entities, relationships, properties based on IFC
4. Create Schema Extension
5. Validate Schema, create sample models
6. Publish Schema extension



11 Expert Panel Meetings (8 online)

Project Schedule



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

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

WP1: Bridge Type Coverage

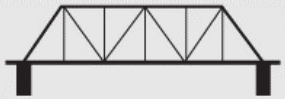
BRIDGE TYPES

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

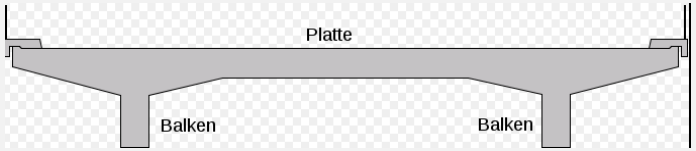


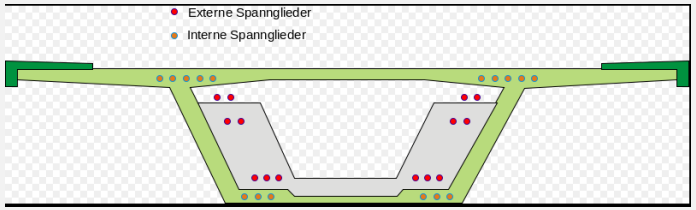



WP1: Bridge Type Coverage

Construction Type Covered

- Beam bridges
- Slab-girder bridges
- Box-girder bridges





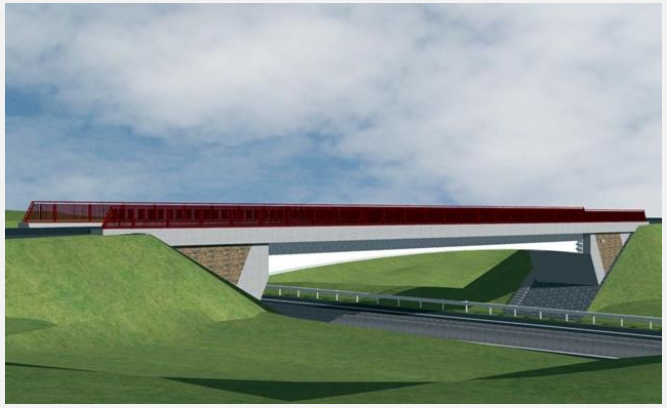
Superstructure Geometry

- Straight
- Haunched
- In curve

WP1: Bridge Type Coverage

Material

- Reinforced Concrete bridges
- Prestressed Concrete bridges
- Steel/Concrete Composite bridges
- Steel girder bridges
- Steel bridges



Use cases

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

Use cases

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

Use cases

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

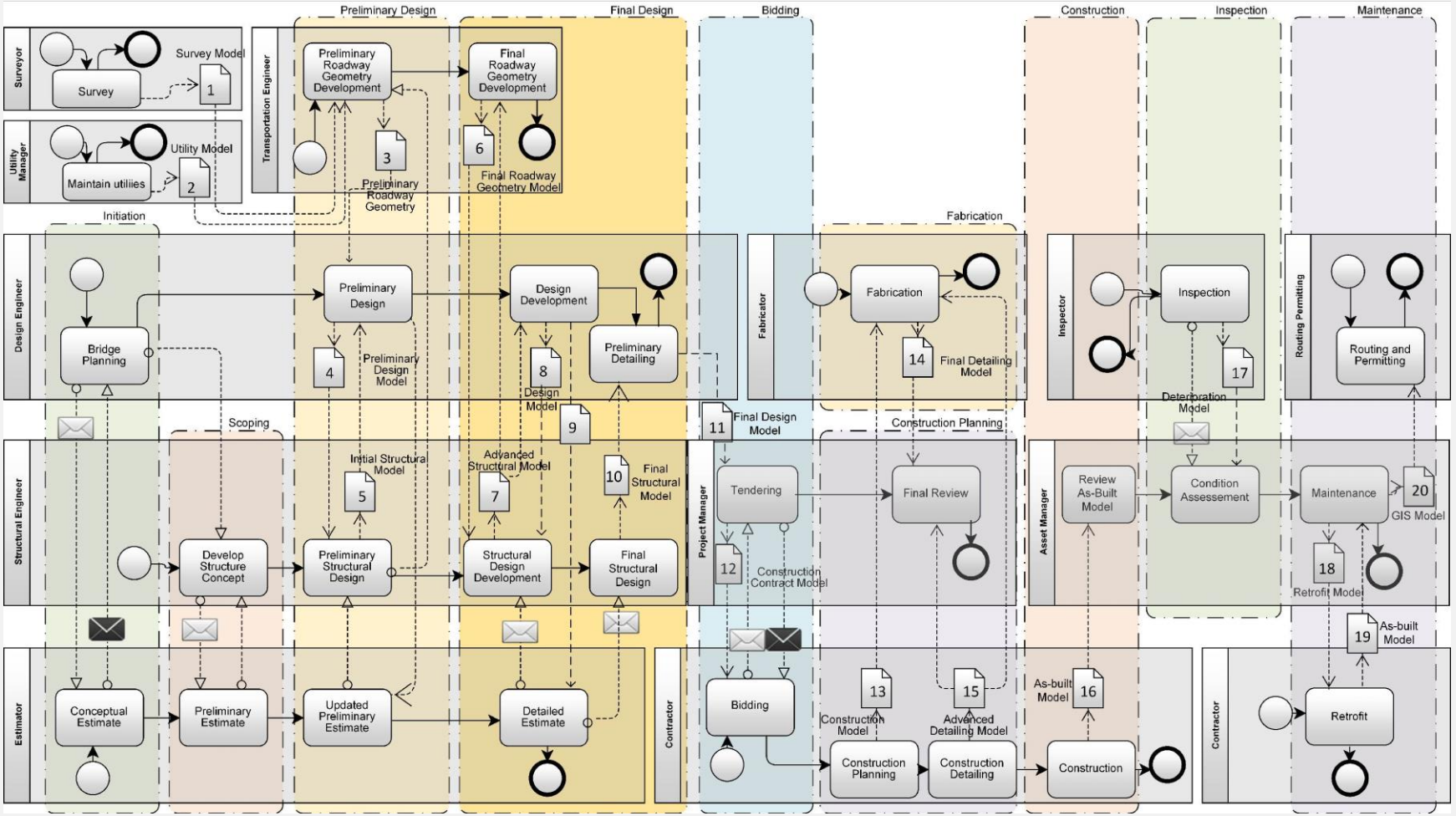
Use cases

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	?

Use cases

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	?

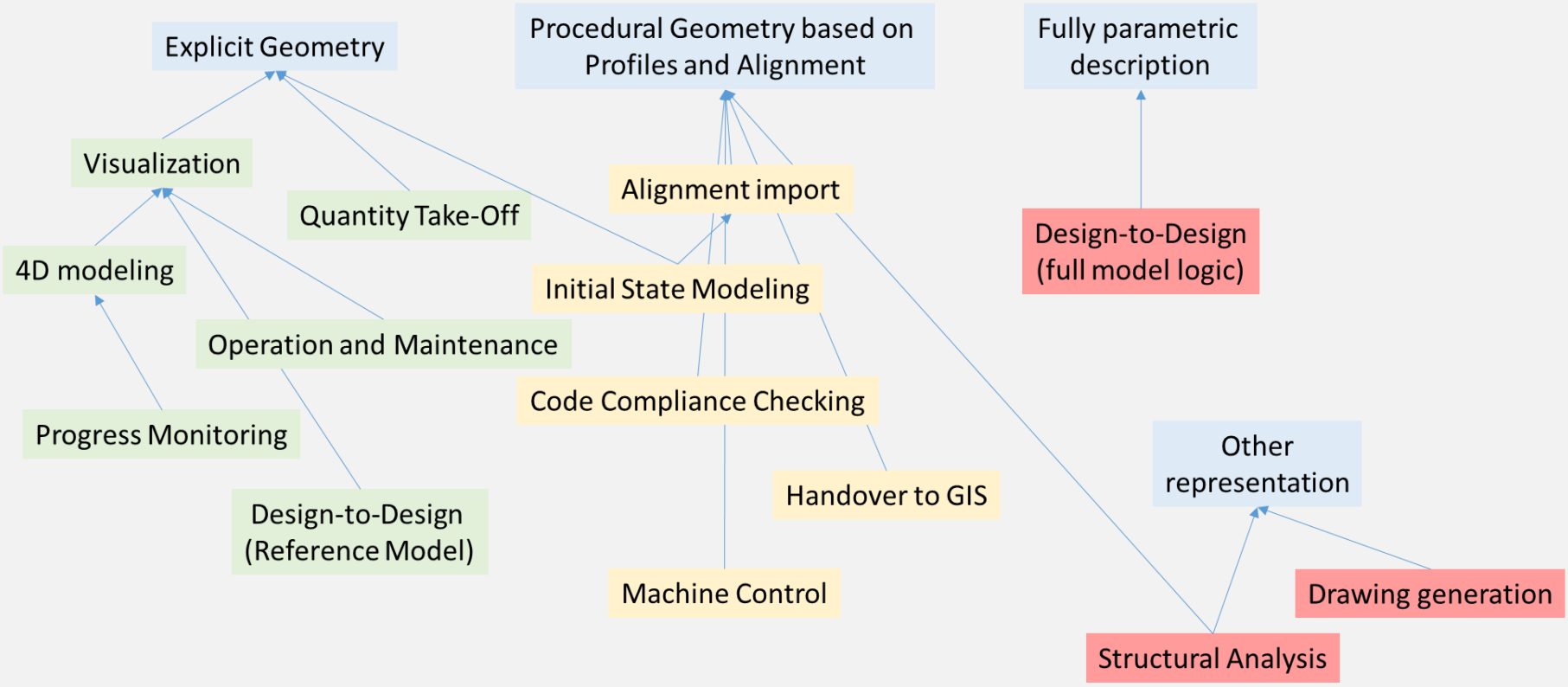
Reference Process Map



based on work by FHWA

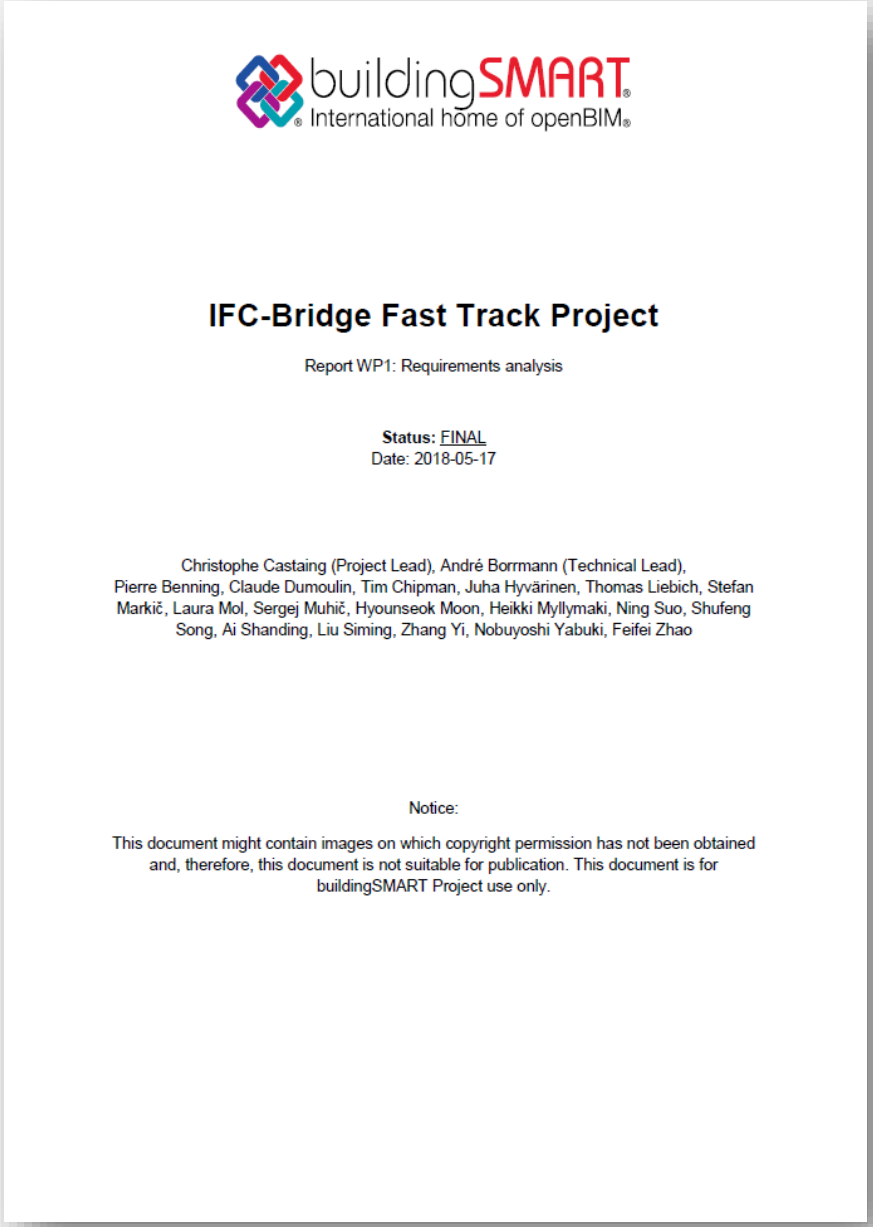
WP1: Requirements analysis

IFC-Bridge: Geometry required for use cases



Requirements

Final Report published 05/2018



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IFC-Bridge Fast Track Project

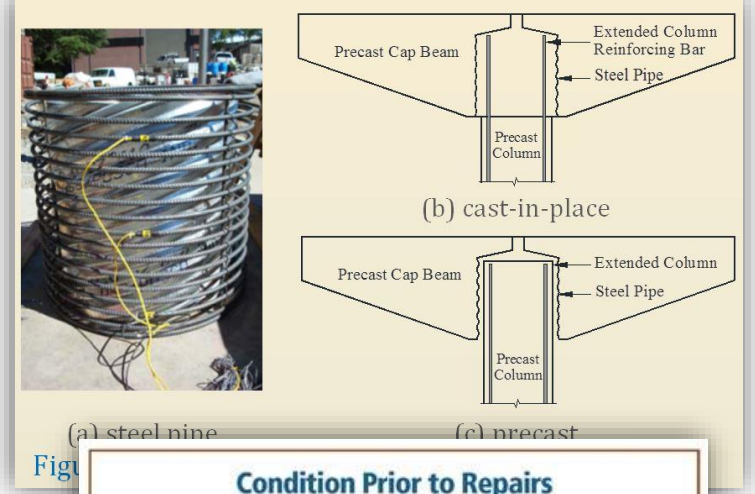
Report WP1: Requirements analysis

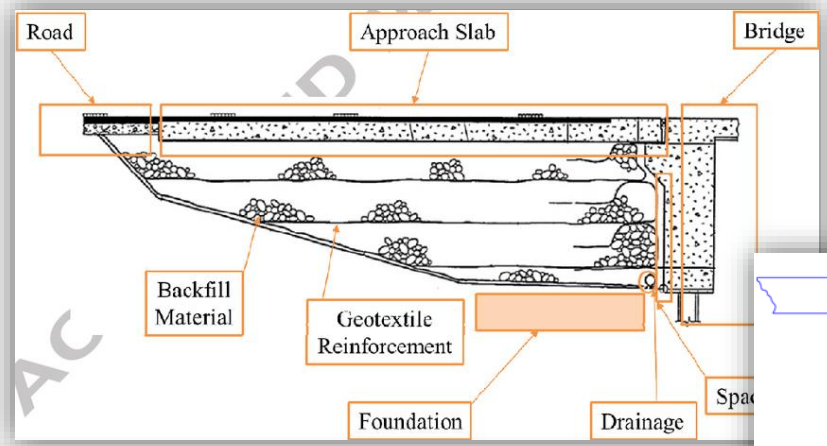
Status: FINAL
Date: 2018-05-17

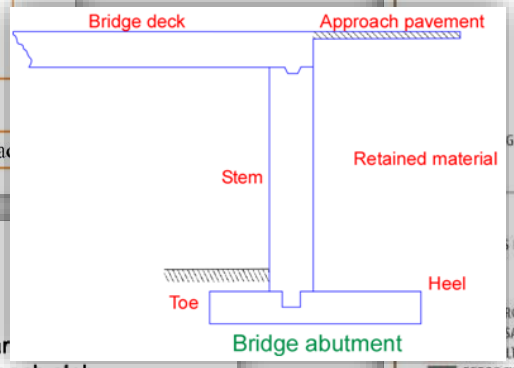
Christophe Castaing (Project Lead), André Borrmann (Technical Lead),
Pierre Benning, Claude Dumoulin, Tim Chipman, Juha Hyvärinen, Thomas Liebich, Stefan Markič, Laura Mol, Sergej Muhič, Hyounseok Moon, Heikki Myllymaki, Ning Suo, Shufeng Song, Ai Shanding, Liu Siming, Zhang Yi, Nobuyoshi Yabuki, Feifei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

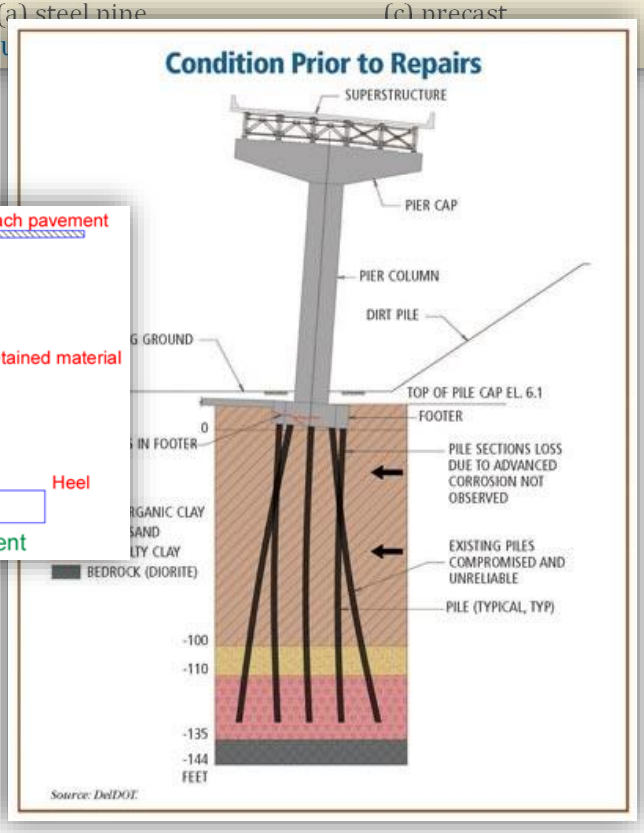
Taxonomy

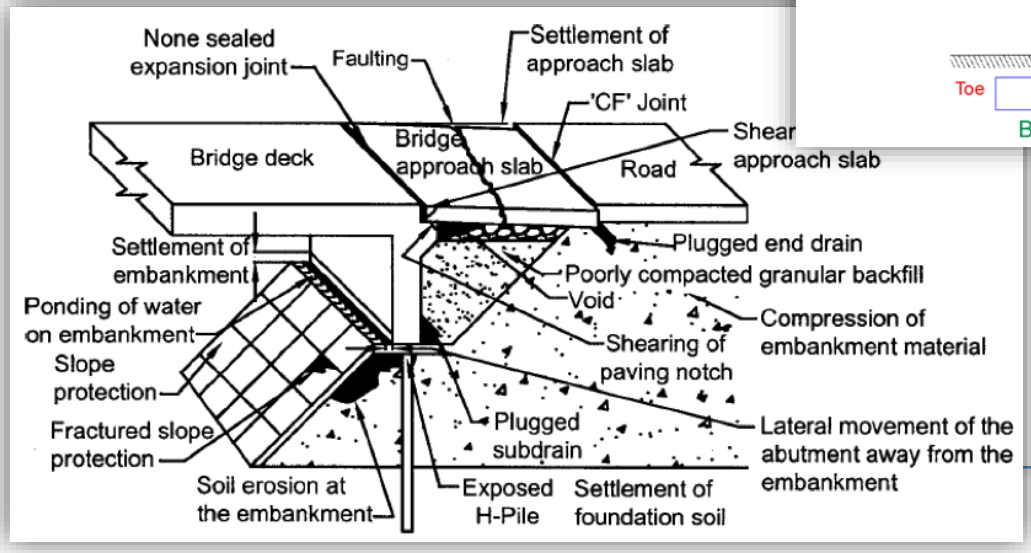
Established joint vocabulary for all bridge items







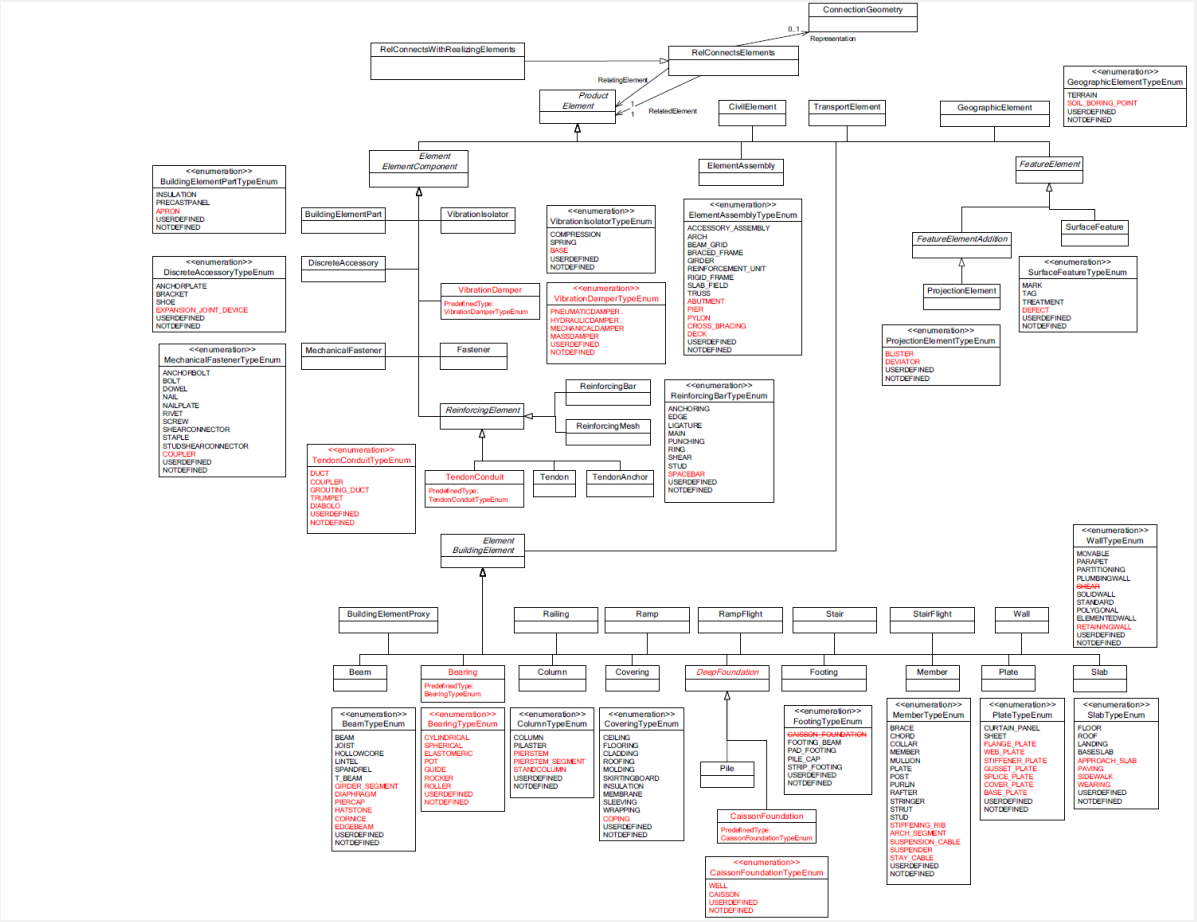




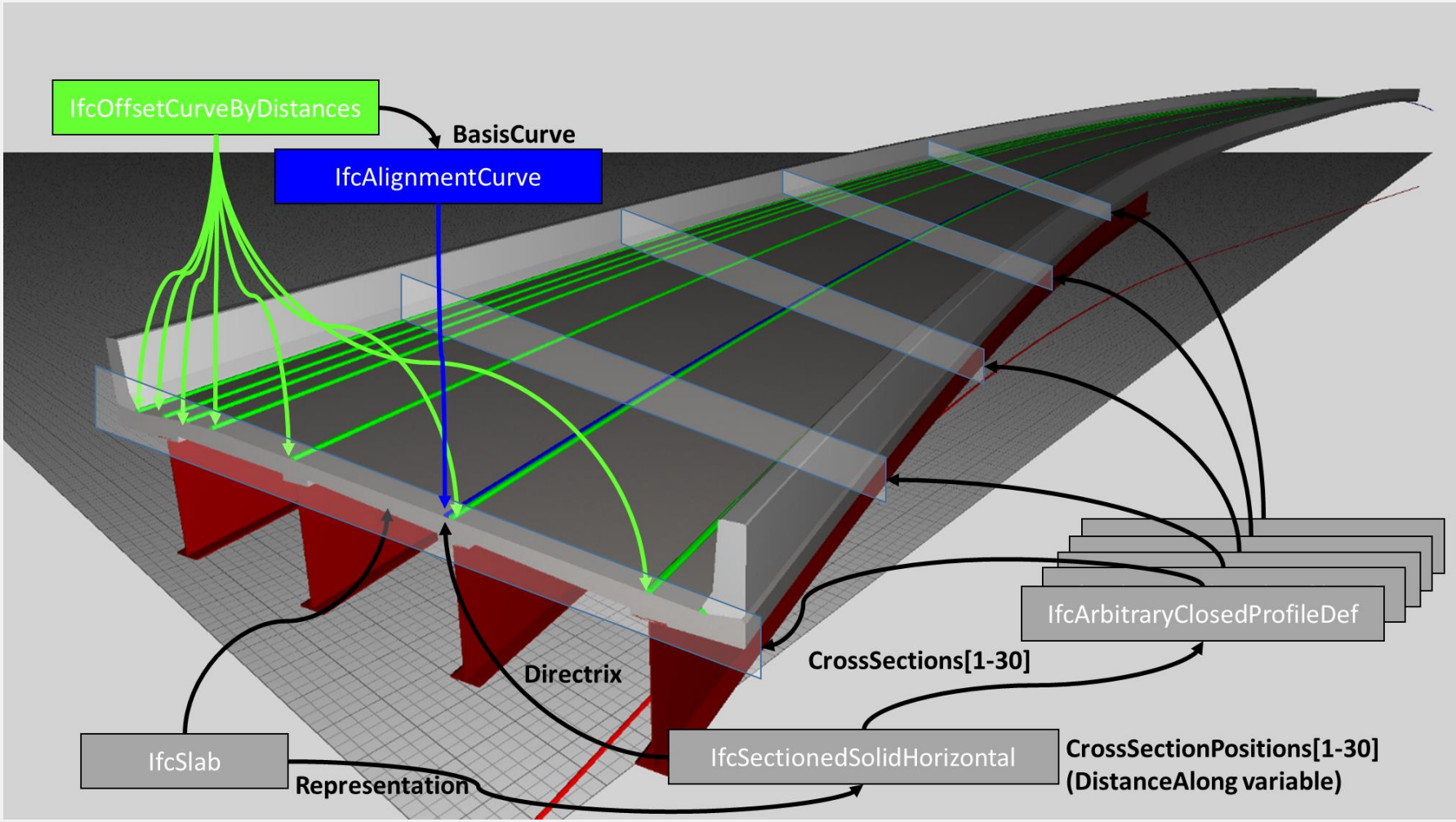
Conceptual Model

Conceptual model of the IFC Schema extension

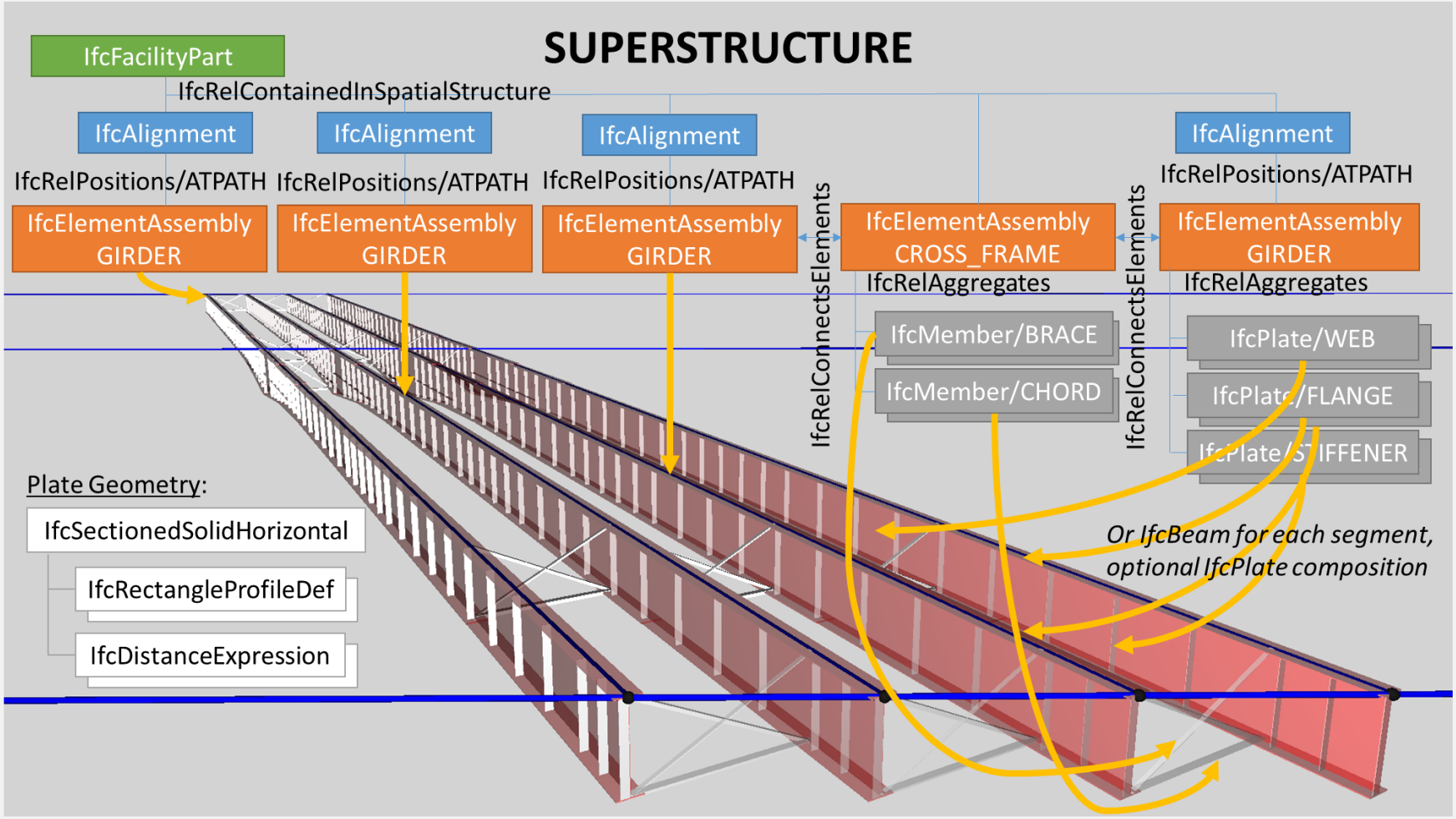
- conformance with IFC-Infra extension guidelines
- only very few new classes
- extension of the predefined types in many classes



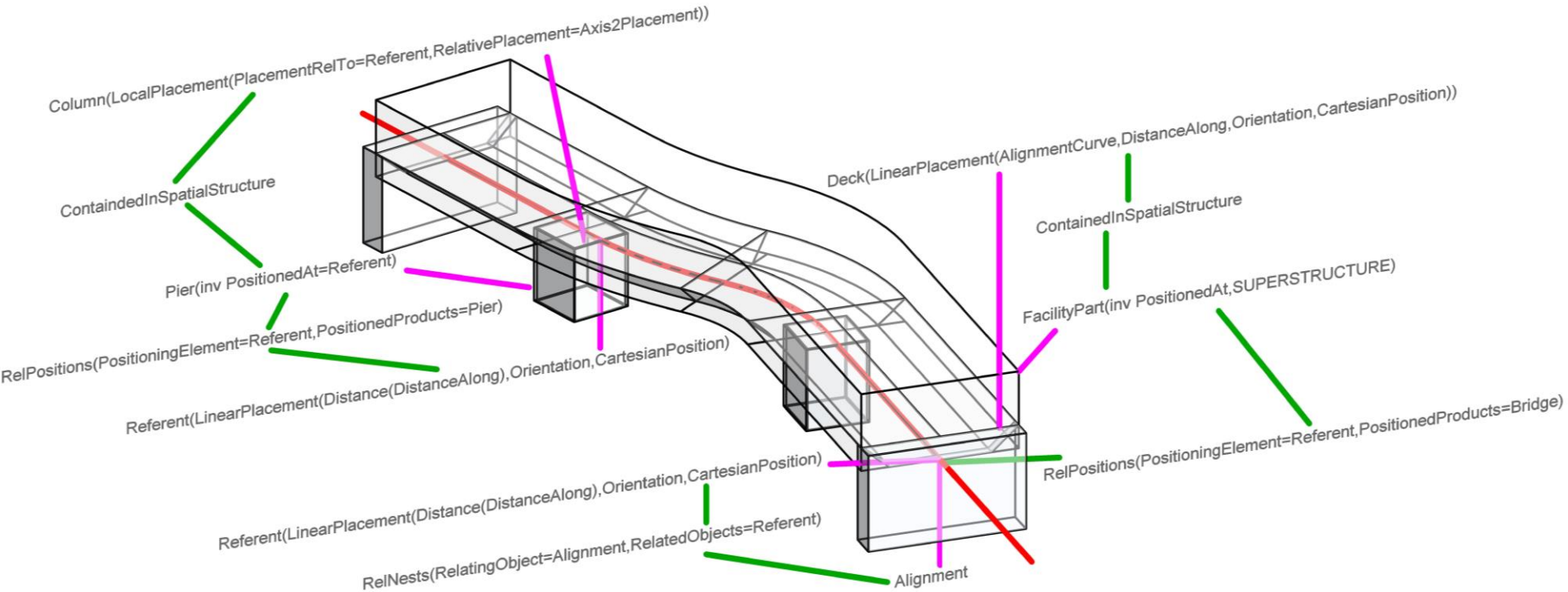
Geometry



Geometry



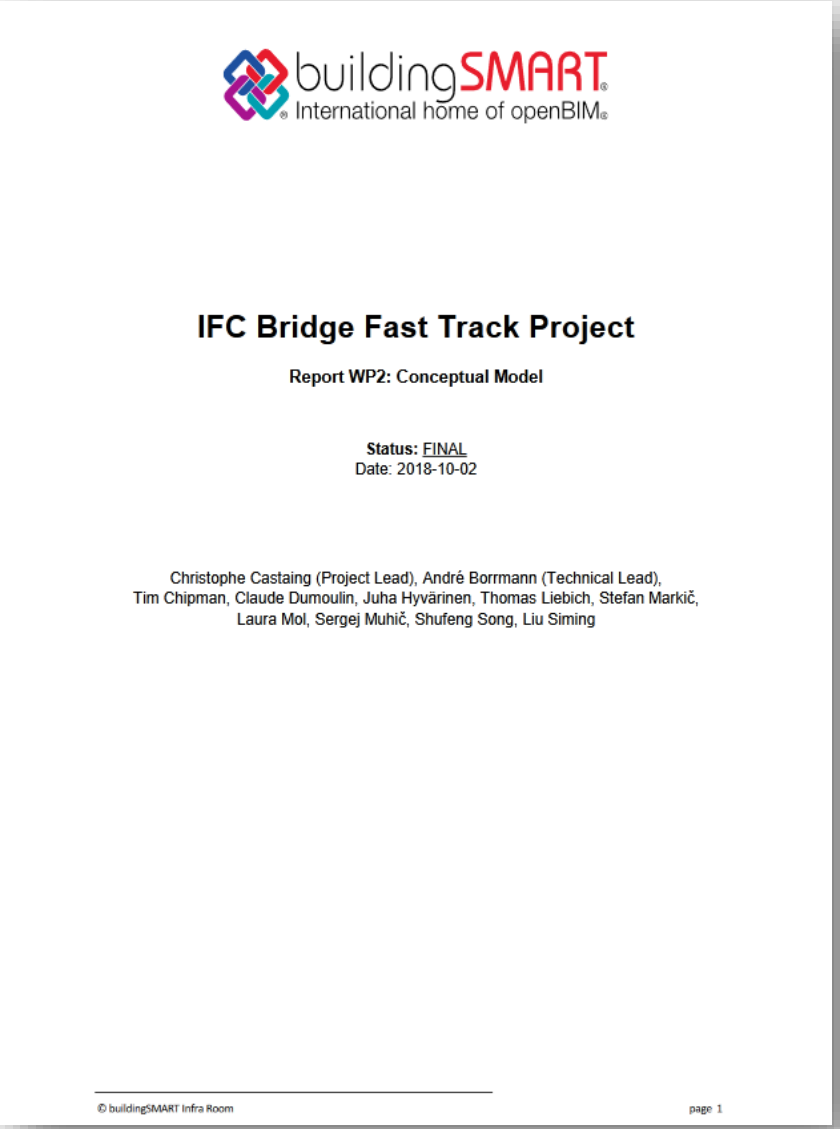
Alignment, Relative Positioning



Conceptual Model

Final Report

- published on 2018/10/02



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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 extension and documentation

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
 SUBTYPE OF (IfcBuildingElementType);
    PredefinedType : IfcBeamTypeEnum;
 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

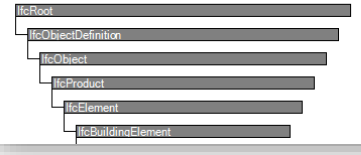
#	Attribute	Type	Cardinality	Description
9	PredefinedType	IfcBearingTypeEnum	?	Predefined generic type for a bearing that is specified in an enumeration. The NOTE The *PredefinedType* shall only be used, if no IfcBearingType is as

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

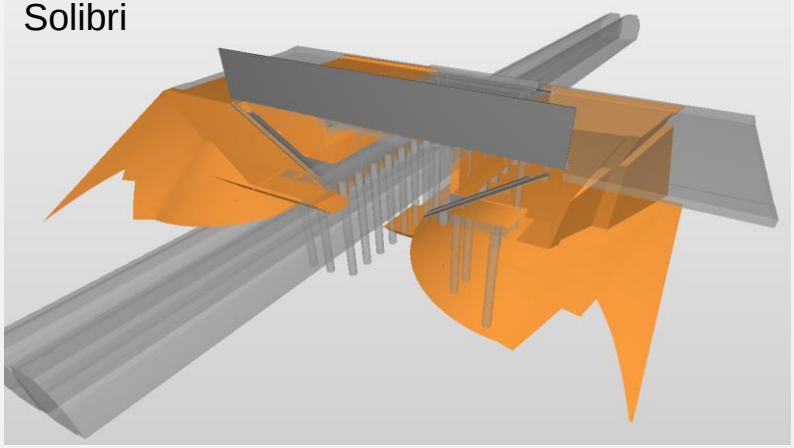
6.1.3.4.2 Inherited definitions from supertypes

Entity inheritance



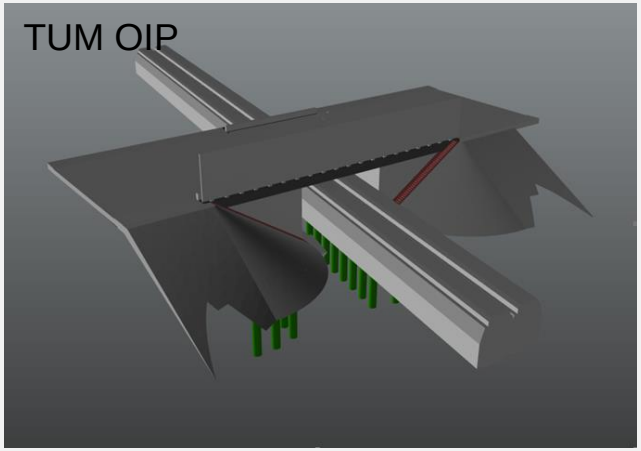
Sample Files

Solibri

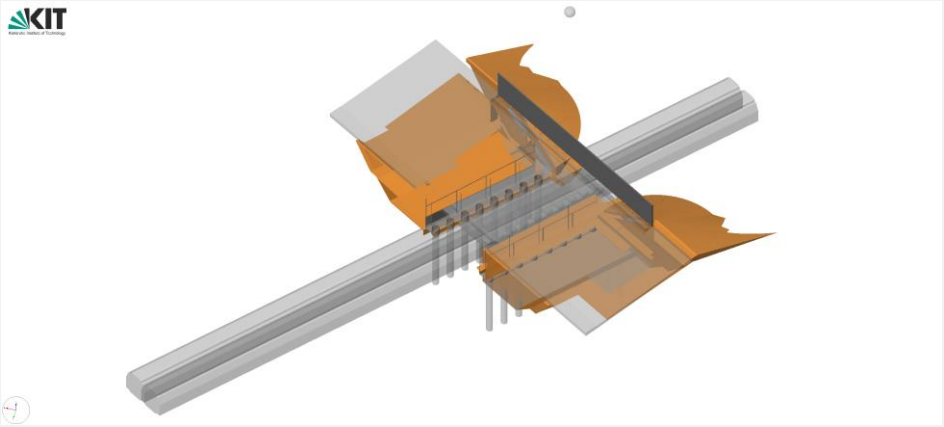


- Spatial Structure: IfcFacility / IfcBridge
- Predefined Types
- Brep geometry
- No alignment

TUM OIP



KIT

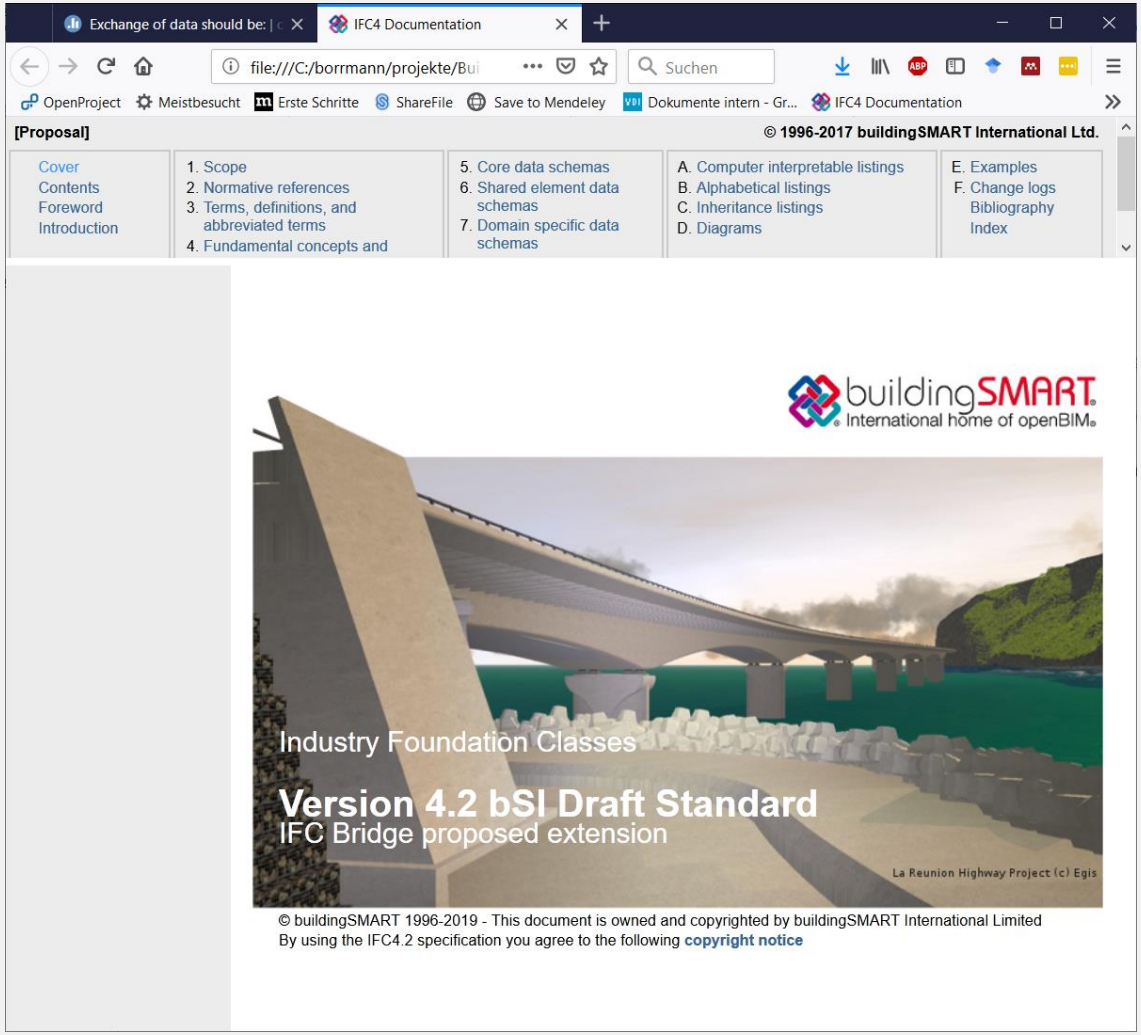


bSI Draft Standard IFC 4.2

Available on **Sharefile**

Will be brought to

standards.buildingsmart.org



buildingSMART International home of openBIM

IFC-Bridge Model View Definitions (MVDs)

Bridge Reference View (based on IFC4 Reference View)
→ Faceted Brep + Simple Sweeps

Aligment-based Bridge Reference View (based on IFC4 Reference View)
→ Faceted Brep + Profile Sweep (IfcSectionedSolidHorizontal)

Bridge Design Transfer View (based on IFC4 Design Transfer View)
→ Alignment
→ Faceted Brep + Profiles Sweeps **+ CSG**

Bridge Asset Management View
→ Alignment
→ Faceted Brep

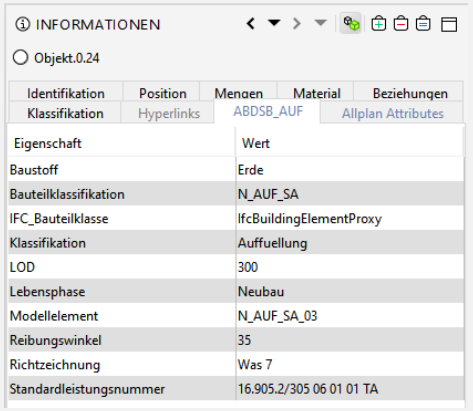
IFC-Bridge Model View Definitions (MVDs)

	IFC4 RV	Bridge RV	Bridge ARV	IFC 4 DTV	Bridge DTV
IfcSolidModel	x	x	x	x	x
IfcCsgSolid				x	x
IfcManifoldSolidBrep				x	x
IfcAdvancedBRep				x	x
IfcAdvancedBRepWithVoids					
IfcFacetedBrep				x	x
IfcFacetedBrepWithVoids					
IfcSweptAreaSolid	x	x	x	x	x
IfcExtrudedAraSolid	x	x	x	x	x
IfcExtrudedAreaSolidTapered				x	x
IfcFixedReferenceSweptAreaSolid				x	x
IfcRevolvedAreaSolid	x	x	x	x	x
IfcRevolvedAreaSolidTapered				x	x
IfcCurveSweptAreaSolid				x	x
IfcSweptDiskSolid	x	x	x	x	x
IfcSweptDiskSolidPolygonal					
IfcSectionedSolid			**x**		**x**
IfcSectionedSolidHorizontal			**x**		**x**
IfcTesselatedItem	x	x	x	x	x
IfcTesselatedFaceSet	x	x	x	x	x
IfcTriangulatedFaceSet	x	x	x	x	x
IfcPolygonalFaceSet	x	x	x	x	x

IFC-Bridge Model View Definitions (MVDs)

	IFC4 RV	Bridge RV	Bridge ARV	IFC 4 DTV	Bridge DTV
IfcCurve	x	x	x	x	x
IfcBoundedCurve	x	x	x	x	x
IfcAlignmentCurve			**x**		**x**
IfcOffsetCurve					**x**
IfcOffsetCurveByDistances					**x**
IfcDistanceExpression			**x**		**x**
IfcOrientationExpression			**x**		**x**
IfcLinearPlacement			**x**		**x**
IfcPositioningElement	x	x	x	x	x
IfcAlignment			**x**		x
IfcAlignment2DHorizontal			**x**		x
IfcAlignment2DVertical			**x**		x
IfcAlignment2DSegment			**x**		x
IfcAlignment2DVerticalSegment			**x**		x
IfcAlignment2DHorizonalSegment			**x**		x

Properties



Project Properties | Project Properties

Project Properties | Project Properties

Project Properties | Project Properties

Project Properties | Project Properties

Agency Properties

Agency Properties

Agency Properties

Agency Properties

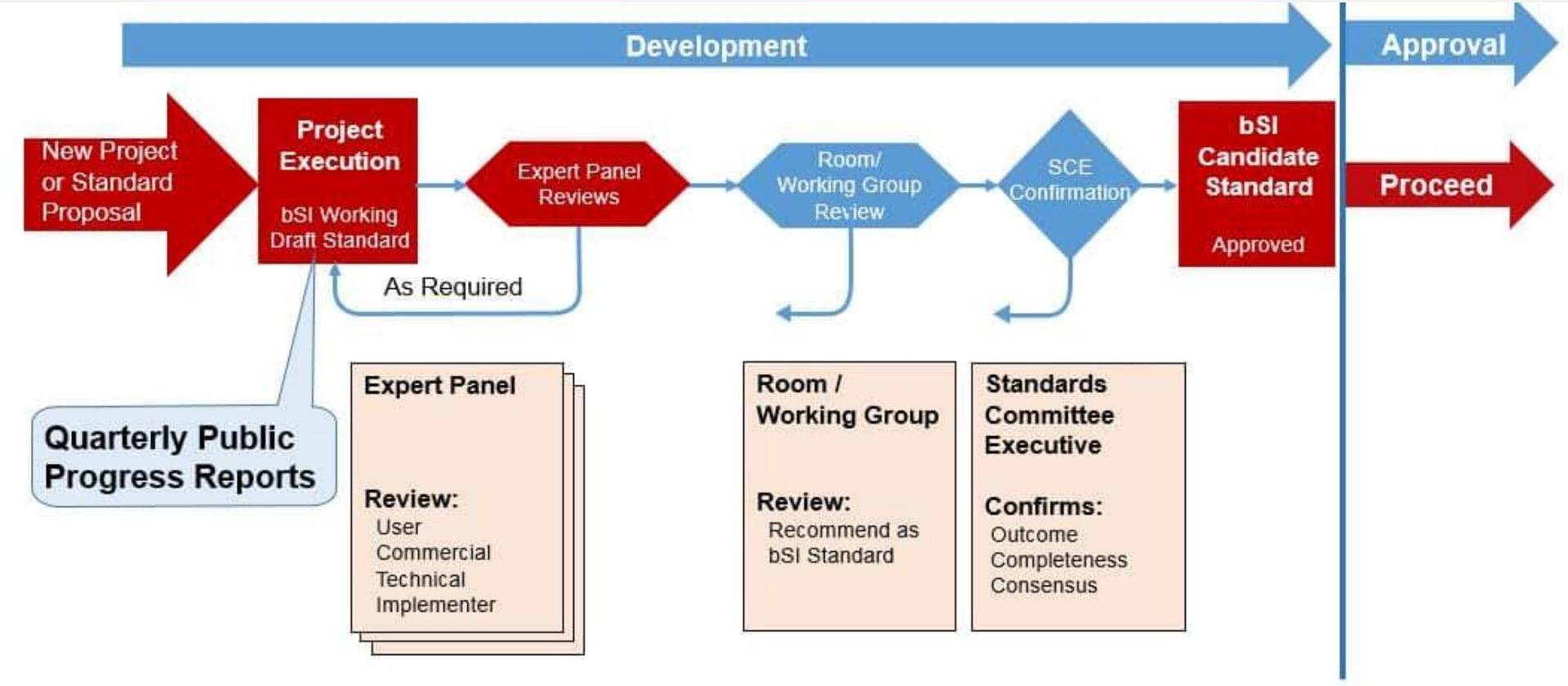
National Properties

National Properties

International Properties

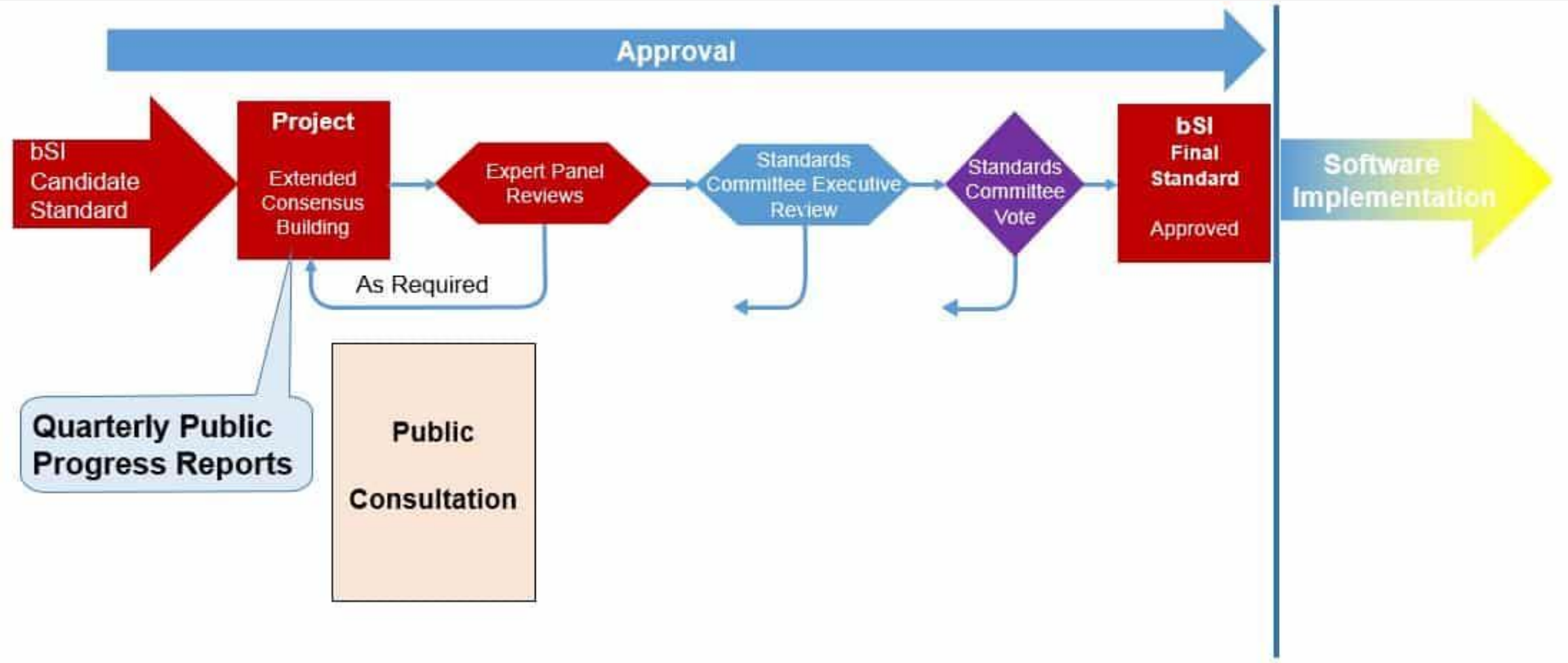
IFC Schema

Standard Adoption Process



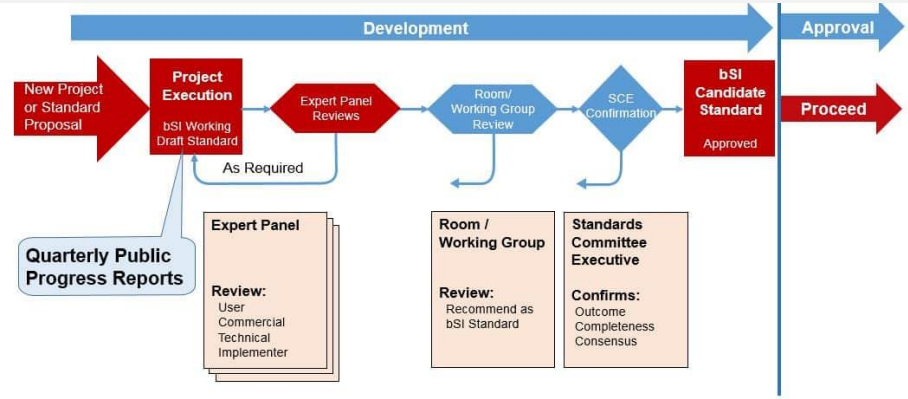
https://www.buildingsmart.org/standards/standards-process/#spe

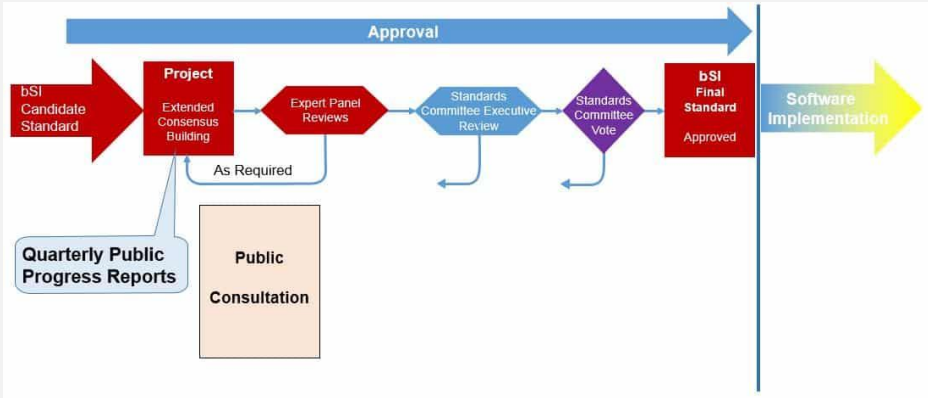
Standard Adoption Process



https://www.buildingsmart.org/standards/standards-process/#spe

Standard Adoption Process

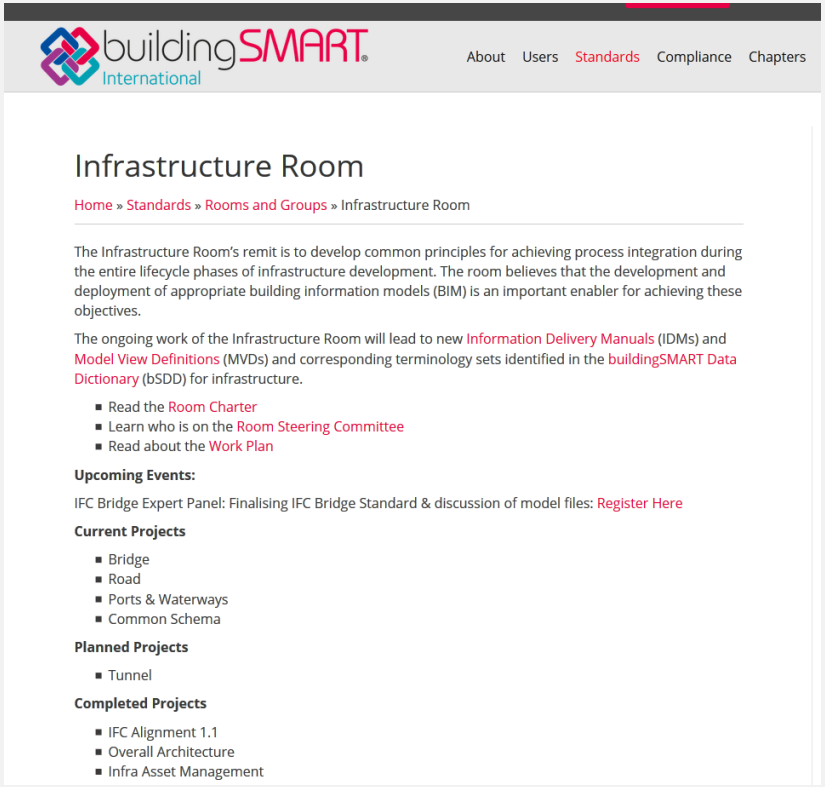




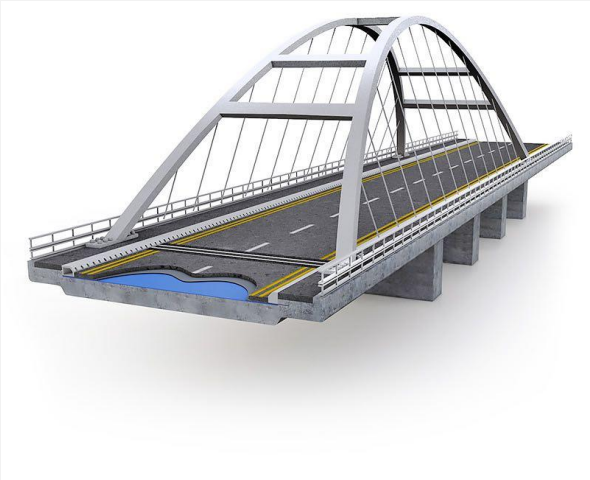
From	To	Voting & Notification
bSI Standards Proposal	bSI Working Draft Standard	SCE supports proposal. Simple majority of SC members and at least three Chapters or Members commit to take part and nominate experts.
bSI Working Draft Standard	bSI Draft Standard	Project consortia agree that the project's 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.

Deployment Project

- Deployment project will be started directly after the end of the development project
- Role model: IFC-Alignment project
- Allows fast uptake of the standard
- Software vendors can join the project for a fee and get intense support for implementing IFC-Bridge
- Common basis of extensive test cases
- **Call for participation**

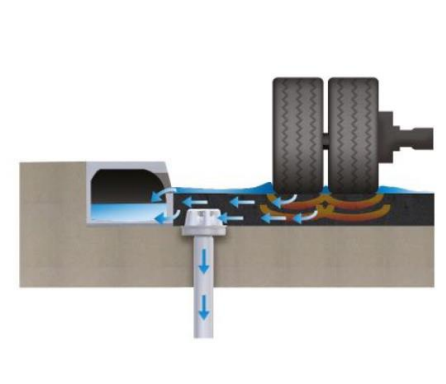


Not yet covered



Parts

- Drainage
- Earthworks / Geotechnics
- Equipment
- (Defects)



Excluded use cases

- Structural analysis
- Design-to-Design, etc.

Bridge types

- More complex bridges types
- Wooden bridges, etc.