The National Academies of
SCIENCES · ENGINEERING · MEDICINE

TRANSPORTATION RESEARCH BOARD

Delivering Bridge Projects with Building Information Modeling (BIM)

August 26, 2020

@NASEMTRB
#TRBwebinar

PDH Certification Information:

- 1.5 Professional Development Hour (PDH) – see follow-up email for instructions
- You must attend the entire webinar to be eligible to receive PDH credits
- Questions? Contact Reggie Gillum at RGillum@nas.edu

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#TRBwebinar

Learning Objectives

1. Describe how bridge projects are currently being delivered in a BIM environment

2. Identify content of BIM technical requirements for design and construction contracts

3. Discuss the current implementation readiness of IFC data exchanges for bridges

#TRBwebinar

Delivery of Bridge Projects with BIM

TRB
TRANSPORTATION RESEARCH BOARD

Meet our team

Joe Brenner

Lead Structural Engineer

WSP USA

Francesca Maier

Principal

Fair Cape Consulting

Tim Chipman

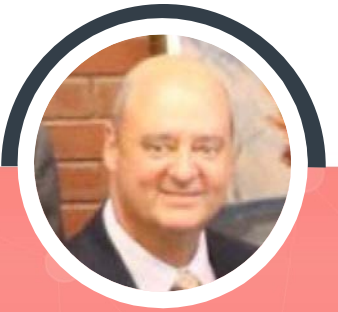
Software Developer

Constructivity

Roger Grant

Executive Director, Building Information Management

NIBS



Tom Saad

Senior Structural Engineer

FHWA

Today's Agenda

- FHWA and Industry Background – Tom Saad and Joe Brenner
- Current BIM for Bridges & Pilot Projects – Joe Brenner
- Technical Requirements and Specifications – Francesca Maier
- Bridge Data Exchanges – Tim Chipman
- Key Findings and Recommendations – Joe Brenner

FHWA and Industry Background

FHWA Interest to Advance BIM

FHWA support for BIM implementation

Building Information Modeling (BIM) is a collaborative work method for structuring, managing, and using data and information about transportation assets throughout their lifecycle

Benefits realized:

Improved staff effectiveness - fewer errors and increased worker safety

Improved project communications

Greater ability to predict cost

Improved project schedule performance

Optimized design

FHWA BIM for Bridges Current Projects

Demonstration of BIM for Bridges

BIM for Bridges and Roadways – Project Delivery Workflow and National Library

Resources and Information on BIM:

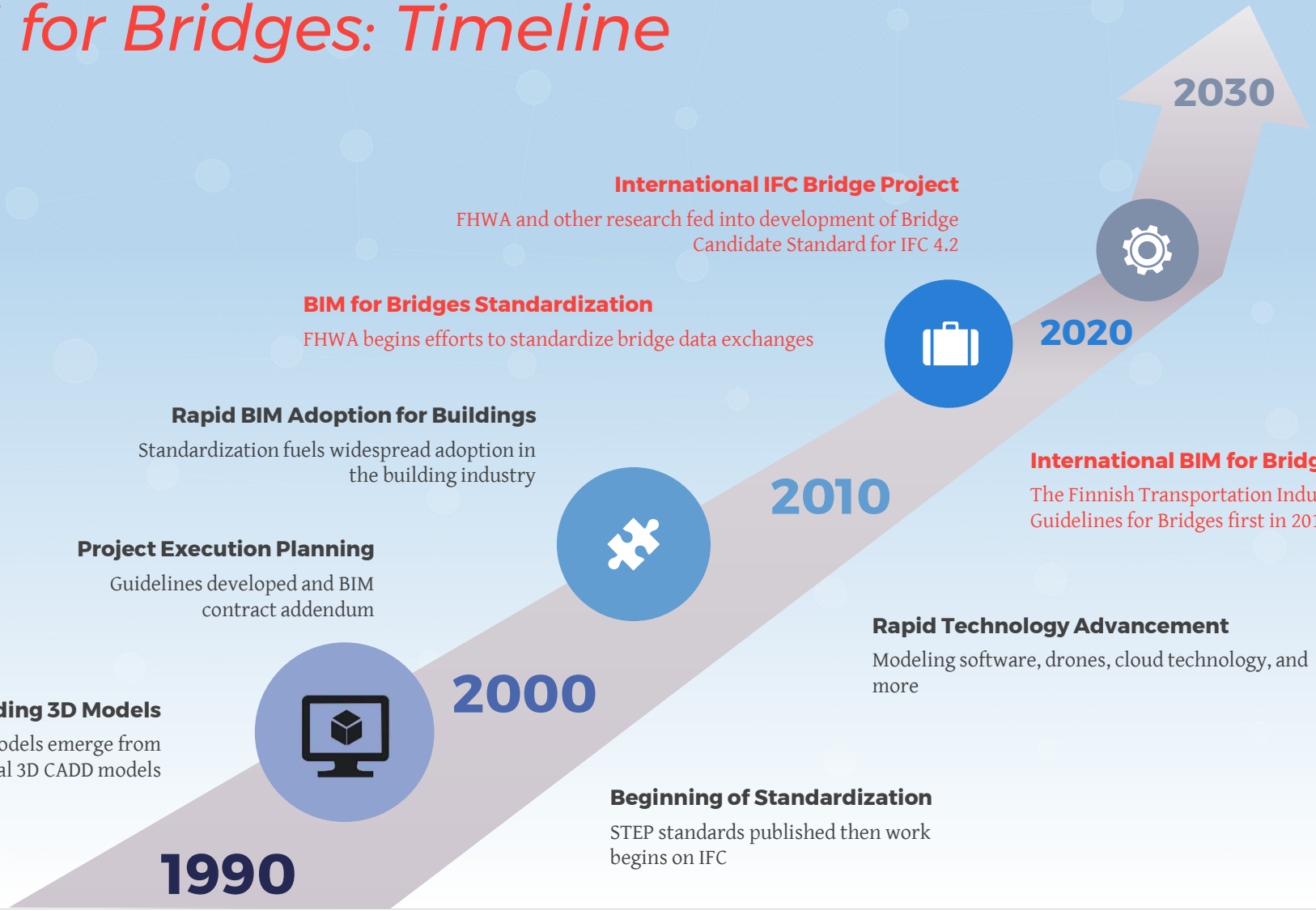
Building Information Modeling (BIM) for Bridge and Structures

https://www.fhwa.dot.gov/bridge/steel.cfm

BIM (BIM) for Infrastructure

https://www.fhwa.dot.gov/construction/bim/

BIM for Bridges: Timeline



Building 3D Models

Database models emerge from graphical 3D CADD models

Project Execution Planning

Guidelines developed and BIM contract addendum

Rapid BIM Adoption for Buildings

Standardization fuels widespread adoption in the building industry

BIM for Bridges Standardization

FHWA begins efforts to standardize bridge data exchanges

International IFC Bridge Project

FHWA and other research fed into development of Bridge Candidate Standard for IFC 4.2

Beginning of Standardization

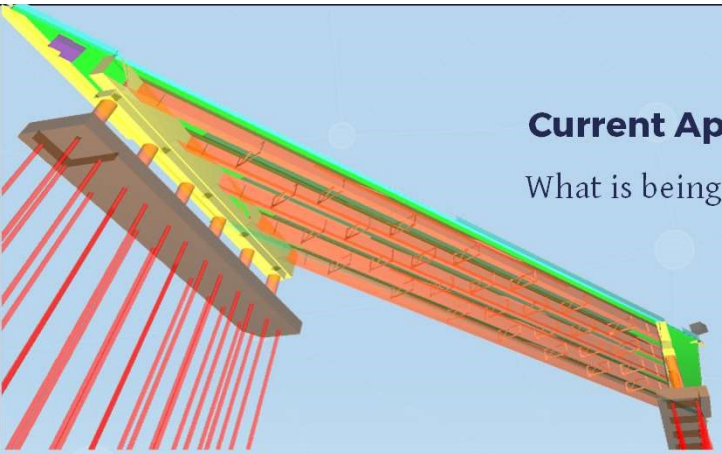
STEP standards published then work begins on IFC

International BIM for Bridges Efforts

The Finnish Transportation Industry publishes BIM Guidelines for Bridges first in 2014

Rapid Technology Advancement

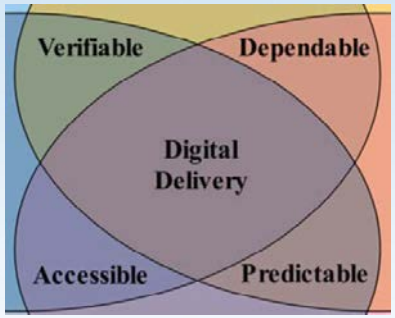
Modeling software, drones, cloud technology, and more



Current Applications and Pilot Projects

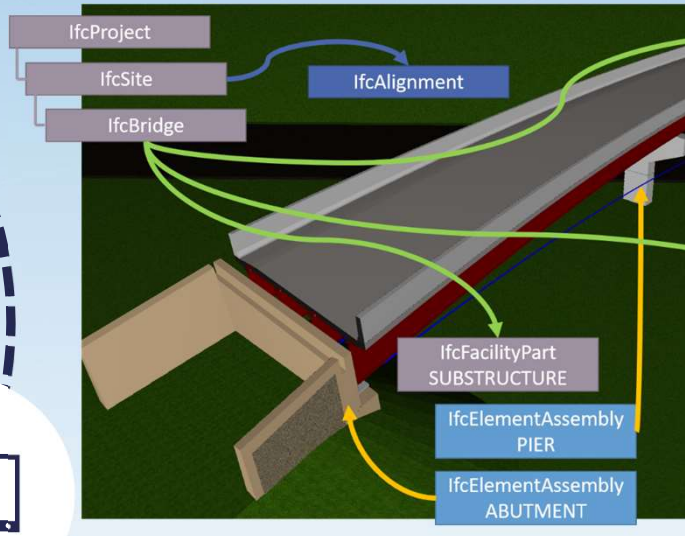
What is being done today?

Advance Implementation of Bridge Projects with BIM



Technical Requirements and Specifications

What needs to change with content that is delivered?

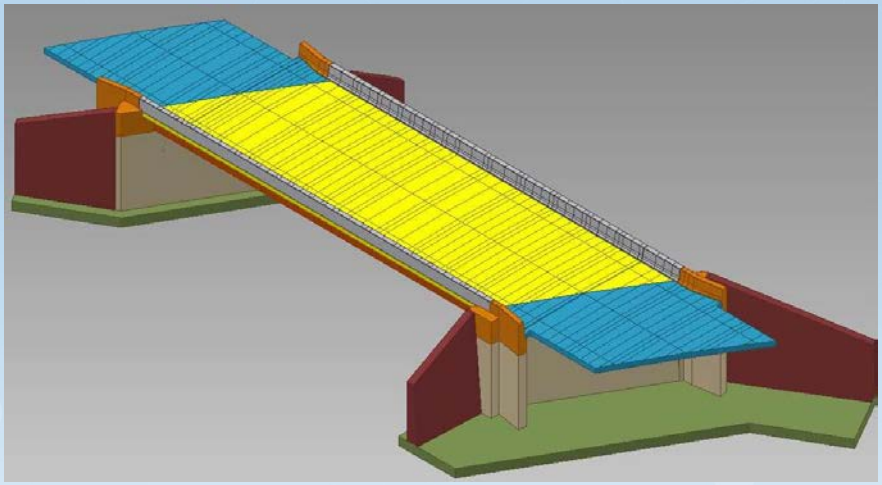


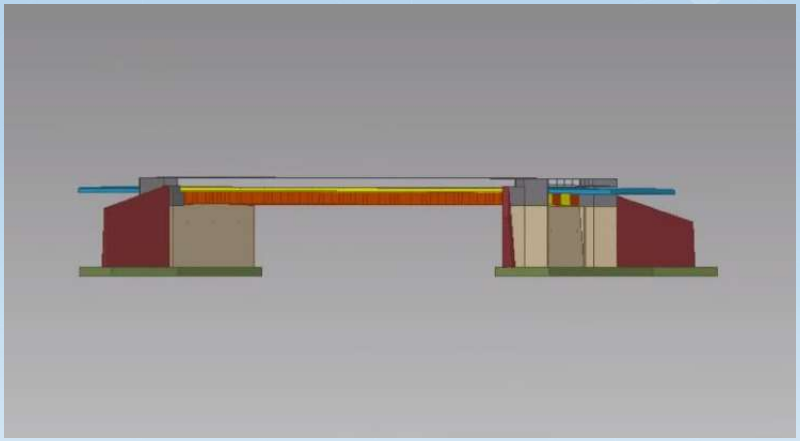
Data Exchanges

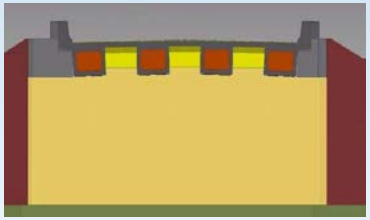
How can we extend efficiency and uses of digital data?

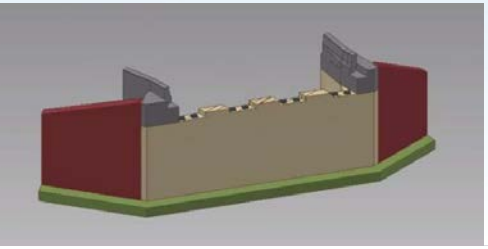
Current BIM for Bridges & Pilot Projects

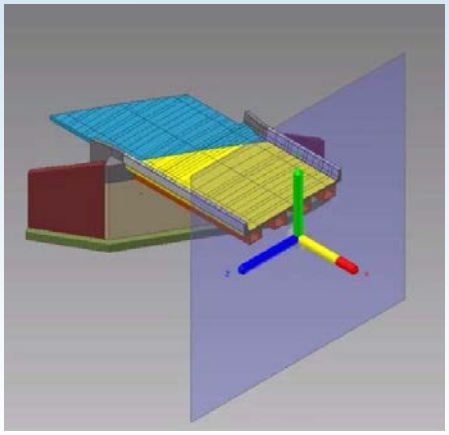
Current BIM for Bridges Applications

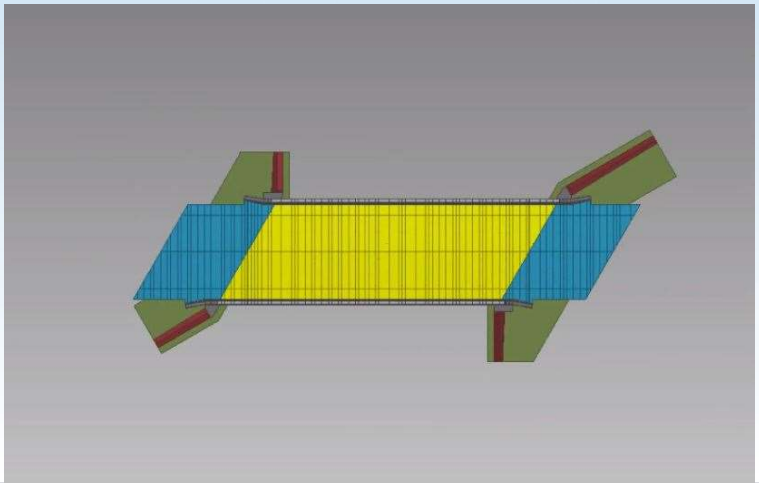












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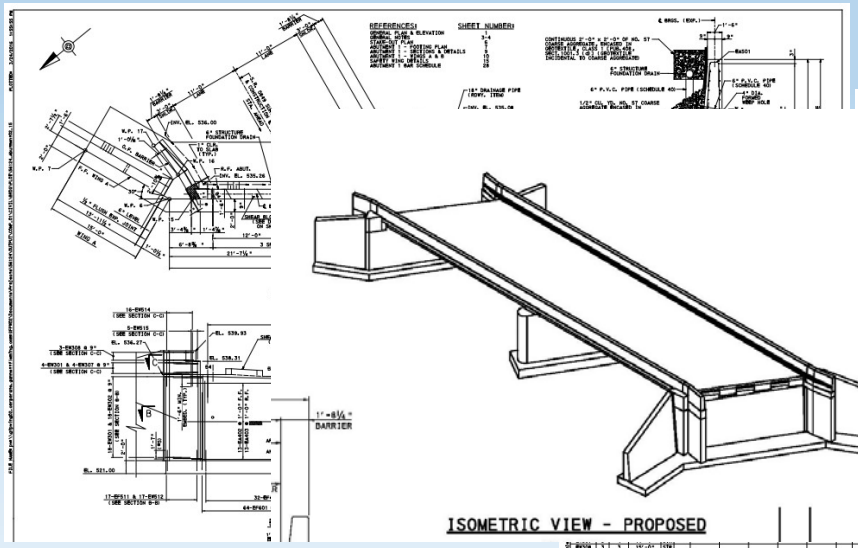

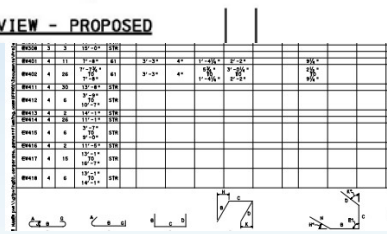

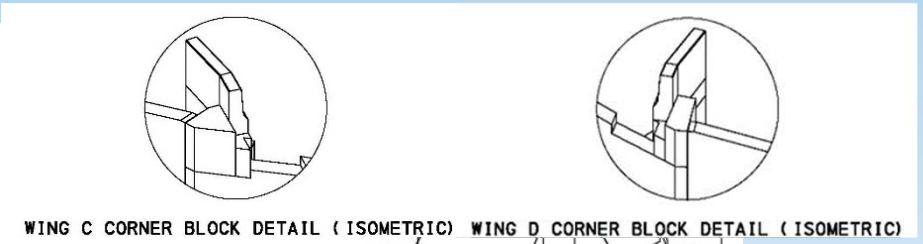

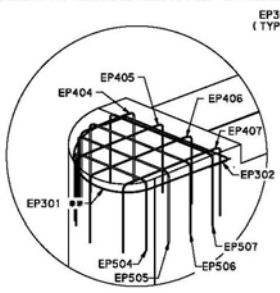

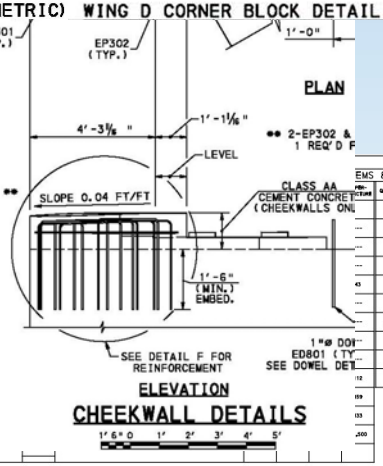

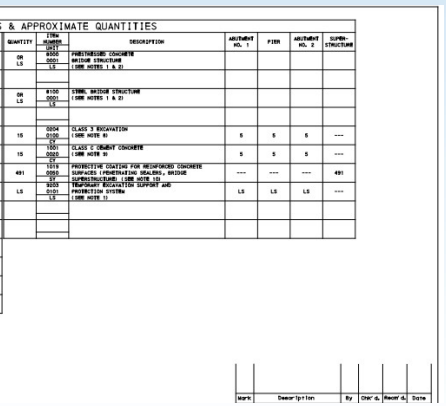

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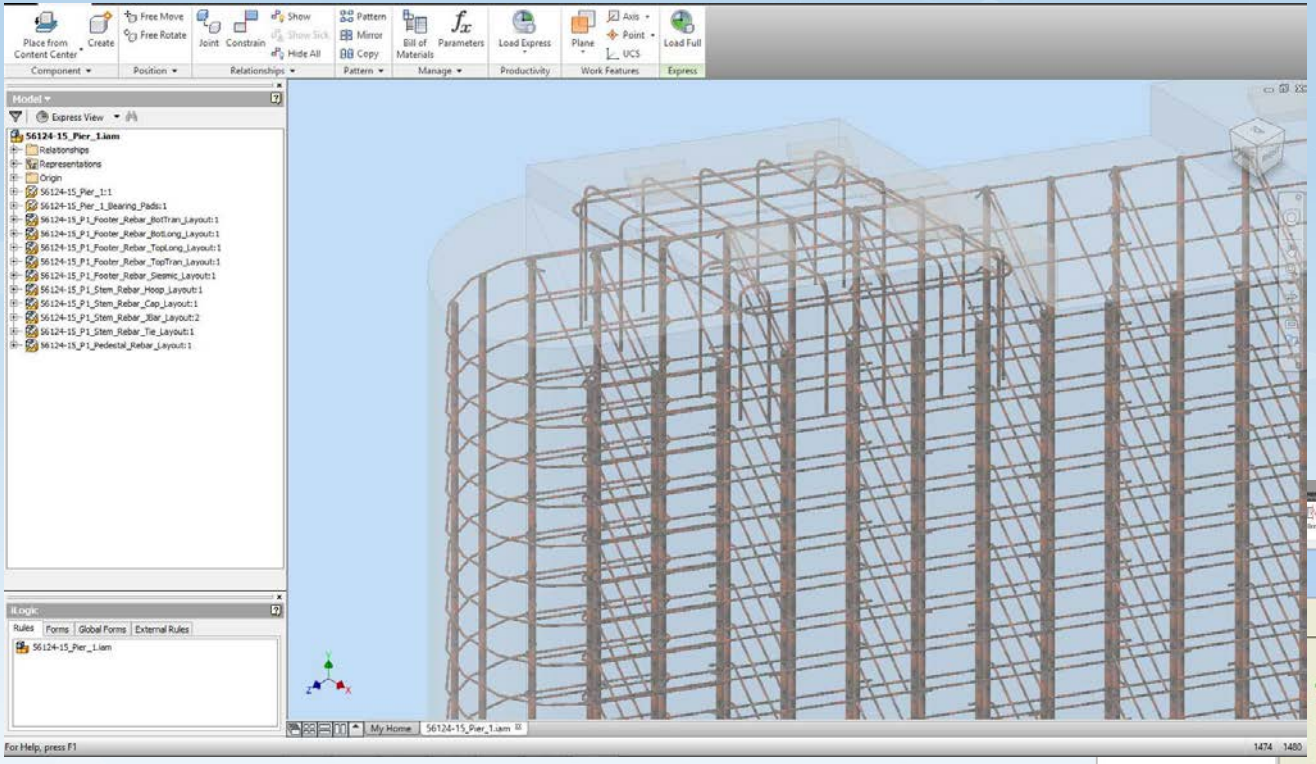
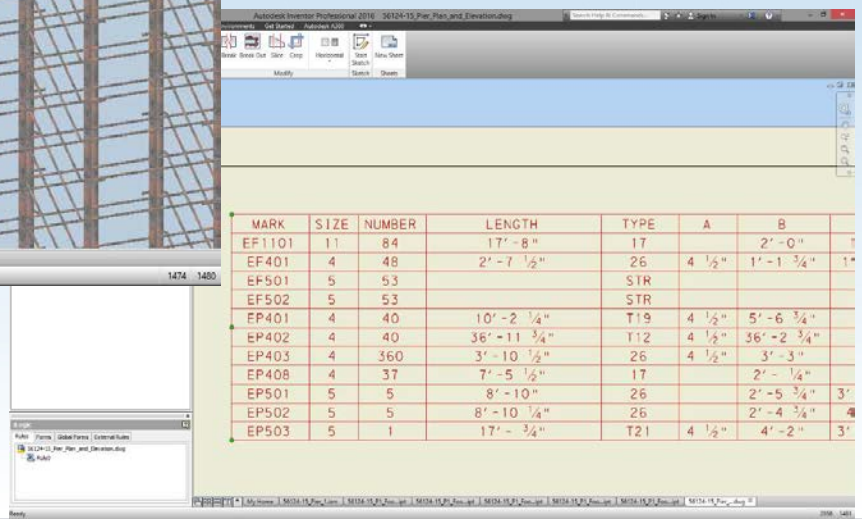
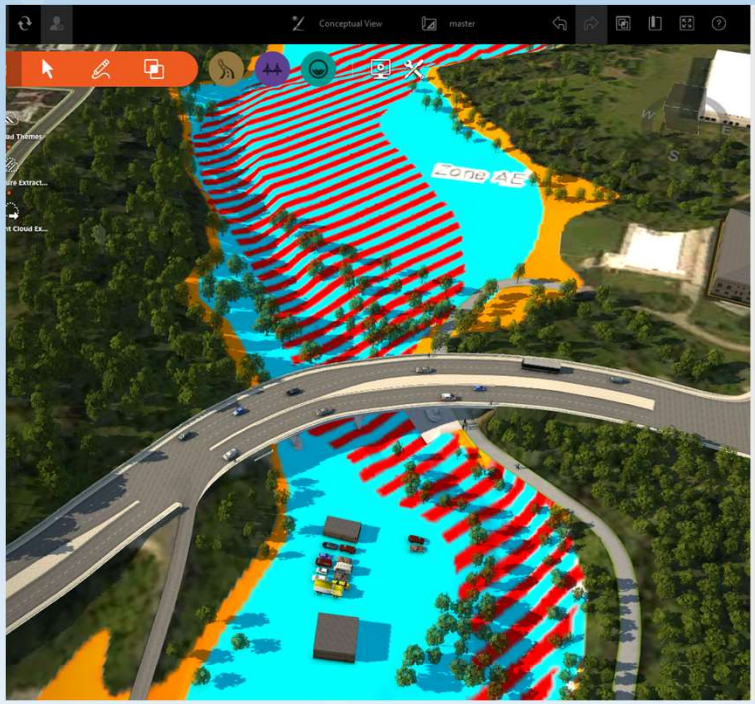
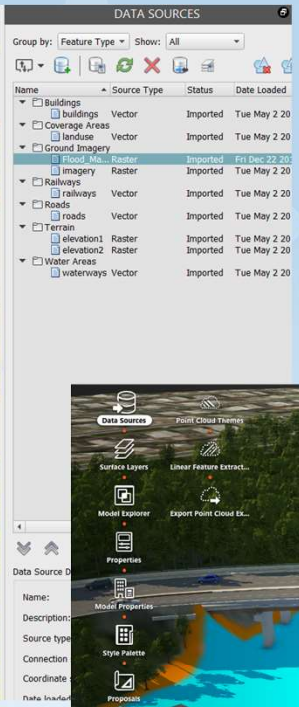


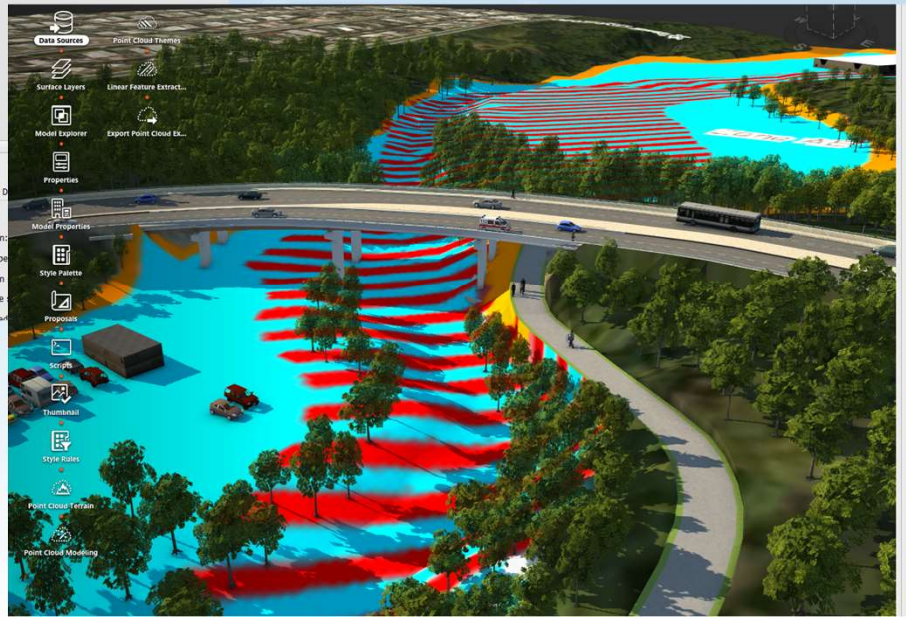


MARK	SIZE	NUMBER	LENGTH	TYPE	A	B
EF1101	11	84	17' -8"	17		2' -0"
EF401	4	48	2' -7 1/2"	26	4 1/2"	1' -1 3/4"
EF501	5	53		STR		
EF502	5	53		STR		
EP401	4	40	10' -2 1/4"	T19	4 1/2"	5' -6 3/4"
EP402	4	40	36' -11 3/4"	T12	4 1/2"	36' -2 3/4"
EP403	4	360	3' -10 1/2"	26	4 1/2"	3' -3"
EP408	4	37	7' -5 1/2"	17		2' - 1/4"
EP501	5	5	8' -10"	26		2' -5 3/4"
EP502	5	5	8' -10 1/4"	26		2' -4 3/4"
EP503	5	1	17' - 3/4"	T21	4 1/2"	4' -2"

Current BIM for Bridges Applications







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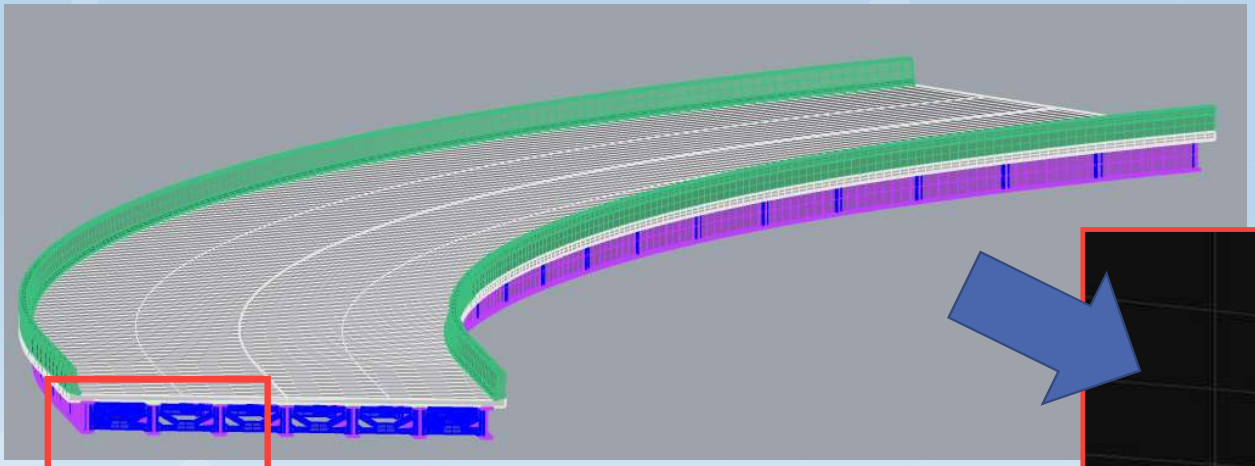

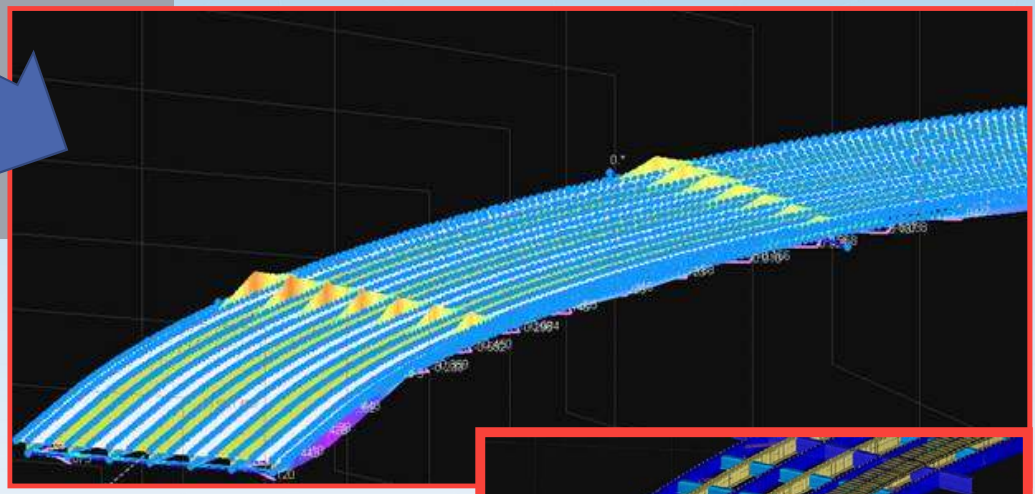

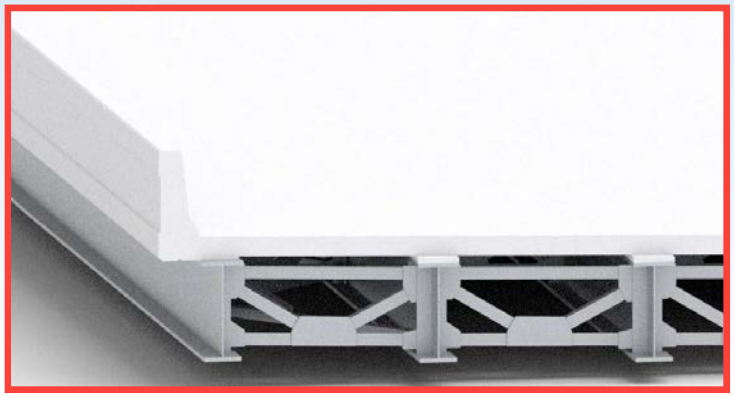

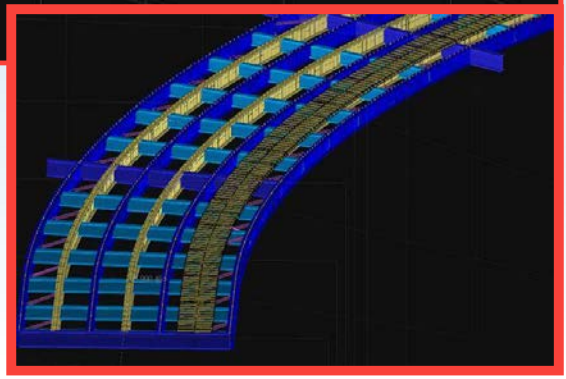

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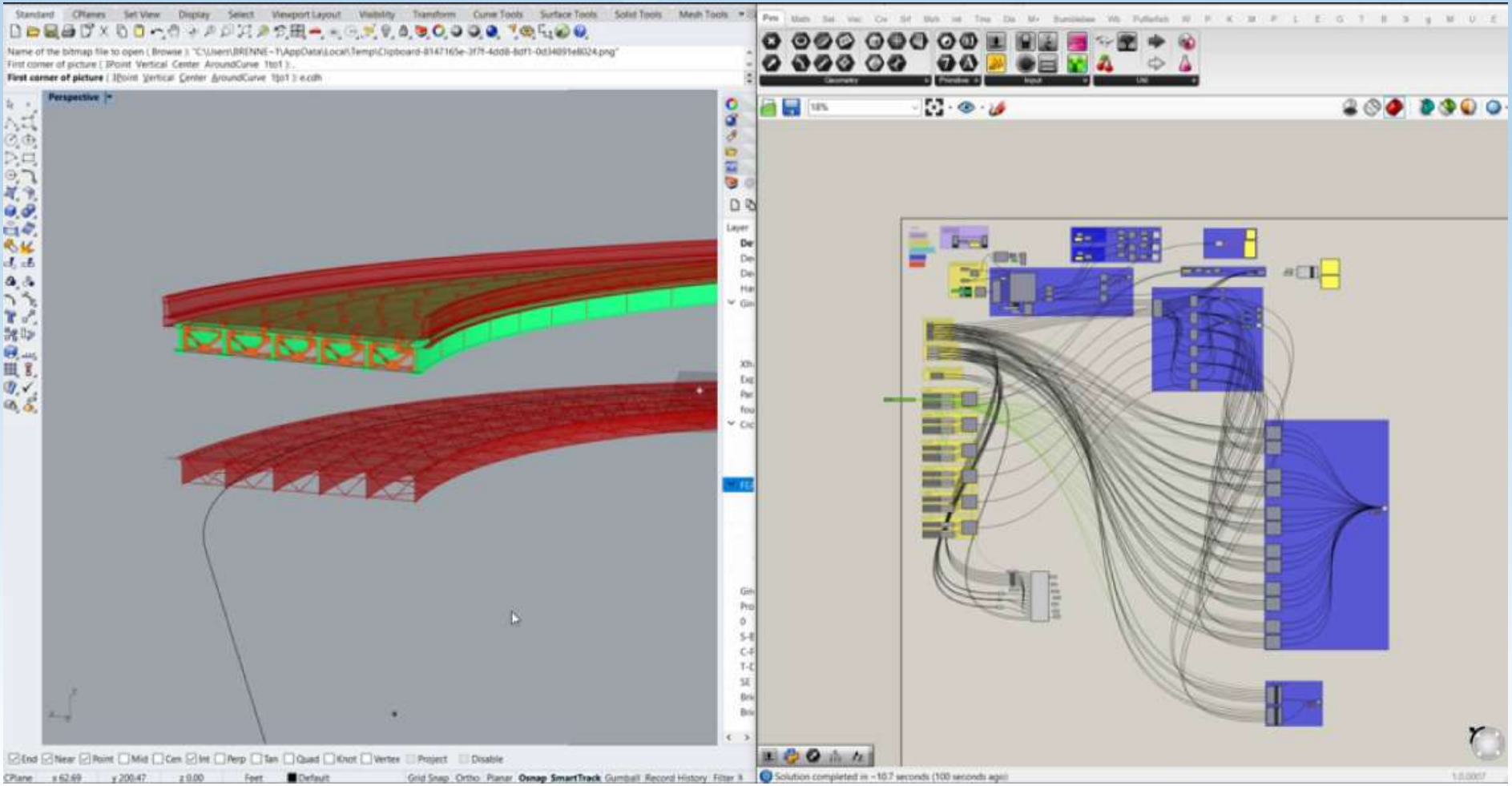
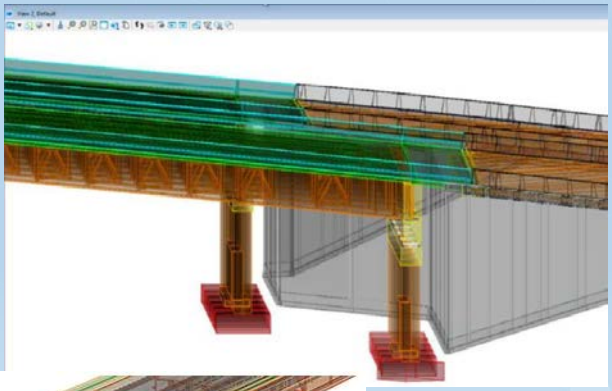
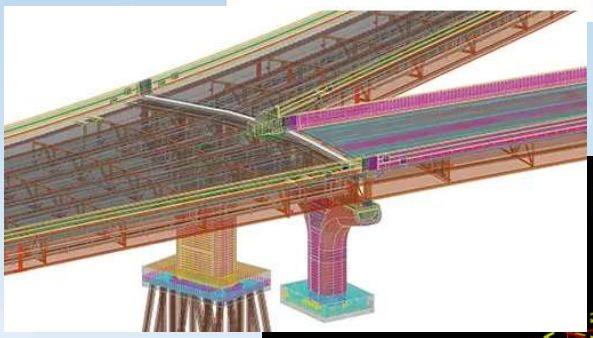
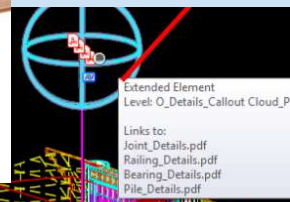


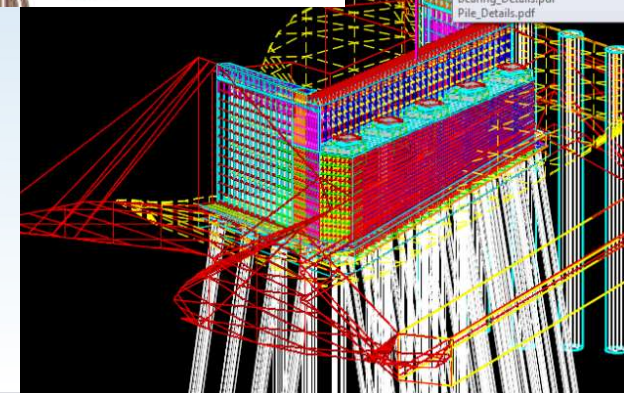
DOT Pilot Projects and Implementation

- Utah DOT – I-80 Blackrock Project (2017 – present)
  - *Major interstate, complex replacements*
  - *Bridge Designer: Michael Baker, HDR; Structures Contractor: Granite*
  - *Model as the contract document – 3 bridges total*
  - *Model delivery: Detailed model with embedded links to pdf drawing views, tables, etc.*
  - *Other model uses: Visualization, interdisciplinary coordination, collaboration with contractor, inspection*
- Iowa DOT – I-80/I-380 Reconstruction (2016 – present)
  - *Major complex interchange reconstruction*
  - *Bridge Designer: HDR; Structures Contractor: United Contractors*
  - *3 flyover bridges modeled with 1 used as the contract document*
  - *Model delivery: Detailed model with embedded links to tables, etc.*
  - *Other model uses: Visualization, interdisciplinary coordination, formwork, cut sections/views on-demand*
- NYSDOT – Rt. 28 over the Esopus Creek (2018 – present)
  - *Full staged structure replacement*
  - *Bridge Designer: NYSDOT*
  - *Bridge, highway, utilities modeled*
  - *Model included as "Electronic files" identified as contract plans*
  - *Model delivery: 2D plans for certain elements, detailed model with attributed elements, saved views, and embedded links for others*
  - *Other model uses: Visualization, interdisciplinary coordination, quantities, GPS/survey/conflict identification*



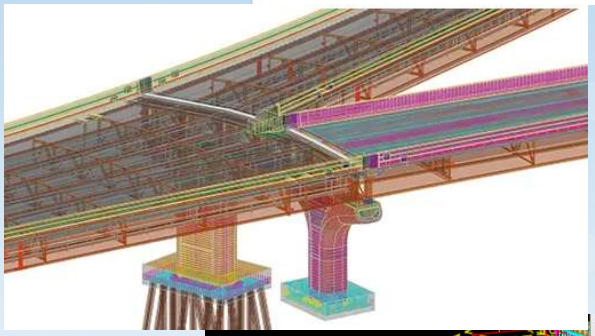


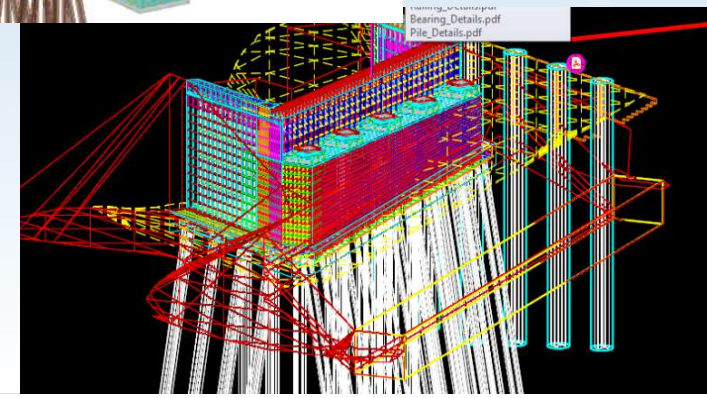




DOT Pilot Projects – Key Elements

- Model as the contract document
- Proprietary files delivered
- Challenges encountered:
  - *Software limitations*
  - *Software/data compatibility*
  - *Lack of experience with model and tools*
  - *Model-based technical requirements*
- Next steps
  - *Additional projects*
  - *Guidance documents and standards*



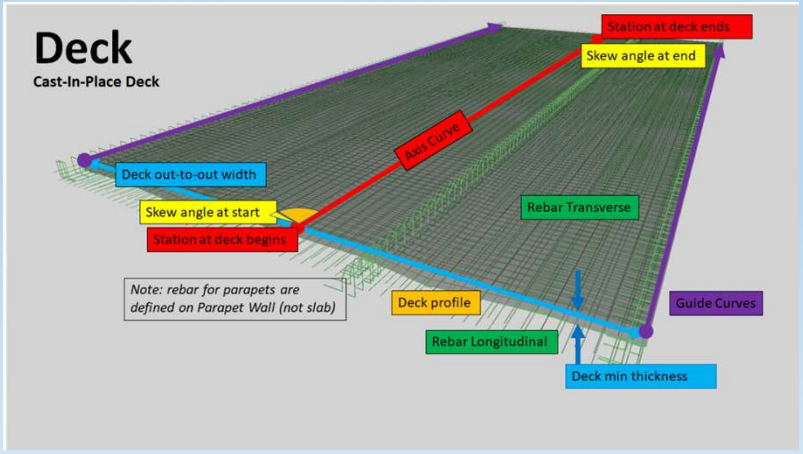


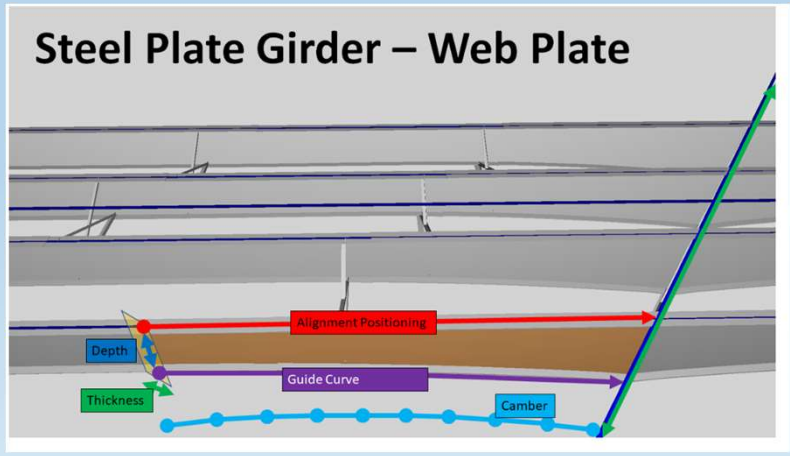
Key Findings and Recommendations

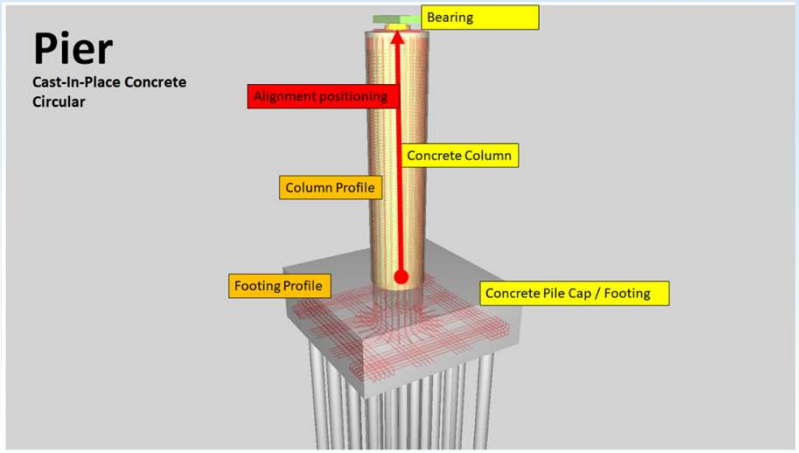
Key findings and recommendations

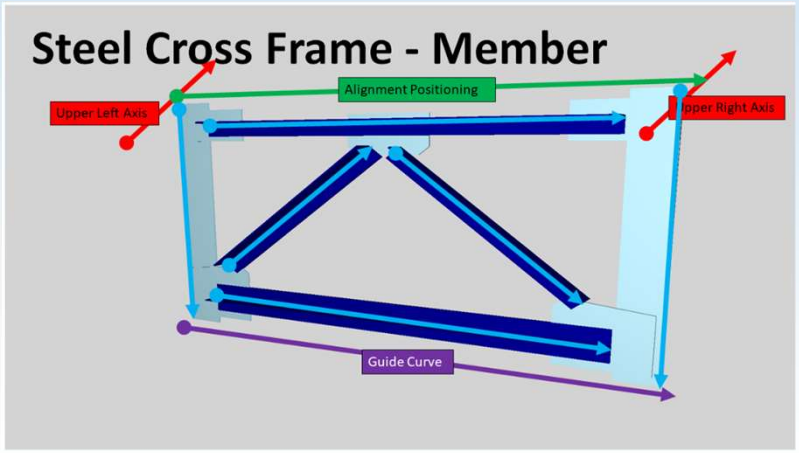
- Lack of familiarity with tools and location of data is a challenge
- Need for documented workflows, design standards, guidance documents
  - *Training needs*
- Exchange of bridge data through IFC
  - *Limitations in certain areas including position by skew, repetitive components/assemblies, parametric descriptions of common elements*
  - *Updates and additional exchanges to develop further*
- Define common digital objects for common bridge elements
  - *Template*
  - *BIM Library*

Ongoing efforts: National library framework









Ongoing efforts

- FHWA BIM for Bridges and Roadways
  - *BIM Workflows*
  - *National BIM Library Framework*
- AASHTO Pooled Fund – BIM for Bridges and Structures - TPF-5(372)
  - *IFC development*
  - *Data Dictionary*
- BIM for Infrastructure
  - *Integrating 3D Digital Models into Asset Management*
  - *BIM Data Governance*
  - *National Strategic Workplan*
  - *Pooled Fund for BIM for Infrastructure*
- Continued DOT Development and Pilot Projects

Opportunities to get involved!

Thank you!

Question and Answer Session

Please add your questions into the "Questions" pane of the control panel.

TRB Webinar

Delivering Bridge Projects with Building Information Modeling (BIM)

Technical Requirements and Specifications

August 26, 2020

Francesca Maier, PE

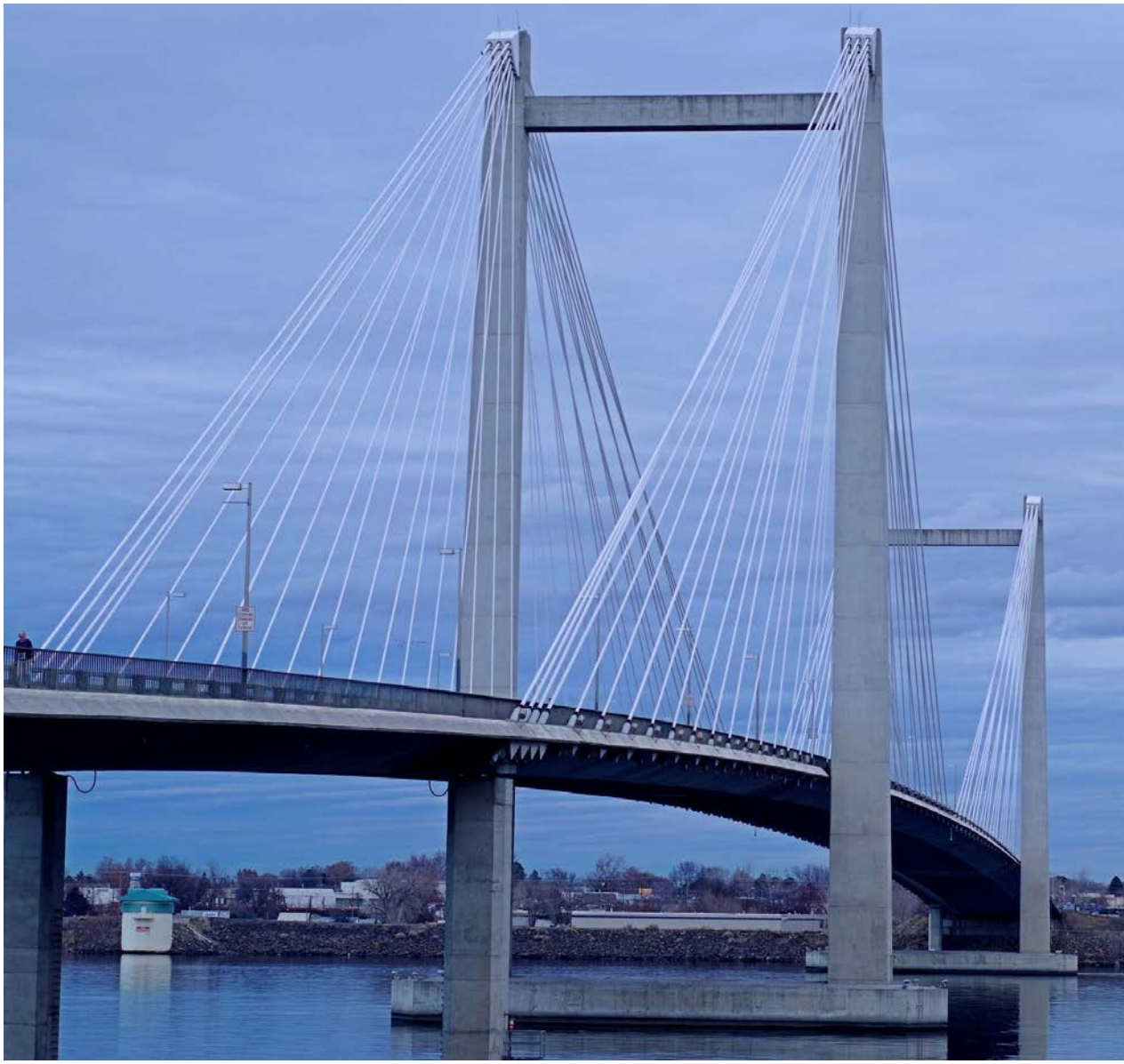
Topics

1. Issues
2. Technical Requirements
3. Specifications

Previous webinar recording:

Contract Language for BIM for Bridges

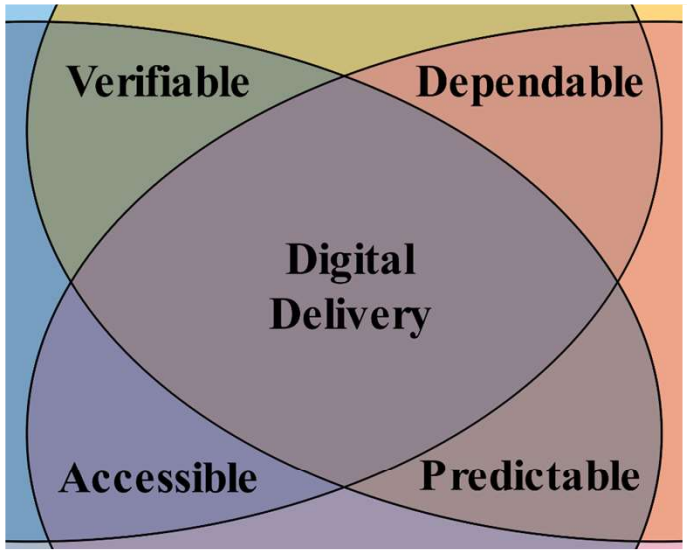
https://connectdot.connectsolutions.com/ptbxh0tfzv6u

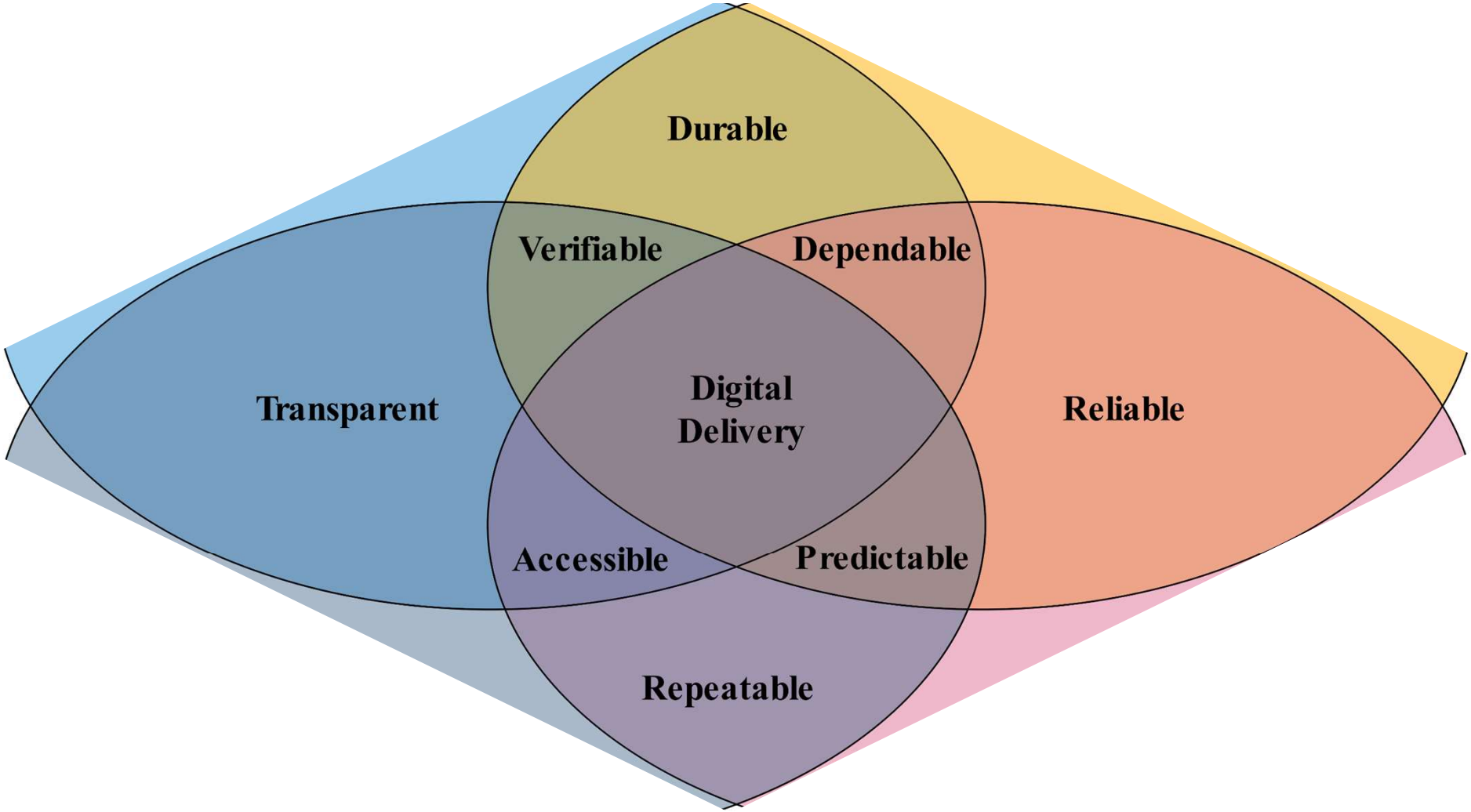


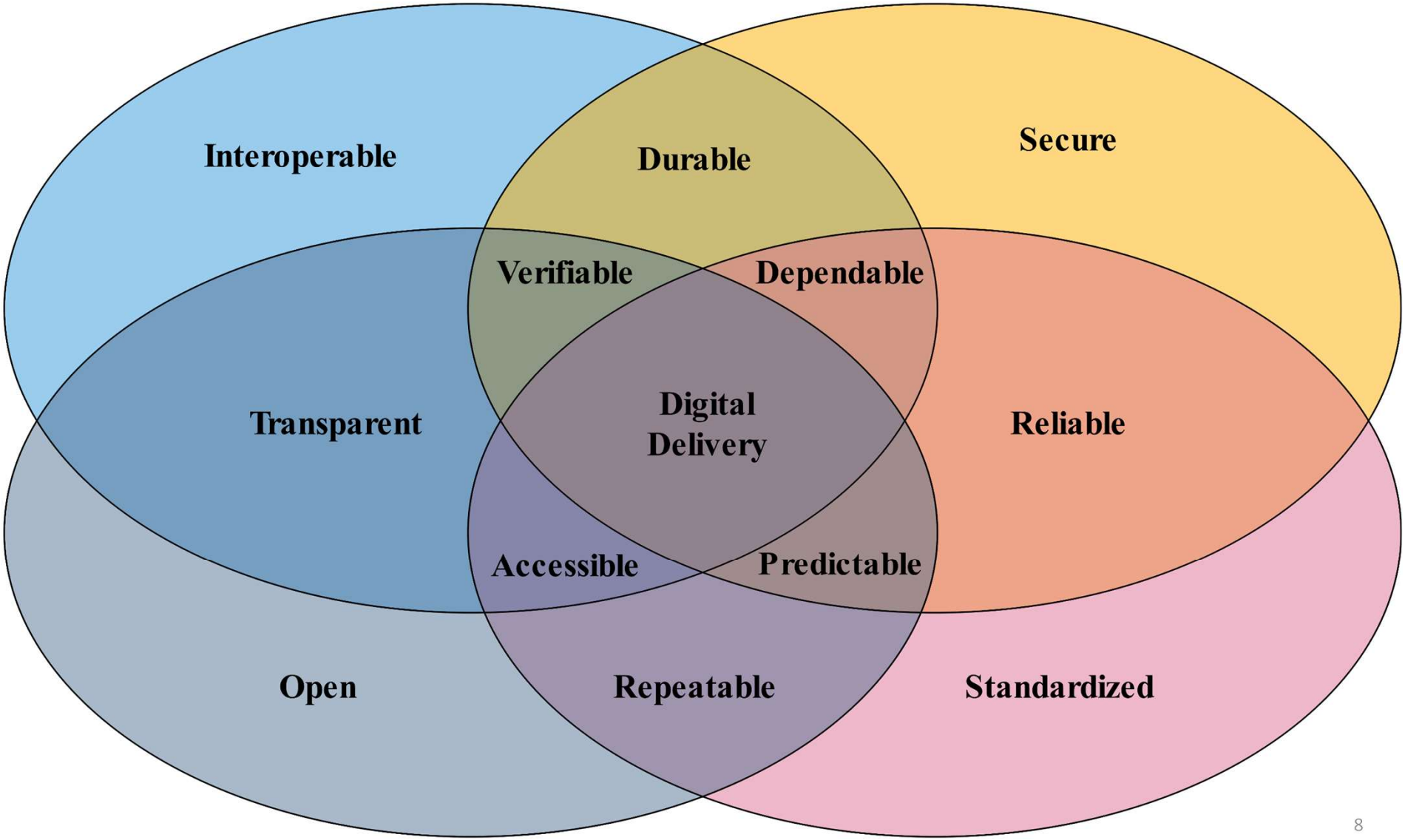
Walker

BALL
STRIKE
OUT
GUEST
6
HOME
2
MEMORIAL FIELD
5

Digital Delivery

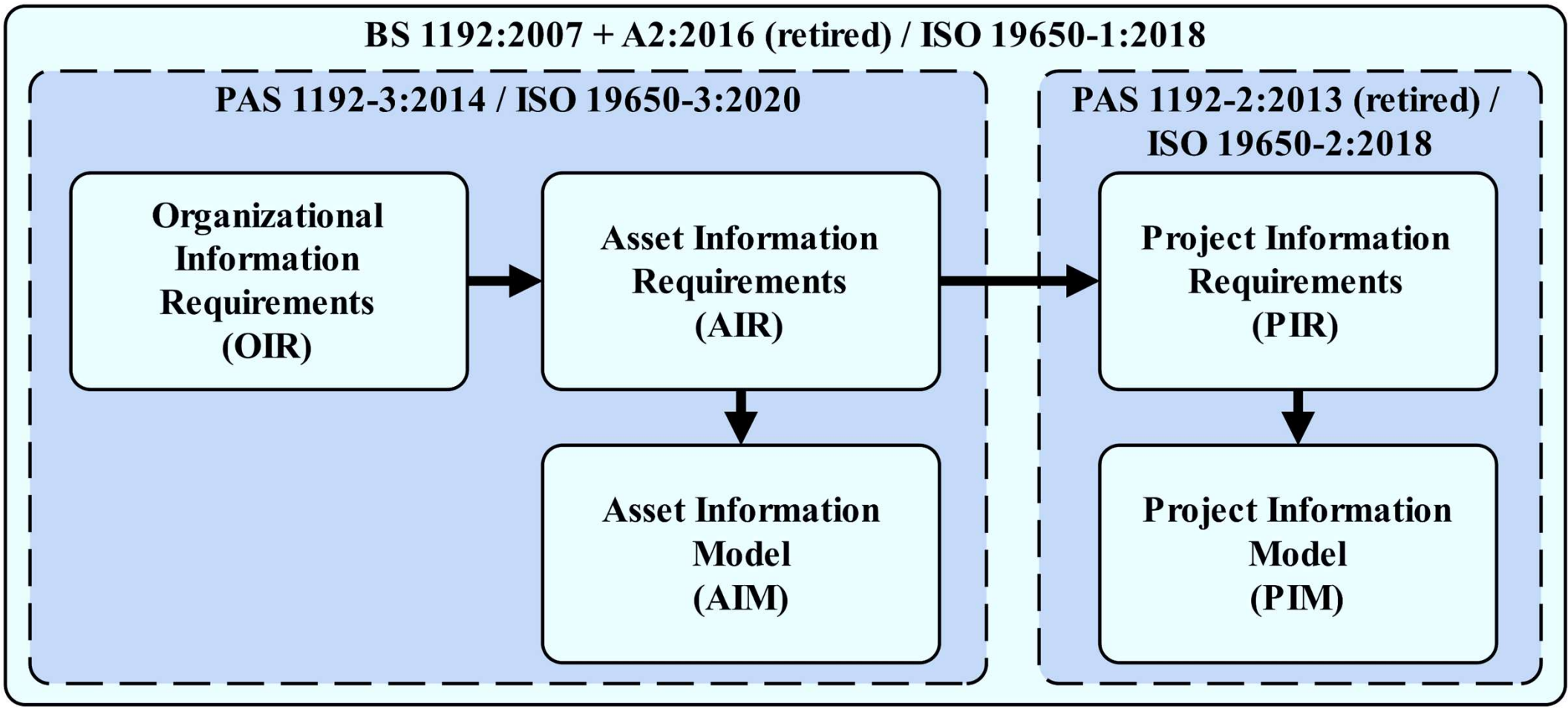

Verifiable
Dependable
Digital
Delivery
Accessible
Predictable


Durable
Verifiable
Dependable
Transparent
Digital
Delivery
Reliable
Accessible
Predictable
Repeatable


Interoperable
Durable
Secure
Verifiable
Dependable
Transparent
Digital
Delivery
Reliable
Accessible
Predictable
Open
Repeatable
Standardized

Resources:

1. PennState guides for Project Execution Planning, implementation for facility owners, and more
2. National BIM Guide for Owners and National BIM Standard
3. UK PAS 1192 – now ISO 19650


BS 1192:2007 + A2:2016 (retired) / ISO 19650-1:2018
PAS 1192-3:2014 / ISO 19650-3:2020
PAS 1192-2:2013 (retired) / ISO 19650-2:2018
Organizational Information Requirements (OIR)
Asset Information Requirements (AIR)
Asset Information Model (AIM)
Project Information Requirements (PIR)
Project Information Model (PIM)

OD • EXPEDITED
OD • GLOBAL
OD • TECHNOLOGY

Organizational Information Requirements

Management	Technical	Commercial
• Standards and guidelines • Contract terms and conditions • Roles and responsibilities for project delivery • Enterprise asset management systems • Model authoring and management protocols	• Software • IT and system performance constraints • Data exchange formats • Common coordinate systems • Levels of definition • Specified data formats • Specified attribute data model	• Information deliverables aligned to project delivery milestones • BIM capability and capacity evaluation criteria for business partners • BIM evaluation criteria for awards

Adapted from: https://www.cdbb.cam.ac.uk/system/files/documents/Framework_EIR_Core_Content_and_Guidance__V0.7_170329.pdf

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NCHRP Synthesis 20-05/Topic 52-14
Models as Construction Contract Documents

The objective of this synthesis is to document current practice in DOTs for providing 3D engineered models to highway contractors, in particular as the legal construction contract document.

Committees of Interest

TRB Standing Committee on Visualization in Transportation

AASHTO Joint Technical Committee on Electronic Engineering Standards

Transportation Pooled Fund study for BIM for Bridges and Structures

Design Review and 3D Model Quality Management for Model-based Design and Construction

The objective of this research is to provide guidance to agencies on how to develop design review QC and review documentation QA procedures for a 3D model environment, as well as to provide guidance for quality control of the digital, 3D model-based construction contract documents.

TRB Standing Committee on Visualization in Transportation

Previous webinar recording:

Contract Language for BIM for Bridges

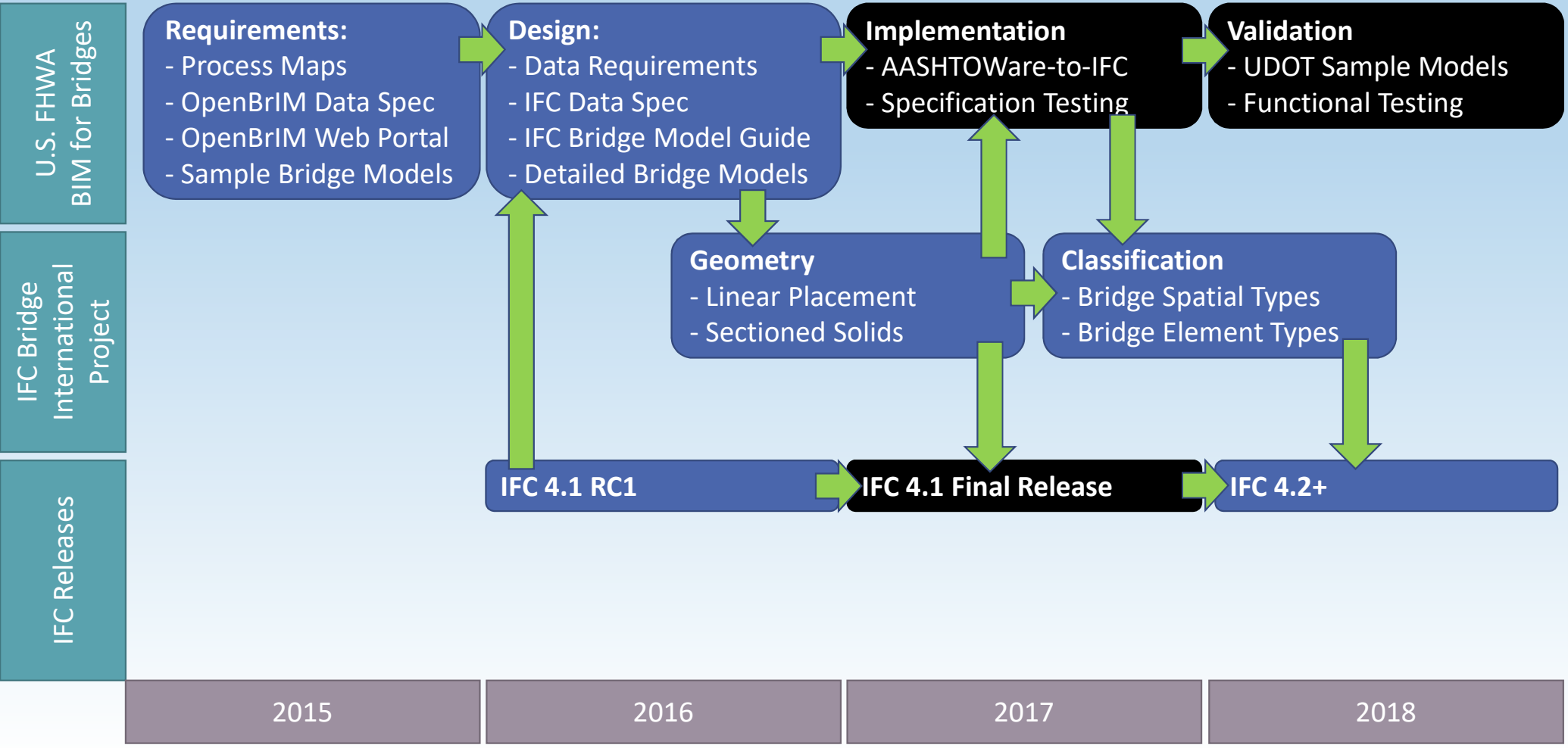
https://connectdot.connectsolutions.com/ptbxh0tfzv6u

Contact

Francesca Maier
ches@consultfaircape.com
443-208-8386

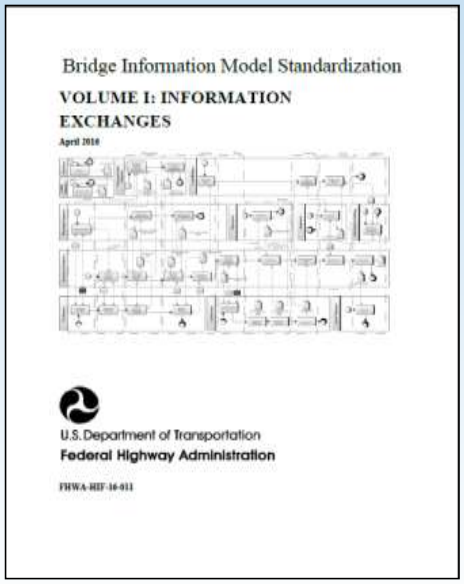
Bridge Data Exchanges

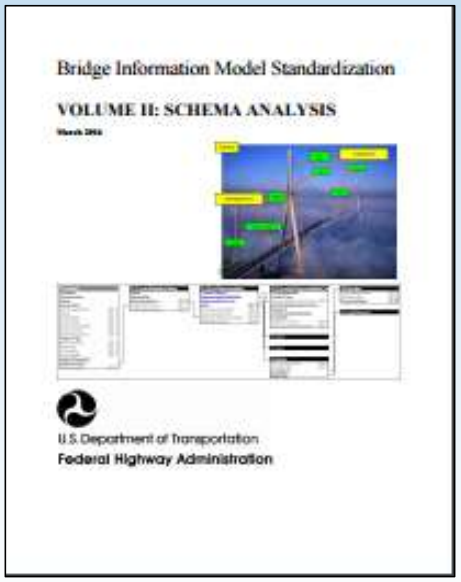
Background and History

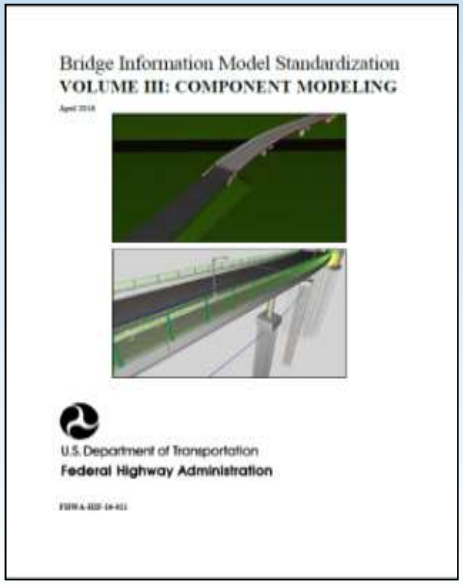


FHWA Bridge Design-to-Construction Exchange

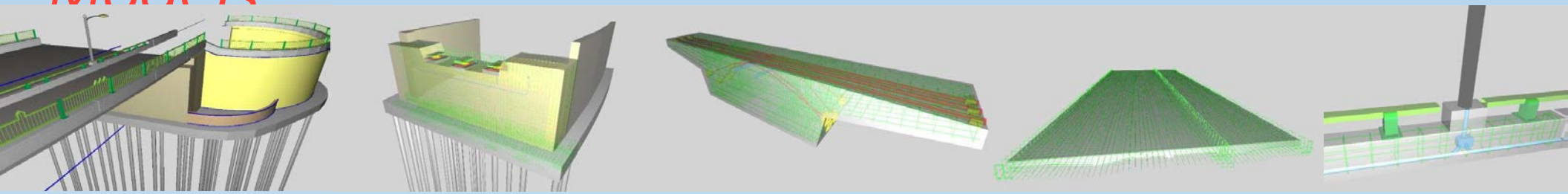
- Exchange Analysis: Information to be captured – who, what, when, and why?
- Schema Analysis: How can data be described in digital form?
- Component Modeling: What does specific data look like?

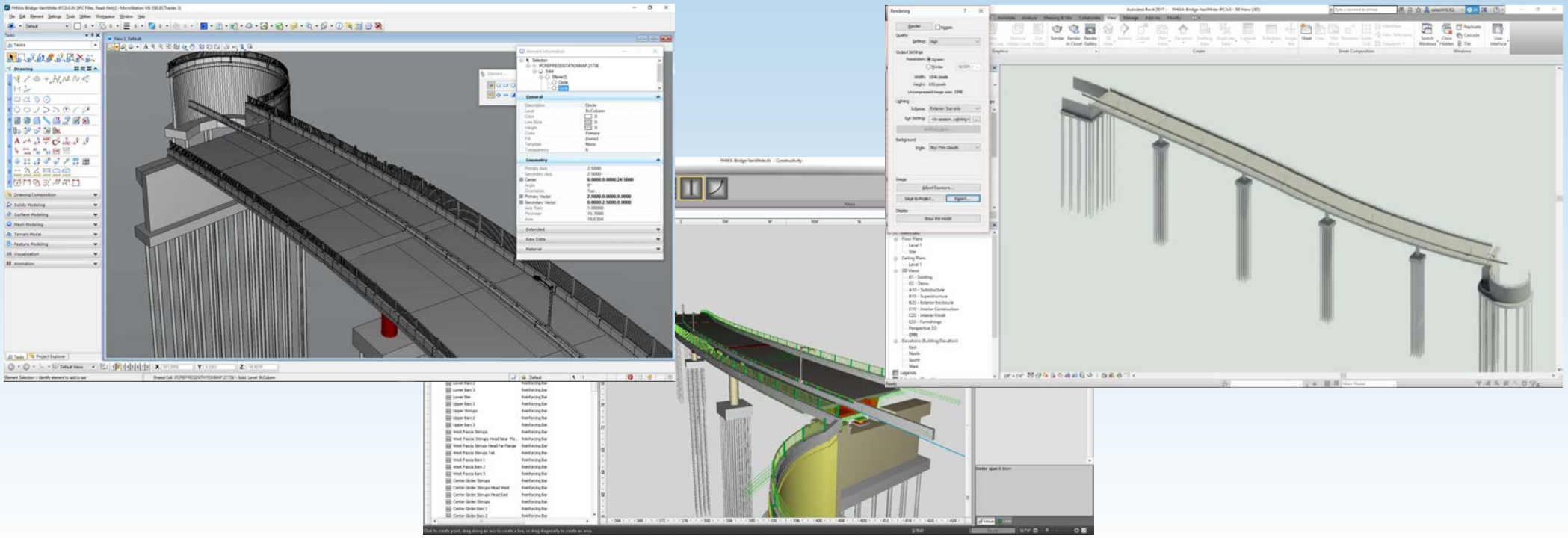






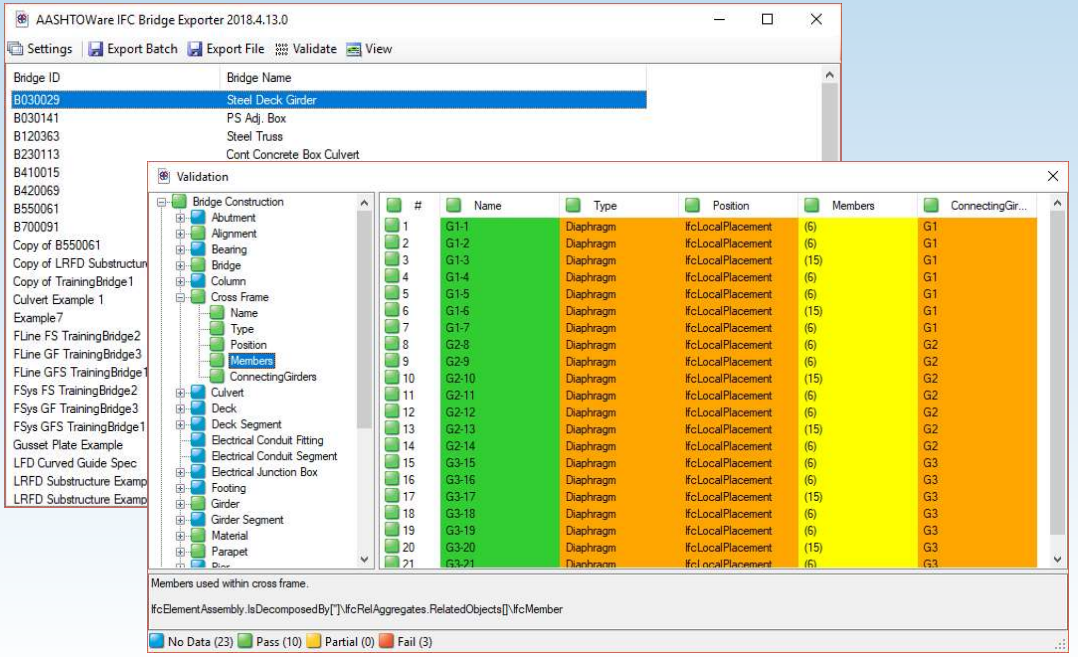
FHWA Bridge Design-to-Construction Exchange – Models



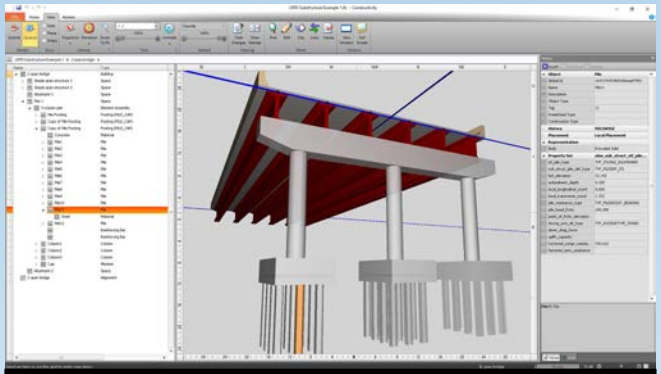


AASHTOWare Bridge Design/Rating IFC Converter: Goals

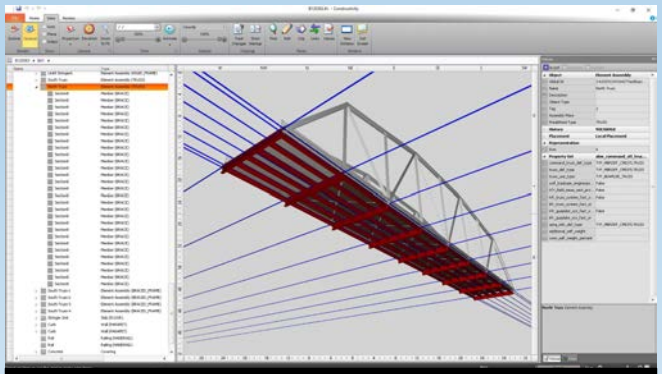
- Rapidly generate inventory of bridge models from existing data that can be immediately used by software vendors and bridge engineers to gain visibility into what is currently possible with candidate data standards
- Move data into other tools for 3D visualization, validation, downstream usage
- Prerequisite for consuming data (going in the other direction) for rating bridges authored by industry tools



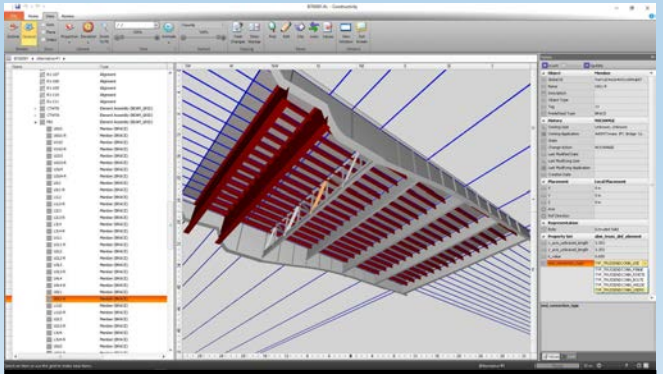
AASHTOWare Bridge Design IFC Converter: Sample Bridges



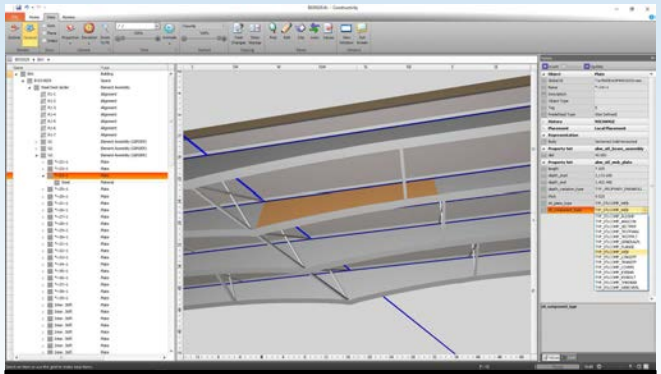
Substructures



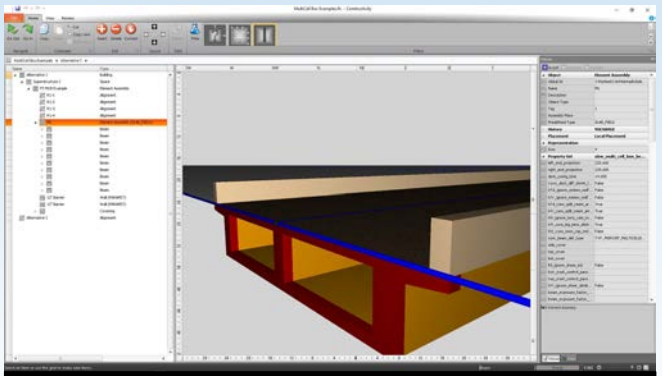
Trusses



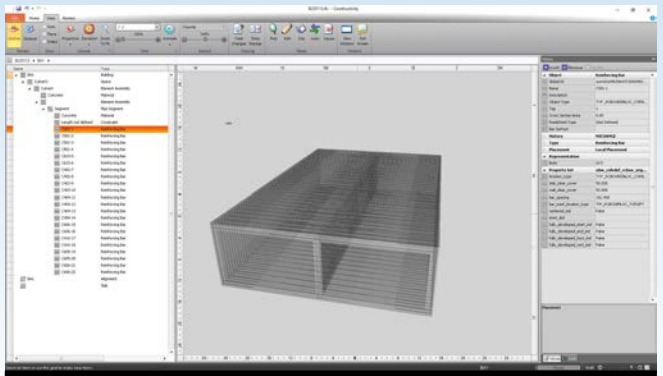
Girder Floor Systems



Girder Systems

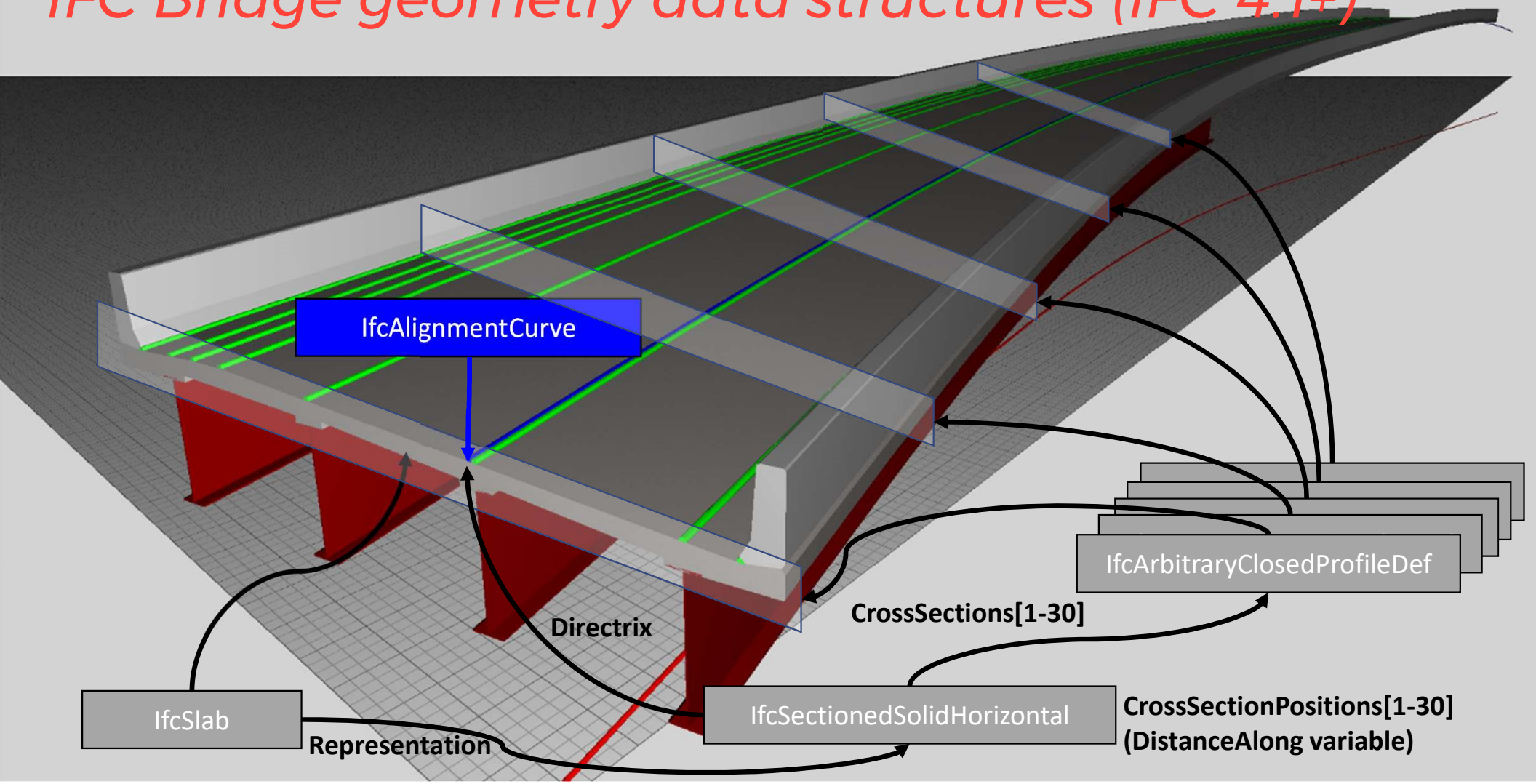


Multi-Cell Box Girders

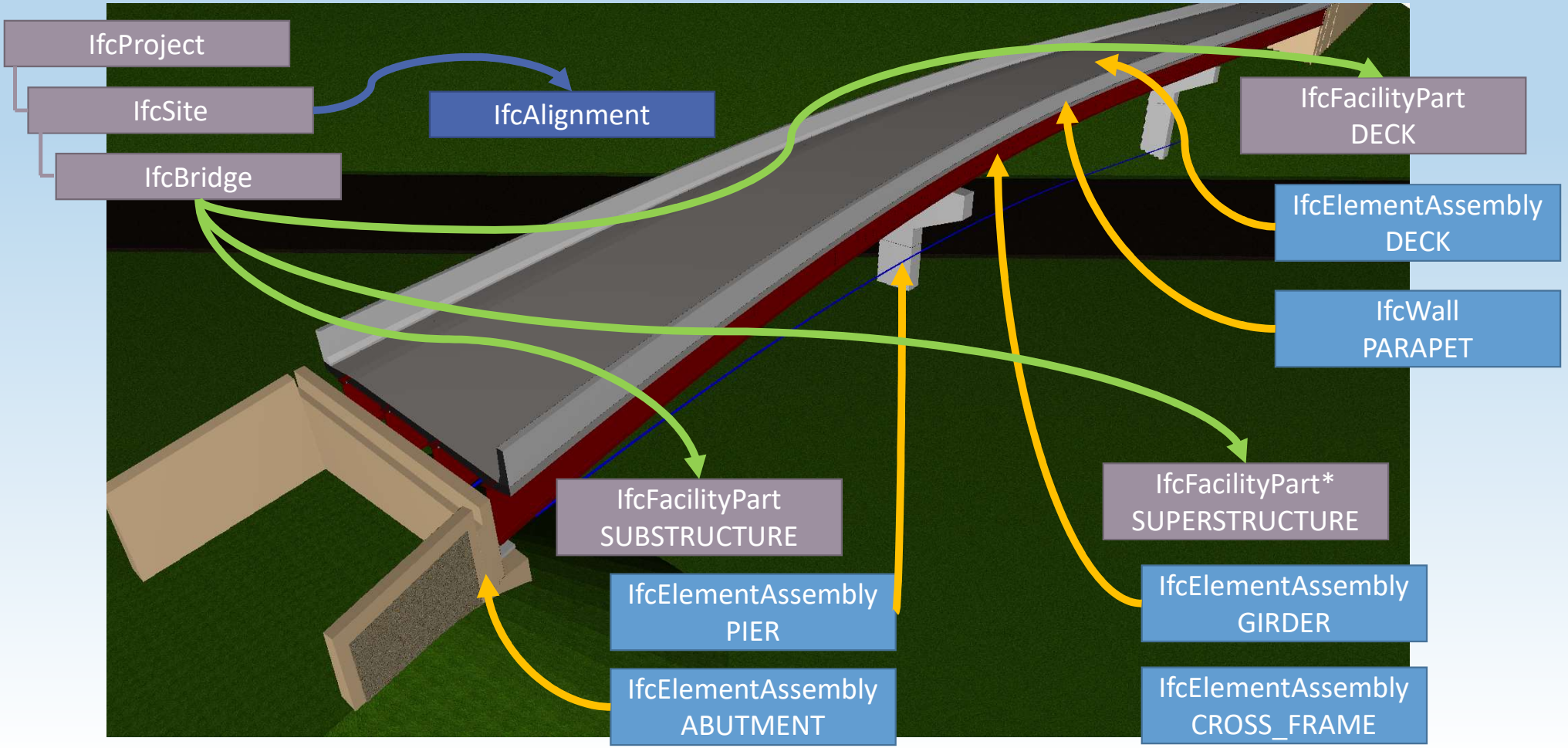


Culverts

IFC Bridge geometry data structures (IFC 4.1+)



IFC Bridge element classifications (IFC 4.2+)



Typical challenges in moving 3D data between software

Parametric (e.g. AW BrDR)
can define exactly if template is available, but cannot compose otherwise

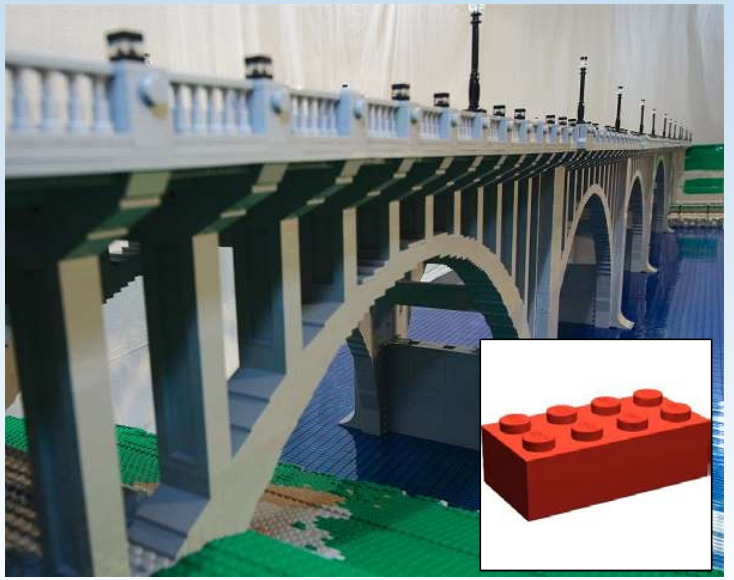
BrDR:
616 data types
18274 data fields

IFC:
1201 data types
8204 data fields

Generate primitives from templates

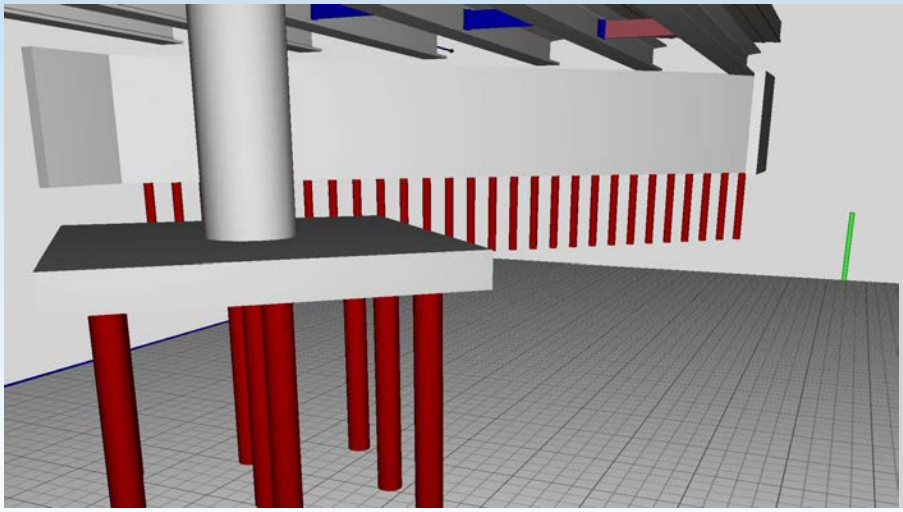
Pattern match to fit templates

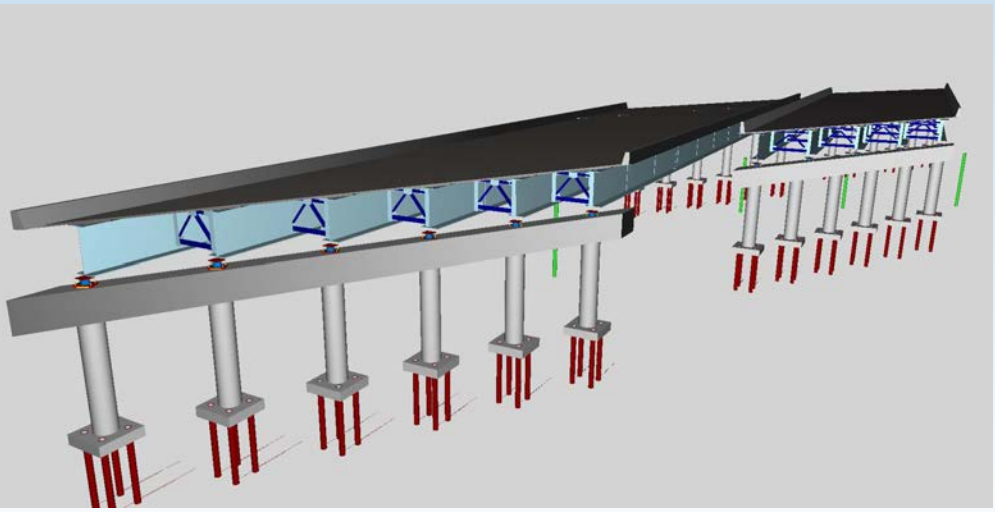
Primitive Geometry (e.g. IFC)
can compose primitives to approximate, but cannot always define exactly



IFC Models of Case Study Bridges

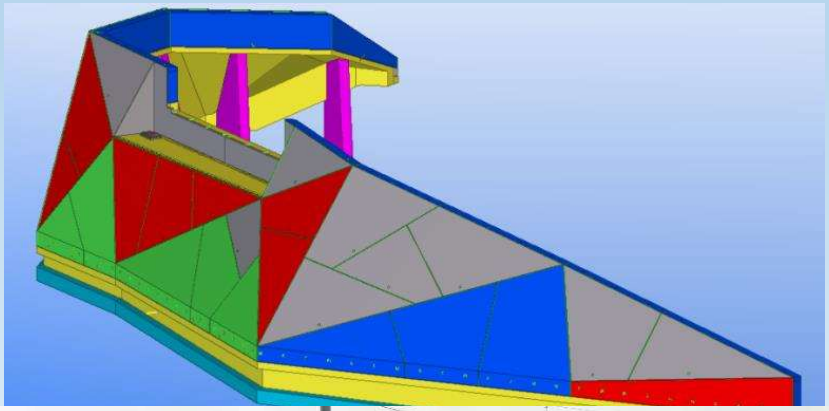
- Utah DOT Blackrock Case Study
- Generated parametric models from tessellated models of project data
- Loaded models into software for various uses (fabrication, qto, analysis, ...)

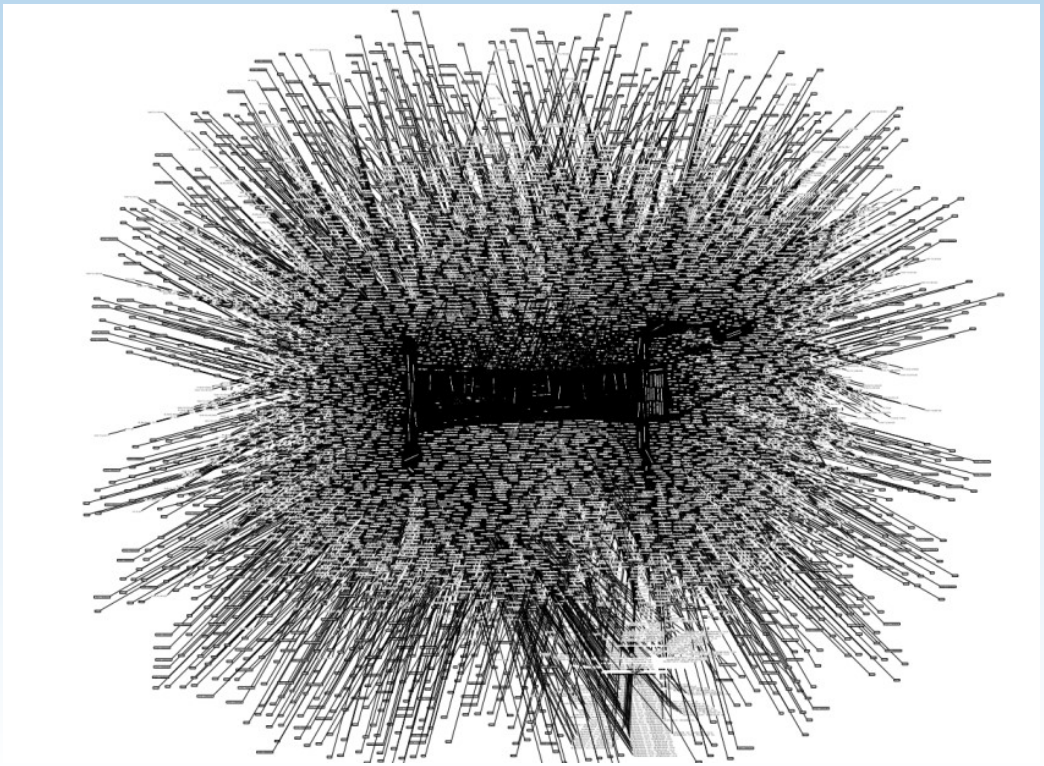




Limitations with data exported from project tools

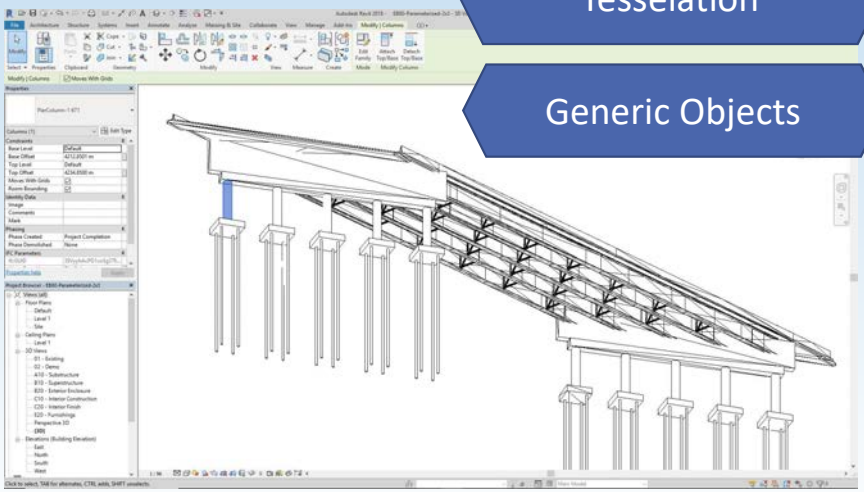
Saying a model is “delivered in IFC format” is like saying design plans are “delivered in paper format”





IFC Models of Case Study Bridges: model re-parameterization

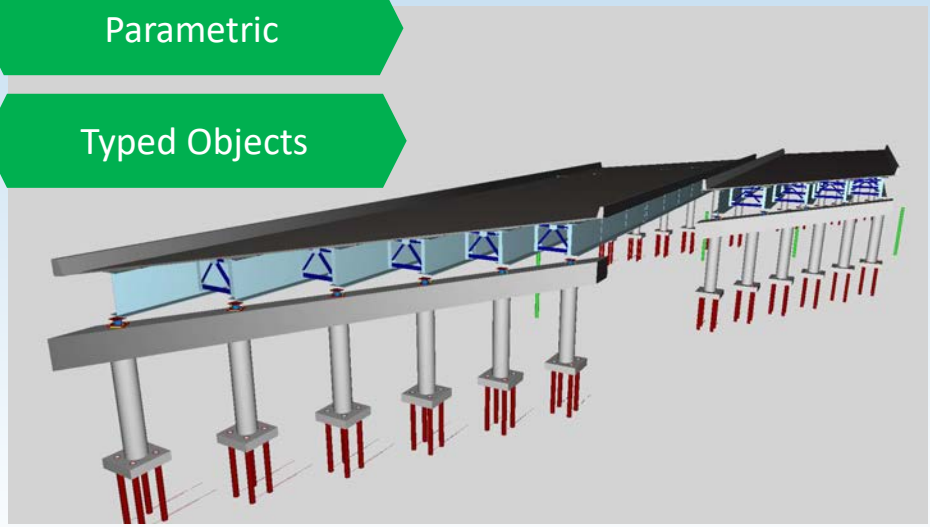
- Native software for project exported data as triangular meshes
- Models re-parameterized programmatically to support IFC 4.1 data structures



Redundant → Normalized

Tesselation → Parametric

Generic Objects → Typed Objects



Use Cases and Results

In general: at the time conversions were done [and still the case today], available software only supported IFC 2.3 and 4.0, so most uses cases required down-converting, losing linear referencing and geometry deriving from it

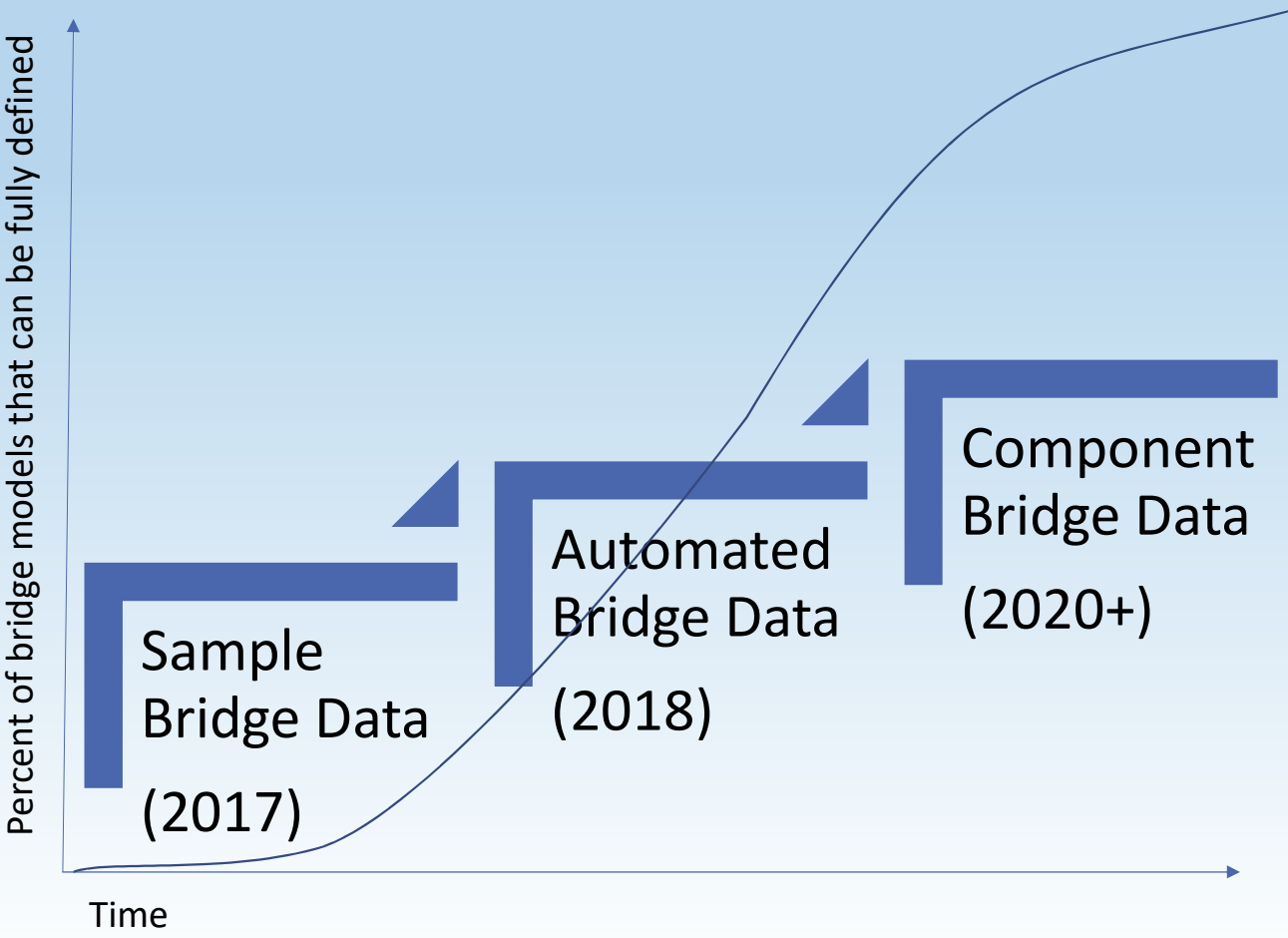
- Visualization – possible in most viewers if converted to IFC 2.3 or 4.0
- Quantity Takeoff – most viewers display quantity results
- Fabrication – rebar possible if normalized (collapsing repetitive bars)
- Structural Analysis – finite element analysis, but nothing code-specific

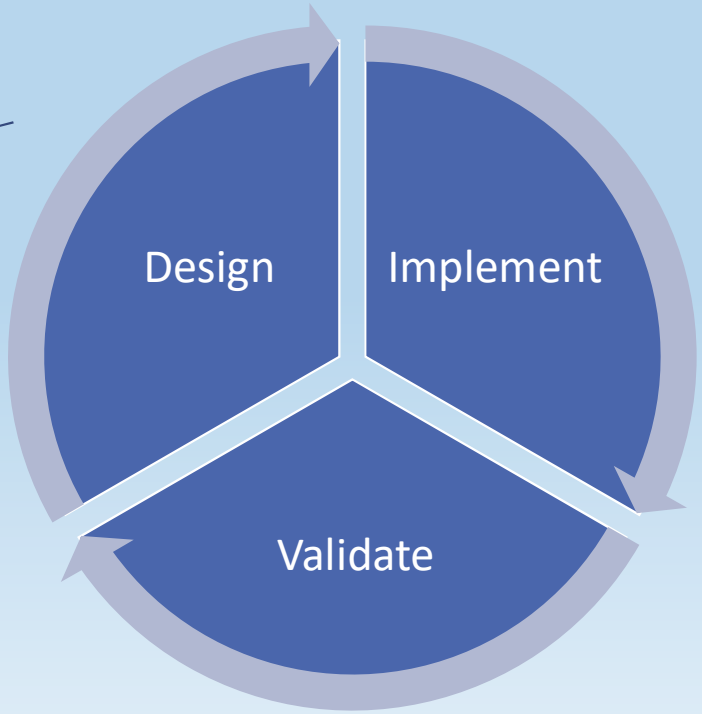
What gaps still exist with IFC data exchanges?

Some of the more obvious ones...

- Alignments with skew to define element positions and shapes
- Parabolic girders (defining exactly without interpolation or B-Rep)
- Pattern definitions (e.g. rebar, shear studs, cross frames)
- Material definitions to support U.S. standards
- Weld definitions (e.g. for machine control)

Development Lifecycle





Today's Panelists

#TRBWebinar

Joe Brenner

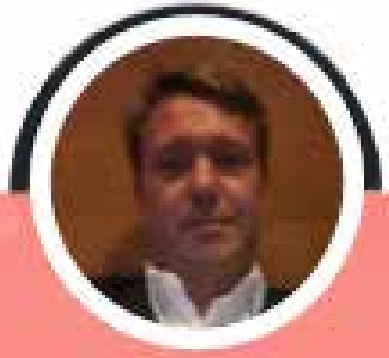
Consultant PM

WSP USA

Francesca Maier

Technical Requirements and Specifications

Fair Cape Consulting



Tim Chipman

Bridge Data Exchange and IFC

Constructivity

Roger Grant

IFC and Vertical Construction

NIBS

Upcoming relevant webinars

- September 22: Designing Beyond - Improving Airport Operations through BIM

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