CI123061: BIM Evolution for Wet Infrastructure: What If We Started Panama Canal Expansion Today?

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About the Speakers

Joseph Huang
- BIM Practice Leader at Stantec
- Registered Architect (Illinois)
- BIM Manager for Panama Canal Third Set of Locks
- PhD degree from Illinois Institute of Technology
- AU Speaker in 2011, 2013, 2016, 2017

Raghavendra Bhat
- Pune (RNet) BIM Leader at Stantec
- Sr. Civil Engineer
- Autodesk Certified Associate and Professional
- Integrator, Mentor & Trainer
- AU Speaker in 2013, 2016, 2017
Class Summary

This class will review the BIM uses in Panama Canal Expansion project and explore the latest technologies with “what if” scenario to propose a new template for projects in the future. Moreover, we will cover some workflows to integrate design, engineering and visualization process throughout the design and construction phases and discover some unique tools inside of Revit.
Key Learning Objectives

At the end of this class, you will be able to:

- Apply BIM to any unique project types with some strategic planning
- Optimizing the integrated design and engineering plus visualization workflows
- Best practices of design collaboration and coordination methods
- Exploring the latest technologies for large complex infrastructure projects
Agenda

- Brief History of Panama Canal
- Reason for Panama Canal Expansion
- BIM Uses & Challenges
- Lessons Learned
- Moving Forward
Brief History of Panama Canal
Canal History

- **1904** – Construction Began of the Original Canal
- **1914** – Original Canal opened
- **1939** – Third Set of Locks project initiated & abandoned due to WWII
- **1977** – Carter-Torrijos treaty signed for handing Canal over
- **1999** – Canal handed over to Panama
1881-89 – Failed French attempt at Sea-Level Canal
Facts about Panama Canal

- A ship sailing from New York to San Francisco via the canal travels **9,500 kilometers**, well under half the **22,500 kilometer** route around South America.
- **80 percent** of Panama’s economy is linked to canal activity.
- In **2009**, the Panama Canal Authority announced an expansion project for the Canal to allow larger ships to pass through the Canal.
Reason for Panama Canal Expansion
Economies of Scale

12 oz.
79 cents
6.6 cents/oz

VS.

67 oz.
(2 liters)
99 cents
1.5 cents/oz
Existing Locks vs. New Locks

Current status
Before work is completed
4,500 containers

Future status
Once canal is widened
12,000 containers

New water-saving basin uses 7 pct less than old system

Traffic in two directions

Neo-Panamax vessels
Technical Complexity

- Lock Structures
- Water Saving Basins
- Rolling Gates
- Operations and Maintenance
Design Innovation – Water Saving Basins

60% Savings
BIM Uses & Challenges

Panama Canal Third Set of Locks
How Big is Too Big?

Atlantic Locks Complex (length) vs. American football field (length) $\times 18$

Each Chamber can fit one Empire State Building (1250-1454’)

Global Team

- Seattle
- Denver
- Chicago
- Panama City
- Rotterdam
- Milan
- Pune
- Buenos Aires
- Milan
- Rotterdam
- Panama City
- Denver
- Seattle
- Buenos Aires
- Pune
- Milan
- Rotterdam
- Panama City
- Denver
- Seattle
BIM Requirements

- **FIM**: Facility Information Modeling
- **BIM**: Building Information Modeling
- **FIM ≠ FM** (Facility Management)
- AutoCAD & Revit
- No BEP back to 2009
Revit Model Organization

Atlantic Locks Complex
- Lock Heads 1, 2, 3, 4 (BA-Structure)
- Lock Wall UC/MC/LC (BA-Structure)
- MEP (BA-Mech & Elec)
  Buildings (BA-Arch)
  Gates A3, A7 (IV)
  Wing Walls, WSB Valves, Trifurcation (TT)

Pacific Locks Complex
- Lock Heads 1, 2, 3, 4 (CHI-Structure)
- Lock Wall UC/MC/LC (CHI-Structure)
- MEP (CHI-Mech & Elec)
  Buildings (BA-Arch)
  Gates P1, P3, P7 (IV)
  Wing Walls, WSB Valves, Trifurcation (TT)
Data Exchange – Globalscape and Workarounds

Workaround procedure – 2 types of Revit files:

(1) Working Model (live data)
(2) Published Model (detached / daily-based)
## Revit Family Creation with Special Requirements

### Basic Family – Lift

<table>
<thead>
<tr>
<th>Sub Category Name</th>
<th>Object Mapping Identification</th>
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</thead>
<tbody>
<tr>
<td>CLASS I MARINE</td>
<td>Assigned to all Class I Marine Concrete objects at the family level.</td>
</tr>
<tr>
<td>CLASS II INT</td>
<td>Assigned to all Class II Interior Concrete objects at the family level.</td>
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<tr>
<td>CLASS III STRUCTURAL</td>
<td>Assigned to all Class III Structural Concrete objects at the family level.</td>
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<td>CLASS V TREMIE</td>
<td>Assigned to all Class V Tremie Concrete objects at the family level.</td>
</tr>
<tr>
<td>CLASS VI MISC</td>
<td>Assigned to all Class IV Miscellaneous Concrete objects at the family level.</td>
</tr>
<tr>
<td>CONTRACTION JNT</td>
<td>Assigned to all Contraction joints in Plan and Elevation as symbolic lines at the family level.</td>
</tr>
</tbody>
</table>

Note: The illustrations below are showing the Contraction joint representation after each family is updated and information is matched to a specific subcategory.

Plan:

Outline 5: Assigned to all symbolic representation using symbolic lines for any area of the outer edge of an object needs to be represented at a thicker representation than the inner one.
Revit Family – Components & Modules

Valve Tower – Trifurcation – Monolith

Basic Family – UE-M5

Upper Chamber
Quantity Schedule from Revit – Lock Wall
Quantity Schedule from Revit – Lock Head

Schedule Concrete Volume -

Concrete Volume by Material

<table>
<thead>
<tr>
<th>Material Name</th>
<th>Material Area</th>
<th>Material Volume</th>
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<tbody>
<tr>
<td>CLASS I-STRUCT MARINE CONCRETE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L R-12-C2</td>
<td>1100 m²</td>
<td>343.22 m³</td>
</tr>
<tr>
<td>L R-11-C2</td>
<td>1100 m²</td>
<td>329.07 m³</td>
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<tr>
<td>L R-10-C2</td>
<td>1000 m²</td>
<td>324.04 m³</td>
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<td>1121 m²</td>
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<td>245.09 m³</td>
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<td>205.38 m³</td>
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<td>415.21 m³</td>
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<tr>
<td>L R-6-C1</td>
<td>1118 m²</td>
<td>304.11 m³</td>
</tr>
</tbody>
</table>

Grand total: 185590.30 m³
Interoperability between BIM applications

Tekla Model

IFC

Revit Model

DWG
Engineering Analysis Integration

- Revit
- Abaqus (FEA)
- Flow-3D (CFD)

SAT

STL
Clash Detections by NavisWorks
Clash Detections by NavisWorks

Excavation Model vs. Proposed Design Model
Facility and Asset Management in CMMS

Database for FM

Parameters in Revit

Revit direct outputs

Access Database

FM Model

Revit DB Link

Nomenclature

Revit Project Parameters

Revit Shared Parameters

Revit Family Parameters

Revit Schedule

Revit Tag
Facility and Asset Management in CMMS

Revit MEP

Navisworks Manage

Find Items by Element ID (will be the same in Revit, Navisworks & Access database)
Change Management

Cost / Efficiency

- Cost of design changes
- Traditional drafting-centric workflow
- Perceived BIM design process
- Recommended BIM design process

Unfamiliar with BIM tools & workflow

BIM best ROI

PD SD DD CD PR CA OP/FM

30% 60% 90 - 100%
Lessons Learned (what if we start with...?)
# BIM Execution Plan & Agreement

## Planning Phase
- LOD 100-200

## Design Phase
- LOD 200-300

## Construction Phase
- LOD 350-400

## Operations & Maintenance
- LOD 500

### 1. BEP
- Required Information
- Deliverable strategy

### 2. Survey
- Site Info
- As-Built
- Point Cloud

### 3. Model Authoring
- Per Discipline
- Scope/ Phase

### 4. Design Validation
- Engineering Analysis
- Bi-direction

### 5. Clash Detection
- Constructability
- Job Safety

### 6. Cost Estimate
- QTO
- Visualize the Progress

### 7. Site Logistics
- Construction Sequencing

### 8. Facility Management
- Life Cycle Data
- CMMS
### BIM Integration Map

<table>
<thead>
<tr>
<th>Site Information Model</th>
<th>Model Authoring Tools</th>
<th>Engineering Analysis</th>
<th>Navisworks</th>
<th>Deliverable Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>InfraWorks 360</td>
<td>Civil 3D</td>
<td>Flow-3D</td>
<td>Navisworks</td>
<td>NWD, DWF</td>
</tr>
<tr>
<td>Reality Capture As-built Model</td>
<td>Revit</td>
<td></td>
<td>A360 / BIM 360 Glue</td>
<td>PDF / 3D PDF</td>
</tr>
<tr>
<td>InfraWorks 360</td>
<td>Navisworks</td>
<td></td>
<td>AutoCAD</td>
<td>Object Enabler</td>
</tr>
<tr>
<td>ReCap 360 Ultimate</td>
<td>A360 / BIM 360 Glue</td>
<td></td>
<td>SimLab</td>
<td>(read 360 in AutoCAD)</td>
</tr>
<tr>
<td>Edgewise</td>
<td></td>
<td></td>
<td>BlueBeam</td>
<td></td>
</tr>
<tr>
<td>Acute 3D (ContextCapture)</td>
<td></td>
<td></td>
<td>BentleyModel</td>
<td></td>
</tr>
<tr>
<td>Pix4D</td>
<td></td>
<td></td>
<td>Revit</td>
<td></td>
</tr>
</tbody>
</table>

#### Legend
- **Collaboration:**
  - Final Output:
    - Software Plugin/Tool: Blue Text
    - Software Format: BLACK TEXT
    - Token Rate: Revit

- **Analysis:**
  - Direct Plugin

Common Data Environment: Local Server, Project Wise, Vault, A360, BIM 360

Interoperability w/Bentley, PLS-CADD & others: IFC, I-Model (Edgex), DXF, FBX
Infraworks: Site Planning & Feasibility Study
Infraworks: Site Planning & Feasibility Study
Reality Capture – Photogrammetry

- Helicopter/ Drone
- Capture Sequence
- 3D Mesh vs. Point Cloud
- Another option besides Laser Scanning / LiDAR
Reality Capture – Point Cloud
Revit Parts – Lift Modeling
Revit Parts – Lift Modeling
Revit Parts – Lift Modeling
Revit Parts – Lift Modeling

Displace Elements (view)
Revit Parts – Lift Modeling
Free Form Rebar in Revit 2018.1

- Rebar distribution along multiple curved face segments
- Create schedules and drawings to drive fabrication
- Increase 3D rebar modeling versatility
- File size increased & in-place family only

Work Breakdown Structure (WBS)

- No single file should be larger than 350 MB (+ or – 10%). Inefficiencies are rampant above this threshold and can adversely affect the health of a model. A model should be split into links if it reaches this range.

- However, too many linked models in a project will increase the management effort.
Rebranding of A360 Team to BIM 360 Team (AEC) and Fusion Team (Product & Manufacturing)

### A360 – Platform

#### A360 Drive
**Document & File Storage**
- Personal & Ad hoc storage
- Direct Sharing Capabilities
- Simple versioning
- 3D & 2D viewing of files.
- Limited mark-up and commenting
- Access via Web-Console and Mobile App(s)

#### A360 “Team”
**Project Based Storage for Data**
- Team site belongs to a company.
- Data is stored in projects.
- Users are granted access to the Team Site & Projects by a site administrator.
- Users from other companies can be invited to access specific projects.
- All the same file storage features as Drive.

#### A360 “Services & Applications”
- Some applications can be used and accessed without Drive or Team
  - Rendering
  - Insight
  - Glue
  - Docs
  - Ops
- Some services are additionally available when using Team
  - Collaboration For Revit (C4R)
A360 Collaboration for Revit (C4R)

RED ROCK POWERHOUSE PROJECT

Collaborate in Cloud

Properties

Drafting View

Detail

Graphics

View Scale: 1/2" = 1'-0"

Detail Level: Medium

Visibility/Graphics Override: Edit

Discipline: Structural

Sub-Discipline: Structural

Visual Style: Hidden Line

Identity Data

View Name: OPEN/CLOSE

Dependency: Independent

Title on Sheet: Referring Sheet

Referencing Detail

Worker: View "Drafting View Options"

Edited by: ADMIN

User Name: MWH_Sample_Proj

Group: -ADMIN

Collaborate using the cloud

You are about to initiate collaboration for the model using the cloud. Your model will be uploaded to a project you select.

Current Revit Model: RedRock_Powerhouse_STR2017_C4R.rvt

Select Project: MWH_Sample_Proj

What is a project?

Initiate Cancel

Collaborate

You are enabling collaboration. This will allow multiple people to work on the same Revit model simultaneously.

How would you like to collaborate?

Collaborate within your network

You can collaborate only on a local or wide area network (LAN or WAN). The model will be converted to a workshared central model.

Collaborate using the cloud

You can collaborate over any Internet connection. A copy of the model will become workshared and be uploaded to the project you select. The original model will remain as a backup.

Which collaboration method should I choose?

OK Cancel
A360 Collaboration for Revit (C4R)
A360 Collaboration for Revit (C4R)
BIM 360 Team – Model Version Comparison
BIM 360 Glue & Navisworks
BIM 360 Glue & BIM 360 Field

- BIM 360 Glue: Share Equipment Sets to Field
- BIM 360 Field: Add a model from BIM 360 Glue
- BIM 360 Field: Mapping Properties (associate the Glue model properties with the Field equipment properties)
- BIM 360 Glue: Sync back the equipment data, installation status, commissioning information from the Field
Use Point Layout to improve office-to-field efficiency and QA/QC
4D Modeling / Construction Sequencing
COBie Extension from Revit and Navisworks
Panama Canal Rendering 2009 – 2012 – 2015
Visualization – A360 Rendering
Revit Live
Workflow & Interoperability: Infraworks, Civil 3D, Revit, & Navis
Moving Forward
The Evolution of Design Technology

- 2D Drawings
- 3D BIM Modeling
- Reality Capture
  - Animations
  - Augmented Reality
  - Rendering Images
  - Virtual Reality
From Design Model to Virtual Reality / Augmented Reality

**BIM Platforms**
- IntraWorks 360
  - Civil 3D
  - Revit
- AECOsim or Open Plant Modeler

**Translator Software**
- IntraWorks 360 iPad App
- NavisWorks + A360 Cloud Render plugin
- Fuzor
- Enscape
- Live / Stingray
- A360 Cloud Render
- VRED
- AR Media (Max plugin)
- 3D Viewer Revit HoloView HoloLive
- Unity + Visual Studio
- Fuzor

**Output / Wearable Devices**
- iPad & IW 360 App
- Google Cardboard VR + QR code & URL
- Oculus Rift
- HTC Vive
- iPad & AR Media Player App
- Microsoft HoloLens
Augmented Reality
Virtual Reality

- Experiencing real spatial environment with human scale & daylighting confirmation.
- Supplement clash detections - Clearance and flaw detection to avoid change orders.
- Enhance training in a facility before and after final build.
- Multiple stakeholders doing the ‘real-time’ collaboration in the virtual space with avatars.
Mixed Reality
DAQRI Smart Helmet

(1) Powerful Process (Intel Core m7)
(2) Tracking Camera
(3) Large Field of View Optical See-through Displays
(4) Thermal Camera
(5) Depth Sensors: an integrated RGB Camera, Stereo Infrared Camera, and an Infrared Light Projector.
Mixed Reality – Revit to HoloLens via HoloLIVE
Mixed Reality – HoloLens
Questions?

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THANK YOU