**BIM Course #1**

**Fundamentals**
- Fundamental Understanding of Building Information Modeling

**Core Curriculum**
- Placed in 3rd-year Construction Documents (including Commercial & Industrial Focus)

**Computer Mediated**
- On-Line Technology
- Learning to supplement the knowledge of the apprenticeship instructor

**Fundamental Content**
- BIM Defined
- Evolving Construction Industry
- Level of Detail/Development
- Project Delivery & Deployment Methods
- Prefabrication
**Development Storyboards**

*(handful of examples)*

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**BIM Today**

Developer: Today, with the addition of computer based technology and modeling called BIM, the ability to visualize construction in 3D view or spatial communication allows for more understanding than a 2D image along with including embedded information (data) such as equipment specifications, installation parameters, etc.

**NOTE:** Selecting correct or incorrect answer returns feedback.

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**ETA KNOWLEDGE CHECK**

Developed by:

Test your knowledge!
Each multiple-choice question has four answer choices. Read each question and answer choice carefully and choose the ONE best answer. Try to answer all questions. In general, if you have some knowledge about a question, it is better to try to answer it.

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**Navigation Notes:**

Next:
Back:
Menu:
### Level of Development Specifications

These levels were created to assist everyone involved in BIM process to understand each person's responsibilities.

<table>
<thead>
<tr>
<th>Levels of Development</th>
<th>100</th>
<th>200</th>
<th>300</th>
<th>350</th>
<th>400</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Six Levels of Development, but only 300, 350, and 400 are relevant to MEP contractors</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Narration:** Although there are six Levels of Development (100, 200, 300, 350, 400, and 500), the levels most important to MEP contractors are LOD 300, LOD 350, and LOD 400.

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### Master Plan

- **Fundamentals (R1)** 2020
- **Modelers (R3)**
- **Construction Workflows (R2a)**
- **Field Layout Tools (R2b)**

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The Future of Construction

Presented by Josh Bone

Josh Bone
Construction Technologist
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@BIM2theBone
https://jbknowledge.com/thecontechcrew-podcast-episodes

- BIM & VDC Specialist
- Construction Technologist
- Podcasting
- Consulting
- Training
- Implementation
- Company Standards

Construction is Changing

Why do we care?
- We are employing over 800,000 (13%) fewer people in the AEC industry today than in 2007. (Lack of Qualified Labor)
- Out of 4,693 worker fatalities in private industry in calendar year 2016, 991 or 21.1% were in construction. (Safety)
- 65% of projects over $1 Billion and 35% of projects under $500m finish over budget or behind schedule. (Lack of Certainty in the Schedule)
- Material cost have risen 5.6% over the past 12 months and are expected to rise another 5-6% in the next 12 months. (Reducing waste is more important than ever)
- More companies like Factory OS, Katerra, KSF, DIRTT, Full Stack RAD Urban, etc. are coming into the AEC industry. (The competition is changing)
Construction is Changing

Why does California care?

• For every 4 people leaving the trades 1 person enters an apprenticeship

• Today California has less than 100k registered apprentices, the governor of California wants 500k registered apprentices by 2028

Chicago Numbers

• For every 4 people leaving the trades 2 person enters an apprenticeship

Breaking Down BIM

BIM = Building Information Modeling
BIM is the Tools we use to create models

VDC = Virtual Design & Construction
VDC is the process we use to leverage models for coordination, prefab, etc.

“We’ll figure it out in the field.”

Is changing to…

“We’ll figure it out in the computer.”
Breaking Down BIM

BIG BIM

Breaking Down BIM

little BIM

Breaking Down BIM

The Right amount of BIM
Leveraging BIM

- 80% of the Risk comes from 20% of the project
- Focus on the 1%
- 1% per $1 million = $10,000.00

Reasons For Adopting Technology

- Ability to impact cost and performance
- Cost of design changes
- Orthographic work flow
- BIM/Revit

Breaking Down BIM

What’s the cost of inefficiency?

9.7 DAYS FOR RFI RESPONSE
$1,080 PER RFI REVIEW & RESPONSE
21.9%

SOURCE: Impact & Control of RFI’s on Construction Projects, Navigant Construction Forum
The cost of a clash

Simple clash detected

• Beam: W8 x 28
• Pipe: 8” thermoplastic PVC sanitary waste

“Clash No. 3: We recommend increasing the size of the beam from W8x28 to W24x55 and providing an opening in the steel beam at the location of the conflict between the pipe and beam. Refer to GS2-4 for the location and SK-6 for the detail.”

The cost of a clash

Recommendation from engineer:

Without BIM

W8 x 28 = $1,300
W24 x 55 replacement = $2,500
Removing old beam = $205
Installing new beam = $195
Cutting a hole for the penetration on site = $464

Total direct cost = $4,664

With BIM

W24 x 55 = $2,500
Cutting a hole for the penetration in the shop = $210

Total direct cost = $2,710
### "We’ll Figure it out in the Field."

#### The cost of a clash

<table>
<thead>
<tr>
<th>Description</th>
<th>Direct cost without BIM: $4,664</th>
<th>Direct cost with BIM: $2,710</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 days of general conditions</td>
<td>$22,000</td>
<td></td>
</tr>
<tr>
<td>5 days delay to other trades</td>
<td>Not Included</td>
<td></td>
</tr>
<tr>
<td>Cost of 5 days lost use</td>
<td>Not included</td>
<td></td>
</tr>
<tr>
<td>Liquidated damages</td>
<td>Not included</td>
<td></td>
</tr>
<tr>
<td>Total cost</td>
<td>$26,664+</td>
<td>$2,710</td>
</tr>
</tbody>
</table>

#### This is what we have to Build from today

[Diagram of building layout]

#### Coordination

[Diagram showing coordination efforts]

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8/7/2019
Virtual Construction

Issues Communicating in the Field

Pushing Models to the Field
Model Viewing for All – On Any Device – Anytime – Anywhere

Autodesk Mobile Viewers

Navisworks Freedom

Trimble Model Viewers

Trimble SketchUp Mobile Viewer
$9.99 Android and iOS

Solibri Model Viewer

2016 Construction Technology Report

HyperModeling - Bentley Pioneered the way

Macro Coordination Tools

revizto
Macro Coordination Tools

- FUZOR
- revizto
- 360 GLUE
- BIMTRACK

2016 Construction Technology Report

- Solibri - Rules based clash detection

4D BIM – Schedule & Planning

- Navisworks, Synchro, Vico, etc.
Two ways to justify BIM

BIM ROI
or
BIM as an Insurance Policy

Case Study: Arizona State University ISTB IV

Background
• Project: Interdisciplinary Science and Technology IV (ISTB IV) Research Building
• Location: Tempe, AZ
• Construction Value: $113 Million
• Project Size: 298,000 sq. ft.
• Industry: Higher Education
• CM: Sundt Construction
• Project Delivery Method: CM at-Risk
Case Study: Arizona State University (Continued)

- ISTB IV is a $113 million research laboratory delivered by CM@R.
- Because of prior relationships, the Construction Manager (Sundt Construction) and Design Team (HDR) managed the project more like an IPD than CM@R, allowing for more open communication and sharing of information.
- Trade subcontractors were shortlisted prior to bid based on their ability to utilize BIM and to maximize prefabrication. The project is currently 100% Complete.

<table>
<thead>
<tr>
<th>Subcontractor</th>
<th>Percent of Projects Utilizing BIM</th>
<th>BIM Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sundt Concrete</td>
<td>80 %</td>
<td>Better work planning and execution</td>
</tr>
<tr>
<td>RCI Systems (Fire Protection)</td>
<td>40 %</td>
<td>Major increase in accountability of trades in coordination</td>
</tr>
<tr>
<td>Dynamic Systems (Mechanical and Plumbing)</td>
<td>100 %</td>
<td>Space Management and coordination with other trades</td>
</tr>
<tr>
<td>Wilson Electric</td>
<td>35 %</td>
<td>Resolving constructability conflicts in the virtual world</td>
</tr>
</tbody>
</table>

BIM saves Money, but BIM also costs Money

<table>
<thead>
<tr>
<th>Subcontractor</th>
<th>Contract Value</th>
<th>Estimated Costs for All Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sundt Construction (GC)</td>
<td>$63,310,132</td>
<td>$63,310</td>
</tr>
<tr>
<td>Sundt Concrete</td>
<td>$12,625,532</td>
<td>$55,000</td>
</tr>
<tr>
<td>RCI Systems (Fire Protection)</td>
<td>$1,000,460</td>
<td>$18,580</td>
</tr>
<tr>
<td>Dynamic Systems (Mechanical and Plumbing)</td>
<td>$27,000,000</td>
<td>$0 (Included in standard labor factors)</td>
</tr>
<tr>
<td>Wilson Electric</td>
<td>$16,674,659</td>
<td>$51,204</td>
</tr>
<tr>
<td>Additional Non-estimated BIM Costs</td>
<td>$40,000</td>
<td></td>
</tr>
<tr>
<td>Totals</td>
<td>$67,819,661</td>
<td>$324,014</td>
</tr>
</tbody>
</table>
The real cost of BIM $324,014

<table>
<thead>
<tr>
<th>BIM Costs to...</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contract Values of Parties Involved with BIM</td>
<td>6%</td>
</tr>
<tr>
<td>Total Contract Value</td>
<td>3%</td>
</tr>
</tbody>
</table>

Pre-fabrication Components Percent Prefabricated

<table>
<thead>
<tr>
<th>Component</th>
<th>Percent Prefabricated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ductwork</td>
<td>100%</td>
</tr>
<tr>
<td>Piping</td>
<td>30%</td>
</tr>
<tr>
<td>Fire Protection</td>
<td>90%</td>
</tr>
<tr>
<td>Electrical</td>
<td>5%</td>
</tr>
</tbody>
</table>

• Schedule Savings due to pre-fabrication = 16 Weeks
  • Weekly General Conditions = $125,000
  • 16 Weeks X $125,000 = $2,000,000 Savings

Trade Coordination / Change Management

<table>
<thead>
<tr>
<th>Subcontractor</th>
<th>Change Order Value (G&amp;O and Contingencies)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sundt Concrete</td>
<td>$0.00</td>
</tr>
<tr>
<td>RCI Systems (Fire Protection)</td>
<td>$0.00</td>
</tr>
<tr>
<td>Dynamic Systems (Mechanical and Plumbing)</td>
<td>$86,450.00</td>
</tr>
<tr>
<td>Wilson Electric</td>
<td>$0.00</td>
</tr>
<tr>
<td>Other Subcontractors and Issues</td>
<td>$504,085</td>
</tr>
<tr>
<td>Total</td>
<td>$589,135</td>
</tr>
</tbody>
</table>
### Change Management / Project Comparison

Change Orders due to design issues and/or field coordination issues. Does not include Change Orders due to Design Changes or Alternate Material selections.

<table>
<thead>
<tr>
<th>Project</th>
<th>Construction Contract Value</th>
<th>Change Orders (A&amp;E and Cont.)</th>
<th>Percent of Contract</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASU BIO 1</td>
<td>$49,793,546</td>
<td>$3,654,281</td>
<td>7.3%</td>
</tr>
<tr>
<td>ASU BIO 2</td>
<td>$52,029,178</td>
<td>$3,616,504</td>
<td>6.9%</td>
</tr>
<tr>
<td>Average</td>
<td>$50,911,362</td>
<td>$3,635,393</td>
<td>7.1%</td>
</tr>
</tbody>
</table>

### Change Management / Project Comparison

<table>
<thead>
<tr>
<th>Project</th>
<th>Construction Contract Value</th>
<th>Percent of Contract</th>
<th>Change Orders</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average of BID 1 &amp; 2</td>
<td>$50,861,362</td>
<td>7.1%</td>
<td>$3,635,393</td>
</tr>
<tr>
<td>Anticipated ISTB IV based on History</td>
<td>$112,400,000</td>
<td>7.3%</td>
<td>$7,994,600</td>
</tr>
<tr>
<td>Actual ISTB IV</td>
<td>$112,400,000</td>
<td>0.8%</td>
<td>$989,135</td>
</tr>
<tr>
<td>Change Order Reduction</td>
<td></td>
<td></td>
<td>$7,005,465</td>
</tr>
</tbody>
</table>

### Project Savings

<table>
<thead>
<tr>
<th>Costs / Savings</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project BIM Costs</td>
<td>$324,014</td>
</tr>
<tr>
<td>Schedule Savings due to Pre-fabrication</td>
<td>($2,000,000)</td>
</tr>
<tr>
<td>Change Order Reduction</td>
<td>($7,005,465)</td>
</tr>
<tr>
<td>Additional Design costs</td>
<td>($0.00)</td>
</tr>
<tr>
<td>Total</td>
<td>($8,681,451)</td>
</tr>
</tbody>
</table>
Digital Layout is Evolving

**Robotic Total Stations**

- Trimble
- Leica
- Sokkia
- Topcon

**2nd Generation Robotic Total Station – Rapid Positioning Systems**

- 5 Arc Seconds
- +/- 1/8" at 164'
- Range of 100m
- 8.8lbs.
- Built-in Wi-Fi
- Auto-Leveling
- Retails around $10,495
2nd Generation Robotic Total Station – Rapid Positioning Systems

- Range of 50m
- Autostationing™
- 300° of tilt for easy overhead measurements.
- Green laser: lets you measure without a prism on a wide range of surfaces.
- Retails around $19,000

New Methods of Layout

“X Marks the Spot”

Spectra QML800 X

Scanning The Built Environment

Reality Capture
• Data Acquisition Speed: 43,200 measurement points/sec
• 3D Measurement Accuracy: +/- 0.1% (typically)
• Maximum Range: Up to 30m (15m outdoors)
• Laser Safety Class: Class 1 Eye Safe
• Angular Field of View: +270 x ~360 degrees
• Weight of Scanner Head: 1.0 kg
• Dimensions of Scanner Head: 86 x 113 x 287mm

• Full 360 Scan
• Thermal Imaging
• Weighs 2.2 lbs.
• Recap 360 Pro App
• View instantly on an iPad
• Registers Scans Automatically
• Transfer into Revit
• 4” x 6 ½”
• $16,000
3D Scanning

- Full 360 Scan
- Weighs 9.2lbs.
- 500,000 points per second
- Accuracy of +/- 3mm
- Registers Scans Automatically
- Range of 70 meters
- $24,000

S150 & S350

Deviation Analysis

What Verity Does

- 3 Hours to Process
- 8 Hours to QA and Create PDF Report
- ~50% of Steel was installed out of tolerance, 8% required follow up
- Initial results found some Steel members 3” out of Place

Faro As-Built for Revit

- Utilize Automatic Fittings Tools
- Create customized Revit family objects based on point clouds
- Benefit from level of accuracy analysis tools
- Fully integrated part of FARO Scan to BIM System
Reality Capture

- Laser Scanning Rebar and Post Tension Cable
- Laser Scanning to check floor flatness
- Convert Scan to BIM
- True As-Built Models
- Future Corrs can be made without scans

Aerial Drones For 3D Data Capture

Computer Vision

Leica DS2000 Utility Detection Radar
Microsoft secures $480 million HoloLens contract from US Army
The military branch could purchase up to 100,000 of the devices
Offsite Construction is the Future of Construction

Why should we be Prefabricating?

Benefits of Prefabrication
- Safer working conditions – fewer ladders, less silica exposure, less tools used overhead, exposure to weather, etc.
- More productive
- Adds certainty to the schedule
- Reduction of Waste
- Improved Quality
- Win more bids
- Etc.

The amount of project work using prefab has almost tripled between 2010 and 2016.

2010: 13% 2016: 35%

2017 FMI/BIMForum Prefabistan Survey
Comparing work in the Shop to the Field

<table>
<thead>
<tr>
<th></th>
<th>Shop</th>
<th>Field</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labor Rate</td>
<td>$75/Hr</td>
<td>$110/Hr</td>
</tr>
<tr>
<td>Single Clevis Hanger</td>
<td>3 Minutes</td>
<td>10 Minutes</td>
</tr>
<tr>
<td>Single Tier Trapeze Hanger</td>
<td>6 1/2 Minutes</td>
<td>17 Minutes</td>
</tr>
</tbody>
</table>

Advances in Digital Fabrication

TigerStop

Accelerated Change

Changes in the Contracts
Owners are requesting Lean Construction

THE ISSUE

The Construction Industry is unsustainable for many reasons. The global economy needs the industry to be more efficient. Current processes are not agile or flexible enough to accommodate change and lack the foresight to envision the operating reality that exists in the future. “If you don’t look, it’s not real.”

Our house is on fire.

RAPID BUSINESS

OUTDATED PROCESSES

FINANCIALLY INFEASIBLE

DIMINISHED VALUE

Internet of Things

...And Has Become Software Driven Buildings

20% of the cost of a building occurs during construction

80% of the cost of a building is operating and maintaining the building.

Smart Cities

70% of the World’s Population is expected to Migrate to Urban Environments by 2050

THE SMART CITY
What can you do?

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