BIM
And Project Constraints
(Best Strategies for Effective Project Control Using BIM)

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Today’s Challenges of AEC Industry

- Complex Projects
- Tighter Budgets & Deadlines
- Internal & External Collaboration
- Information overload
- Project Risks
BIM Foundations
Definition - Benefits and Usage
BIM

- BIM stands for Building Information M.....

- Collaboration process to share information using a smart 3D model.
BIM

- BIM stands for Building Information Model (smart composition of objects + information)
BIM ELEMENT AND ATTRIBUTES
- **Modeling**

The **process** of **Sharing** information about building,

**Defining** the **Execution Plan Implementation** the process of the **C D E**.

- begins with **creating** an intelligent 3D design model

- uses that model to **facilitate** coordination, simulation, and visualization,

- helping owners and service providers **improve** how buildings and infrastructure are planned, designed, built, and managed.
- **Management**

  The **Human** role, making sure **everybody collaborates** for **the benefits of the project** without any conflicts of interest.

  **Right information, in the right form, from the right person, at the right time**
BIM workflow

- BIM enable **Everyone** - access - **All Project Data** at **Anytime**

(**Common Data Environment**)  

( **BIM platform**)
- Cloud-based.
- Manage user access.
- Host different file formats.
- Integrate a 3D BIM model viewer.

**BIM** is about sharing information and working together
One single source of truth for data across the project lifecycle

Deep analytics to inform decision making and planning for future projects

Accelerated computational power to support simulation and visualization (AR/VR)

Real-time, multi-discipline collaboration across geo-dispersed teams

Access to project data anytime; anywhere; on any device

Connected BIM
The BIM lifecycle - **Four** phases:

- **Renovation**
- **Design**
- **Construction**
- **Facility management and maintenance.**

Some studies showed **owners** could save 10% to 20% of **building management expenses**, but in order to do so, the three other phases, need to be correctly implemented.
BUILDING INFORMATION MODELLING

LEVEL 0
NO BIM, CAD, LOW COLLABORATION

LEVEL 1
2D-3D, PARTIAL COLLABORATION

LEVEL 2
4D-5D, FULL COLLABORATION

LEVEL 3
6D, OPEN BIM, iBIM, FULL INTEGRATION
**BIM Principles**: Level – Dimensions - LOD

- **Dimensions**

  *(4D)* refers to 3D + **Time**. Construction Scheduling (accurate program information and visualization, showing how your project will develop sequentially).

  *(5D)* refers to 4D + **cost**. Generating Cost Estimates and practicing Target Value Design allows the stakeholders to keep track - analyze cost / budget over the construction lifecycle.
4D schedule of an airport terminal building prepared using Synchro PRO 4D scheduling and project management software.

Image courtesy of Synchro Software.  source: BIM Handbook
Use of 4D simulation.
Image courtesy of Hyundai E&C.  
source: BIM Handbook
4D simulation of complex ribbon landscape.
Image courtesy of Shimizu Corporation.
BIM Principles: Level – Dimensions - LOD

**LOD** Level of Development (from 100 to 500) defines for each stage of the project how deep the BIM model will be developed regarding

**Two categories.**

1. **Level of detail** - the geometry, maturity,
2. **Level of information (LOI)** - the quantity of data.

- **LOD 100** - basic overall idea of the shape and **no data, just a box**
- **LOD 200** - approximate dimensions, shape, and location
- **LOD 300** - specific size with correct location and orientation with material defined
- **LOD 350** - for coordination purposes. **exact** shape and location.
- **LOD 400** - Construction
- **LOD 500** - As Build.

https://bimforum.org/lo/
Benefits of BIM

The majority (87%) of BIM users in the study report that they are receiving positive value from their use of BIM. Most believe that they have only just begun to experience the full potential.

- 34% Fewer errors
- 22% Greater cost predictability
- 21% Better understanding
- 16% Improved schedule
- 8% Optimized design

Advanced Analysis Example 1: Auditorium
Contract Documentation from BIM extractions

Analysis of roof panels by area in Dynamo.
Image courtesy of BDP.

source: BIM Handbook
Understanding with BIM

Site meetings with BIM

Setting out with BIM

Understanding construction...

Operations & maintenance with BIM
Project constraints and BIM
Project constraints

A constraint, in project management, is any restriction that defines a project's limitations; the scope, for example, is the limit of what the project is expected to accomplish.
How Project Constraints are Interrelated

All of the six constraints influence each other in that any one getting affected impacts one or more of the rest.

If necessary resources are not available, time to deliver will increase. This may also increase project cost, because alternate resources, if available, may be more expensive than planned.

If QA team finds that the quality of a deliverable is going bad, more resources may be required. This increases the cost—for additional resources—and effort to fix the faulty deliverable. This will also increase the time to deliver.

If scope creep happens on the project, it will result in increased time, cost, resources, and potentially reduced quality. And thus increased risk on delivery.
Scope Creep....

44% of projects challenged with scope creep were late and over budget.

Scope creep can cost up to four times as much as initial development costs.
Work Breakdown Structure (WBS)

- Level 1 – Project
  - MTB

- Level 2 – Area
  - Pier 1
  - Pier 2

- Level 3 – Subarea
  - Basement
  - Floor 1

- Level 4 – Fragnet
  - MEP
  - Structural

- Level 5 – Activity
  - Concrete

- Level 6 – Object
  - Columns
  - Slab Zone 5.34

- Level 7 - Operation
  - Rebar
  - Pour Concrete
  - Curing

- Category
  - Columns

- Family
  - Round Columns
  - Rectangular Columns

- Type
  - Rectangular Columns 600 mm
  - Rectangular Columns 600 mm
  - Rectangular Columns 450 x 600 mm
  - Rectangular Columns 600 x 750 mm

- Instances
PMBOK knowledge areas versus BIM roles in construction project management
Integrated project delivery

BIM Collaboration
Current Industry Practice

Communication between teams:
- Mail
- Shipping services
- Fax
- Email
- File transfer protocol (FTP)
- Internal servers configured for access through a firewall

Owner Team
Tools focused on the owner team:
- Capital planning software
- Financial software
- Operations software

End Result
- Potential delays
- Unexpected costs
- Non-environmentally friendly (paper & shipping)

Design Team
Tools focused on the design team:
- Project Information Management (PIM) software
- Design software
- Office management software

Construction Team
Tools focused on the construction team:
- Project management software
- Bid management software
- Estimating software
Integrated Project Collaboration (IPC) software

**Owner Team**
- Tools focused on the owner team:
  - Capital planning software
  - Financial software
  - Operations software

**Web-based**
- Hosted in the cloud

**Collaborative**
- Designed for shared use

**Integrated**
- All parties at the same table
- Equal access & accountability for all team members

**End Result**
- Fewer delays
- Lower costs
- Greener project
- Higher quality building

**Design Team**
- Tools focused on the design team:
  - Project Information Management (PIM) software
  - Design software
  - Office management software

**Construction Team**
- Tools focused on the construction team:
  - Project management software
  - Bid management software
  - Estimating software
BIM Collaboration
Integrated Project Delivery (IPD)

It's about Productivity

- Owner Leadership
- Integrated Project Structure
- Open Information Sharing
- Virtual Building Models

PD: Pre-design
SD: Schematic design
DD: Design development
CD: Construction documentation
PR: Procurement
CA: Construction Administration
OP: Operation

1. Ability to impact cost and functional capabilities
2. Cost of design changes
3. Traditional design process
4. Preferred design process

Graphic originated by Patrick McLeay, AIA / HOK
Integrated Project Delivery (IPD)

BIM supports processes such as **Integrated Project Delivery**.

The American Institute of Architects defines IPD as:

"a project delivery approach that **integrates**

people, systems, business structures and practices

into a process that **collaboratively** harnesses the talents and insights of all participants

**to optimize** project results, **increase value to the owner**, **reduce waste**, and **maximize efficiency through all phases of design, fabrication, and construction**"

*(source: 'Integrated project delivery: a guide').*
The guide identifies nine key principles for successful IPD:

1. Mutual respect and trust
2. Mutual benefit and reward
3. Collaborative innovation and decision making
4. Early involvement of key participants
5. Early goal definition
6. Intensified planning
7. Open communication
8. Appropriate technology
9. Organization and leadership

The guide cites six key factors of IPD, as differentiated from traditional procurement routes:

1. Integrated team comprising key stakeholders, assembled early in the process and working collaboratively and openly
2. Information openly shared at all levels; expertise and knowledge contributed early in the process
3. Collective management, shared appropriately between the stakeholders
4. Team rewards are shared, and based on project success
5. Building Information Modelling is utilized
6. Risks are shared
<table>
<thead>
<tr>
<th>BIM Uses</th>
<th>Asset Management</th>
<th>Design Management</th>
<th>Resources (Time/cost)</th>
<th>Sustainability / Environment</th>
<th>Communication / Information Production</th>
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Best strategies for effective project control
Using BIM
6 Ways **Virtual Reality** Construction Technology Can Save You Money

1. Reducing Rework
2. Improving Safety
3. Lowering Labor Costs
4. Meeting Timelines
5. Resolving Issues Faster
6. Increasing Quality

source: Autodesk
Immersive virtual reality viewing of the BIM model.

Image courtesy of DCA Architects Pte Ltd.
7 Major **Construction Technology Innovations** to Watch in 2018

1. Virtual Reality
2. Augmented Reality
3. Wearable Technology
4. Machine Learning
5. Prefabrication
6. Predictive Analytics
7. Connected Job Sites

source: Autodesk
The Best 10 strategies for effective project control using BIM in Construction

1. Better Collaboration and Communication
2. Model-Based Cost Estimation
3. Preconstruction Project Visualization
4. Improved Coordination and Clash Detection
5. Reduced Cost and Mitigated Risk
6. Improved Scheduling/Sequencing
7. Increased Productivity and Prefabrication
8. Safer Construction Sites
9. Better Build
10. Stronger Facility Management and Building Handover

source: Autodesk
1. Better **Collaboration** and **Communication**
2. **Model-Based Cost Estimation**

Sigma – the most powerful and user-friendly software for Estimating and 5D BIM

Sigma is the next generation 5D BIM solution for construction professionals who need to deliver accurate results faster, in today’s increasingly complex and competitive market.

**SUBCONTRACTOR**

**GENERAL CONTRACTOR**

**ARCHITECT / ENGINEER**

**Save Time**

**Improve accuracy and real-time insights**

**Increase profits**

**Total Cost:**
- 1,874,459.85
- 37,174.20
- 8,847,285.80

**Construction site**

**Model**

**Options:**
- Exterior Insulation
- Insulation - 138mm PIR
- Generic - 200mm
- Generic - 225mm C
- Paret Wall

**File**

**Home**

**View**

**Libraries**

**Reports**

**Data**

**Tools**

**Help**

**Autodesk BIM 360**

**Sigma Templates** - Sigma Enterprise

**New Sigma Document**

- **Construction site**
- **Model**

**Total Costs:**
- 1,674,459.85
- 865,466.04
- 13,459.24

**Hours:**
- 37

**Labor:**
- 665,466.04

**Materials:**
- 965,466.04

**Lease/Equip:**
- 3,459.24
Easy to set up new slice'n'dice views

Follow the project’s main cost drivers
2.5.1.1. Brick wall, cavity, standard face, 4" common back-up, 10" thick, styrofoam cavity fill

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Change numbers anywhere, without ever breaking a formula

Work with multiple classifications and model parameters to create reports
3. Preconstruction Project Visualization

1: Give It the Time It’s Due
2: Promote Early Collaboration
3: Integrate Design with Construction
4: Use the Latest Clash Detection Tools
5: Give Teams Everywhere Visibility
4. Improved **Coordination** and **Clash Detection**
BIM 360 Glue Features

BIM 360 Glue puts BIM coordination into the hands of the whole project team, helping accelerate virtual design and construction workflows.

**3D Model Access**
- Anytime, anywhere access
- 50+ file formats
- Sync models for offline viewing

**Constructability Review Tools**
- Review and annotate models
- Send notifications to project team
- Respond to markups

**Simply Navigate Models**
- Gesture-based pan, zoom and orbit
- Gravity-assisted walk through navigation
- Select, hide and reveal model components

**Measure**
- Point-to-Point tools
- Object snapping
- Automatic calculations

**Navisworks Integration**
- One-click publish to Glue
- Perform more detailed clash detection
- Send links and notifications to reviewers

**Design Tool Integration**
- Upload directly to Glue
- Automatically manage model versions
- Access and isolate clashing elements
5. Reduced Cost and Mitigated Risk

Construction Document Management For Risk Mitigation

Keep the Right Information in the Right Hands

• Permission settings
• Version control
• Audit logs
3 Major Construction Risk Management Issues

1-Jobsite safety
- Use Cloud-based Construction Software to Manage Your Project's Safety Program
- Construction checklist software
- Mobile Construction Safety

2-Scheduling risk
- Lack of scheduling accountability
- Lack of alignment between project teams
- Inefficient work processes
- Create a Realistic Schedule focused on the contract requirements and development at the milestone level.
  Plan frequently to break down into more manageable durations.
  Engage the project team in review process and provide feedback in forecast updates.
- checklists using construction quality software

3-Cost-associated risks
- Conduct Constructability Reviews and Catch Errors Before You Build
- rework can be prevented by conducting a virtual constructability review via clash detection software
- Eliminate Construction Waste: Both Time and Materials
On a typical construction job...

55-65% of craft workers’ time is wasted

90 minutes per day is wasted by employees looking for “stuff”

57% of US construction spending is waste

Productivity in construction declines every year

*Lean Construction Institute, 2008
*foconstrucitngpros.com, 2015
*The Journal of Lean Construction, 2014
Reduced waste

58% of Production Time is Non-Productive

- Waiting: 25%
  - Information
  - Prerequisite Work
  - Materials
  - Equipment & Tools
- Unnecessary Movement: 13%
- Unnecessary Material Handling: 12%
- Rework: 8%

Manufacturing Waste = 26%
Source: Construction Industry Institute - CII
**BIM 360 Build**  Improve construction quality & safety, and streamline daily reporting

- Improve construction **quality** control and **jobsite safety**.
- Improve construction quality control and **reduce rework**.
- Use **checklists** to promote jobsite **safety** program conformance.
- Create, assign and manage issues, **RFIs** and Submittals.
- Track **field performance** with construction **daily reports**.
BIM 360 Build Features

Combine mobile technologies for onsite use with cloud-based collaboration and reporting to manage field processes such as quality, safety and commissioning.

**Quality Control Programs**
- Create and assign issues
- Track work with checklists
- Communicate project status

**Jobsite Safety Management**
- Inspection templates
- Pre-configured checklists
- Safety metrics reporting

**Commissioning & Handover**
- Track equipment and assets
- Update asset information on iPad
- Attach documentation to equipment

**Daily Reporting**
- Dashboards and custom reports
- Export data to Excel for analysis
- View cross-project trends

**Collaboration**
- Access to project data online or offline
- Schedule work for team members
- Automate report distribution

**Access & Permissions**
- Permissions by user, role or company
- Control Subcontractor access
6. Improved Scheduling/Sequencing

- Schedules can be **planned more accurately** and communicated exactly.
- The **improved coordination** helps projects be more likely to be **completed on-time or early**.
**DAY 1**
- AM: Column rebar cage installation and inspection
- PM: Rebar cage for Core wall, Jacking up of internal formwork for core wall, Column Casting

**DAY 2**
- AM: Dismantle of column form work, 4 numbers
- PM: Set table form, Close form work for Core wall, Column form work closing and Casting

**DAY 3**
- AM: Dismantle of column form work, 4 numbers
- PM: Set table form, Install Hollow Core Slab, PC half slab, Core wall form work closing, PC Beams installation

**DAY 4**
- AM: Installation of Hollow Core slab, Installation of PC slab & beams, Rebar for spandrel and RC beam, Formwork closing for core wall
- PM: Installation of Hollow core Slab at Lift Lobby, Rebar for Post tensioning beams, Laying of tendons PT beams, Final Casting of columns, Beams, slabs
**DAY 5**

- AM: Rebar for spandrel and RC beam
- AM: Rebar for half slab area at core wall
- PM: Post tensioning works for PT beams

**DAY 6**

- AM: Laying BRC mesh at south side
- PM: Closing side form works for beams

**DAY 7**

- AM: Laying BRC mesh at north side
- AM: Final adjustment of PT works and completion
- PM: Beam side formwork
- PM: Cleaning and final check of Formwork alignment, rebar works and PT works
- PM: Rebar, and PT works inspection

**DAY 8**

- AM: Inspection of Beam Form work and alignment
- PM: Setting of level pegs and marking of casting level
- PM: Casting of wall, Beam and Slab
7. Increased Productivity and Prefabrication

BIM data can be used to **instantly** generate **production drawings or databases** for manufacturing purposes, allowing for increased use of **prefabrication and modular construction technology**. By designing, detailing and building **offsite** in a **controlled environment**, you can **diminish waste**, **increase efficiency**, and reduce labor and material costs.

- 5 **less** deliveries
- 2 weeks **shaved off** the schedule
- 18 **less** material handling **hours**
- 110 **less** field **hours**
- 13% **cost savings** on materials
(A) BIM model of a multistrade rack. (B) A photograph of the same rack installed in the building. Image courtesy of Mortenson.

Shop drawing for multistrade prefabrication (for manufacturing). Images courtesy of Hyundai P&G.
BIM can help improve construction safety by pinpointing hazards before they become problems and avoid physical risks by visualizing and planning site logistics ahead of time.

Visual risk analysis and safety evaluations can help ensure safety over the course of the project execution.
BIM for Safety

Safety in Design

Site Layout Planning

Worker Training

Monitoring

Safety Planning

Hazard/Risk Analysis

MR AS BUILT (2014)
Navisworks Job Hazard Analysis Add-in
A Rule Based Checking BIM Platform for Safety Planning and Simulation

(Zhang, S., Venugopal, M., Teizer, J., and Eastman, C. 2011)
9. Better Builds

The increased reliability of a **coordinated model** leads directly to greater building quality.

By sharing common BIM tools, more experienced team members work together with builders through all phases of the project, providing better **control over technical decisions** around design execution.

The **optimal ways to construct** a project can be tested and chosen **early** in the project, and structural deficiencies can be identified before building.

With the use of **visualizations**, **better design aesthetics** can be more easily chosen, such as modeling the flow of natural light into a building. Then, during construction, **reality capture technology** can be utilized to **improve accuracy**.
10. Stronger Facility Management and Building Handover

BIM empowers operation of the building after construction is over, providing an ROI well after project completion.

Using construction software, an accurate, ongoing digital record of building information is valuable for facilities management and renovators for the entire lifecycle of the building.

Data can be sent into existing building maintenance software for post-occupancy use.

Using BIM tools contractors can transform building handover by connecting BIM data generated during design and construction to building operations.
BIM technologies applied in construction projects

Case studies
BIM Technologies Applied in Construction Phase of China Zun Tower
• Over 90% of model clashes can be addressed with BIM coordination. 
  Rework and modification drop by 65% compared with traditional practice.
On-site inspection with BIM data presented on iPad simplifies the difficulty of construction management, reduce errors, saves times and improves efficiency.
• 3D scanning data is imported in Autodesk Recap Pro to generate As build BIM models for interior decoration
PRINCE MOHAMMAD BIN ABDULAZIZ INTERNATIONAL AIRPORT, MEDINA, KSA
Building Information Modeling Facilities Management Integration

Project highlights:

• 156,940 m²/Terminal Building and Concourses
• 8,000,000 passengers per year/Terminal Design Capacity
• 14,320 tons/Structural Steel Works
• 89,161 m³/Concrete Works
• 10,000,000 m³/Excavation Works
• 2,800,000 m³/Filling Works
• 1,500,000 m²/Runway, Taxiway, Apron Area
• 32 units/Passenger Boarding Bridges
• 93 units/Lifts, Escalators, Travelators
• 2,200 baggage per hour/Baggage Handling System Capacity

source: BIM Handbook
The following summarize the two main milestones:

- **Develop** a federated BIM model of the terminal, including all discipline systems:
  - BIM **LOD 500** modeling:
    - gathering construction specification, documents, and drawings; modeling the terminal and systems

- **Organize and integrate** BIM with facility management and operation objectives; integrate physical equipment and system information of the terminal:

  [Mechanical systems in BIM model.](#) Image courtesy of TAV Construction.
BIM FM platform interface where detailed visual and element information is available to the user.

Image courtesy of TAV Construction.
Model Elements with Maintainable Content in CMMS Database

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<th>BIM Model File Name</th>
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BIM in the Field

IT infrastructure of the BIM-FM platform and relation to the CMMS application
Lessons Learned: Problems, Challenges, Solutions

- **Specification Requirements**
- **Early Engagement** of FM Stakeholders and Concurrent Data Capture

- **Element Tagging.**
  - Barcode tag numbers
  - Equipment serial numbers
  - As-built shop drawing tags

- **Room Space Definition**

- **System Definition**
  1. Hydronic systems: supply and return water piping
  2. Air duct systems: fresh, supply, return, and exhaust air ducts
  3. Electrical system

### Object IDs compiled of several naming levels

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<th>Object ID Naming Levels</th>
<th>Description</th>
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<td>Level 1: System Code</td>
<td>AA: Two-digit system code as defined by TibaH i.e., 04 for HVAC System</td>
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<tr>
<td>Level 2: Subsystem Code</td>
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<td>Level 4: Unique ID</td>
<td>DDD: Numbering restarting at each room. i.e., 1,2,3, etc.</td>
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Section view of the terminal concourse showing **the room space volume definition** used as part of asset naming.

Image courtesy of TAV Construction.
handling unit (AHU) shown
with both the connected supply/return water supply system and air duct routing
to areas the unit is serving.

Image courtesy of TAV Construction.
SENIOR ARCHITECT
MOHAMED BADAWY EL-SAID

Formal Representative of BIM-Arabia.
PMP - BIM Manager - Autodesk Certified Professional - Autodesk certified instructor - BPAC

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