Utilizing BIM for Integrated design construction, commissioning, operation and maintenance

Barry Wormald
This presentation will show how BiM can be utilized for integrated design, construction, commissioning, operation and maintenance, and includes the following:

- Why change is necessary
- Comparison of IPD using BiM with traditional design
- ROI on BiM from case studies
- Challenges & Barrier to BiM implementation
- BiM benefits
- BiM case studies
- BiM 4FM
Time For Change?

- Construction Industry - No improvement in productivity in 60 years - unlike any other industry.
- CII study in US found 57% wastage in construction. CII: Construction Industry Institute.
- European study found 30-40% wastage.
- US study showed 40-50% construction in US behind schedule.

- No official productivity index to verify this
Reduction in Overdesign

CIBSE Research Report 4 –

“Engineering Design calculations and the use of margins”
  - Most buildings investigated are over engineered. Margins added continuously.
  - Typical excess margins found were 30% with maximum 84%.
  - The calculated peak load only need 0.1% of the year
  - 20% reduction in plant capacity = no difference in comfort

India
  - Typically design base on “Thumb Rules” – Outdated

BIM
  - More accurate design & system capacity selection

From CIBSE Research Report 4

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
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<tr>
<td>Initial Load</td>
<td>100</td>
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<tr>
<td>Margin</td>
<td>10%</td>
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<tr>
<td>Equipment size</td>
<td>10%</td>
</tr>
<tr>
<td>Pipe System Losses</td>
<td>10%</td>
</tr>
<tr>
<td>Margin for chiller</td>
<td>10%</td>
</tr>
<tr>
<td>Select Next size</td>
<td>15%</td>
</tr>
<tr>
<td><strong>Total Margin</strong></td>
<td><strong>65%</strong></td>
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</tbody>
</table>
Early engagement is key for BIM in IPD

Integrated Project Delivery

- BIM for Design & Engineering
- BIM for Construction
- BIM for Operation
- BIM for Maintenance

Early engagement of Stakeholders and Concurrent Value Engineering on BIM is key to Integrated Project Delivery that leads to efficiency & gains.
How IPD impacts – Traditional vs New

Traditional Project Delivery

- Fragmented,
- Liner, distinct, segregated;
- Individual managed, transferred
- Individual pursued
- Paper based, 2 dimensional; analog
- Transfer risk; no sharing

Integrated Project Delivery

- An integrated team entity
- Concurrent and multi-level;
- Collectively managed
- Team success value-based
- Digital based, virtual building information Modeling (3, 4 and 5 dimensional)
- Open sharing collaboration; risk sharing
Typical Lifecycle Cost of a Building

- **Design**: $3% - 1 Year
- **Build**: $17% - 2 Years
- **Operate**:
  - Run / Maintain: $40% - 25 Years
  - Repair: $30% - 25 Years
  - Periodic Replacement / Refurbish: $10% - 25 Years
- **Dispose**: $?% - 1 Year

**Total Cost of Ownership**: 100%
Cost benefits are not easy to quantify as you can’t build the same building twice. The paper lists a number of case studies to demonstrate the benefits of BiM, which includes:

- **Owner and stakeholders**
  - Up to 40% of unbudgeted changes eliminated
  - Cost estimation accuracy increased to within 3%
  - Project cost reductions ranging from 15% - 26%

- **Contractors and Sub-contractors**
  - BiM for pre-fabrication reduced installation schedule from 4-5 weeks to 5 days/floor
  - 65% improvement in supply chain engagement
  - Reduced space and cost savings

- **Architects and Consultants**
  - Reduction in design cost
  - Reduction in wastage
Implementing BiM at any level is not simple and some of the challenges and barriers from a RICS School of Built Environment study are:-

- Requires overcoming mind set barrier
- Initial time and effort needed is more
- Not all stakeholders use BiM
- High cost of Hardware/Software
- More upfront effort and team discipline required
- Changes are quicker and easier in 2D CAD
BiM Case Studies

The following pages will show practical examples of where we have use BiM to benefit projects as follows:-

- **Concept** - Reduction in over design - building / system optimisation
- **Scheme** - Construction drawings – reduction in wastage
- **Detail** - Optimisation of design and space utilised
- **Construction** - Prefabrication – sequence and planning
- **Commissioning** – “Virtual commissioning” or Optimisation
- **Facility Management** – Operation & Manual in digital format
Benefits of BIM in Design - Energy/ System Modeling

- Review & optimise building and system designs at early concept stage.

**Example: Massing options – Same Floor Area**

- **Option E**: 117 kWh/m²/yr, $24/m²/yr, 68% daylit
- **Option C**: 67 kWh/m², $11/m²/yr, 90% daylit
- **Option D**: 74 kWh/m², $12/m²/yr, 87% daylit
Project Example: Preliminary Energy Analysis helped reduce chiller capacity by 633 KW (180 TR)
BIM based Energy Optimization: benefit example

**Peak Space Cooling Demand**

- **Annual Estimated Utility Bill**
  - $9/m²
  - **Energy Use**
    - 21,663,639 kWh
    - 76 kWh/m²

- **Annual Estimated Utility Bill**
  - $8/m²
  - **Energy Use**
    - 19,242,785 kWh
    - 67 kWh/m²
Value Engineering Operating Cost Saving

Building running Cost in USD (mn)

Savings in running cost: US $ 43 Mn
Savings in Capital equipment: US $ 8 Mn
Total Savings: US $ 51 Mn
Drawing wastage
Traditional process: Concept to construction

Pre-construction Stages

- DBR Concept
- Single Line Schematic (Auto Cad)
- Double Line DD (Auto Cad)
- Double Line IFT (Auto Cad)
- Double Line GFC (Auto Cad)

6-7 Steps of drawing production at least

Post-construction Stages

- Shop Drawings
- On-site Clash and Engineering/RFI
- As-built Drawings

Contractor
Contractor
Contractor
Optimized process using BIM
Reduction in time with Cost certainty and control

- LOD 100/200 Concept & Scheme Design
  - Designer

- Value Engineering & User Requirement
  - Nego Contractor

- LOD 300/350 Design Development
  - Contractor

- LOD 400 Construction
  - Contractor

- Shop Drawing if required or straight to Fabrication
  - Contractor

- LOD 500 As-Built and FM, Record
  - Contractor

80% cost certainty

Near 100% cost certainty from Model

- Only 2 Steps of Drawing Production in over all process
- Early engagement of Stakeholders and concurrent value engineering led to efficiency and gain

- 40% reduction in time

- Zoning strategy
- Prefabrication Strategy
Optimization Via Value Engineering using BIM

Savings
- HVAC 30%
- Electrical 12%
- Plumbing 40%
- Fire 25%
- DG 5%
- Lifts 25%

32% reduction in pipe work ~ 48000 m
Construction & Pre Fabrication: savings

BIM Model & Pre Fabrication

- Hotel Project:
  - Guest room riser shafts - 5000 m length riser shafts
  - Shafts modeled and optimized
  - BIM construction sequence
  - Shafts constructed & connected

Savings/ Benefits

- No material wastage as all pre-cut/ ordered for prefabrication in controlled environment.
- Included approximately 2000m pipework saving at average 4% wastage.
- Less supervision/ site labour - all work completed in fabrication yard.
- Time - not restricted by site works + only 2 minutes for connection.
- High Quality

BIM Model & Pre Fabrication

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Link to Video - think BiM
Sequencing & Planning support

Record Modelling

Construction System Modelling

Helps in following ways

- Optimisation of crane laydown time
- Analysing existing and proposed utilities
- Preparing site access
- Visualize safety and evacuation concerns
- Excavation and dewatering studies
- Visualize the schedule, project planning
- Find flaws in logic
- Optimize sequencing on the construction site
- Project phasing and procurement planning support on BiM

Link to Video - Dial
Excess Pressure - 0 ft of H2O

Excess Pressure - 0.5 ft of H2O

Excess Pressure - 0.8 ft of H2O

Excess Pressure - 2.7 ft of H2O

To be verified in practice
Reduction in 2 pipe sizes significantly reduces balancing required.
Benefits for O&M

A platform for managing building data
Benefits for O&M

Edocuments Springboard: as built documents, connected to C-Pad CAFM

Start
Design Construction model -

Export data as CSV
(Future MCC Projects: COBie data/IFC)

CAFM
Concerto - C-Pad
Import data from CSV
(Future MCC Projects: COBie data/IFC)

Edocuments
Online Managed Document Production

Designers, Constructors, End Users and supply chain are tasked to author & review information.

Systems and assets are automatically filtered into industry standard templates.
CIBSE, BSRIA, HSE

Final issue record documents issued on CD / hard disk off-line or on-line, and will link into the model

Link assets in Edocuments production via URL’s

Link assets to Edocuments production via URL’s

Manchester City Council
Benefits for O&M

Define the End User Information Requirements

What do I need to know?

**Employers Requirements**
- Regulatory
- Performance
- Economic
- Risk

**Operators Requirements**
- Health & Safety
- Warranty
- Life
- Training
Benefits for O&M

Systems and Assets

3 BROAD DEFINITIONS

System Asset
Group Asset
Single Asset

EXAMPLES
- Lift
- Boiler
- Transformer
- Pumps
- Luminaires
- Curtain Walls
- Drainage
- Heating

MANCHESTER CITY COUNCIL

Edocuments
## Benefits for O&M

### Set the Common Language

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<th>Client (1) - FM</th>
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### Client (2) Occupant

- **Town Hall Extension**
- **Fourth Floor**
- **4-001**
- **Committee Room**
- **N/A**
- **N/A**
- **N/A**
- **N/A**
- **N/A**
- **N/A**
Benefits for O&M

Model > Assets > System O & M

Click asset in model  View asset data  View system and asset data

3D Graphical Interface

Linked to O&M Asset Data

Asset embedded into System O&M data

Linked to Video
Benefits for O&M

Lesson Learnt
- Remember the basics
- Diligence
- Communication
- Control

- Information providers
- Skills, Critical Thinking
- Resources
- Deliverables

- Small Data – FM Brain
- Content in Context
- 3 Clicks to my data