Building Information Models (BIM) and Facilities O&M

George Korte, P.E.
Vice President
Total Resource Management
December 17, 2008
• National Institute of Building Sciences
• Building Information Modeling
• BIM Case Studies
• Industry Alliance for Interoperability (IAI)
• BIM Benefits to Facilities O&M
• buildingSMART alliance
National Institute of Building Sciences

• 1974 - Public Law 93-383, Sect. 809
  – Bridge between Private and Public Construction
  – Non-governmental – Unique 501c3 Organization

• 1992 - Facility Information Council
  – Mission: “Improve the performance of facilities over their full life-cycle by fostering common and open standards and an integrated lifecycle information model for the AEC & FM industries.”

• Related NIBS Products
  – Construction Criteria Base
  – Whole Building Design Guide
  – National CAD Standard
  – National BIM Standard
NIBS Responsibilities

• Development, promulgation, and maintenance of performance criteria, standards, and other provisions
• Evaluation of building technology
• Conduct needed investigations
• Assembly, storage and dissemination of technical information
NIBS Activities

- Board of Directors
- Consultative Council
- Building Envelope Thermal and Environmental Council
- Building Seismic Safety Council
- Construction Metrication Council
- Facility Information Council
- Multihazard Mitigation Council
- Facility Maintenance and Operations Committee
- National Clearinghouse for Educational Facilities
- Construction Criteria Base/Whole Building Design Guide
- buildingSMART alliance
What is a Building Information Model?

National BIM Standard:

“A Building Information Model (BIM) is a digital representation of physical and functional characteristics of a facility. It serves as a shared knowledge resource for information about a facility, forming a reliable basis for decisions during its lifecycle, from inception onward.”
Evolution of BIM

• 2D CAD
  – Diagrammatic, layered representation of building & construction details
  – Geometric shapes, symbols, text, and blocks/cells
  – Attributes associated with graphic elements

• 3D CAD
  – 3D perspective of physical building components

• 4D CAD
  – Adds temporal dimension for construction process visualization

• nD BIM
  – Adds any/all attribute information (e.g., cost, material properties, etc.)
BIM and the Facility Life Cycle

BIM Content Accumulates Over the Facility Lifecycle

Information Content

- Scope
- Schedule
- Budget
- Quality
- Criteria

Planning ♦ Design ♦ Construction ♦ Tenant ♦ Closeout

Feasibility
Program Development
Final Concepts
Design Development
Construction Documents
Bid/Award
Cost Loaded CPM
Submittals / Shop / Coordination Drawings
As Built
O&M Manuals

Tenant Improvement Drawings
FF&E and Move Management
Project Archives and POE

BIM
BIM-Related Systems and Processes

Planning                      Design         Construction Operations and Maintenance

Geospatial Information
Product Selection

Fabrication

Invoicing/ Payment

Ordering/ Delivery

Code Compliance Checking

Computerized Maintenance Management System (CMMS)

Invoicing/ Payment

Computer Aided Facility Management

Planning

Legal Information

Engineering Analysis

Design

Construction

Operations and Maintenance

Project photos courtesy of Dennis R. Shelden, Ph.D., Chief Technology Officer, Gehry Technologies. The picture is of the Disney Conference Hall, designed by Frank Gehry.
**BIM Supports Integrated Design**

### Traditional Design Process

- Project prioritized
- Assign PM
- PM site visit
- Plans, specs, and cost est.
- 35% design briefing
- Owner approval
- 95% design review
- Finalize design
- Construction contracting
- Contract award

<table>
<thead>
<tr>
<th>Months:</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
</table>

### Integrated Design Process

- Establish project team
- Team site visit
- Develop 3D model
- 3D images, 2D drawings, site photos
- Detailed design inputs from team
- Present to owner
- Finalize design
- Construction contracting

<table>
<thead>
<tr>
<th>Weeks:</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
</table>
Demonstrated BIM-supported Analyses

M&R Cost by System

Illuminance Contours

Operating Costs

Daylight Studies

Solar Plots

Building in OPS

Structural Engineering

Courtesy of AEC Infosystems and Onuma Design
NIBS is tackling “Big BIM,” issues that firms, associations and agencies cannot:

- Manufacturer Objects
- Education
- Code Compliance
- Best Business Processes
- International Standards
- National Standards
- Certification
- Capability Maturity Model
BIM Case Studies – Visualization

Courtesy Benjamin D. Hall Interdisciplinary Research Building
BIM Case Study - Energy Simulation

EnergyPlus Output

Hourly Comfort - ADERMA MANUFACTURING, Building 1
1 Jan - 31 Dec

<table>
<thead>
<tr>
<th>Time/Date</th>
<th>April</th>
<th>May</th>
<th>June</th>
<th>July</th>
<th>August</th>
<th>September</th>
<th>October</th>
<th>November</th>
<th>December</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Temperature (°C)</td>
<td>17.82</td>
<td>17.77</td>
<td>25.72</td>
<td>21.84</td>
<td>28.29</td>
<td>36.14</td>
<td>13.14</td>
<td>17.81</td>
<td></td>
</tr>
<tr>
<td>Radiant Temperature (°C)</td>
<td>17.86</td>
<td>16.22</td>
<td>24.74</td>
<td>22.36</td>
<td>28.42</td>
<td>26.54</td>
<td>21.41</td>
<td>16.31</td>
<td></td>
</tr>
<tr>
<td>Operative Temperature (°C)</td>
<td>15.74</td>
<td>16.50</td>
<td>25.28</td>
<td>22.00</td>
<td>20.41</td>
<td>26.94</td>
<td>20.61</td>
<td>13.80</td>
<td>16.58</td>
</tr>
<tr>
<td>Outside Dry-Bulb Temperature (°C)</td>
<td>-10.20</td>
<td>1.30</td>
<td>11.40</td>
<td>24.00</td>
<td>14.70</td>
<td>18.10</td>
<td>19.10</td>
<td>14.40</td>
<td>10.50</td>
</tr>
<tr>
<td>Relative Humidity (%)</td>
<td>42.60</td>
<td>34.14</td>
<td>36.06</td>
<td>28.01</td>
<td>52.10</td>
<td>47.94</td>
<td>58.03</td>
<td>63.98</td>
<td>63.74</td>
</tr>
<tr>
<td>Discomfort hrs (all clothing) (hrs)</td>
<td>0.00</td>
<td>0.00</td>
<td>1.00</td>
<td>1.00</td>
<td>0.00</td>
<td>0.00</td>
<td>1.67</td>
<td>0.00</td>
<td>11.00</td>
</tr>
<tr>
<td>Fanger PMV (%)</td>
<td>-3.13</td>
<td>-0.42</td>
<td>-1.32</td>
<td>0.57</td>
<td>-0.04</td>
<td>1.03</td>
<td>1.03</td>
<td>-0.33</td>
<td>-0.71</td>
</tr>
<tr>
<td>Pierce PMVSET (%)</td>
<td>-2.86</td>
<td>-1.62</td>
<td>-1.07</td>
<td>0.08</td>
<td>-0.81</td>
<td>1.12</td>
<td>0.88</td>
<td>-0.50</td>
<td>-1.85</td>
</tr>
<tr>
<td>Pierce PMVSET (%)</td>
<td>-1.22</td>
<td>-0.12</td>
<td>-0.98</td>
<td>0.18</td>
<td>-0.15</td>
<td>1.28</td>
<td>0.92</td>
<td>-0.34</td>
<td>-0.32</td>
</tr>
<tr>
<td>Kansas Uni TSV (%)</td>
<td>-1.31</td>
<td>0.29</td>
<td>0.62</td>
<td>1.28</td>
<td>0.47</td>
<td>2.11</td>
<td>1.55</td>
<td>0.32</td>
<td>-0.17</td>
</tr>
</tbody>
</table>

Courtesy Prof. Ezio Arlati, Politecnico Di Milano – Architecture Preservation
BIM Case Study – Energy Analysis

Energy Simulation of interoperable models by Energy Plus

Courtesy Prof. Ezio Arlati, Politecnico Di Milano
BIM Case Study – Conflict Analysis

Daniel Libeskind’s Denver Art Museum

2D Visualization with Conflict Analysis

3D Reality

Slide courtesy of C. Eastman
"On a recent hospital job the first phase was done in 2D and the follow-on phases were done in 3D – We had an 18% improvement in productivity in the follow on phases."

-- Matt Cramer, Dee Cramer Sheet Metal
BIM Case Study: Parking Garage

Charles Town Casino & Slots
Parking Garage

- Owner, Architect, Engineer of Record and Contractor were the customers
- Conversion of Contract Drawings to Initial Model was completed in 8 ½ Hours vs 60 Hours in 2D
- Web View of Model and PDF’s Submitted
- Additional Modifications
- Piece Report sent to Estimating For Pricing
- HCSI awarded project 3 Days following initial submittal

Project Requirements / Specifications
- 585’ Long
- 240’ Wide
- 5 Supported Levels
- 1,290 Pieces of Precast
- Redesigned Bay Spacing from 36’ to 45’
- Multiple Exterior Finishes
- Accommodate Fire Codes & Future Expansion/Additions

- Zero drafting errors
- 15% Under Budget
  - Potential for greater savings as proficiency increases and libraries are developed
- Project erected 3 weeks ahead of schedule
  - Connections lining up
  - Pieces fit because the model fit
“Despite numerous design layout changes that were required by Lucas Film Ltd. due to company restructuring, the LDAC project was completed on time and below the estimated budget....over two hundred design conflicts were identified, most of which were corrected before construction, resulting in an estimated savings of over $10 million on this $350 million project.”

Courtesy of AECbytes “Building the Future” Article (September 30, 2006)

Building Owners Driving BIM: The “Letterman Digital Arts Center”

Story: Mieczyslaw (Mitch) Boryslawski, Associate AIA

Founder, View By View, Inc.
General Motors Flint Engine Plant addition

3D modeling used to design plant in the computer, then to fabricate, computer model was forced to be the as-built model

Slide courtesy of C. Eastman
International Alliance for Interoperability
What is the IAI?

...a voluntary organization, created in 1995, to represent the public and private sectors in an effort to facilitate the exchange of dynamic information among members of the building community.
Industry Foundation Classes (IFC)

- A way of specifying “things” occurring in the built environment using a standard, object-oriented, data structure to assemble shared information models.

- Tangible items like doors, windows, fans, ceilings, actors etc.

- Abstract concepts like schedule activity, spaces, organization, etc.
Shape (explicit)

Shape (extrusions)
beams, pipes, ducts, walls etc.

Shape (topology)
line representations for pipe, duct, etc.

Spaces, Space Structure
space, storey, part, building, site

Compartmentation
fire, workstation

Grids

Building Elements
wall, door, window, roof, stairs, etc.

Equipment
chillers, fans, pumps, etc.

Relations Between Elements
holes, chases, voids, zones

Furniture
inc. system furniture
Current Capabilities: IFC 2x

**Actors**
people, organizations, addresses

**Costing**
cost planning, estimates, budgets

**Work Plans and Schedules**
inc. nested schedules, resource allocation

**Orders**
work orders, change orders, purchase orders

**External Data**

**Classification**

**Associated Documents**

**Move Management**

**Asset Identification**
Maintenance History, Inventories
New or expanded capabilities for:

• General Facilities
• Architectural
• Building Services
• Structural Analysis
• Facility Management
Improved asset definition
Improved allocation of time, cost and work order data

Simplified order provision
Improved allocation of time and cost data

Extended cost model
Enables costing of any object, with any type of cost, at any and all points in the lifecycle, total lifecycle cost capture, budgets, estimates, cost roll up

Condition Monitoring
Captures condition data including both measured (by Instrumentation) and assessed (by visual inspection).

Request Capture
Captures ad hoc requests made for operating and maintenance work and allocation of requests to work orders.

Service Life Data
Inclusion of capabilities for service life capture and management including reference and expected service life and ISO based service life factors.

Environmental impact
Capture of environmental impact data for objects allowing impact assessment to be carried out in support of sustainable working.

Permits
Allocation of permits for access, security, work

Operating and Maintenance information
Provision of capability to capture operating and maintenance instruction information based on the US Navy/Dept of Health developed OMSI XML standards
Modeling Manufactured Building Components

Industry Foundation Class (ifc)

Courtesy of Graphisoft
### Specifiers Property Sets

<table>
<thead>
<tr>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Basic Generic Properties</strong></td>
<td><strong>Design Properties</strong></td>
<td><strong>Proprietary Properties</strong></td>
</tr>
<tr>
<td>3’-0” x 6’-8” Exterior Door</td>
<td>3’-0” x 6’-8” Exterior Door</td>
<td>Steel Entry Door Twin 8 x 6 Colonial Light Insulating Door.</td>
</tr>
</tbody>
</table>

Each door has an energy-efficient and environmentally safe polystyrene core, providing outstanding comfort and stability. Weatherproofing System. Foam compression weather-stripping system helps prevent air and water infiltration around the perimeter of the door panel. Weather-resistant foam rod. Adds protection against air and water infiltration under the sill of the door. Energy-efficient door sweep. Forms a tight seal against air infiltration between the door and the sill.
BIM - Benefits to Facilities O&M

• Comprehensive building information at commissioning in a standard digital format, object model, and taxonomy
  – Equipment items: manufacturers, names, model numbers, serial numbers, locations, instruction manuals, specifications, and spare parts
  – Recommended PM and safety tasks: frequency, materials, tools, training, procedures
  – Warranties
  – Component purchase costs, dates, and suppliers
• CMMS interface to BIM can maintain “As-builts” “As-is”
• **Know** “what’s out there”
  – Preventive and corrective maintenance
  – Building modification, renovation, disposal
• O&M phase informs Acquisition phase
BIM – Benefits to Related Initiatives

- Virtual Design and Construction
- Lean Construction
- Building Green
- Integrated Project Delivery
- Code Compliance Checking
- Real Property Asset Management
- Sustainability
- Preventative Maintenance
- Energy Conservation
- Environmental Stewardship
- Value Engineering
- Life Cycle Costing

Focus

All stakeholders benefit from the practice of collecting information in a model and providing it to future lifecycle phases
buildingSMART alliance™

Deke Smith, FAIA
Executive Director
www.buildingsmartalliance.org
buildingSMART alliance

- Established by NIBS
- Goals
  - Positive changes in the real property industry
  - Full lifecycle implementation of BIM
  - Open interoperability of IT systems and data
  - Lowest overall cost of ownership
  - Optimum sustainability
  - Energy conservation
  - Environmental stewardship
buildingSMART alliance

• Over 50 active open standards projects
  – NBIMS Development
  – AECOO Testbed (Cost & Energy)
  – Education baseline and projects
  – International (ifc, IDM, MVD, IFD)
• $25K+ Sponsors Become International Members
• Speakers Bureau
• Conferences
• Workshops
• Local user groups
• Magazine
Products Coordinated by the buildingSMART alliance
buildingSMART alliance Membership

• Participants support the delivery of no-cost products to the industry
  – Journal of Building Information Modeling Magazine
  – Support to buildingSMART International ($25K Sponsors are International members)
  – Sponsorship of Alliance projects and project promotion (e.g. Smart Market Report and BIM Storm)
  – Presentations, workshops and seminars to nearly 100 organizations a year
  – Coordination with all organizations involved in BIM
  – National BIM Standard Development
  – buildingSMART Alliance web site
  – Two conferences per year
  – Coordination of Speakers Bureau
  – Support for Local Interest Groups
  – Central staff support for the Alliance
Joining the buildingSMART alliance

1. Visit www.buildingsmartalliance.org

2. Apply on-line or contact:
   Deke Smith – dsmith@nibs.org (202) 289-7800 or
   Peter Smeallie - smeallie@verizon.net
Additional Material

• buildingSMART alliance web site: www.buildingsmartalliance.org
  – Current news and events
  – Order copies of the Journal of BIM Magazine
  – Conference presentations
  – Continuing Education
  – Interest Groups
  – Programs and projects
  – Memorandum of Understanding open to all signatories
  – Join or sponsor the buildingSMART Alliance

• United States National BIM Standard: www.facilityinformationcouncil.org
  – Order copies of the NBIMS Version 1, Part 1
  – Purchase copies of the National CAD Standard
Additional Material

• AIA Integrated Practice Manual: 
  http://www.aia.org/ipdg#ipdguide

• McGraw-Hill Smart Market Report – Interoperability: 
  http://www.buildingsmartalliance.org/pdfs/smri.pdf

• AECbytes Feature (March 30, 2004): The IFC Building Model: A Look Under the Hood 

• AECbytes "Building the Future" Article (October 11, 2006): The AGC's BIM Initiatives and the Contractor's Guide to BIM 

• Pankow Foundation Reports 
  http://www.spur.org/pankowreports/abstract_precastconcrete.shtm
Re-Prints

• ENR Article: Is There a Revolution on the Doorstep?
  http://enr.ecnext.com/coms2/article_febiar080604b

• Economist Article: From blueprint to database

• Article: “Connecting the Dots - building information modeling is poised to bundle a fragmented design and construction process” by Cheryl Weber Residential architect / may 2008 pg 13.
  http://www.residentialarchitect.com/industry-news.asp?sectionID=280&articleID=701474
BIM Handbook: A Guide to Building Information Modeling for Owners, Managers, Designers, Engineers and Contractors
by Charles M. Eastman, Rafael Sacks, Paul Teicholz, and Kathleen Liston

“This is clearly the most comprehensive book to date on the subject of building information modeling. It covers the entire spectrum and provides many comparative analyses of existing products, to help you make an educated choice of tools.”

Deke Smith
• Willem Kymell - practicing architect with 30 years experience
• Associate Professor of Construction Management at CalState (Chico)
• Classroom Text
Questions?