BIM for Facility Management:
“Design for maintenance”

Birgitta Foster
SSA/Sandia National Labs
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"The views expressed in this presentation are those of the author and do not reflect the official policy or position of Sandia National Laboratories, Dept of Energy, or the US Government."
Career Path

- Manufacturer: Ingersoll Rand
- Engineering & Construction: John Brown E&C
- Fabrication: Caterpillar
- General Contractor: for Intel
- Specialty Contractor: for Intel/Sandia National Lab
- Mechanical Contractor: for Sandia National Lab
- Owner: Sandia National Lab
Four sites (~ 1100 bldg, 7M GSF)
- NM (Albuquerque)
- CA (Livermore)
- NV (Tonopah)
- HI (Kauai)

Sandia NM
- 891 Bldgs
- 6M GSF
- 8700 acres
**Federal Agency Overview**

**FY 2008 Total Number of Buildings and Structures and Total Building Square Footage**

<table>
<thead>
<tr>
<th>Agency Name</th>
<th>Total Number of Buildings and Structures</th>
<th>Total Building Square Footage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Army</td>
<td>251,906</td>
<td>943,982,008</td>
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<tr>
<td>Interior</td>
<td>163,789</td>
<td>125,967,288</td>
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<tr>
<td>Air Force</td>
<td>136,883</td>
<td>598,814,805</td>
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<tr>
<td>Navy</td>
<td>118,906</td>
<td>436,720,834</td>
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<tr>
<td>Transportation</td>
<td>56,637</td>
<td>27,263,882</td>
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<tr>
<td>Agriculture</td>
<td>57,523</td>
<td>57,558,472</td>
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<tr>
<td>Homeland Security</td>
<td>26,436</td>
<td>47,179,709</td>
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<tr>
<td>Energy</td>
<td>18,202</td>
<td>130,611,778</td>
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<tr>
<td>State</td>
<td>15,322</td>
<td>69,716,153</td>
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<tr>
<td>Corps of Engineers</td>
<td>9,410</td>
<td>15,764,737</td>
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<td>Veterans Affairs</td>
<td>8,938</td>
<td>154,388,241</td>
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<tr>
<td>General Services Administration</td>
<td>8,915</td>
<td>396,017,856</td>
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<tr>
<td>National Aeronautics and Space Administration</td>
<td>4,719</td>
<td>44,152,732</td>
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<tr>
<td>Justice</td>
<td>4,196</td>
<td>70,694,594</td>
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<td>Labor</td>
<td>3,395</td>
<td>24,087,958</td>
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<td>Health and Human Services</td>
<td>3,178</td>
<td>35,115,583</td>
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<tr>
<td>United States Agency for International Development</td>
<td>1,139</td>
<td>4,949,622</td>
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<tr>
<td>Commerce</td>
<td>1,099</td>
<td>7,779,613</td>
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<td>Smithsonian</td>
<td>617</td>
<td>12,149,461</td>
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<td>National Science Foundation</td>
<td>597</td>
<td>2,247,073</td>
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<tr>
<td>Peace Corps</td>
<td>434</td>
<td>2,146,436</td>
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<tr>
<td>Defense/Washington Headquarters Services</td>
<td>399</td>
<td>8,178,307</td>
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<tr>
<td>Independent Government Offices</td>
<td>302</td>
<td>608,462</td>
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<td>Environmental Protection Agency</td>
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<td>4,261,243</td>
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<tr>
<td>Tennessee Valley Authority</td>
<td>249</td>
<td>5,985,593</td>
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<tr>
<td>American Battle Monuments Commission</td>
<td>137</td>
<td>454,685</td>
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<tr>
<td>Treasury</td>
<td>126</td>
<td>6,194,894</td>
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<tr>
<td>National Archives and Records Administration</td>
<td>31</td>
<td>4,780,204</td>
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<tr>
<td>National Gallery of Art</td>
<td>6</td>
<td>1,330,083</td>
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<td>United States Holocaust Memorial Council</td>
<td>5</td>
<td>319,749</td>
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<td>Merit Systems Protection Board</td>
<td>4</td>
<td>58,821</td>
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<tr>
<td>Office of Personnel Management</td>
<td>2</td>
<td>82,245</td>
</tr>
<tr>
<td>John F. Kennedy Center for the Performing Arts</td>
<td>2</td>
<td>1,500,000</td>
</tr>
</tbody>
</table>

**TOTAL Building Footage = 3.29B SF**

**TOTAL Number of Buildings/Structures = 895,923**

Annual Operating Costs
by Building Predominant Use and Square Footage

2008 Total Annual Operating Costs = $12B
The State of Ohio BIM Protocol does not establish a “standard” that requires specific software or hardware to be used by the state’s vendors, but provides general guidance that ensures that building owners know what they should include in their requests for qualifications, agreements, bidding requirements, contracts, and other documents affected by this new medium.
State of Ohio: BIM Protocol

HIGHLIGHTS

All projects (new construction, additions, and alterations) with
- A total project value of $4 million or greater
- The total estimated value of plumbing, fire protection, HVAC, and electrical work within the project is greater than 40% of the value of construction.

Ownership of the Model:
- BIM models and facility data developed for the project are the property of the project owner.
- The owner may make use of this data as allowed under the laws of the State of Ohio for electronic data and contract documents.
State of Ohio: BIM Protocol

HIGHLIGHTS

• Requiring BIM on a project should **not result** in increased fees.

### FEE Schedule:

<table>
<thead>
<tr>
<th>Project Stage</th>
<th>% Payment (Non-BIM)</th>
<th>% Payment (BIM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Predesign</td>
<td>5%</td>
<td>5%</td>
</tr>
<tr>
<td>Schematic Design</td>
<td>15%</td>
<td>20%</td>
</tr>
<tr>
<td>Design Development</td>
<td>15%</td>
<td>20%</td>
</tr>
<tr>
<td>Construction Documents</td>
<td>30%</td>
<td>20%</td>
</tr>
<tr>
<td>Bid and Award</td>
<td>5%</td>
<td>5%</td>
</tr>
<tr>
<td>Conformed Documents</td>
<td>2%</td>
<td>2%</td>
</tr>
<tr>
<td>Construction Administration</td>
<td>25%</td>
<td>25%</td>
</tr>
<tr>
<td>Contract Closeout</td>
<td>3%</td>
<td>3%</td>
</tr>
</tbody>
</table>

The cost for purchasing BIM authoring software and training will **not be compensated by the owner** as a reimbursable for the project requiring BIM implementation.

Additional service fees may be considered for further model development and enhancement during the construction phase, but not for as-built or post construction documentation requirements.
Costs of **NOT** doing BIM

**NIST Survey (2004)**

- **Inefficiency Costs**: $15B/yr
- 66% borne by Owners
- $0.23/ existing SF/year
Putting in to Context

- **Sandia**
  - 6M GSF
  - @ $0.23/SF/yr
  - **Wasting:** $1.38 M/yr

- **DOE**
  - 127M GSF
  - @ $0.23/SF/yr
  - **Wasting:** $29 M/yr

- **All Federal Agencies**
  - 2.59B GSF
  - @ $0.23/SF/yr
  - **Wasting:** $0.595 B/yr
BIM for FM: Evidence of savings

- NIST: Industry Study
- Sandia “Straw man” Study validation
- University of New Mexico Survey
Industry Study

NIST Survey (2004)

- Inefficiency Costs: $15B/yr
- 66% borne by Owners
- $0.23/ existing SF/yr

Sandia National Labs (Albuquerque, NM)

- ~ 900 buildings
- ~ 6M GSF
- Costs (wasting): ~ $1.4 M/year
Sandia “straw man” survey

Using BIM, if you could get all needed information in 5 minutes, how much time would that save?

Response:
• up to 2 hours per work order (WO)
  2 hrs x $50/hr = $100/hr
  WO/yr = ~ 24,000

Potential savings: $2.4 M/year
UNM BIM for FM Survey:
"View of the Future for Facilities Management"

Francisco Forns-Samso
Graduate student
Construction Program
Civil Engineering Department
Survey on BIM for FM
Survey on BIM for FM

Preliminary Findings

- 77% of our respondents are Owners.
- Majority manage campus-type facilities.
- Over 50% manage facilities over 1M GSF:
  - 22% over 1-5M GSF
  - 35% over 5M GSF
- Respondents were a good cross-section with Education, Office, Gov't, Laboratory.
- Majority had over 30,000 WO per year.
- There is a perceived time savings up to 40% per WO.
What best describes your current accessibility to O&M information?

- Poor – Never can find what I needed: 9%
- Below Average – Find some information, but takes time: 24%
- Average – Most information is available, but not in one place: 43%
- Above Average – Most information is easily accessible, but not in one place: 20%
- Perfect - All information is ready available in one location: 4%
"View of the future for Facilities Management" Video
> 25% respondents were either "unfamiliar" or "vaguely familiar" with BIM

Better able to answer the questions on accessing information using a model interface

If they could access info as shown in the video, how often would they use BIM:

- 63% said they use it often or all the time,
- 39% could see a possible savings between 20-40 % per WO.
FM Barriers to BIM

- Unwillingness to Change Process
- Funding/Cost
- Lack of understanding
- Lack of personnel and resources
- Data Updating/Maintenance
- Seamless interfaces with current software
- Lack of proven benefits
- Time to produce model
- Lack of standards and processes
- Lack of contractual documentation
- BIM not ready for O&M
What does this mean?

- Know there is a need
- Know there is perceived savings

- Federal Agencies
  - Annual Operating Costs
    - ✓ Strategy for Energy reduction
    - ?? Strategy for Operations and Maintenance
  - Design for Maintenance Strategy
Federal Annual Operating Costs

- **Custodial**
  - Pest control/refuse collection
  - Recycling costs

- **Roads/Grounds**
  - Landscaping/snow-ice removal

- **Utilities**
  - Plant operations and energy

- **Reoccurring Maintenance and Repair**
  - Work orders

(source: FRPC Real Property Inventory – Users Guidance FY09)
Covering Operating Costs: Space Charge Back

- Energy: 26%
- Custodial: 6%
- Roads/Grounds: 13%
- O&M Admin: 14%
- Maintenance & Repairs (WO): 26%
- Restoration/DM projects: 15%

O&M > 50%
“Design For Maintenance” Strategy:
Main Premise

WARNING

Non-BIM enabled Owners require accompanying General Contractor or Sub-Contractor
“Design for maintenance” strategy

“Maintenance Friendly”

NOT “Maintenance Friendly”
“Maintenance Friendly”
NOT “Maintenance Friendly”
“Maintenance Friendly”
NOT “Maintenance Friendly”

FM Impact:
- 2x PM time
- 4x CM time

......... Over 25 years
# Maintenance: Equipment Check Lists

## 9.9.11 Pumps Checklist

<table>
<thead>
<tr>
<th>Description</th>
<th>Comments</th>
<th>Maintenance Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pump use/sequencing</strong></td>
<td>Turn off/sequence unnecessary pumps</td>
<td>Daily: X</td>
</tr>
<tr>
<td><strong>Overall visual inspection</strong></td>
<td>Complete overall visual inspection to be sure all equipment is operating and safety systems are in place</td>
<td>X</td>
</tr>
<tr>
<td><strong>Check lubrication</strong></td>
<td>Assure that all bearings are lubricated per the manufacturer’s recommendation</td>
<td>X</td>
</tr>
<tr>
<td><strong>Check packing</strong></td>
<td>Check packing for wear and repack as necessary. Consider replacing packing with mechanical seals.</td>
<td>X</td>
</tr>
<tr>
<td><strong>Motor/pump alignment</strong></td>
<td>Aligning the pump/motor coupling allows for efficient torque transfer to the pump</td>
<td>X</td>
</tr>
<tr>
<td><strong>Check mountings</strong></td>
<td>Check and secure all pump mountings</td>
<td>X</td>
</tr>
<tr>
<td><strong>Check bearings</strong></td>
<td>Inspect bearings and drive belts for wear. Adjust, repair, or replace as necessary.</td>
<td>X</td>
</tr>
<tr>
<td><strong>Motor condition</strong></td>
<td>Checking the condition of the motor through temperature or vibration analysis assures long life</td>
<td>X</td>
</tr>
</tbody>
</table>

## 9.10.10 Electric Motors Checklist

<table>
<thead>
<tr>
<th>Description</th>
<th>Comments</th>
<th>Maintenance Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Motor use/sequencing</strong></td>
<td>Turn off/sequence unnecessary motors</td>
<td>X</td>
</tr>
<tr>
<td><strong>Overall visual inspection</strong></td>
<td>Complete overall visual inspection to be sure all equipment is operating and safety systems are in place</td>
<td>X</td>
</tr>
<tr>
<td><strong>Motor condition</strong></td>
<td>Check the condition of the motor through temperature or vibration analysis and compare to baseline values</td>
<td>X</td>
</tr>
<tr>
<td><strong>Check lubrication</strong></td>
<td>Assure that all bearings are lubricated per the manufacturer’s recommendation</td>
<td>X</td>
</tr>
<tr>
<td><strong>Check packing</strong></td>
<td>Check packing for wear and repack as necessary. Consider replacing packing with mechanical seals.</td>
<td>X</td>
</tr>
<tr>
<td><strong>Motor alignment</strong></td>
<td>Aligning the motor coupling allows for efficient torque transfer to the pump</td>
<td>X</td>
</tr>
<tr>
<td><strong>Check mountings</strong></td>
<td>Check and secure all motor mountings</td>
<td>X</td>
</tr>
<tr>
<td><strong>Check terminal tightness</strong></td>
<td>TIGHTENS CONNECTION TERMINALS AS NECESSARY</td>
<td>X</td>
</tr>
<tr>
<td><strong>Cleaning</strong></td>
<td>Remove dust and dirt from motor to facilitate cooling</td>
<td>X</td>
</tr>
<tr>
<td><strong>Check bearings</strong></td>
<td>Inspect bearings and drive belts for wear. Adjust, repair, or replace as necessary.</td>
<td>X</td>
</tr>
<tr>
<td><strong>Motor condition</strong></td>
<td>Checking the condition of the motor through temperature or vibration analysis assures long life</td>
<td>X</td>
</tr>
<tr>
<td><strong>Check for balanced three-phase power</strong></td>
<td>Unbalanced power can shorten the motor life through excessive heat build up</td>
<td>X</td>
</tr>
<tr>
<td><strong>Check for over-voltage or under-voltage conditions</strong></td>
<td>Over- or under-voltage situations can shorten the motor life through excessive heat build up</td>
<td>X</td>
</tr>
</tbody>
</table>

(FEMP: O&M Best Practice 3.0)
NOT “Maintenance Friendly”
By-Pass Feeders locations....

NOT “Maintenance Friendly”
By-Pass Feeder location....

“Maintenance Friendly”
Steam Traps....

### Job Plan Details

**1453: Steam Trap Bi-Annual PM**

<table>
<thead>
<tr>
<th>Task ID</th>
<th>Description</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>Visually check for leaks**</td>
<td>00:04</td>
</tr>
<tr>
<td>20</td>
<td>Read cautions**</td>
<td>00:01</td>
</tr>
<tr>
<td>30</td>
<td>Ultrasonic and infrared temperature**</td>
<td>00:04</td>
</tr>
<tr>
<td>40</td>
<td>Leaking detection device**</td>
<td>00:02</td>
</tr>
<tr>
<td>50</td>
<td>Fill out maintenance report**</td>
<td>00:00</td>
</tr>
<tr>
<td>60</td>
<td>For easy access 20 minutes per steam trap.</td>
<td>00:00</td>
</tr>
<tr>
<td>70</td>
<td>For hard access 45 minutes per steam trap.</td>
<td>00:00</td>
</tr>
</tbody>
</table>

### Labor

<table>
<thead>
<tr>
<th>Task ID</th>
<th>Craft</th>
<th>Skill Level</th>
<th>Vendor</th>
<th>Contract</th>
<th>Labor Qty</th>
<th>Labor Hours</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>00:11</td>
<td>46.47</td>
</tr>
</tbody>
</table>

**Total Planned Labor:** 8.52

*October 6, 2010 2:48:40 PM MDT*
Steam Traps....

"Maintenance Friendly"

NOT "Maintenance Friendly"
Roof Top Unit (RTU) : piping
Roof Top Unit (RTU) : piping

External box :
2-way HW piping
3-way CW piping
Roof Top Unit (RTU) : piping

Standard Detail

3-way CW piping  2-way HW piping

pump
Roof Top Unit (RTU) : piping

“MEANS & METHODS” ??
RTU piping install

Current 2D = **56 hrs**
- A/E = 0 hrs
- Mech Contractors
  - Field design = **16 hrs**
  - Install = **32 hrs**
- O&M = **8 hrs**

BIM enabled = **36 hrs**
- A/E = **8 hrs**
- Mech Contractor
  - Field design = 0 hrs
  - Prefab = **8 hrs**
  - Install = **16 hrs**
- O&M = **4 hrs**

- Reduces by **20 hrs**....~35% time savings
Four Maintenance Strategies

**Reactive Maintenance (Breakdown or Run-to-Failure Maintenance)**

Basic philosophy
- Allow machinery to run to failure.
- Repair or replace damaged equipment.

Cost: $18/hp/yr

This maintenance philosophy allows damaged equipment only when obvious failures are about $18 per horsepower. Equipment shutdowns do not affect production.

---

**Preventive Maintenance (Time-Based Maintenance)**

Basic philosophy
- Schedule maintenance activities at predetermined time intervals.
- Repair or replace damaged equipment.

Cost: $13/hp/yr

This philosophy entails the repaired equipment is repaired, have shown the costs of preventive approaches as a way to prevent problems.

---

**Predictive Maintenance (Condition-Based Maintenance)**

Basic philosophy
- Schedule maintenance activities when mechanical or operational conditions warrant.
- Repair or replace damaged equipment before obvious problems occur.

Cost: $9/hp/yr

This philosophy consists of scheduling maintenance activities based on periodic monitoring and, when needed, perform maintenance activities on a scheduled basis. This makes the cost of maintenance relatively predictable.

---

**Reliability Centered Maintenance (Pro-Active or Prevention Maintenance)**

Basic philosophy
- Utilizes predictive/preventive maintenance techniques with root cause failure analysis to detect and pinpoint the precise problems, combined with advance installation and repair techniques, including potential equipment redesign or modification to avoid or eliminate problems from occurring.

Cost: $6/hp/yr

This philosophy utilizes all of the previously discussed predictive/preventive maintenance techniques, in concert with root cause failure analysis. This not only detects and pinpoints precise problems that occur, but ensures that advanced installation and repair techniques are performed, including potential equipment redesign or modification, thus helping to avoid problems or keep them from occurring. According to studies, when it is done correctly, operating in this fashion costs about $6 per hour per year. One advantage to this approach is that it works extremely well if personnel have the knowledge, skills, and time to perform all of the required activities. As with the predictive-based program, equipment repairs are scheduled in advance, but additional improvement efforts also can be undertaken to reduce or eliminate potential problems from repeatedly occurring. Furthermore, it allows lead-time to purchase materials for necessary repairs, thus reducing the need for a high parts inventory. Since maintenance work is performed only when it is needed, and extra efforts are put forth to thoroughly investigate the cause of the failure and determine ways to improve machinery reliability, there can be a substantial increase in production capacity.

---

*Comparison of Four Maintenance Programs (Piotrowski 2001)*
“Design For Maintenance” Strategy

SELECT……

your Maintenance Strategy

Table 5.5.1. Reliability centered maintenance element applications

<table>
<thead>
<tr>
<th>Reliability Centered Maintenance Hierarchy</th>
<th>Reactive Element Applications</th>
<th>Preventive Element Applications</th>
<th>Predictive Element Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small parts and equipment</td>
<td>Equipment subject to wear</td>
<td>Equipment with random failure patterns</td>
<td></td>
</tr>
<tr>
<td>Non-critical equipment</td>
<td>Consumable equipment</td>
<td>Critical equipment</td>
<td></td>
</tr>
<tr>
<td>Equipment unlikely to fail</td>
<td>Equipment with known failure patterns</td>
<td>Equipment not subject to wear</td>
<td></td>
</tr>
<tr>
<td>Redundant systems</td>
<td>Manufacturer recommendations</td>
<td>Systems which failure may be induced by incorrect preventive maintenance</td>
<td></td>
</tr>
</tbody>
</table>

THEN……

Share with your Design Teams!
BIM Vision

การออกแบบและบำรุงรักษาในรูปแบบร่วมกัน

- O&M 的战略计划
  - 与A/E分享O&M策略
  - 开发O&M标准用于设计
  - 维护教育A/E在访问要求上的知识
  - 减少“手段与方法”——>BIM工具
Thank you!

Questions?

Birgitta Foster
btfoste@sandia.gov

BIMworkx.com