# “Meaningful Management” 2011

SAND2011-2045C

## BIM for FM

## *Design for Maintenance* strategy

**Birgitta Foster**

**Facilities BIM Champion**

SSA/Sandia National Labs

April 6, 2011

Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

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# Overview

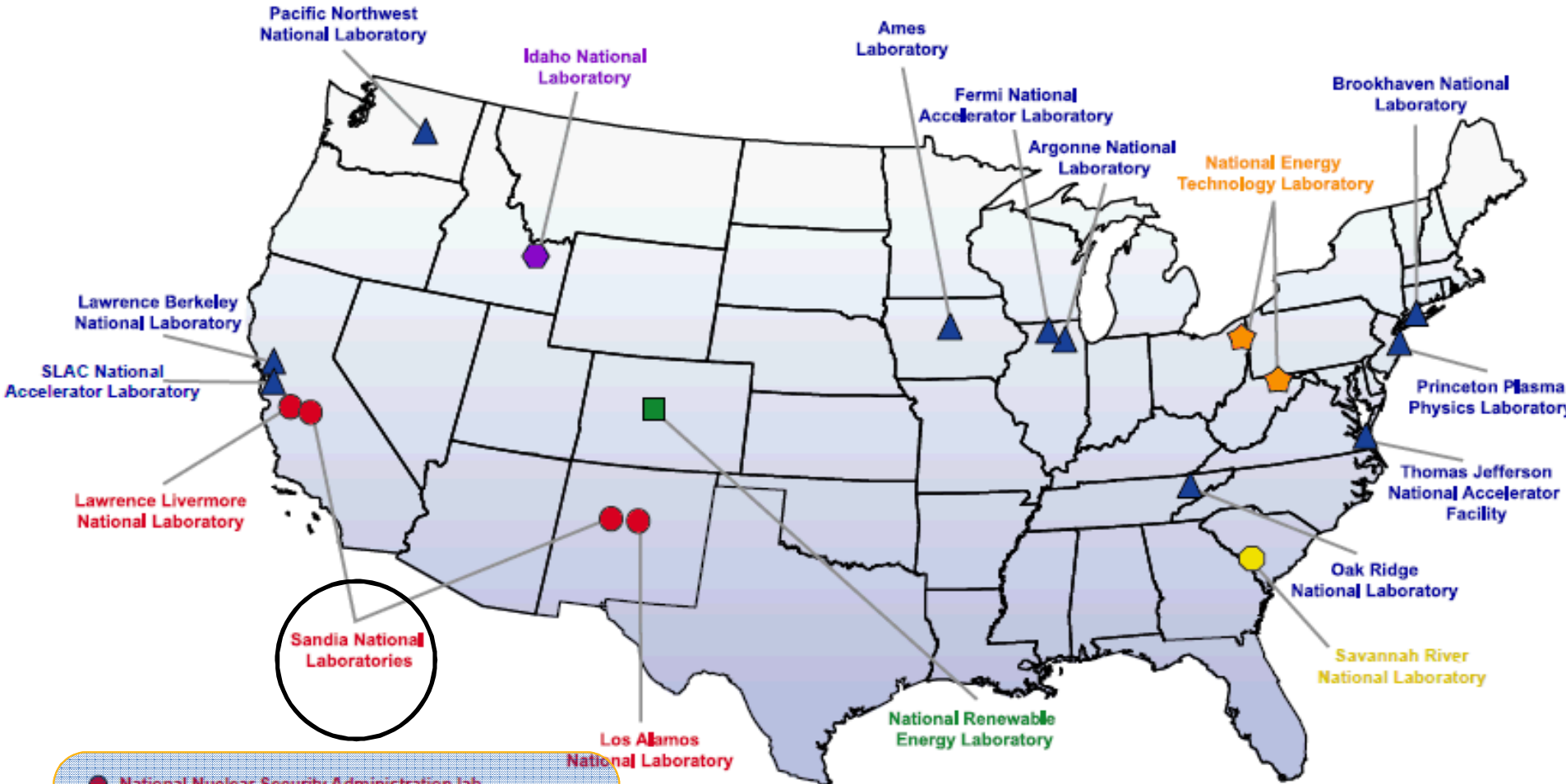
- Introduction
- Owners : Cost of NOT doing BIM
- BIM for Operational Savings
  "Design for Maintenance" Strategy
- Tying it all together
- Resource Recommendations

# Birgitta Foster, BSME, MBA

## Career Path

- Manufacturer : Ingersoll Rand
- Engineering & Construction : John Brown E&C
- Fabrication : Caterpillar
- General Contractor: for Intel
- Specialty Contractor : for Intel/Sandia National Labs
- Mechanical Contractor : for Sandia National Labs
- Owner : Sandia National Labs

# Department of Energy National Laboratories



# DOE : GO/CO* structure


*Gov't Owned/Contractor Operated

Sandia National Laboratories

# National Missions

## SANDIA'S NATIONAL SECURITY MISSIONS

Nuclear Weapons
Ensure a safe, secure, & reliable nuclear deterrent.

Energy & Infrastructure Assurance
Ensure clean, abundant, & affordable energy and water.

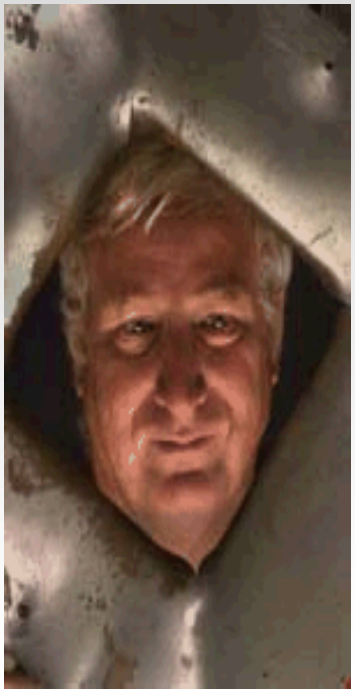
Nonproliferation
Reduce proliferation of weapons of mass destruction & threat of accidents.

Defense Systems & Assessments
Help maintain U.S. military weapon-systems superiority.

Homeland Security
Help protect our nation against terrorism through advanced technology.

Science, Technology, & Engineering
Conduct R&D programs to support all national security missions.

# Mission: Tech Transfer

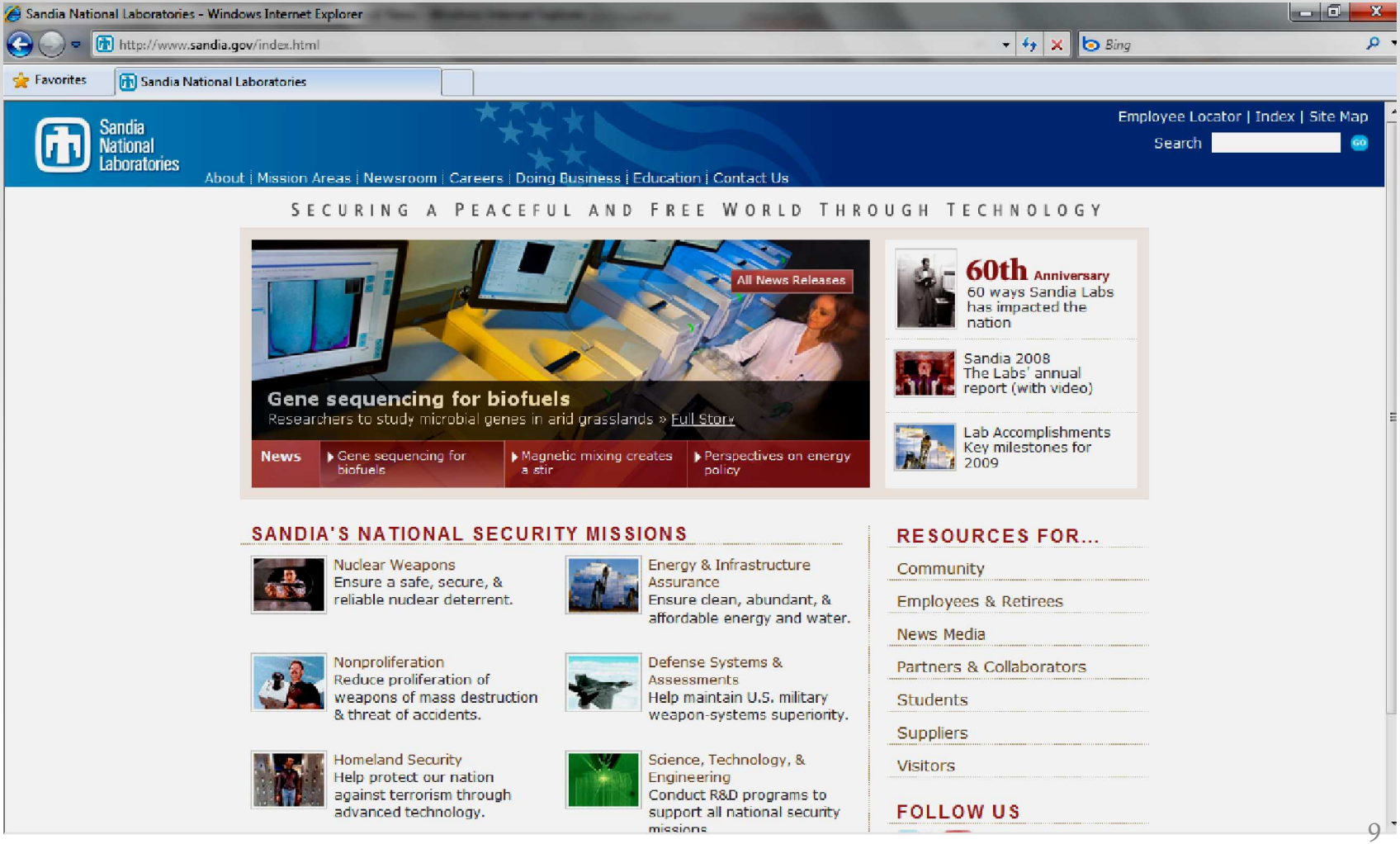


## Magic Cube

The Sandia-developed "Magic Cube" can blow a fragment-free hole in 1/4-inch steel. It can be used to safely look at a terrorist bomb inside a vehicle or create an opening to see accident victims and send them supplies.

Sandia National Laboratories

# www.sandia.gov



# Sandia Overview

**Four sites ( ~ 1100 bldg, 7M GSF)**

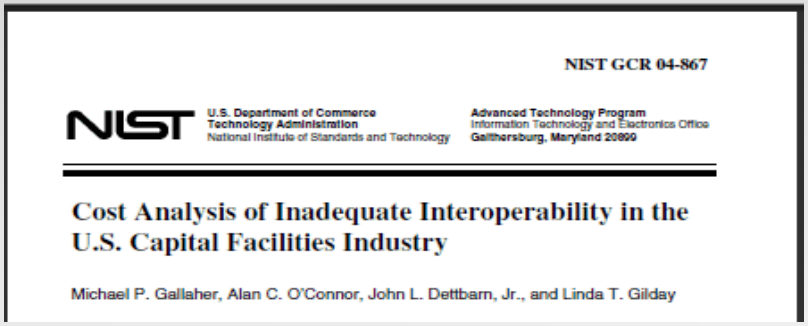
- NM (Albuquerque )
- CA (Livermore)
- NV (Tonopah)
- HI (Kauai)

**Sandia - NM site**

- 891 Bldgs
- 6M GSF
- 8700 acres

# Owners: Cost of NOT doing BIM

## NIST Survey (2004)



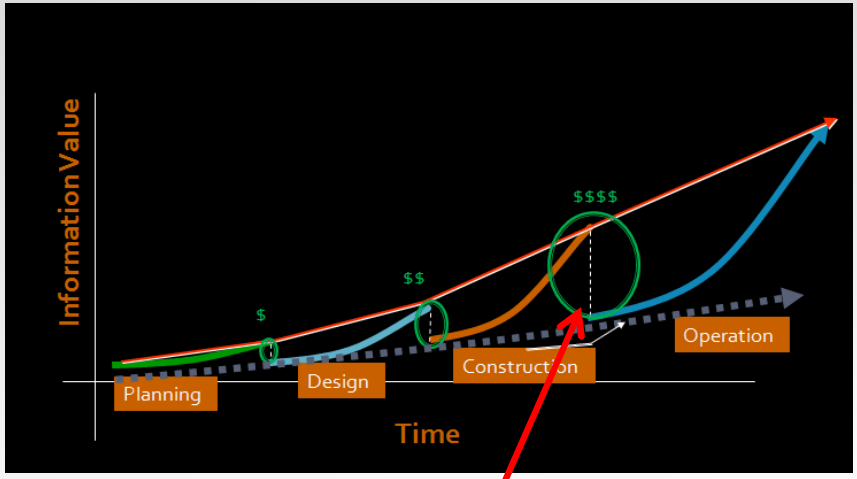
NIST GCR 04-867

NIST U.S. Department of Commerce Technology Administration National Institute of Standards and Technology

Advanced Technology Program Information Technology and Electronics Office Gaithersburg, Maryland 20899

**Cost Analysis of Inadequate Interoperability in the U.S. Capital Facilities Industry**

Michael P. Gallaher, Alan C. O'Connor, John L. Dettbarn, Jr., and Linda T. Gilday




Industry Inefficiency Costs : **$15B/yr**

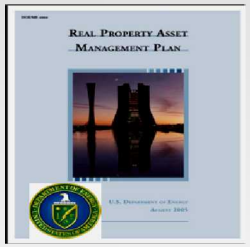
- 66% borne by Owners
- Increased O&M costs = $9.9B/yr
- $0.23/ existing SF/yr

# Putting in to Context…@0.23/SF

Sandia

- 6M GSF

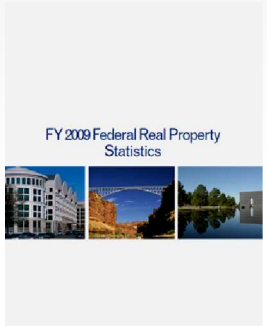
Costing : **$1.38 M/yr**




DOE

- 127M GSF

Costing : **$29 M/yr**

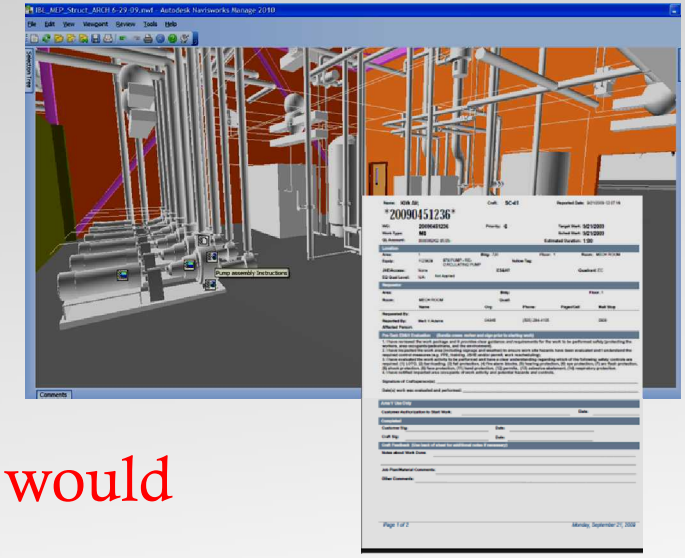



All Federal Agencies

- 3.38B GSF

Costing : **$0.77 B/yr**

# NIST Study Validation



NIST Study = ~$1.4M

**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/WO x $50/hr = $100/WO

WO/yr = ~ 24,000

**Potential savings: $2.4 M/year**

# BIM for FM : Evidence of savings

2004


## NIST Industry Study

*Cost Analysis of Inadequate Interoperability*

2009

Sandia National Laboratories

## NIST Validation

"Straw man" Survey

2010

THE UNIVERSITY of NEW MEXICO

## BIM for FM Survey :

*"View of the future for FM"*

# UNM BIM for FM Survey :

## *"View of the Future for Facilities Management"*

**Francisco Forns-Samso**
Graduate student
Construction Program
Civil Engineering Department

THE UNIVERSITY of NEW MEXICO

# Survey on BIM for FM

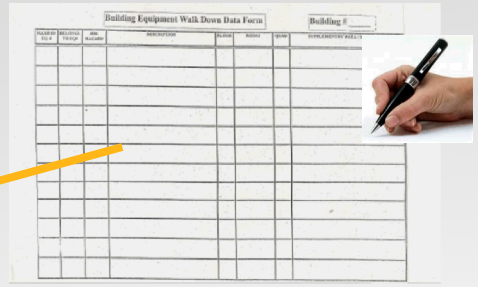
THE UNIVERSITY of NEW MEXICO

# Survey on BIM for FM

- **77%** Owners
- Majority manage campus-type facilities
- over 50% over 1M GSF
  - 22% 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

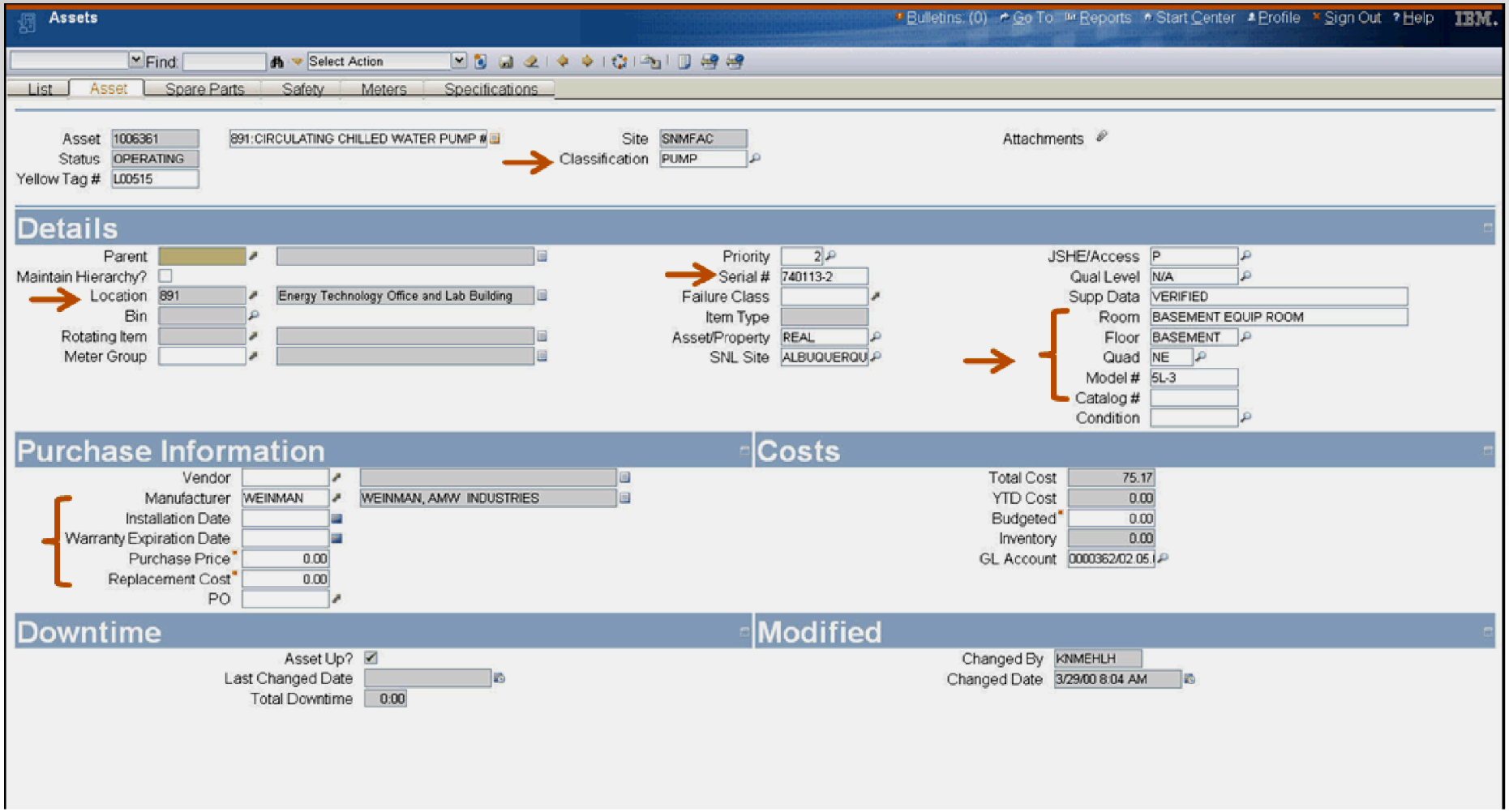
# FM Data Collection dilemma

- Current condition : Inefficient
  - Manual / Reentry
  - Not Trusted
  - Hard to locate




- Future vision : Efficient
  - Automated
  - Manufacture supplied
  - Entered Once, then Shared

# What data do we need?



# How to collect data?

| | AE to complete this section | | | | | | | | CONTRACTOR to complete this section | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Asset number | EQUIPMENT Classification | New Replace Remove | AREA | Location (Bldg#) | RM | FLR | Quadrant | Manufacturer | Model # | Catalog # | Serial Number | Installation date | Warranty Expiration date |
| 3 | 100567 | PUMP | Replace | I | 880 | 26 | BSMT | NE | Goulds | | | | | |
| 4 | | PUMP | New | I | 880 | 26 | BSMT | NE | | | | | | |
| 5 | 100570 | MOTOR | Replace | I | 880 | 26 | BSMT | NE | Baldor | | | | | |
| 6 | | MOTOR | New | I | 880 | 26 | BSMT | NE | | | | | | |
| 7 | | CHILLER | New | I | 880 | 26 | BSMT | NE | | | | | | |
| 8 | 101845 | CHILLER | Remove | I | 880 | 26 | BSMT | NE | Trane | | | | | |
| 9 | 101846 | CHILLER | Replace | I | 880 | 26 | BSMT | NE | Trane | | | | | |
| 10 | | BOILER | New | I | 880 | 26 | BSMT | NE | | | | | | |
| 11 | | | | | | | | | | | | | | |

Autodesk Revit Architecture 2010 - [5940036_MEP 2-25-2010.rvt - Schedule: MASTER EQUIP...

Home | Insert | Annotate | Modify | Massing & Site | Collaborate | View | Manage | Add-Ins | Modify Schedule/Quantities

Schedule

MASTER EQUIPMENT LIST - Asset Changes

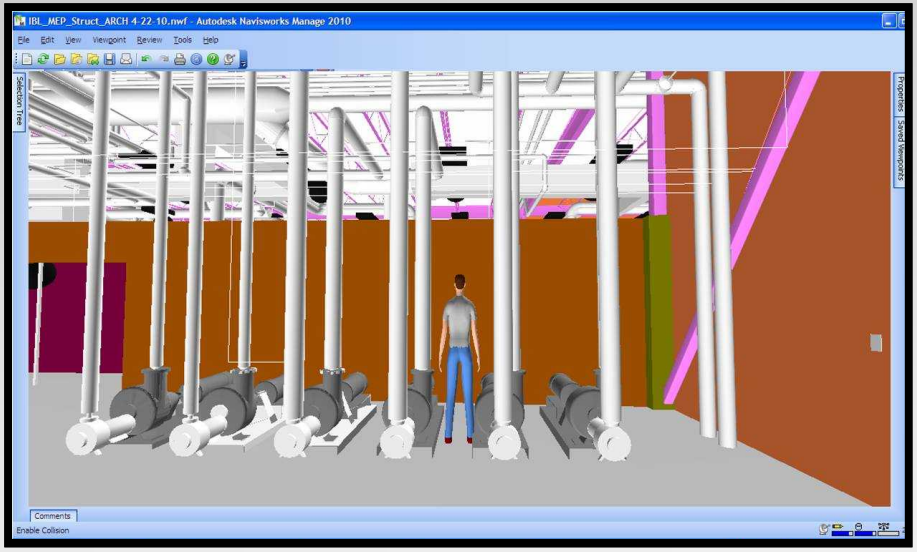
| AE to complete this section | | | | | | | | CONTRACTOR to complete this section | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Asset Number | EQUIPMENT Classification | New Replace Remove | AREA | Location (Bld | Room | Floor | Quadrant | Manufacturer | Model | Catalog # | Serial # | Installation Da | Warranty Exp | JSHE/Access |
| 111 | PUMP | NEW | I | 720 | 212 | 1st | NW | BELL & G | 1510 5A | | | | | |
| 112 | PUMP | NEW | I | 720 | 212 | 1st | NW | BELL & G | 1510 5A | | | | | |
| 113 | PUMP | NEW | I | 720 | 212 | 1st | NW | BELL & G | 1510 4BC | | | | | |
| 114 | PUMP | NEW | I | 720 | 212 | 1st | NW | BELL & G | 1510 4BC | | | | | |
| 115 | PUMP | NEW | I | 720 | 212 | 1st | NW | BELL & G | 1510 2BC | | | | | |
| 116 | PUMP | NEW | I | 720 | 212 | 1st | NW | BELL & G | 1510 2BC | | | | | |
| 121 | BOILER | NEW | I | 720 | 212 | 1st | NW | LOCHINV | PBN-1002- | | | | | |
| 122 | BOILER | NEW | I | 720 | 212 | 1st | NW | LOCHINV | PBN-1002- | | | | | |
| 245 | AIRHDLR | NEW | I | 720 | | ROOF | NE | | | | | | | |
| 247 | CHILLER | NEW | I | 720 | | 1st | NW | | | | | | | |
| 256 | MOTOR | NEW | I | 720 | 212 | 1st | NW | | | | | | | |

# Operational Savings with BIM

- ☑ Know there is a need
- ☑ Know there are perceived savings
- ☑ Cost Reduction Strategies
  - ☑ Energy
  - ?? Operations and Maintenance

***"Design for Maintenance"*** *Strategy*

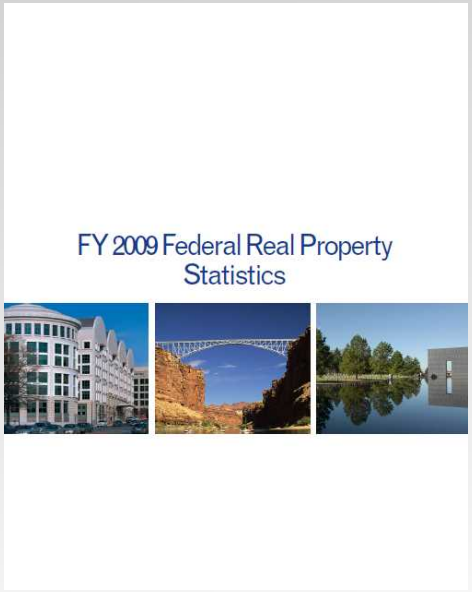
# *"Design for Maintenance"* strategy




***"Maintenance Friendly"***

***NOT "Maintenance Friendly"***

# Federal Agency Overview




Agency Profile:
FY 2009 Total Number of Buildings and Structures and Total Building Square Footage

Overview

| | | |
|---|---|---|
| Federal Communications Commission | 65 | 170,000 |
| National Archives and Records Administration | 32 | 5,170,000 |
| DC Court Services and Offender Supervision Agency | 11 | 294,000 |
| National Gallery of Art | 8 | 1,414,000 |
| United States Holocaust Memorial Council | 5 | 320,000 |
| Merit Systems Protection Board | 4 | 59,000 |
| Office of Personnel Management | 2 | 81,000 |
| John F. Kennedy Center for the Performing Arts | 1 | 1,500,000 |
| **Totals** | **912,780** | **3,388,992,000** |

Total GSF

[1] *Agencies listed in blue font (those same agencies subject to the CFO Act) are required to submit data under EO 13327 and sections 901 (b)(1) and (b)(2) of title 31, United States Code.*

FY 2009 Federal Real Property Report 1

http://www.gsa.gov/graphics/ogp/FY2009_FRPR_Statistics.pdf

# Federal Agency Overview

## Key Statistics: FY 2009 CFO Act Agencies

The chart on this page represents data from the 24 agencies required to submit data (those same agencies subject to the CFO Act). All data in this report starting on this page through the end of the report includes data from only those agencies.

FY 2009 Federal Real Property Statistics

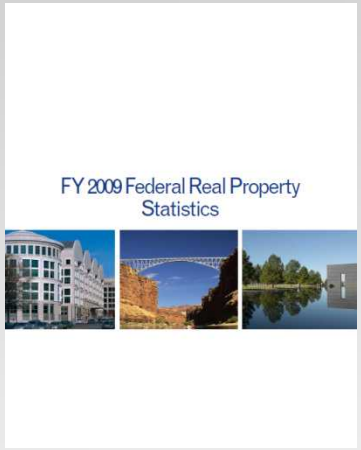
| | FY 2008 | FY 2009 | Variance |
|---|---|---|---|
| Total Federal Building Assets[2] | 406,000 | 429,000 | 23,000 |
| Total Area of Building Assets[3] | 3.26 billion square feet | 3.34 billion square feet | 71.0 million square feet |
| Total Federal Structures | 489,000 | 482,000 | -7,000 |
| Total Federal Land Acreage | 40,905,000 | 39,790,000.00 | -1,115,000 |
| **Total Federal Buildings and Structures** | **895,000** | **911,000** | **16,000** |

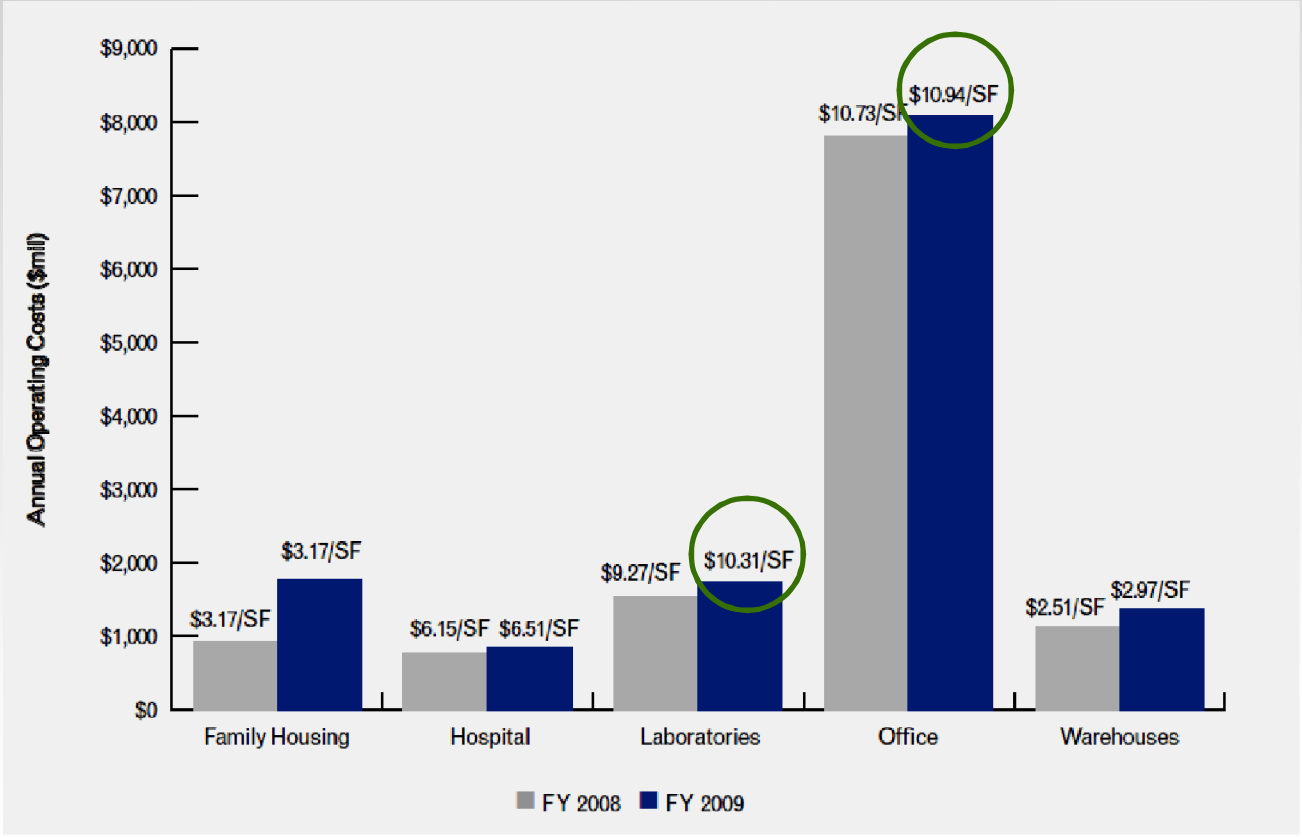
[2] *May include multiple leases in one building.*

[3] *All square feet data is represented in gross square feet.*

# Federal Buildings: Annual Operating Costs

## by Building Predominant Use and Square Footage



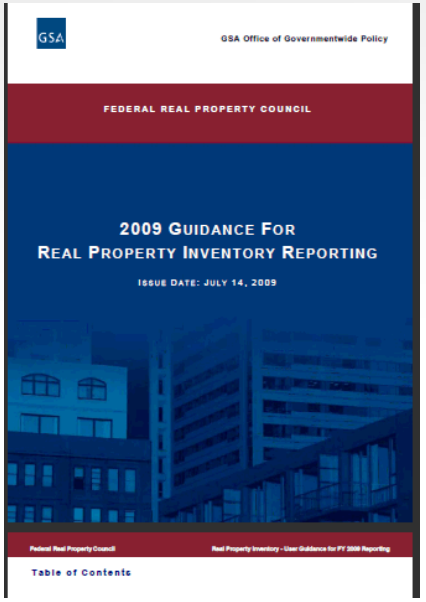
# Federal Annual Operating Costs

- **Custodial**
  - Pest control/refuse collection
  - Recycling costs
- **Roads/Grounds**
  - Landscaping/snow-ice removal
- **Utilities**
  - Plant operations and energy
- **Reoccurring Maintenance and Repair**
  - Work orders

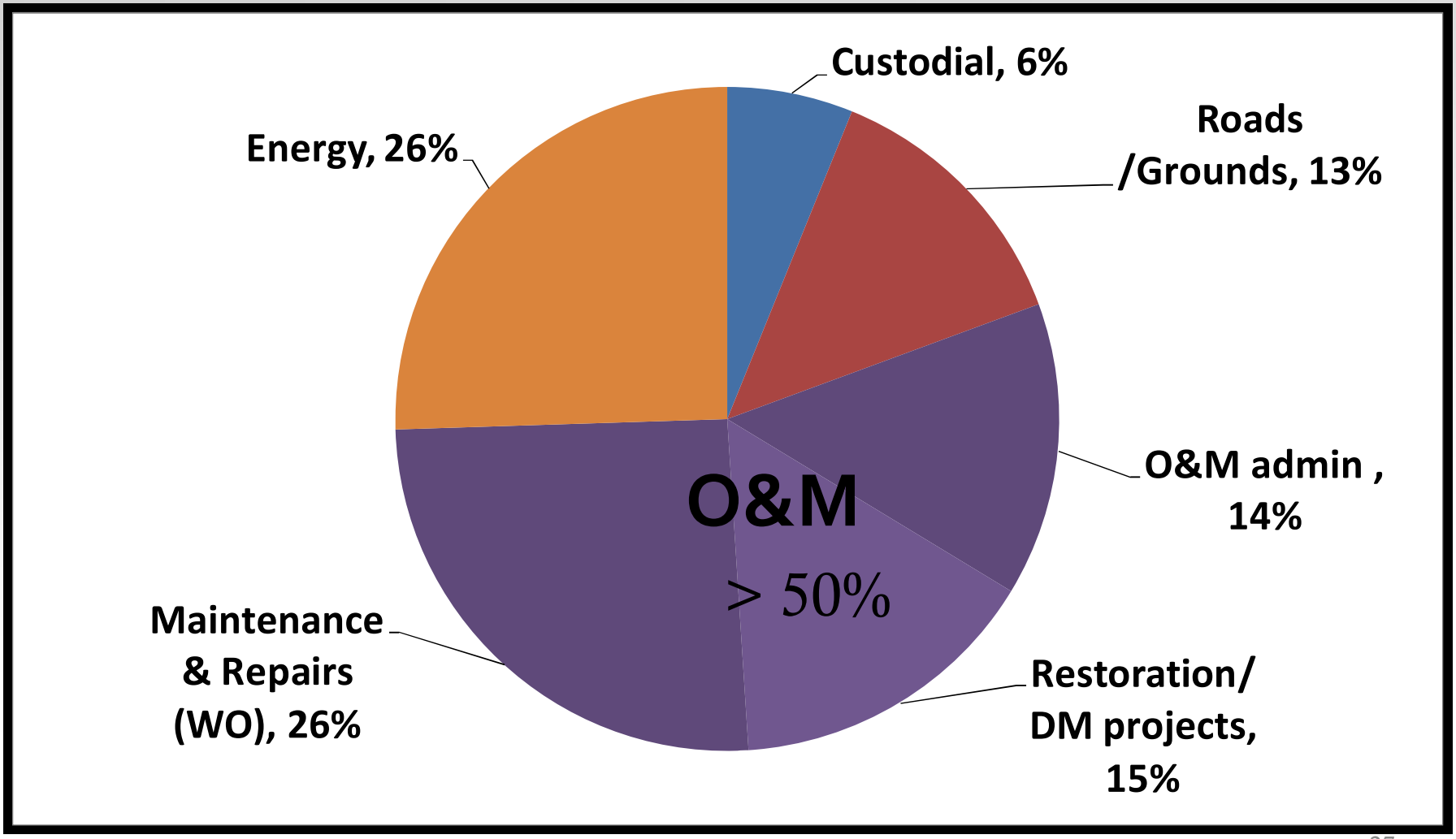
(source : FRPC Real Property Inventory – Users Guidance FY09)

| | Owned Buildings | | |
|---|---|---|---|
| | Annual Operating Costs | Total Square Feet (SF) | Annual Operating Costs/SF |
| FY 2008 | $12,036,779,000 | 2,588,928,000 | $4.65 |
| FY 2009 | $13,212,448,000 | 2,576,552,000 | $5.13 |

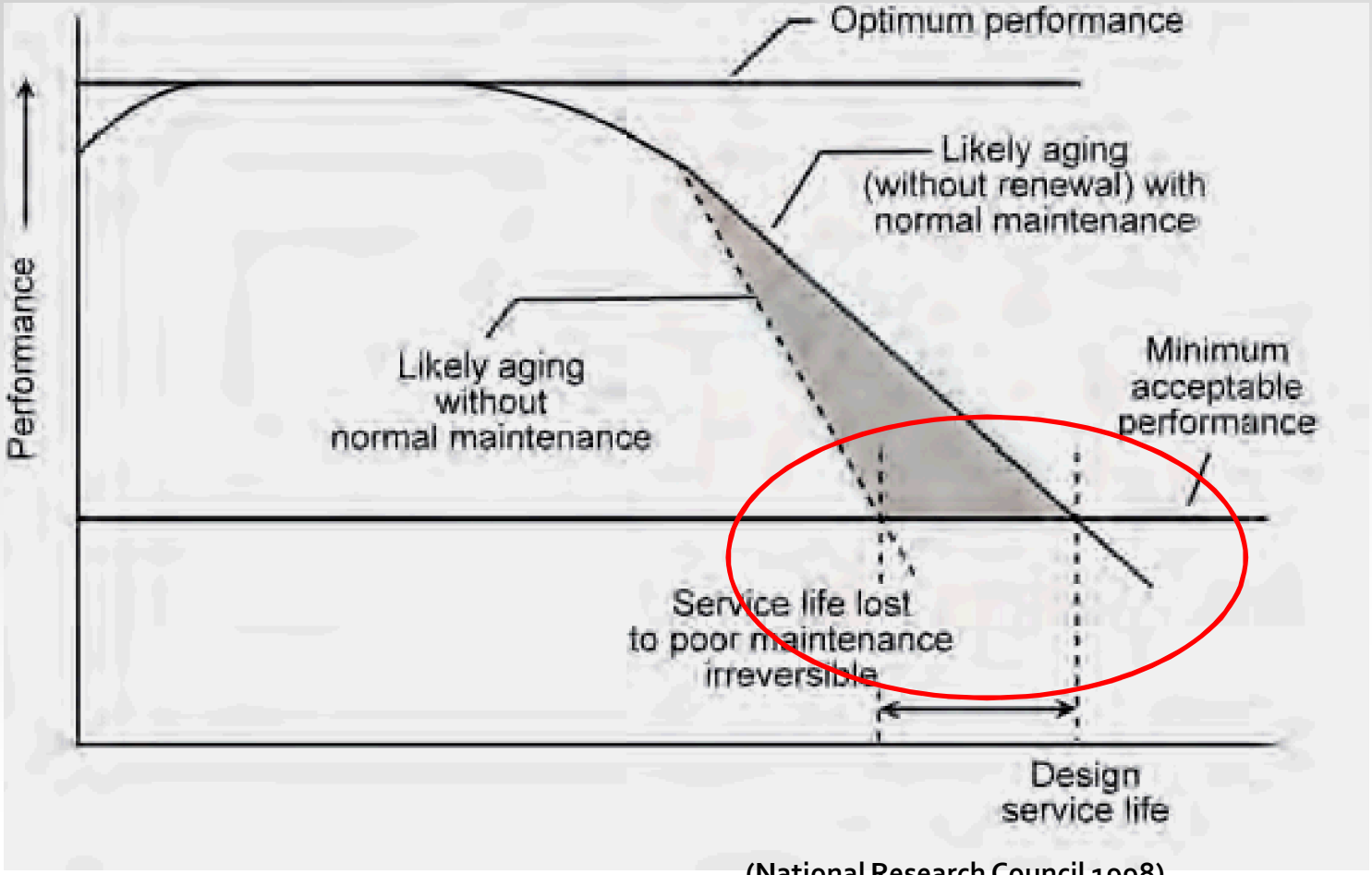
http://www.gsa.gov/graphics/ogp/FY2009_FRPR_Statistics.pdf



# Covering Operating Costs :
## Space Charge Back

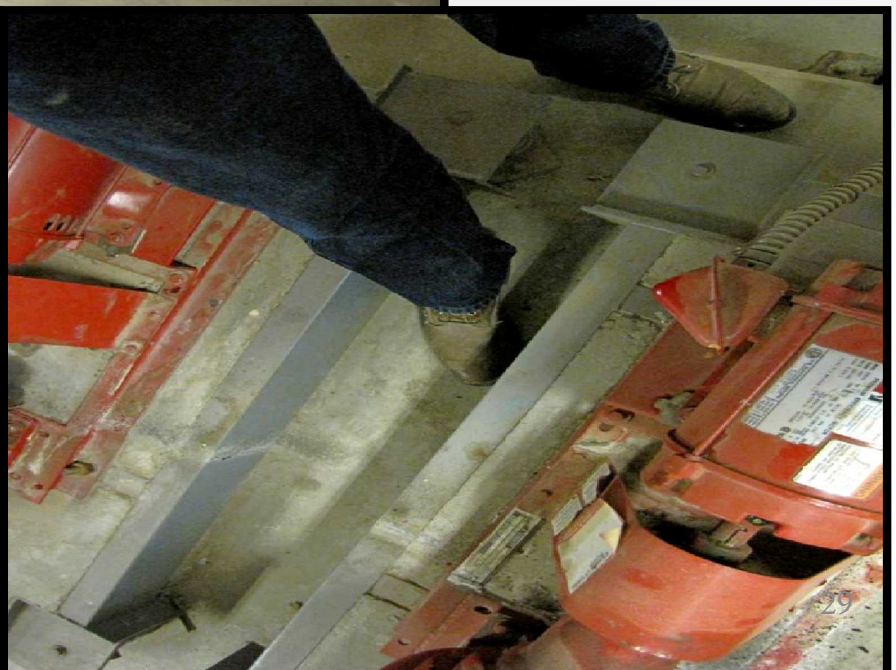


# *"Design For Maintenance" Strategy:*
# Main Premise

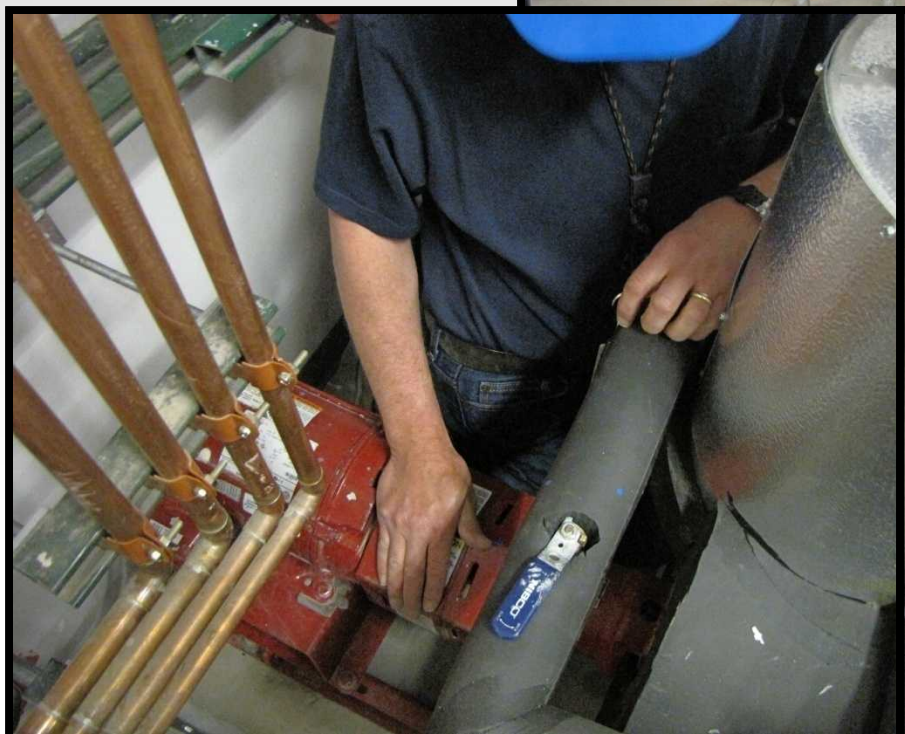



(National Research Council 1998).

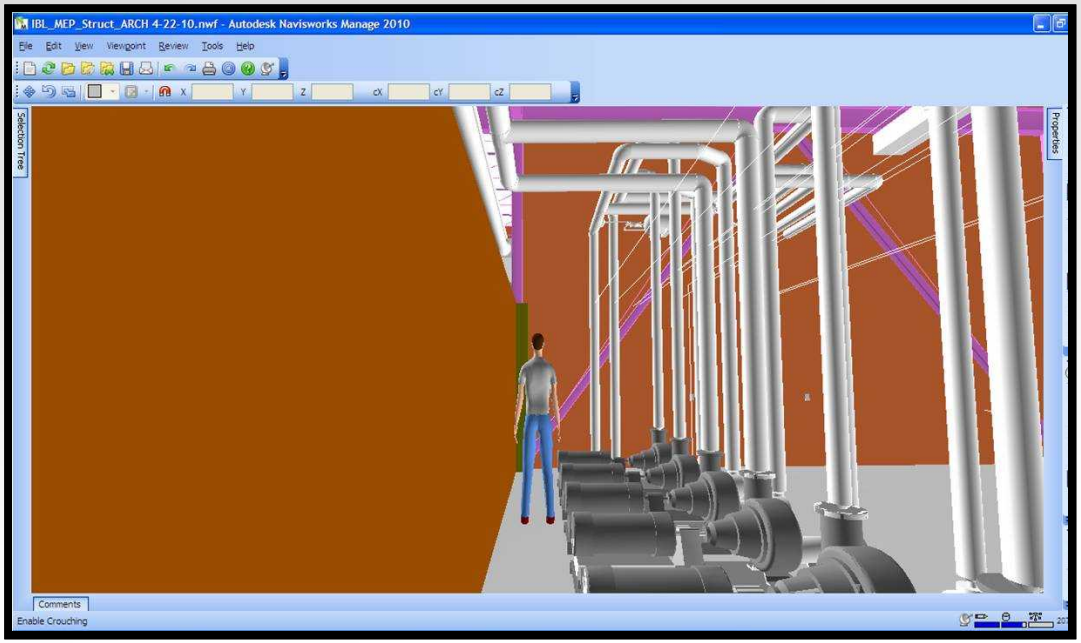
# *"Maintenance Friendly"*



# *NOT "Maintenance Friendly"*



# *"Maintenance Friendly"*



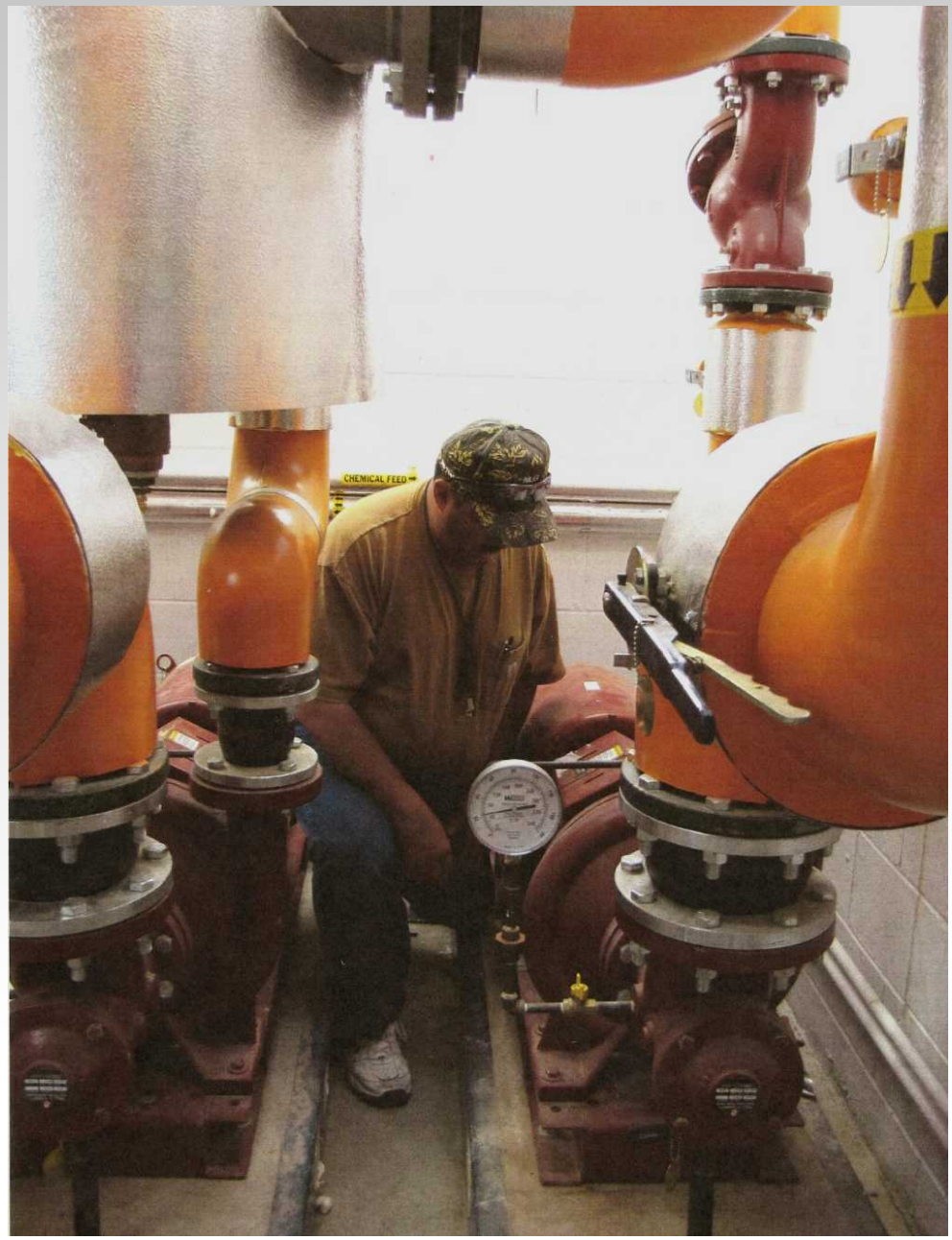
# *NOT "Maintenance Friendly"*

**O&M Impact :**

**2x PM time**

**4x CM time**

**…….. Over 25 years**


CHEMICAL FEED

# Maintenance : Equipment Check Lists

### 9.9.11 Pumps Checklist

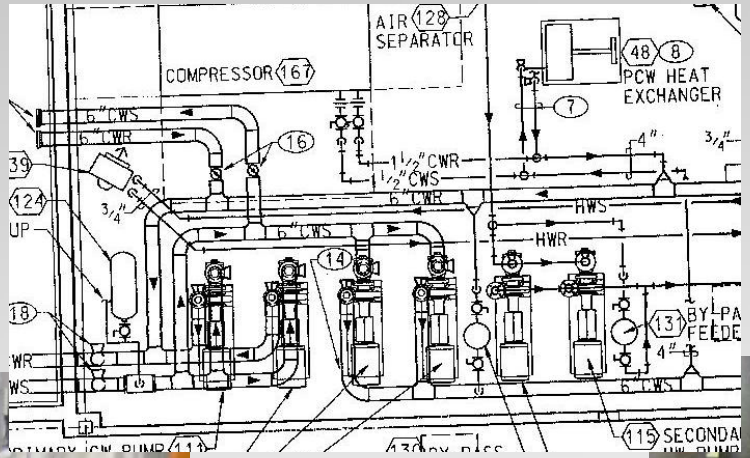
| Description | Comments | Maintenance Frequency | | | |
|---|---|---|---|---|---|
| | | Daily | Weekly | Monthly | Annually |
| Pump use/sequencing | Turn off/sequence unnecessary pumps | X | | | |
| Overall visual inspection | Complete overall visual inspection to be sure all equipment is operating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

(FEMP: O&M Best Practice 3.0)

### 9.10.10 Electric Motors Checklist

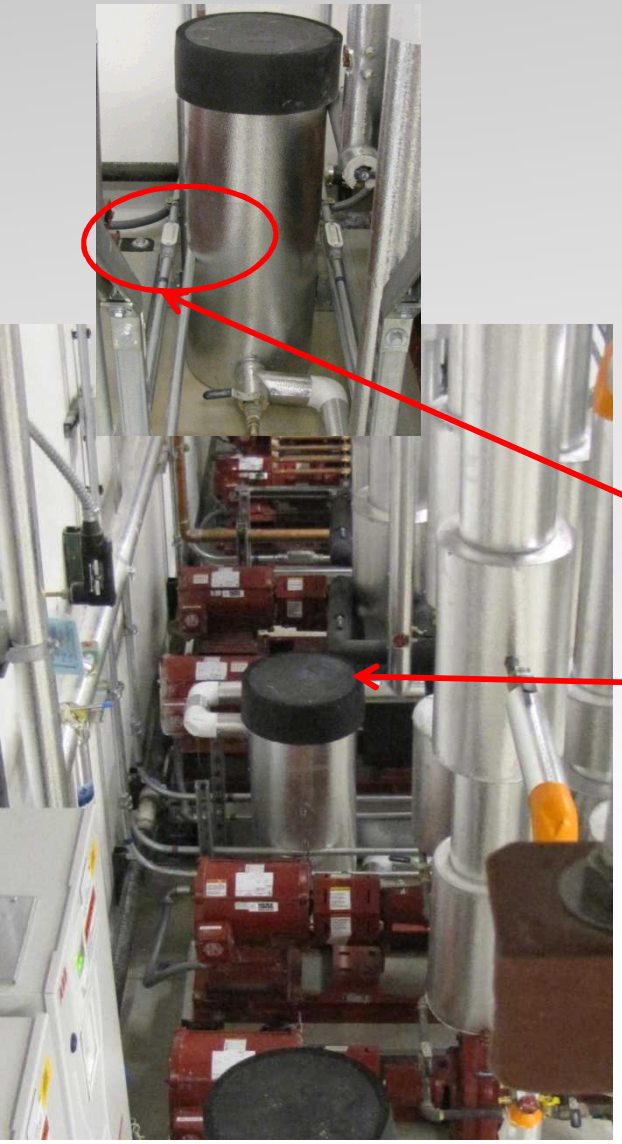
| Description | Comments | Maintenance Frequency | | | |
|---|---|---|---|---|---|
| | | Daily | Weekly | Monthly | Annually |
| Motor use/ sequencing | Turn off/sequence unnecessary motors | X | | | |
| Overall visual inspection | Complete overall visual inspection to be sure all equipment is operating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

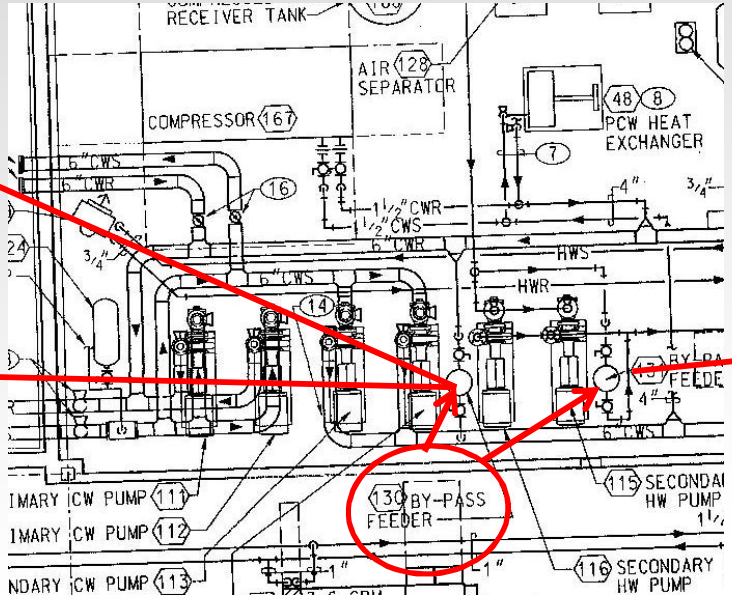
# *NOT "Maintenance Friendly"*




# By-Pass Feeders locations….

*NOT "Maintenance Friendly"*

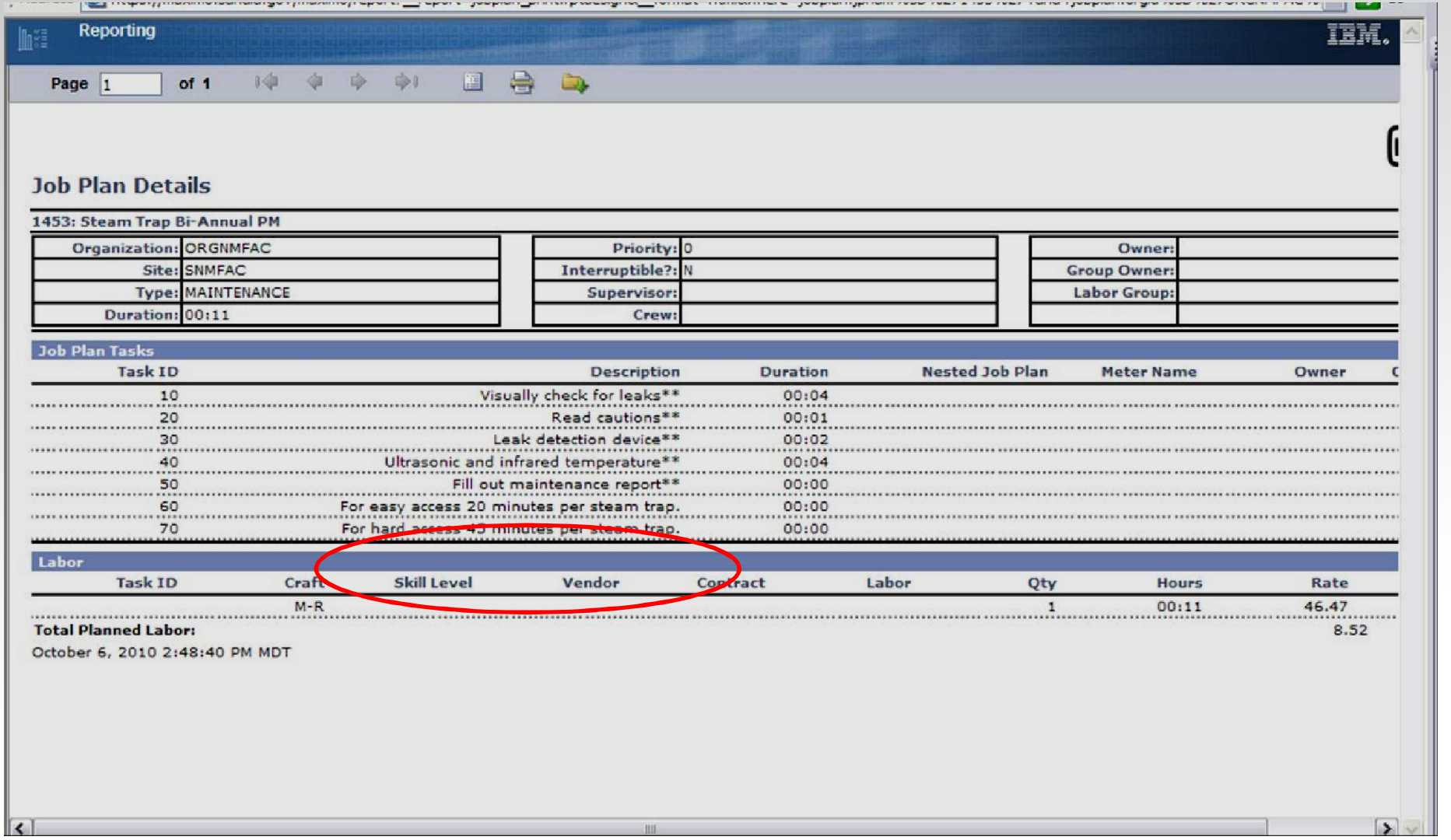





# By-Pass Feeder location….

*"Maintenance Friendly"*

# Steam Traps….



Reporting

Page 1 of 1

## Job Plan Details

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

| | | | | | |
|---|---|---|---|---|---|
| Organization: | ORGNMFAC | Priority: | 0 | Owner: | |
| Site: | SNMFAC | Interruptible?: | N | Group Owner: | |
| Type: | MAINTENANCE | Supervisor: | | Labor Group: | |
| Duration: | 00:11 | Crew: | | | |

**Job Plan Tasks**

| Task ID | Description | Duration | Nested Job Plan | Meter Name | Owner |
|---|---|---|---|---|---|
| 10 | Visually check for leaks** | 00:04 | | | |
| 20 | Read cautions** | 00:01 | | | |
| 30 | Leak detection device** | 00:02 | | | |
| 40 | Ultrasonic and infrared temperature** | 00:04 | | | |
| 50 | Fill out maintenance report** | 00:00 | | | |
| 60 | For easy access 20 minutes per steam trap. | 00:00 | | | |
| 70 | For hard access 45 minutes per steam trap. | 00:00 | | | |

**Labor**

| Task ID | Craft | Skill Level | Vendor | Contract | Labor | Qty | Hours | Rate |
|---|---|---|---|---|---|---|---|---|
| | M-R | | | | | 1 | 00:11 | 46.47 |

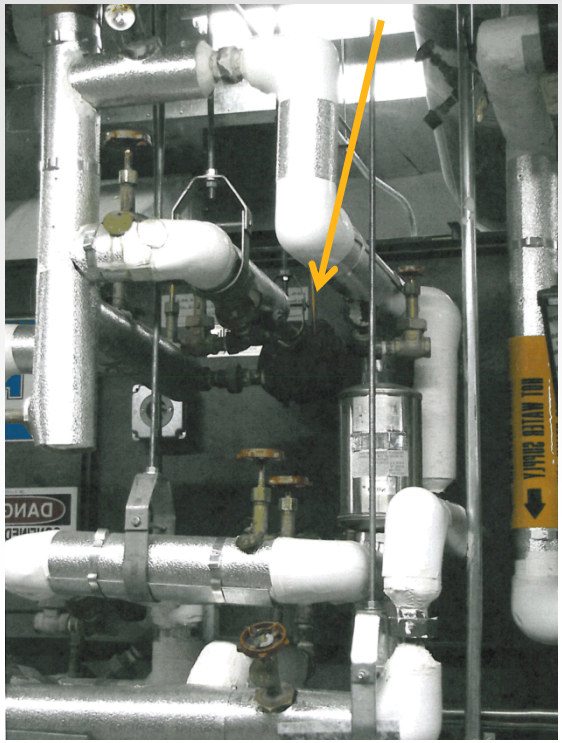
**Total Planned Labor:** 8.52

October 6, 2010 2:48:40 PM MDT

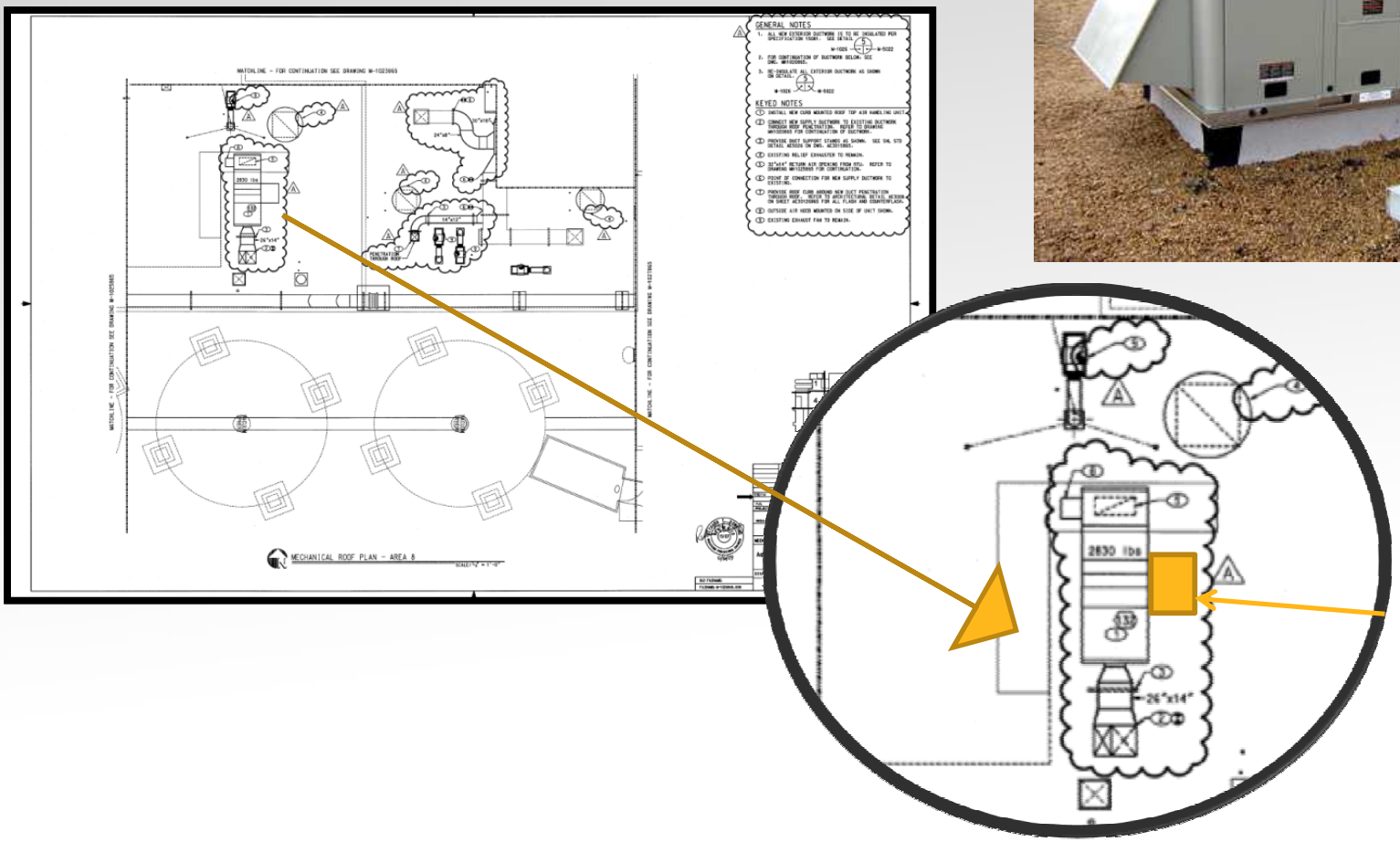
# Steam Traps….


*"Maintenance Friendly"*

*NOT "Maintenance Friendly"*

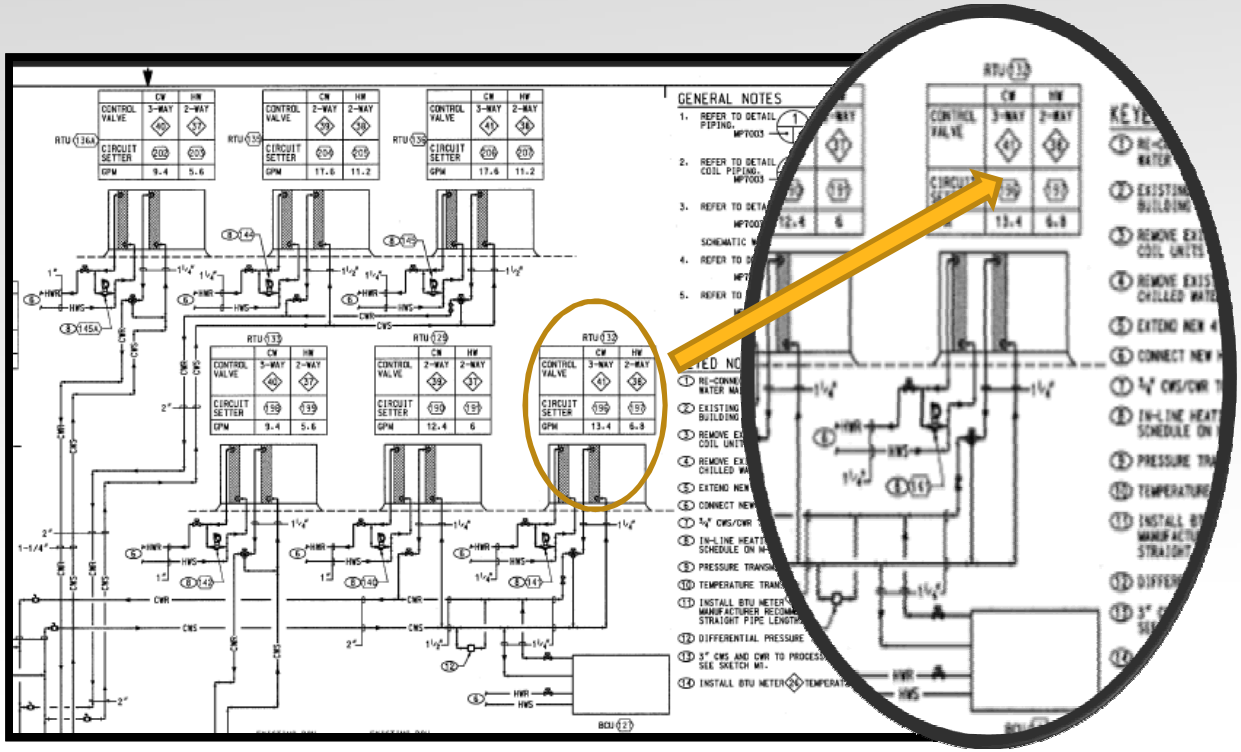


# Roof Top Unit (RTU) : piping




External box
for
HW/CW piping

# Roof Top Unit (RTU) : piping




External box :

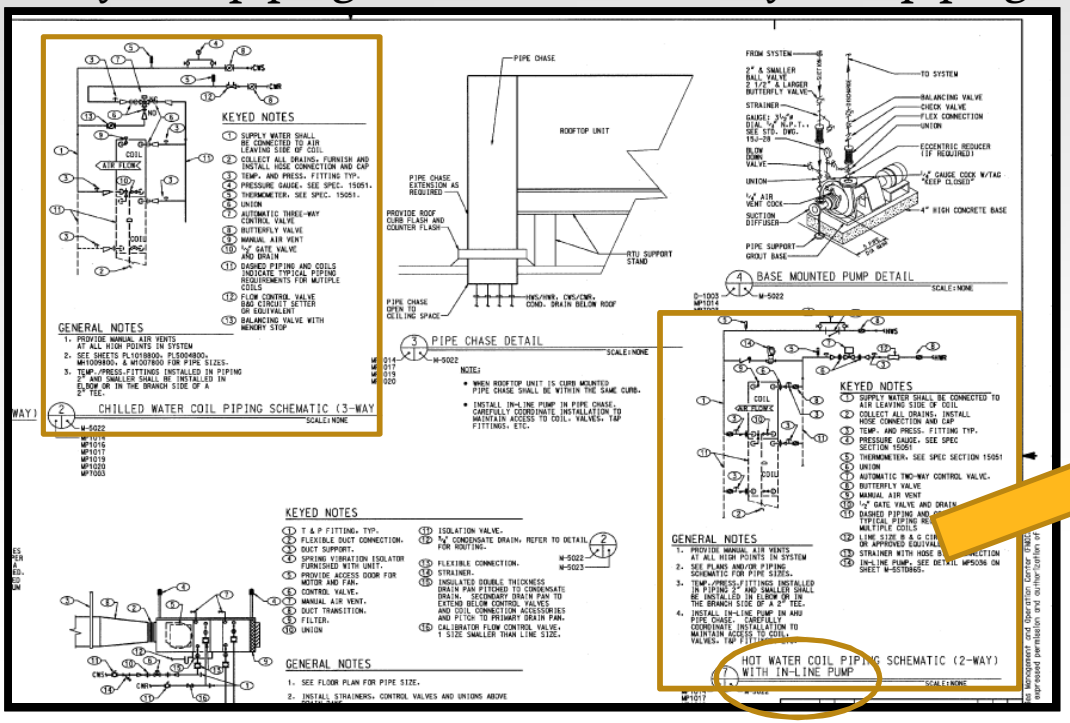
2-way HW piping
3-way CW piping

# Roof Top Unit (RTU) : piping

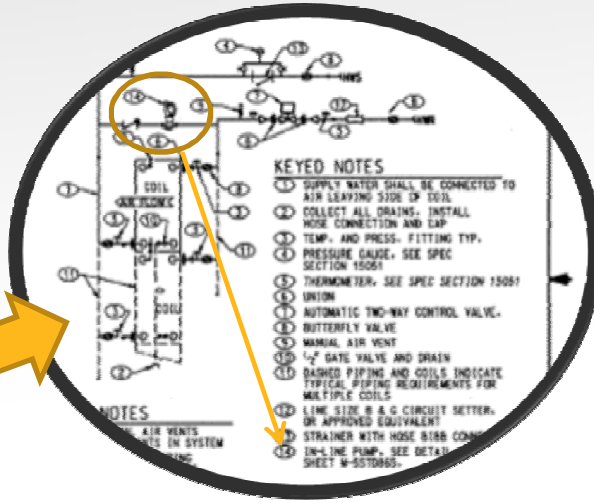
## Standard Detail

3-way CW piping

2-way HW piping




pump



# Roof Top Unit (RTU) : piping

Pump failed in 2 months :

design issue

or

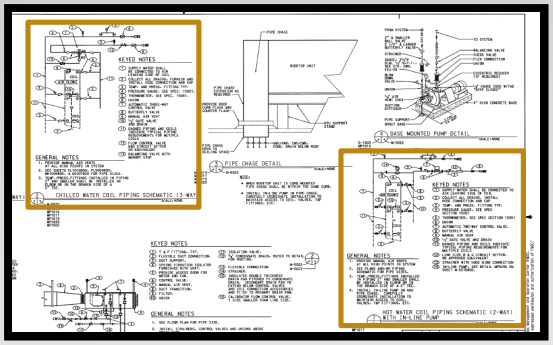
poor quality ??

"MEANS & METHODS" ??

# RTU piping install

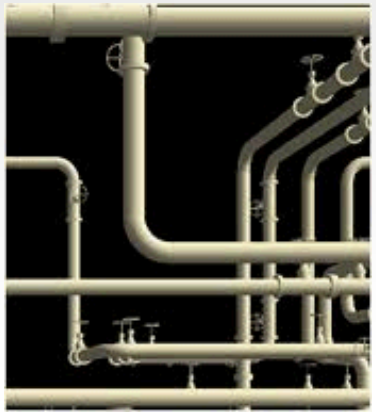
**Current 2D**

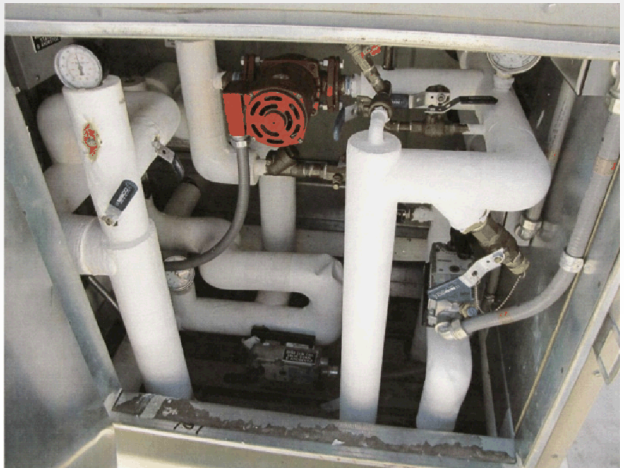
- Design = **0** hrs
- Install = **48 hrs**
  Mech Contractors
  - Field design = 16 hrs
  - Install =**32 hrs**
- O&M = **8** hrs



**If BIM enabled**

- Design = **8** hrs
- Install = **24 hrs**
  Mech Contractor
  - Field design = 0 hrs
  - Prefab = **8** hrs
  - Install = **16** hrs
- O&M = **4** hrs





**8 Hrs of BIM design could reduced Install and O&M by 50%**

# Latest example… Relief Fan

**Dec 1, 2010** **Forward email from a Facilities Senior Manager**

**From**: Q J
**Sent**: Wednesday, December 01, 2010 05:03 PM
**To**: Foster, Birgitta T
**Subject**: FW: Building [redacted] Relief Fan Access

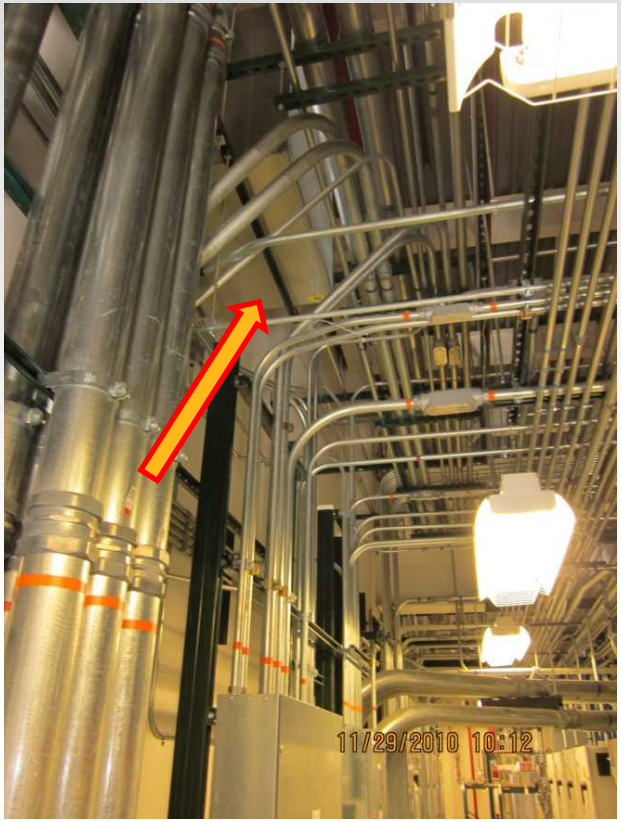
BIM anyone?

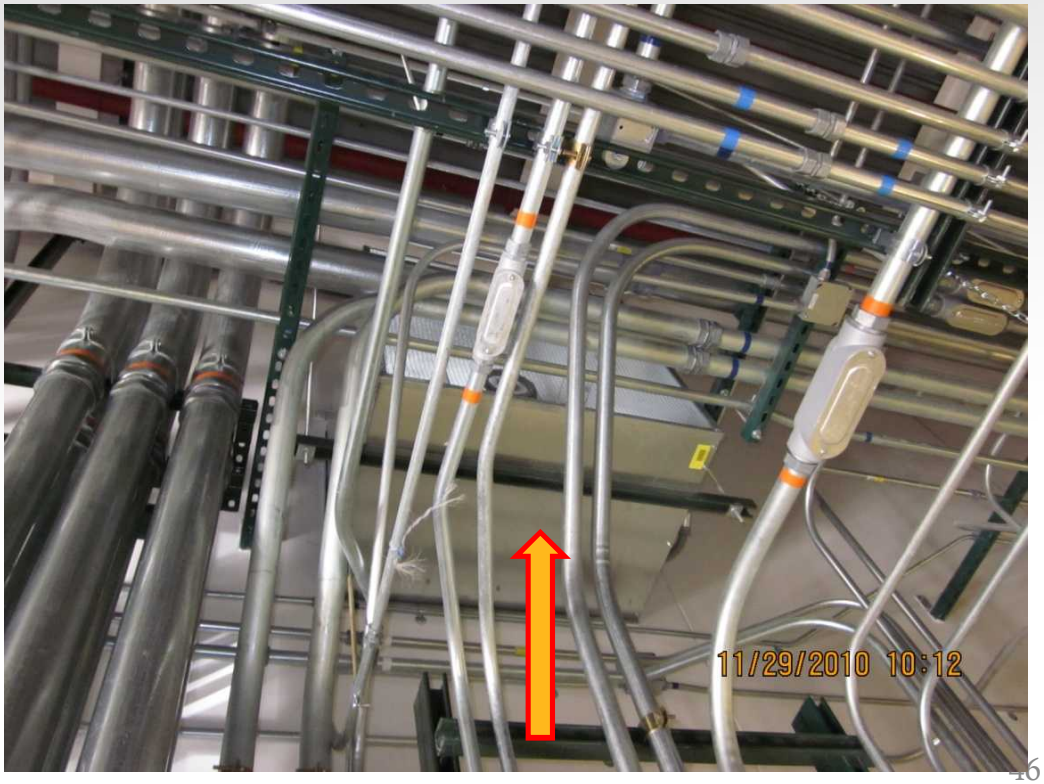
**from Service Manager team**

"Unless a team member can find an innovative access solution I will be initiating an end of any maintenance activities for Relief Fan, EF1,….I could not find a means of improving access to this fan.. thanks for bringing this to our attention the safety concerns that are associated with gaining access to this piece of equipment"

# Latest example…Relief Fan

"I have put in service request …to find a solution to meeting the relief needs of the building, perhaps another exhaust fan can be used….Please discontinue any Preventative Maintenance to this exhaust fan."



# Four Maintenance Strategies

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

Basic philosophy

- Allow machinery to run to failure.
- Repair or replace damaged equipme

Cost: $18/hp/yr

This maintenance philosophy allows damaged equipment only when obvio fashion are about $18 per horsepowe equipment shutdowns do not affect pr

### Preventive Maintenance (Time-Based Maintenance)

Basic philosophy

- Schedule maintenance activities at predetermined time intervals
- Repair or replace damaged

Cost: $13/hp/yr

This philosophy entails the damaged equipment is repair have shown the costs of oper approach are that it works we enough knowledge, skills, an

### 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 conditions warrant-by periodically moni lubrication degradation, or by observin gets to a predetermined unacceptable l components so as to prevent a more co Studies have shown that when it is done year. Advantages of this approach are and time to perform the predictive main an orderly fashion. It also provides son the need for a high parts inventory. Sin likely to be an increase in production c

### 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 advanced 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 hp 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 can be scheduled in an orderly fashion, 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

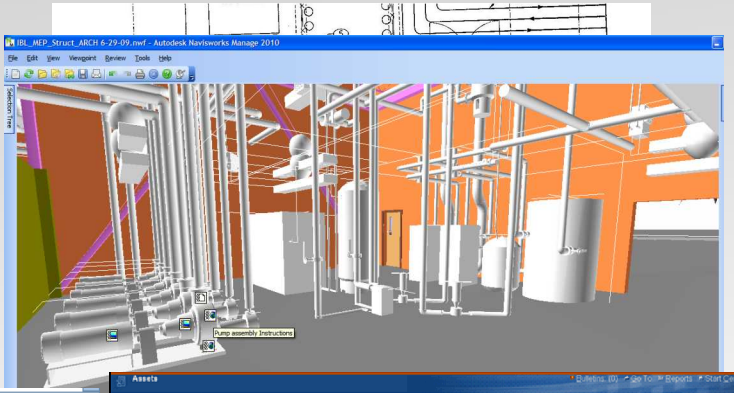
| Reliability Centered Maintenance Hierarchy | | |
|---|---|---|
| *Reactive* Element Applications | *Preventive* Element Applications | *Predictive* Element Applications |
| Small parts and equipment | Equipment subject to wear | Equipment with random failure patterns |
| Non-critical equipment | Consumable equipment | Critical equipment |
| Equipment unlikely to fail | Equipment with known failure patterns | Equipment not subject to wear |
| Redundant systems | Manufacturer recommendations | Systems which failure may be induced by incorrect preventive maintenance |

THEN.....

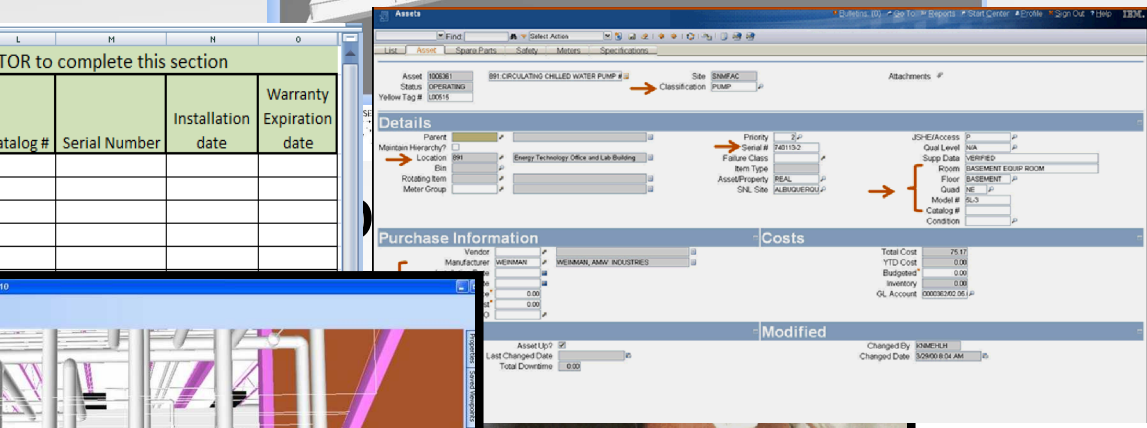
Share with your Design Teams !

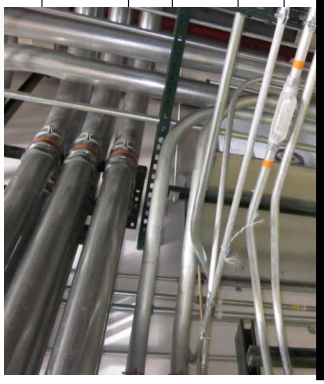
# OWNERS…Tying it all together

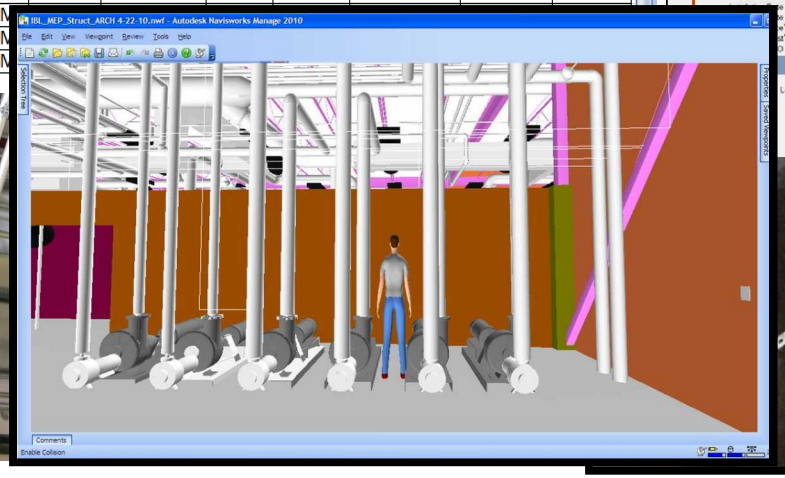
- Visual : 3D Models
- Data collection




| AE to complete this section | | | | | | | | CONTRACTOR to complete this section | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Asset number | EQUIPMENT Classification | New Replace Remove | AREA | Location (Bldg#) | RM | FLR | Quadrant | Manufacturer | Model # | Catalog # | Serial Number | Installation date | Warranty Expiration date |
| 100567 | PUMP | Replace | I | 880 | 26 | BSMT | NE | Goulds | | | | | |
| | PUMP | New | I | 880 | 26 | BSMT | NE | | | | | | |
| 100570 | MOTOR | Replace | I | 880 | 26 | BSMT | NE | Baldor | | | | | |
| | MOTOR | New | I | 880 | 26 | BSMT | NE | | | | | | |
| | CHILLER | New | I | 880 | 26 | BSMT | NE | | | | | | |
| 101845 | CHILLER | Remove | I | 880 | 26 | BSN | | | | | | | |
| 101846 | CHILLER | Replace | I | 880 | 26 | BSN | | | | | | | |
| | BOILER | New | I | 880 | 26 | BSN | | | | | | | |

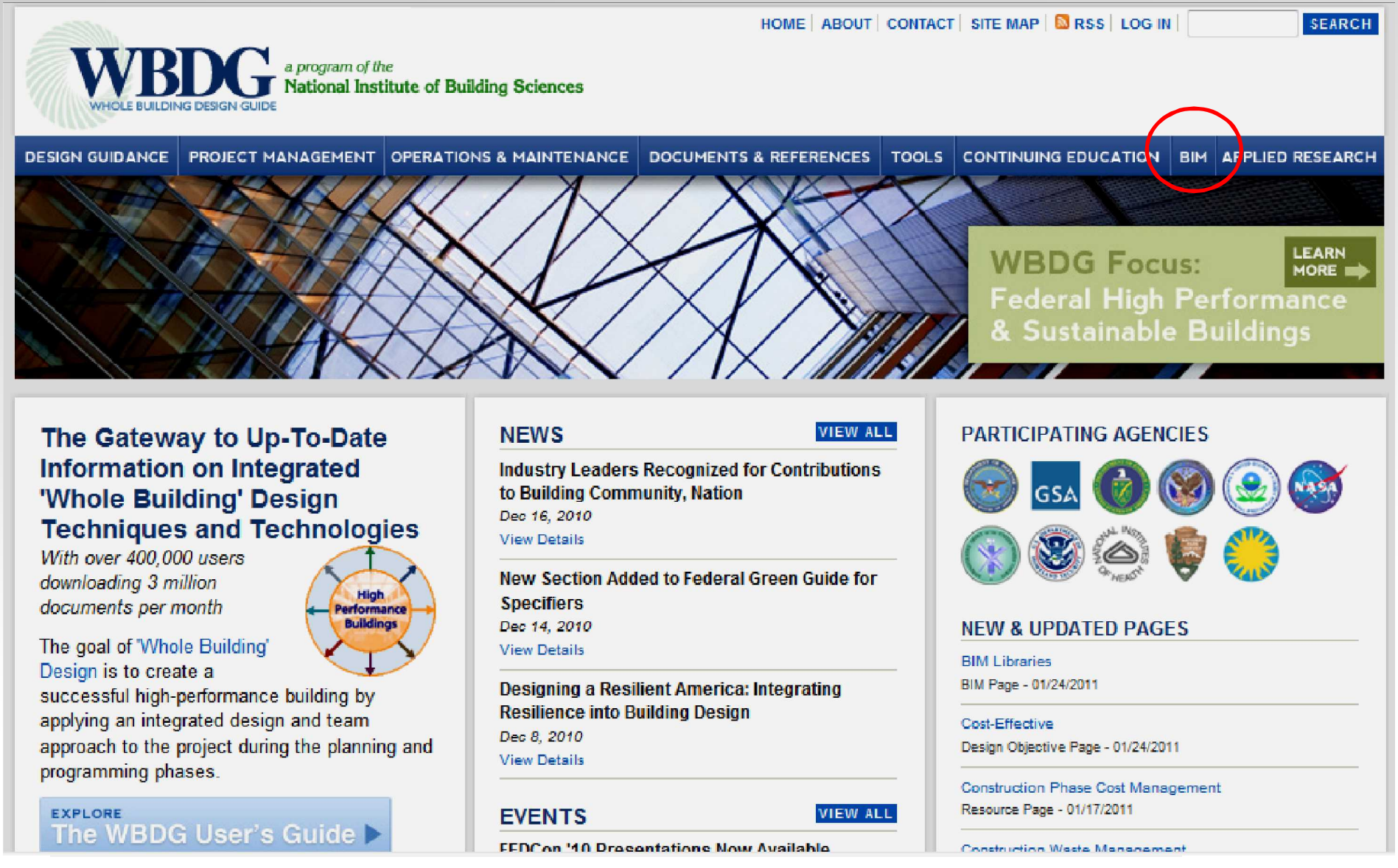


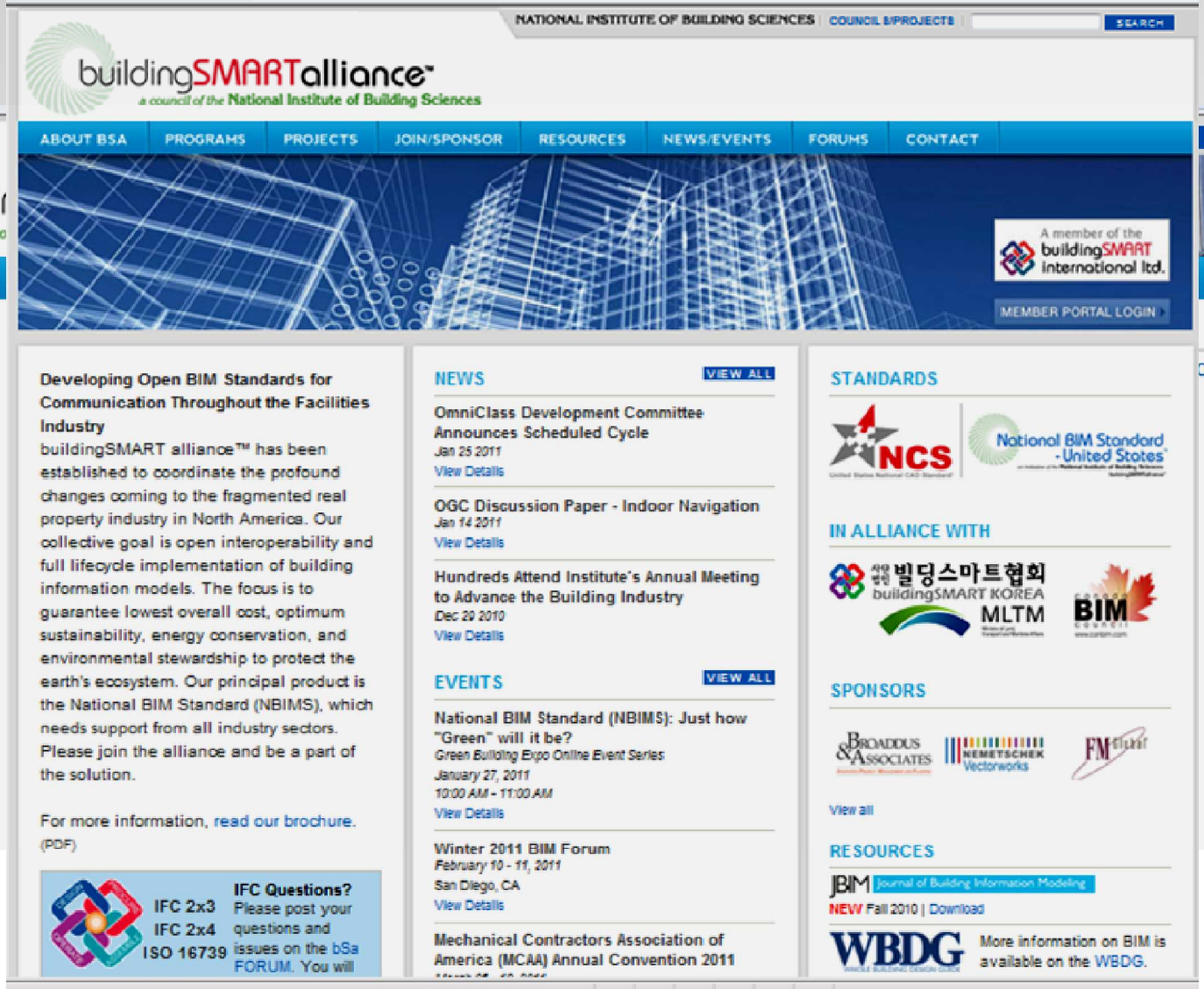



WBDG

wbdg.org



buildingsmartalliance.org



# Thank you!…any questions??

**Building Information Model *Model* ?**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**Facilities BIM Champion**