BIM for Facility Management :
"Design for maintenance"

Birgitta Foster
SSA/Sandia National Labs

November 17, 2010

Northwest Construction Consumer Council

Sandia National Laboratories

Disclaimer

"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."

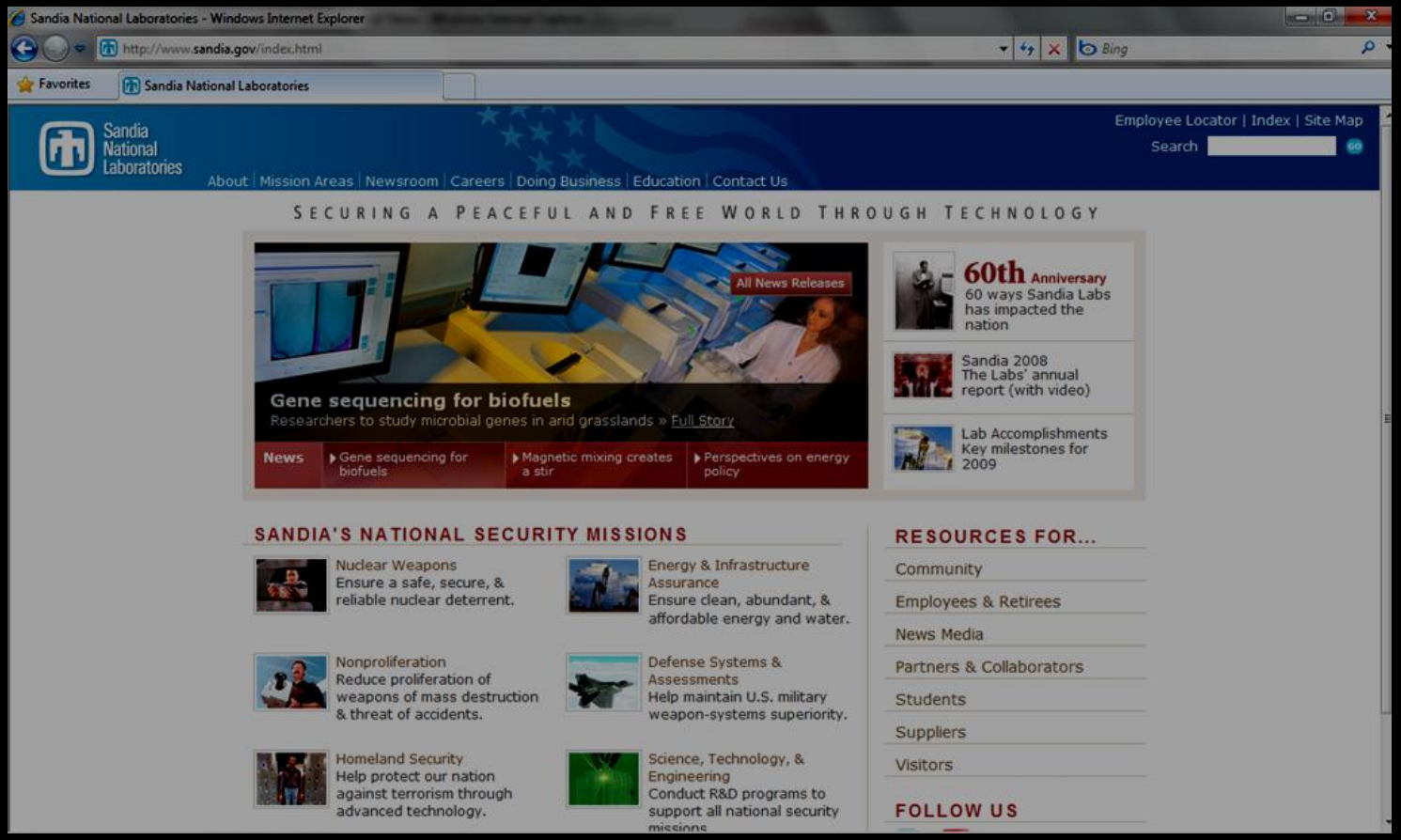
Birgitta Foster, BSME, MBA

Career Path

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

Sandia National Laboratories

www.sandia.gov



Sandia National Laboratories

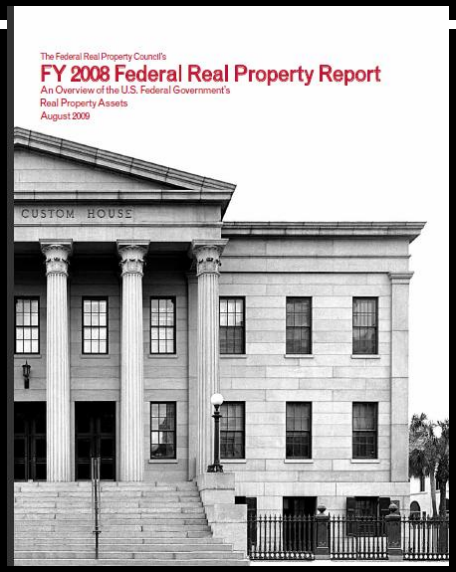
Four sites (~ 1100 bldg, 7M GSF)

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

Sandia NM

- 891 Bldgs
- 6M GSF
- 8700 acres

Federal Agency Overview



TOTAL Building Footage = 3.29B SF

TOTAL Number of Buildings/Structures = 895,923

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

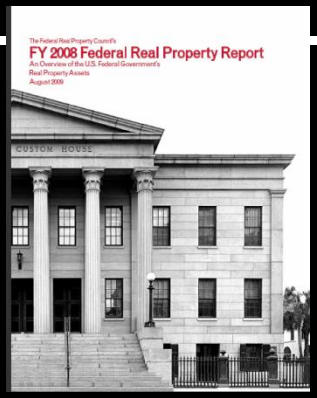
Agency Name[1]	Total Number of Buildings and Structures	Total Building Square Footage
Army	251,966	943,982,068
Interior	163,789	122,987,288
Air Force	136,883	598,814,805
Navy	118,906	486,720,884
Transportation	58,637	27,263,882
Agriculture	57,523	57,558,472
Homeland Security	26,436	47,178,709
Energy	18,202	130,611,778
State	15,322	69,716,158
Corps of Engineers	9,410	15,764,737
Veterans Affairs	8,938	154,388,241
General Services Administration	8,915	398,017,856
National Aeronautics and Space Administration	4,719	44,152,752
Justice	4,195	70,694,594
Labor	3,595	24,087,958
Health and Human Services	3,178	35,115,583
United States Agency for International Development	1,139	4,949,622
Commerce	1,009	7,779,613
Smithsonian	617	12,149,481

Agency Name	Total Number of Buildings and Structures	Total Building Square Footage
National Science Foundation	597	2,247,073
Peace Corps	434	2,146,486
Defense/Washington Headquarters Services	399	8,178,367
Independent Government Offices	302	608,462
Environmental Protection Agency	249	4,261,243
Tennessee Valley Authority	249	5,985,593
American Battle Monuments Commission	137	464,685
Treasury	128	6,194,864
National Archives and Records Administration	31	4,780,204
National Gallery of Art	6	1,330,083
United States Holocaust Memorial Council	5	319,749
Merit Systems Protection Board	4	58,821
Office of Personnel Management	2	82,245
John F. Kennedy Center for the Performing Arts	1	1,500,000
TOTALS	**895,9[illegible]**	**3,290,092,356**

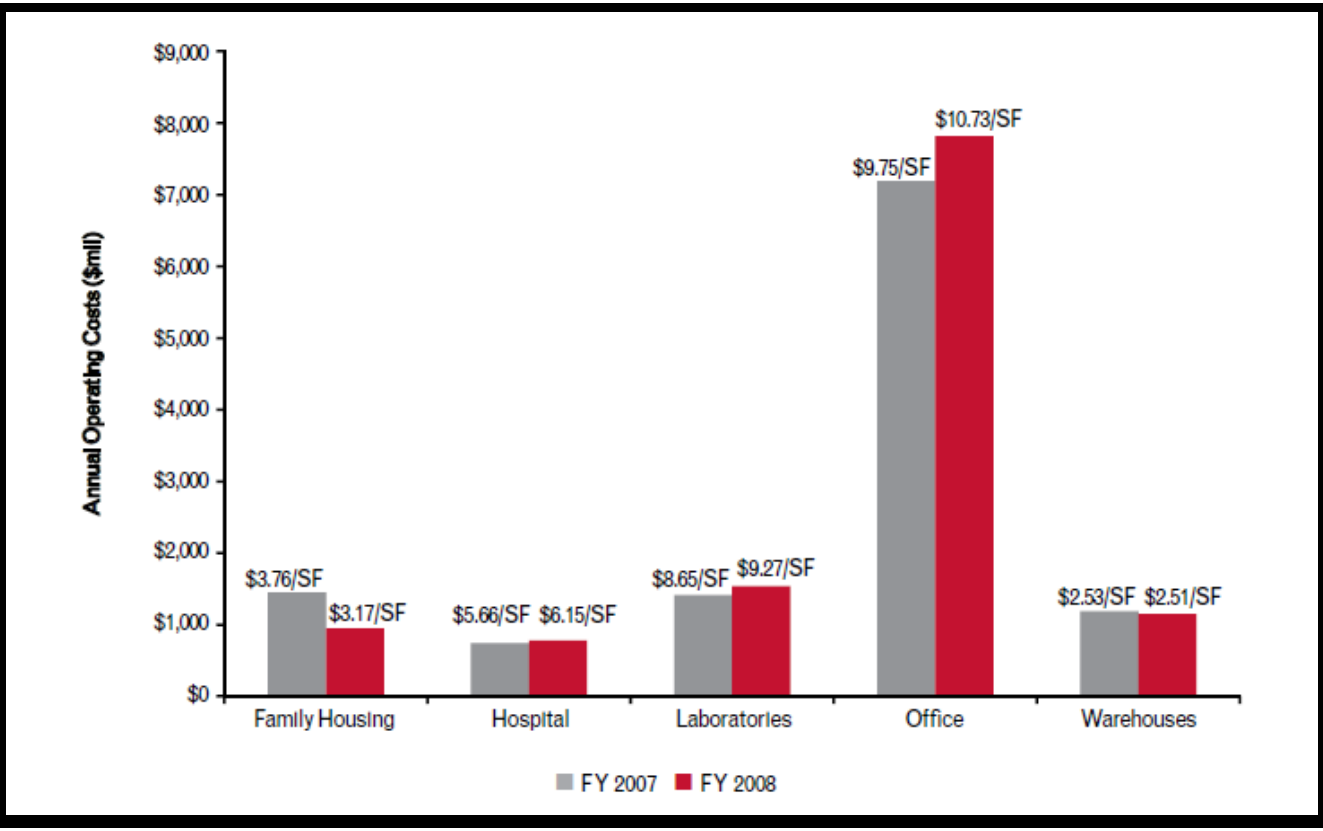
[1] *Agencies listed in blue font (those same agencies subject to the CFO Act) are required to submit data under EO 13327 and sections 901 (b)(1) and (b)(2) of title 31, United States Code.*

http://www.gsa.gov/graphics/ogp/FY_2008_Real_Property_Report.pdf

Annual Operating Costs
by Building Predominant Use and Square Footage



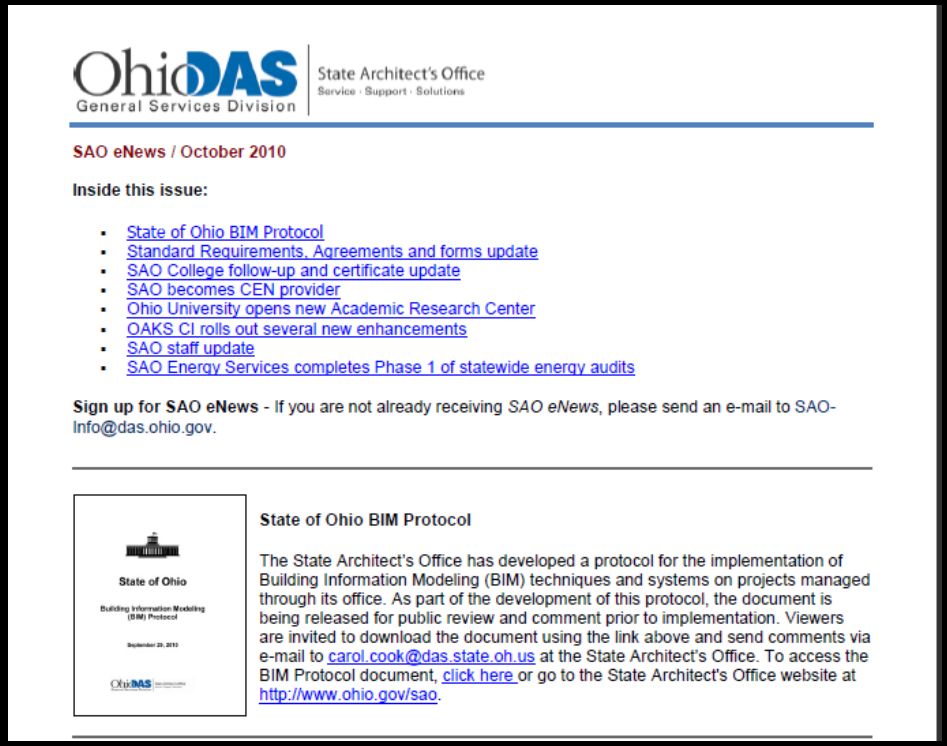
2008 Total Annual Operating Costs = $12B



Building Predominant Use Annual Operating Costs

Reporting Year	Family Housing	Hospital	Laboratories	Office	Warehouses
FY 2007	$1,447,930,000	$741,651,000	$1,411,727,000	$7,191,179,000	$1,185,899,000
FY 2008	$946,790,000	$775,894,000	$1,539,617,000	$7,819,284,000	$1,145,618,000

State of Ohio : BIM Protocol



OhioDAS General Services Division | State Architect's Office
Service · Support · Solutions

SAO eNews / October 2010

Inside this issue:

- State of Ohio BIM Protocol
- Standard Requirements, Agreements and forms update
- SAO College follow-up and certificate update
- SAO becomes CEN provider
- Ohio University opens new Academic Research Center
- OAKS CI rolls out several new enhancements
- SAO staff update
- SAO Energy Services completes Phase 1 of statewide energy audits

Sign up for SAO eNews - If you are not already receiving *SAO eNews*, please send an e-mail to SAO-Info@das.ohio.gov.

State of Ohio
Building Information Modeling (BIM) Protocol

State of Ohio BIM Protocol

The State Architect's Office has developed a protocol for the implementation of Building Information Modeling (BIM) techniques and systems on projects managed through its office. As part of the development of this protocol, the document is being released for public review and comment prior to implementation. Viewers are invited to download the document using the link above and send comments via e-mail to carol.cook@das.state.oh.us at the State Architect's Office. To access the BIM Protocol document, click here or go to the State Architect's Office website at http://www.ohio.gov/sao.

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

OhioDAS General Services Division | State Architect's Office Service · Support · Solutions

All projects (new construction, additions, and alterations) with

- A total project value of $4 million or greater

  or

- 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

OhioDAS General Services Division | State Architect's Office Service · Support · Solutions

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

FEE Schedule:

Project Stage	% Payment (Non-BIM)	% Payment (BIM)
Predesign	5%	5%
Schematic Design	15%	20%
Design Development	15%	20%
Construction Documents	30%	20%
Bid and Award	5%	5%
Conformed Documents	2%	2%
Construction Administration	25%	25%
Contract Closeout	3%	3%

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)

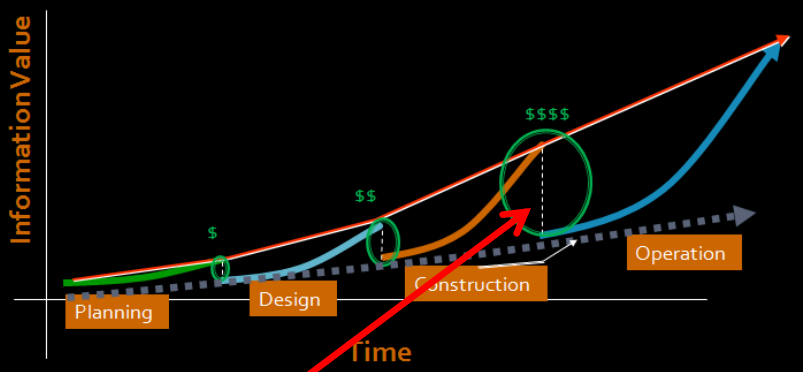
NIST GCR 04-867

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

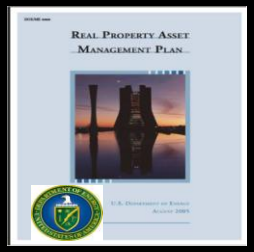


- Inefficiency Costs : **$15B/yr**
  - 66% borne by Owners
  - $0.23/ existing SF/year

Putting in to Context

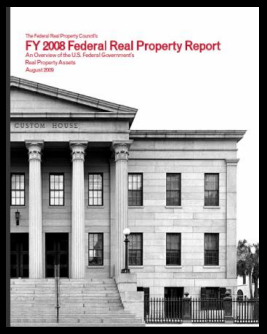
- Sandia
  - 6M GSF
  - @ $0.23/SF/yr

  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

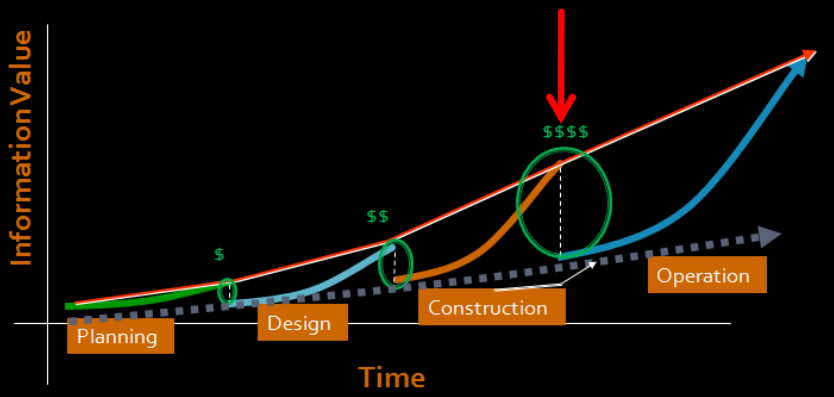
BIM for FM : Evidence of savings

- NIST : Industry Study

- Sandia "Straw man" Study validation

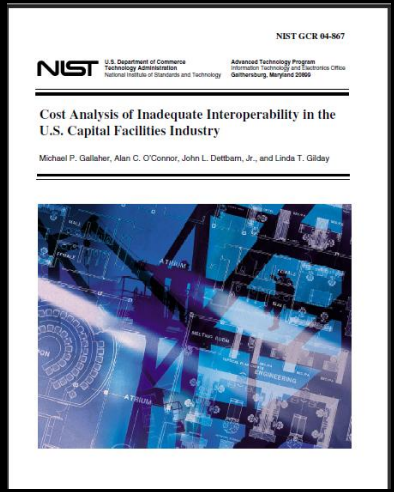
- University of New Mexico Survey

Industry Study



NIST Survey (2004)

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


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

Sandia National Labs (Albuquerque, NM)

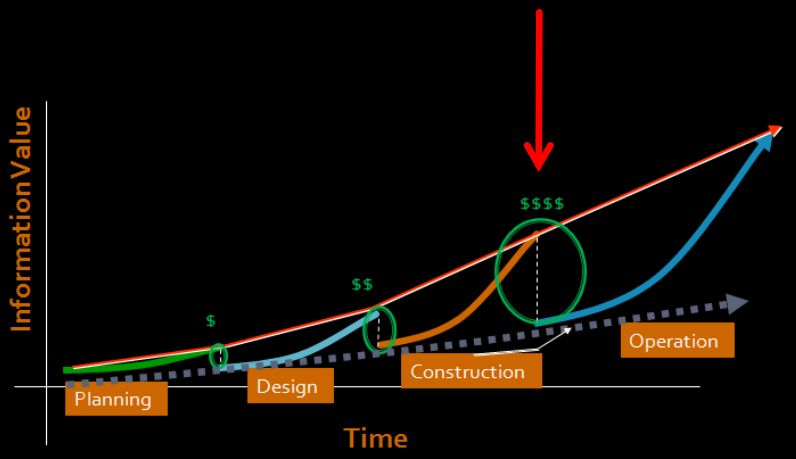
- ~ 900 buildings
- ~ 6M GSF

Costs (wasting) : ~ **$1.4 M/year**

NIST : Study Validation

Sandia "straw man" survey

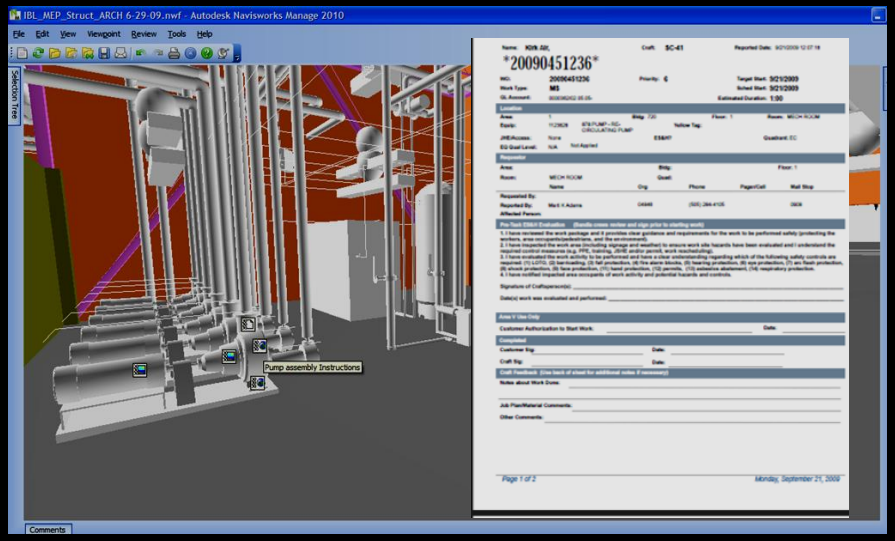
Using BIM, if you could get all needed information in 5 minutes, how much time would that save?



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

THE UNIVERSITY of NEW MEXICO

Survey on BIM for FM

THE UNIVERSITY of NEW MEXICO

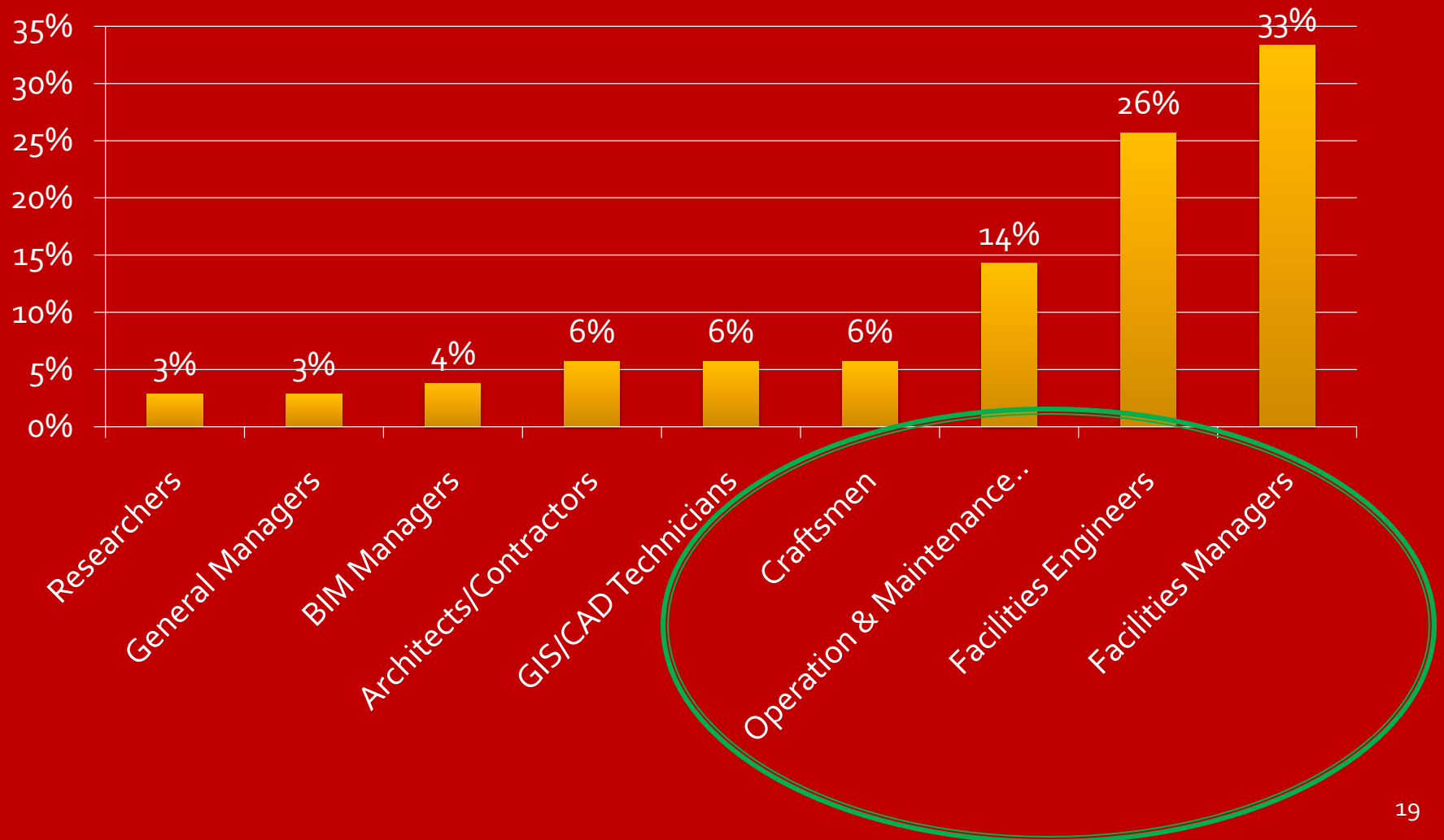
Survey on BIM for FM

Preliminary Findings

- 77% our respondents Owners
- Majority manage campus-type facilities
- over 50% over 1M GSF
  - **22% 1-5M**
  - **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

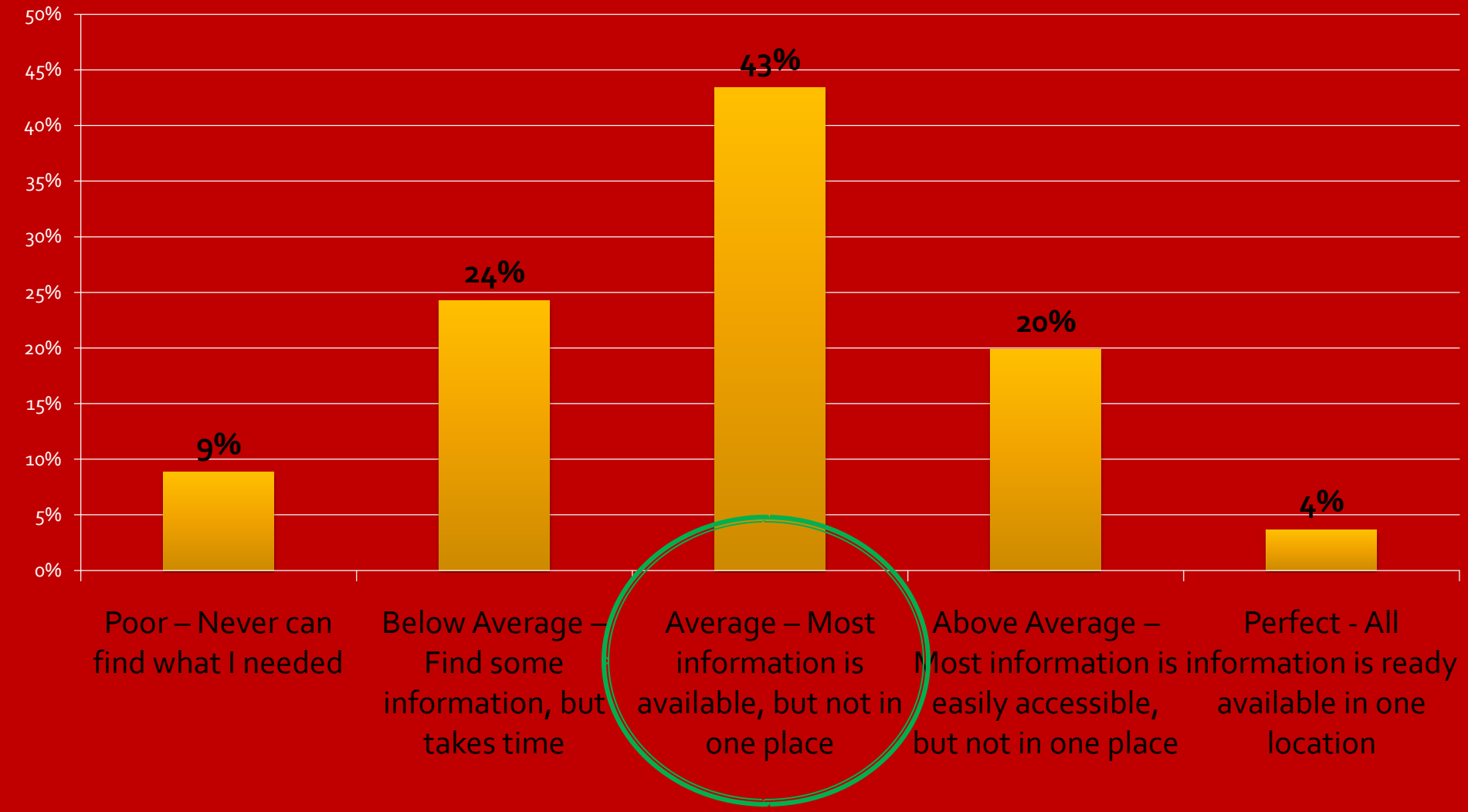
THE UNIVERSITY of NEW MEXICO

Owner Participates



THE UNIVERSITY of NEW MEXICO

What best describes your current accessibility to O&M information?



"View of the future for Facilities Management" Video

Work Order Details // 20100320705 - 720: SUSPECTED LEAKING SEAL ON PUMP

Name: Kirk Air, Craft: SC-41 Reported Date: 5/26/2010 9:58:09

20100320705

WO: 20100320705 Priority: 7 Target Start: 5/27/2010

Work Type: PROJ Sched Start: 5/27/2010

GL Account: 0000000/SERVICE Estimated Duration: 0:30

Location

Area: 1 Bldg: 720 Floor: 1 Room: NW MECH. RM

Equip: 1136414 720:PUMP- PRIMARY CHILLED WATER # 112 Yellow Tag:

JHE/Access: Access-User ES&H?

EQ Qual Level: N/A Not Applied

Requestor

Area: Bldg: Floor:

Room: Quad:

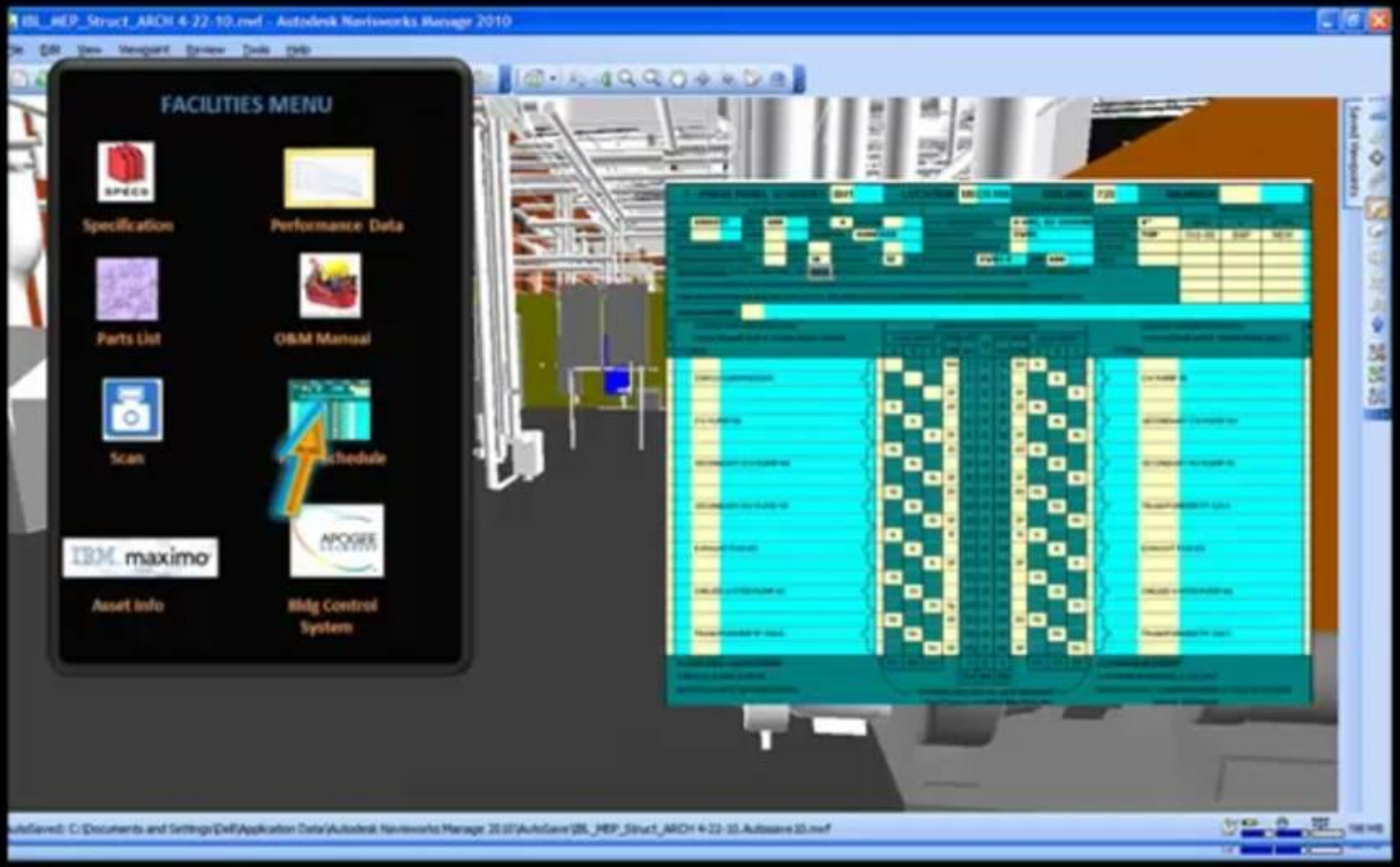
	Name	Org	Phone	Pager/Ce	Mail Stop
Requested By:					
Reported By:	JOHN Q SMITH -		555-1234		
Affected Person:					

Pre-Task ES&H Evaluation

1. I have reviewed the work package and it provides clear guidance and requirements for the work to be performed safely (protecting the workers, area occupants/pedestrians, and the environment).
2. I have inspected the work area (including signage and weather) to ensure work site hazards have been evaluated and I understand the required control measures (e.g. PPE, training, JSHE and/or permit, work rescheduling).


FACILITIES MENU
Specification
Performance Data
Parts List
Scan
Panel Schedule
IBM maximo
Asset Info
Bldg Control System
ITT
Goulds Pumps
Installation, Operation, and Maintenance Manual
Model 3196 i-FRAME
Engineered for life

00:46

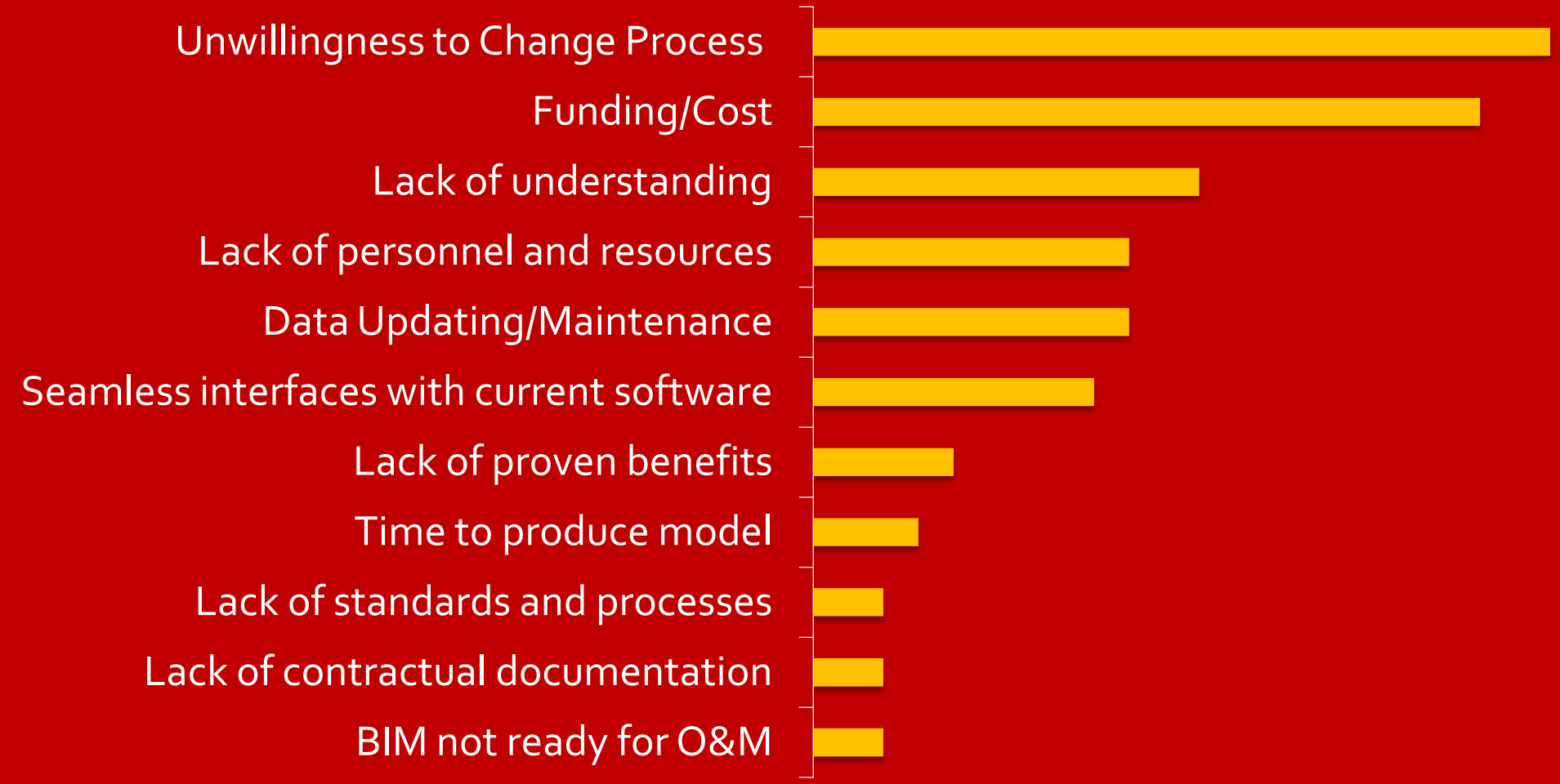

FACILITIES MENU
Specification
Performance Data
Parts List
O&M Manual
Scan
Asset Info
Bldg Control System
01:56

THE UNIVERSITY of NEW MEXICO

Significance of the Video in survey

- **> 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



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*

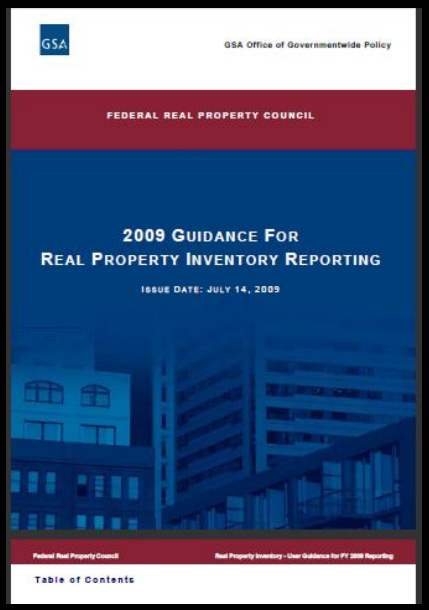
Federal Annual Operating Costs

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

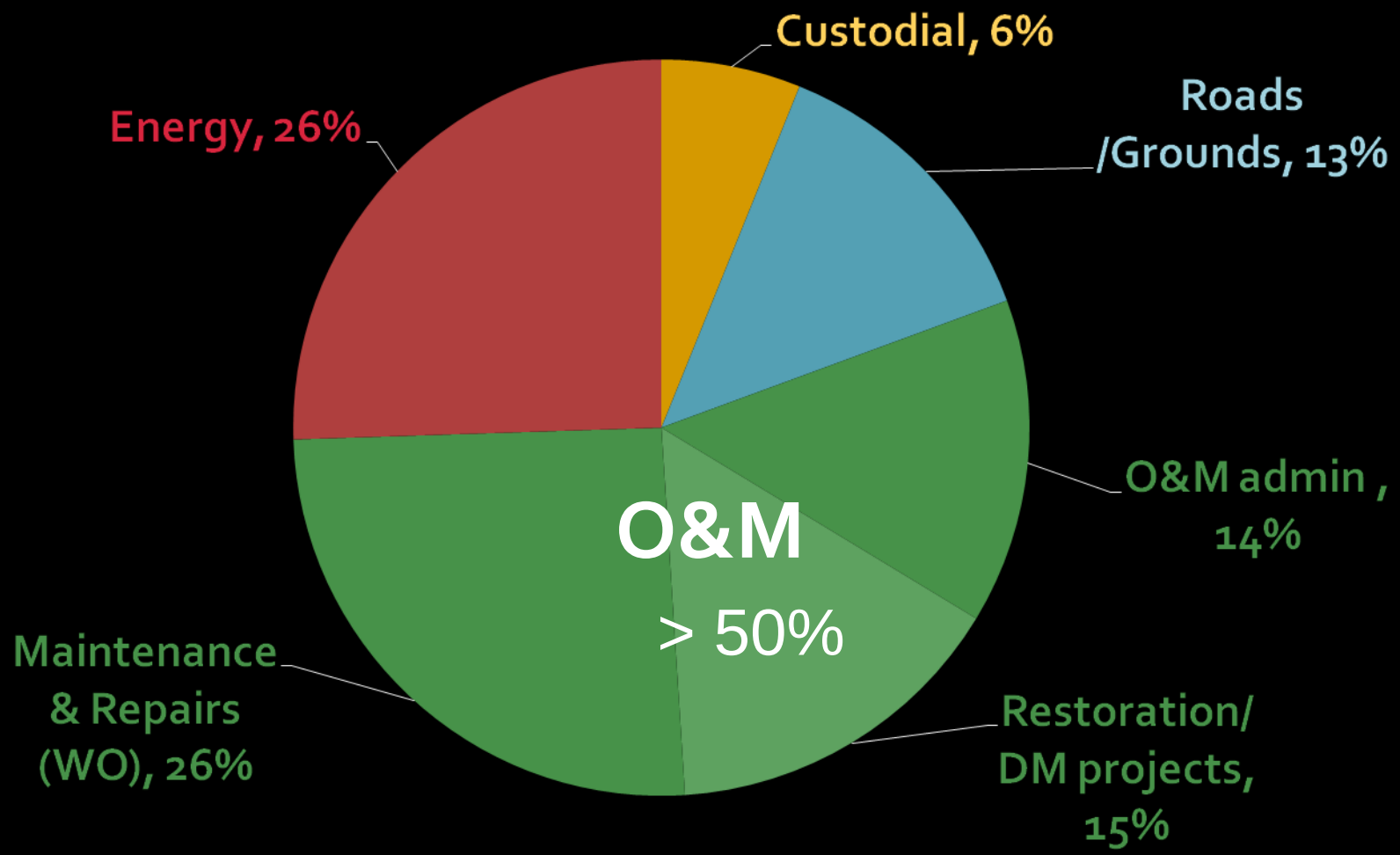
(source : FRPC Real Property Inventory – Users Guidance FY09)

	Owned Buildings		
	Annual Operating Costs	Total Square Feet (SF)	Annual Operating Cost/SF
FY 2007	$12,056,164,000	2,673,854,000	$4.51
FY 2008	$12,036,779,000	2,588,928,000	$4.65

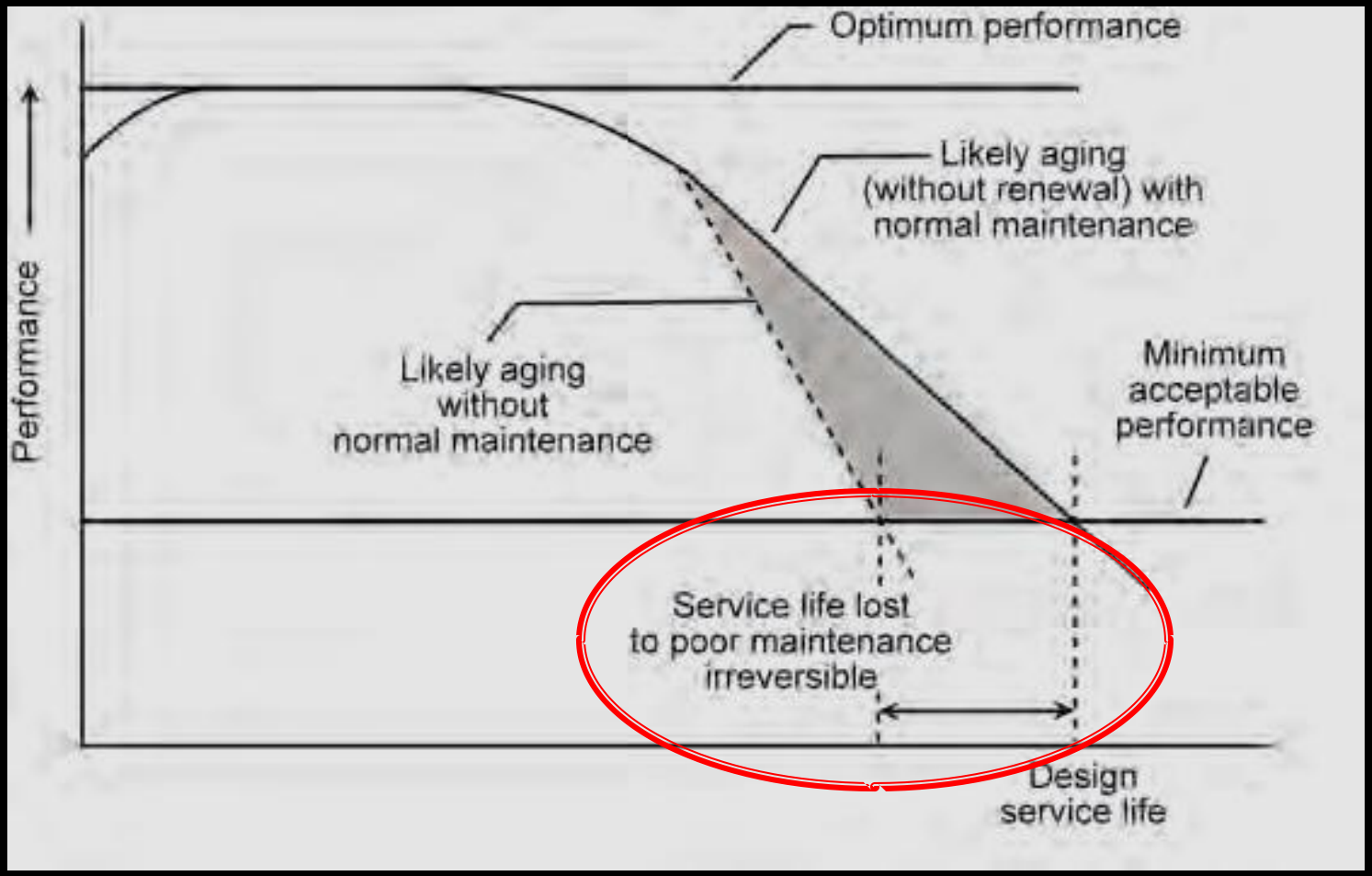
http://www.gsa.gov/graphics/ogp/FY_2008_Real_Property_Report.pdf



Covering Operating Costs :
Space Charge Back



"Design For Maintenance" Strategy: Main Premise

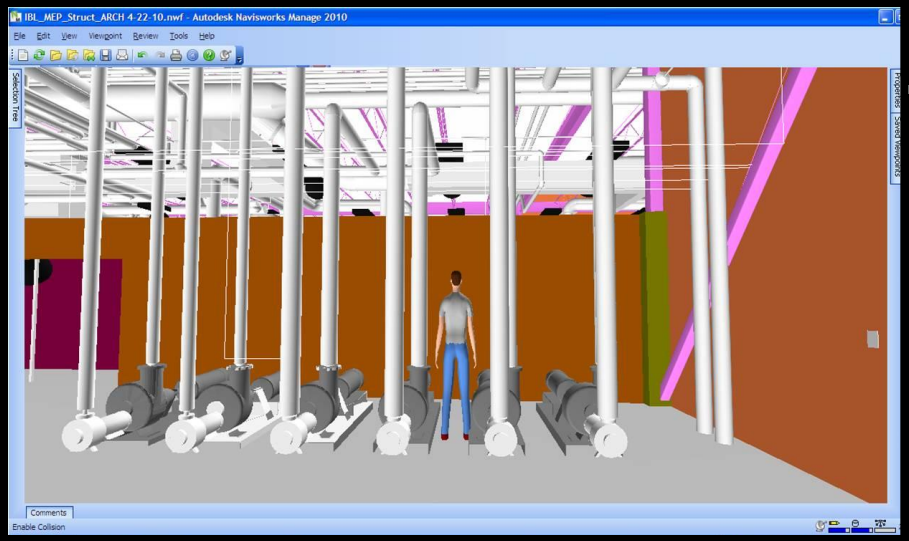


(National Research Council 1998).

WARNING


R
RESTRICTED
Non-BIM enabled Owners require accompanying General Contractor or Sub-Contractor

"Design for maintenance" strategy



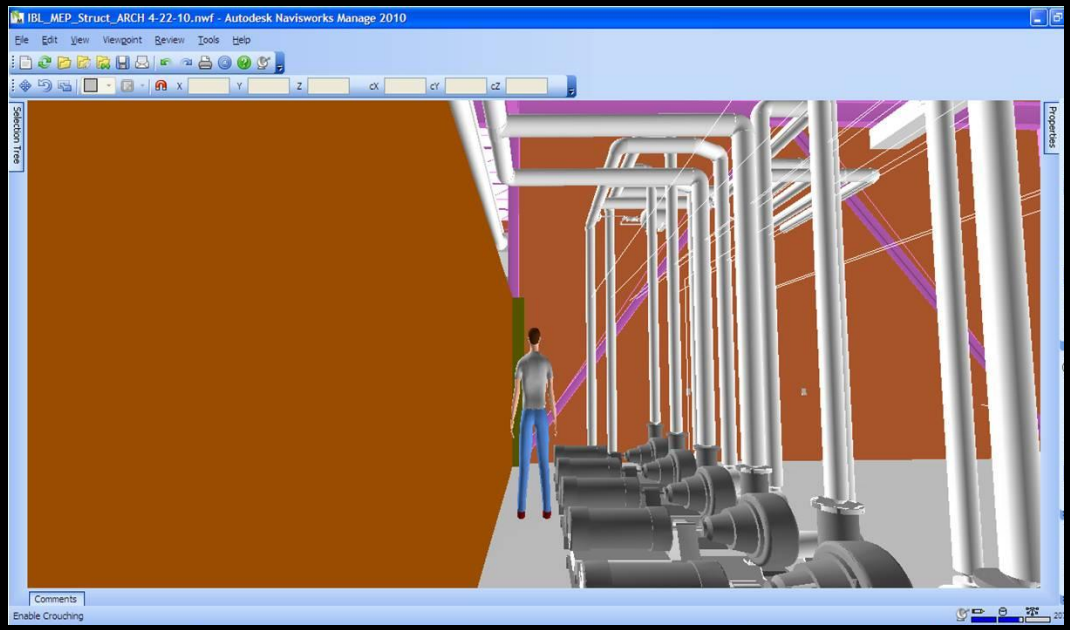
"Maintenance Friendly"

NOT "Maintenance Friendly"

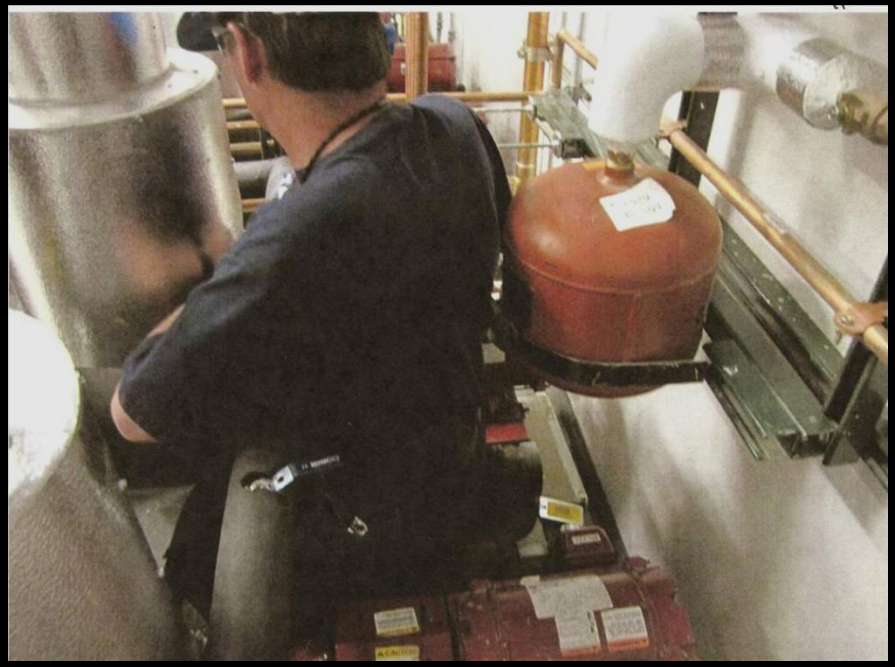
"Maintenance Friendly"

NOT "Maintenance Friendly"

"Maintenance Friendly"



NOT "Maintenance Friendly"

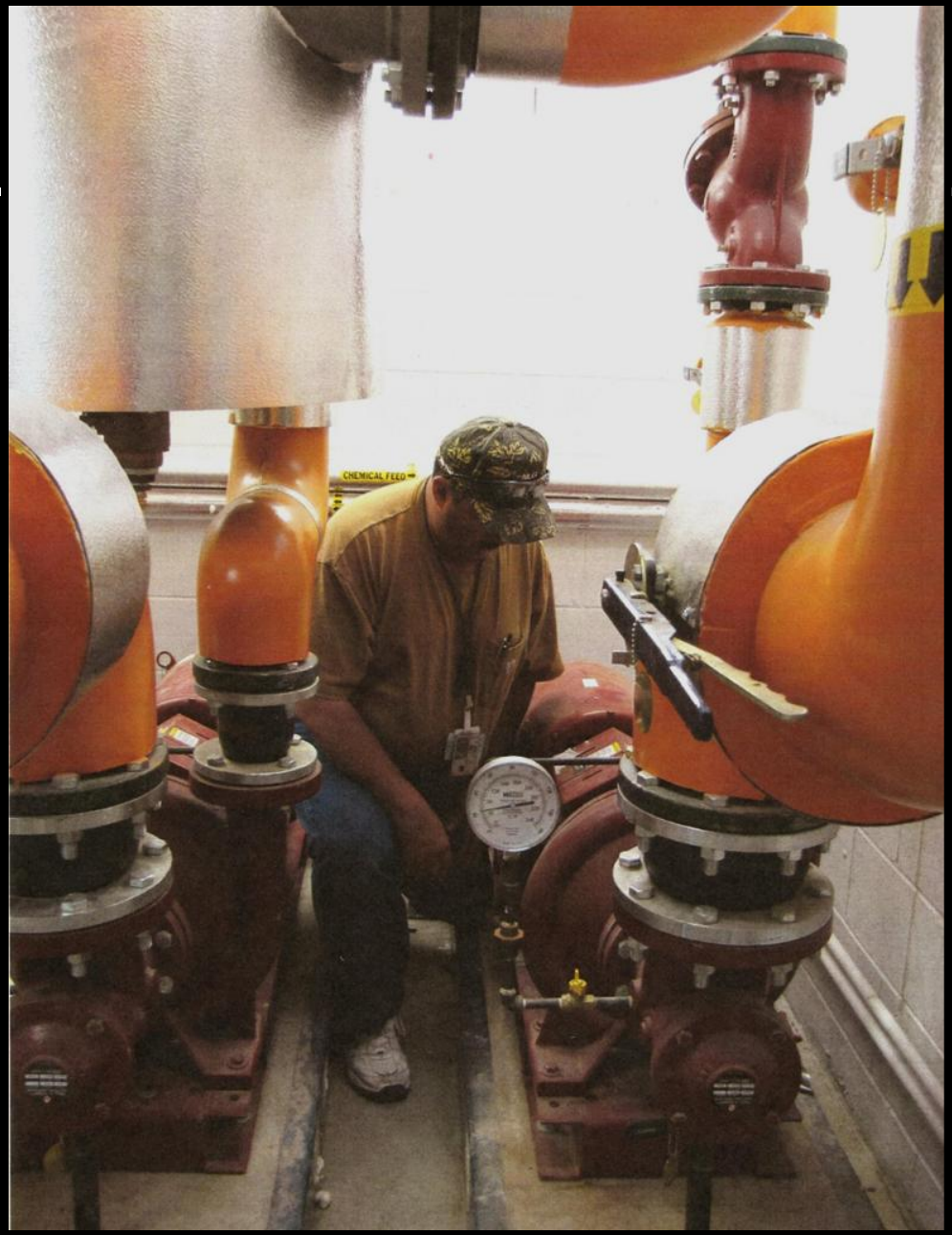


FM Impact :

2x PM time

4x CM time

…… Over 25 years


CHEMICAL FEED

Maintenance : Equipment Check Lists

9.9.11 Pumps Checklist

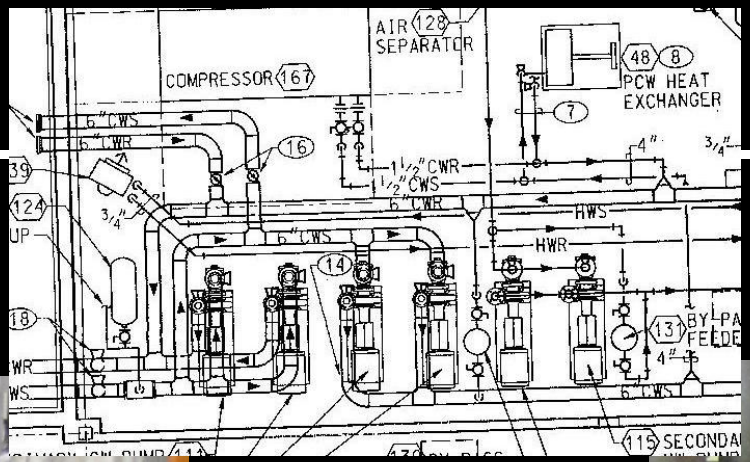
Description	Comments	Maintenance Frequency			
		Daily	Weekly	Monthly	Annually
Pump use/sequencing	Turn off/sequence unnecessary pumps	X			
Overall visual inspection	Complete overall visual inspection to be sure all equipment is operating and safety systems are in place	X			
Check lubrication	Assure that 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

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

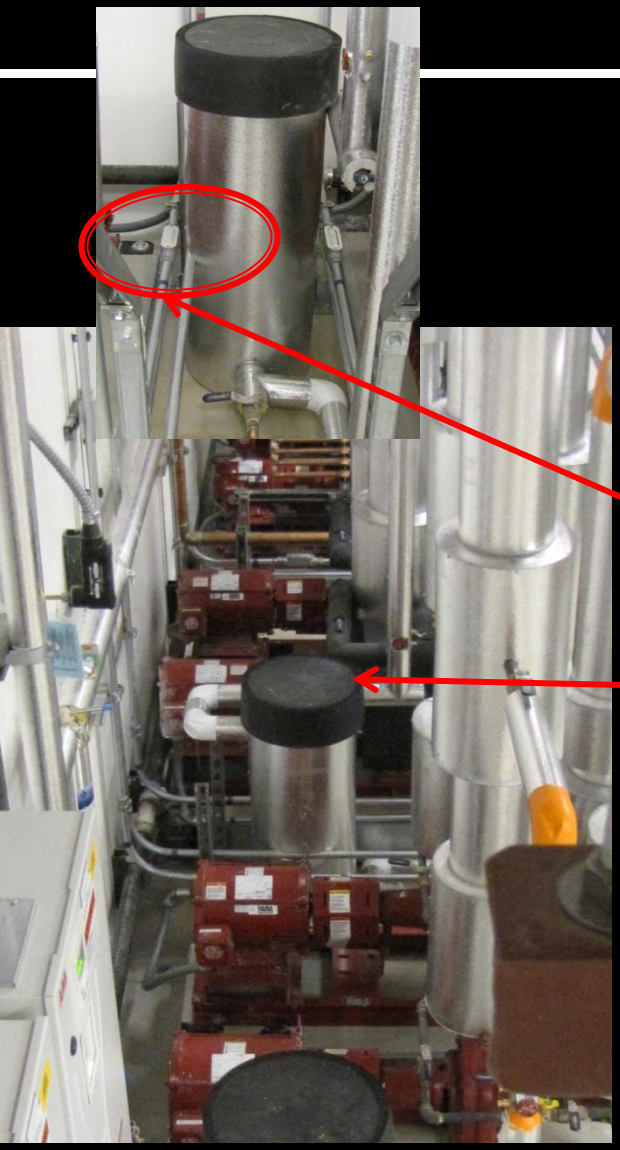
(FEMP: O&M Best Practice 3.0)

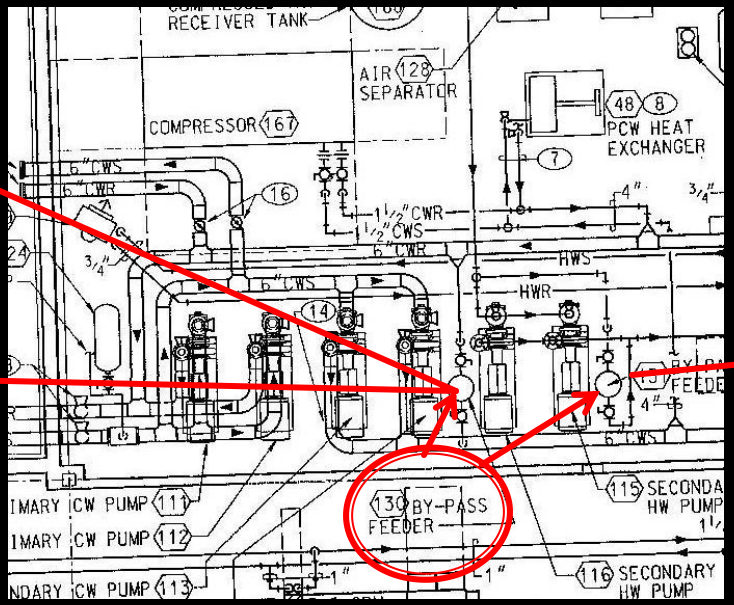
NOT "Maintenance Friendly"



By-Pass Feeders locations….

NOT "Maintenance Friendly"

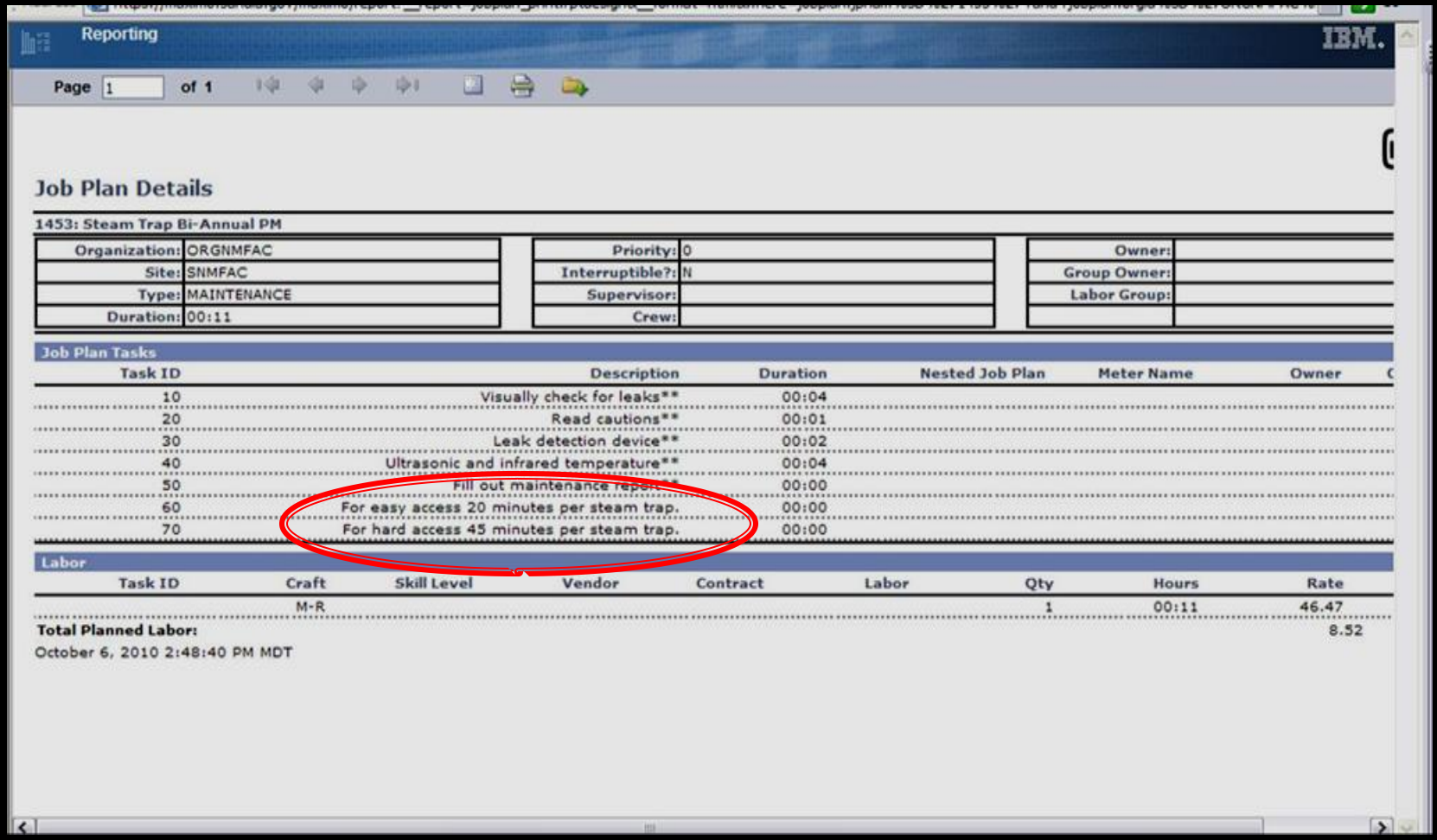




By-Pass Feeder location….

"Maintenance Friendly"

Steam Traps….



Reporting

IBM.

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 repo…	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

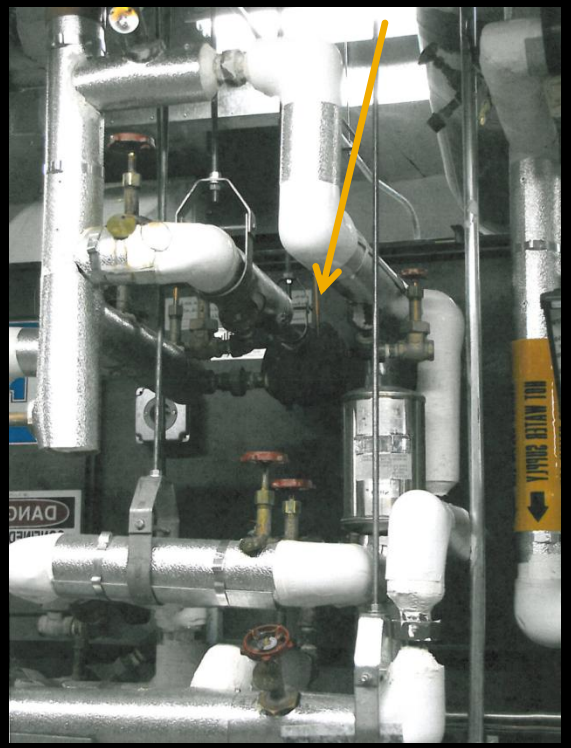
Total Planned Labor: 8.52

October 6, 2010 2:48:40 PM MDT

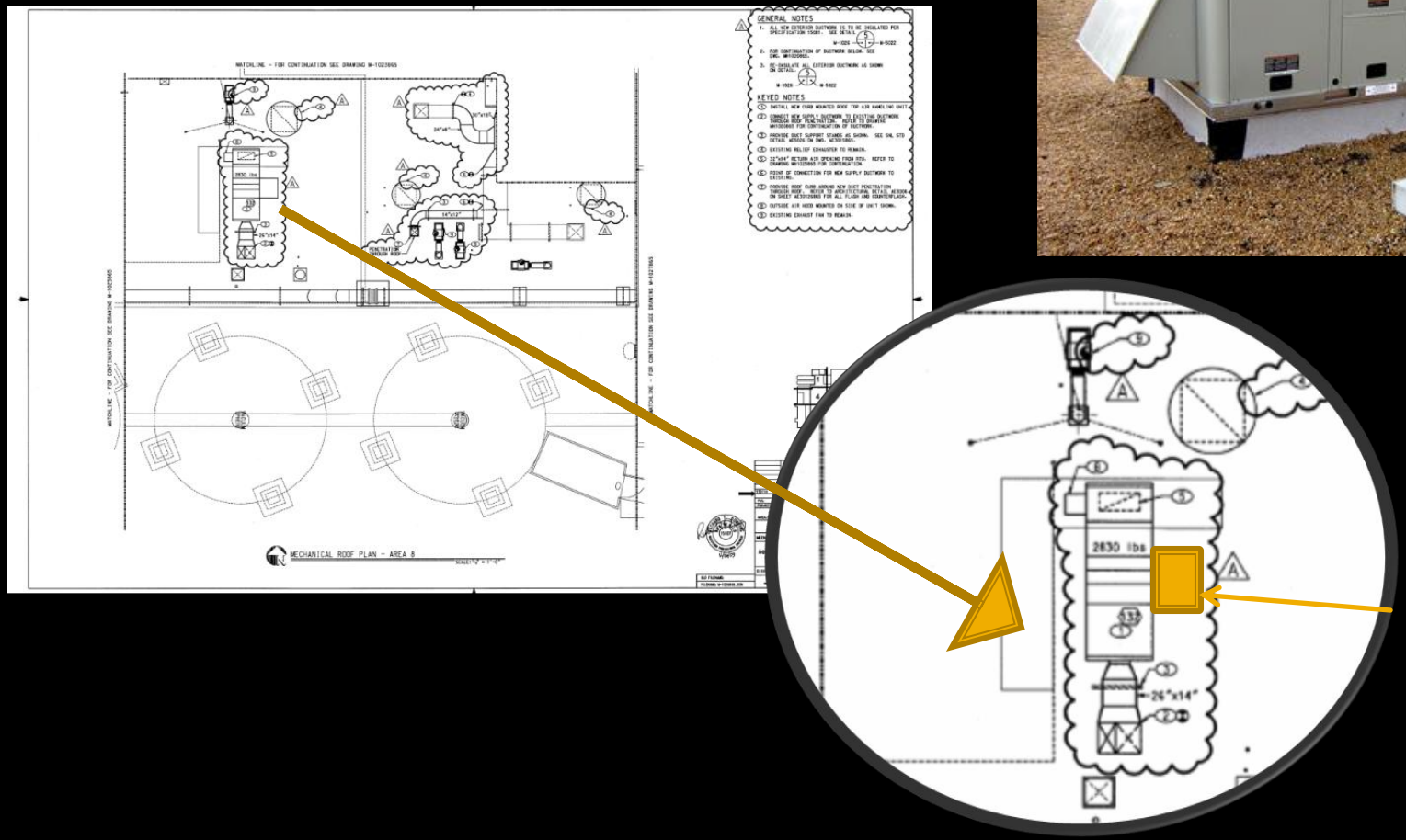
Steam Traps….

"Maintenance Friendly"

NOT "Maintenance Friendly"

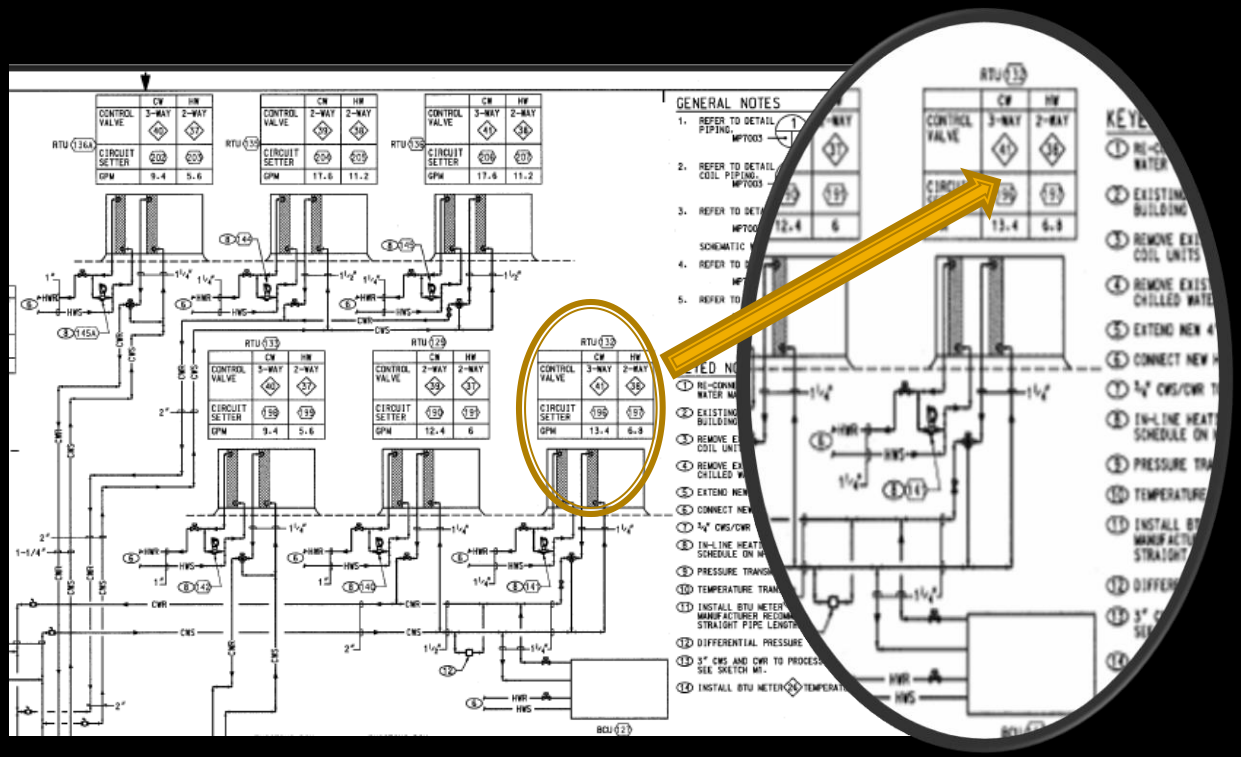


Roof Top Unit (RTU) : piping



External box for HW/CW piping

Roof Top Unit (RTU) : piping

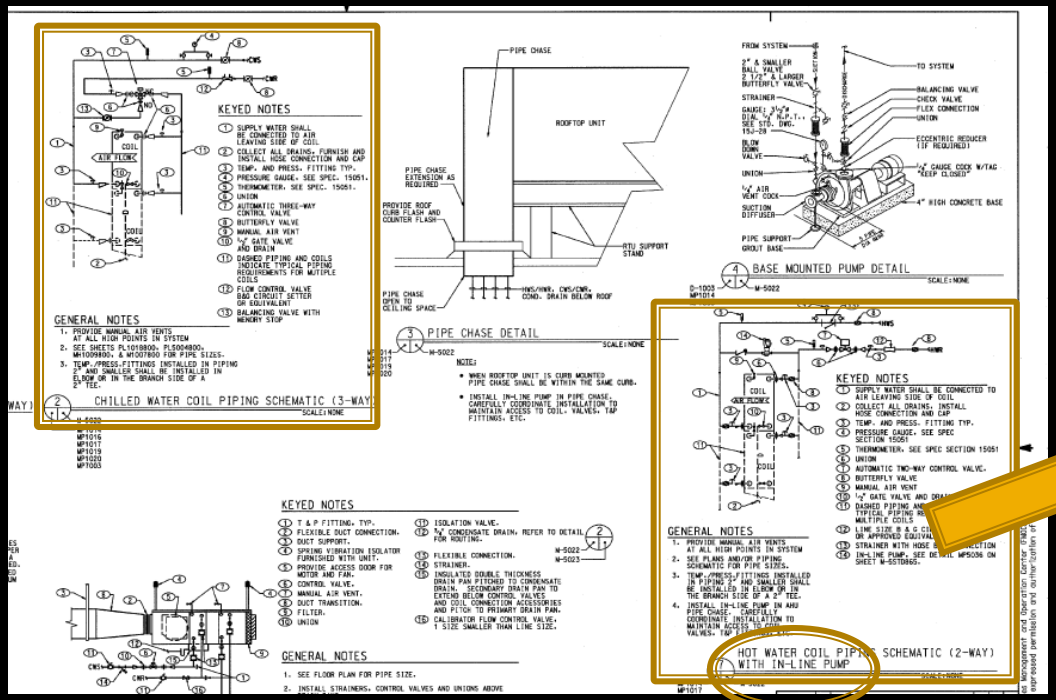


Roof Top Unit (RTU) : piping

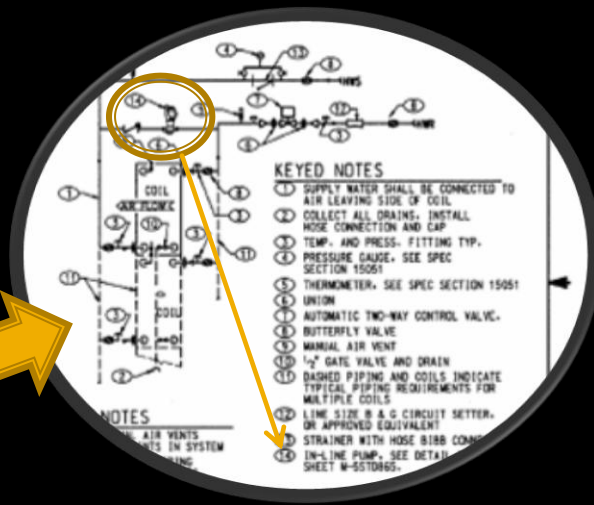
Standard Detail

3-way CW piping

2-way HW piping

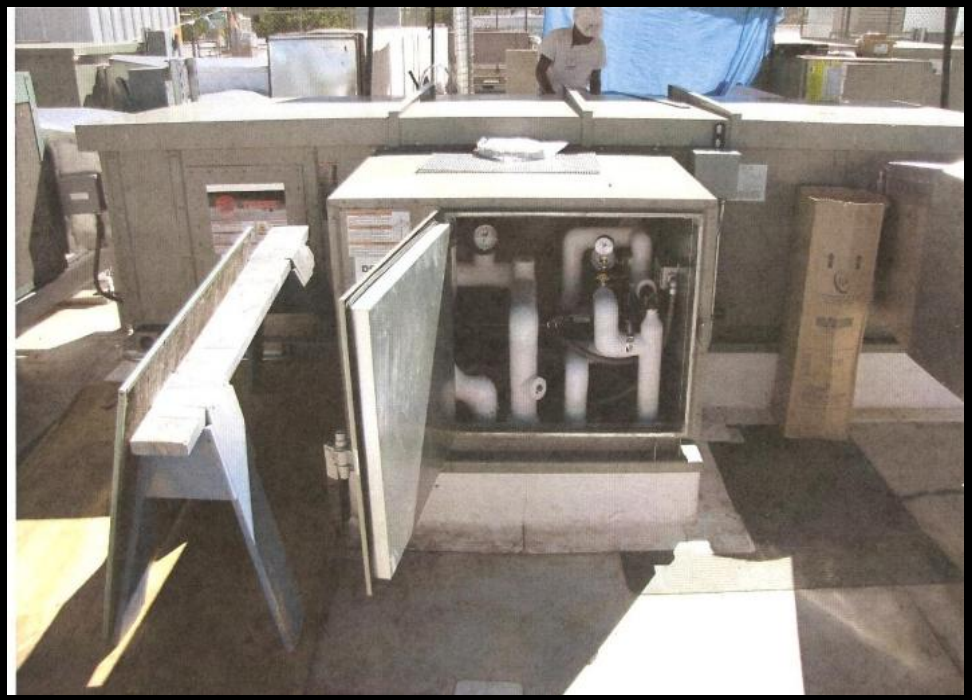


pump



Roof Top Unit (RTU) : piping

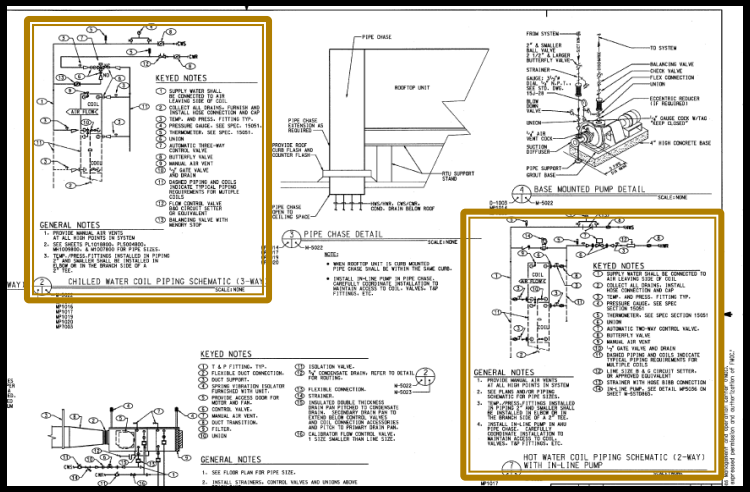
"MEANS & METHODS" ??



RTU piping install

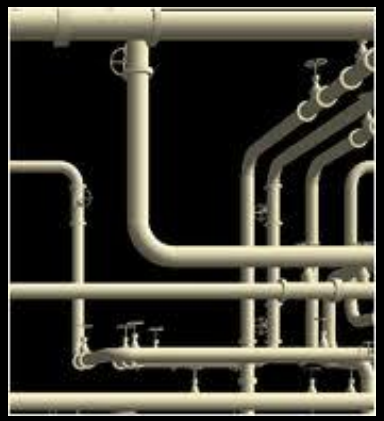
Current 2D = **56 hrs**

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



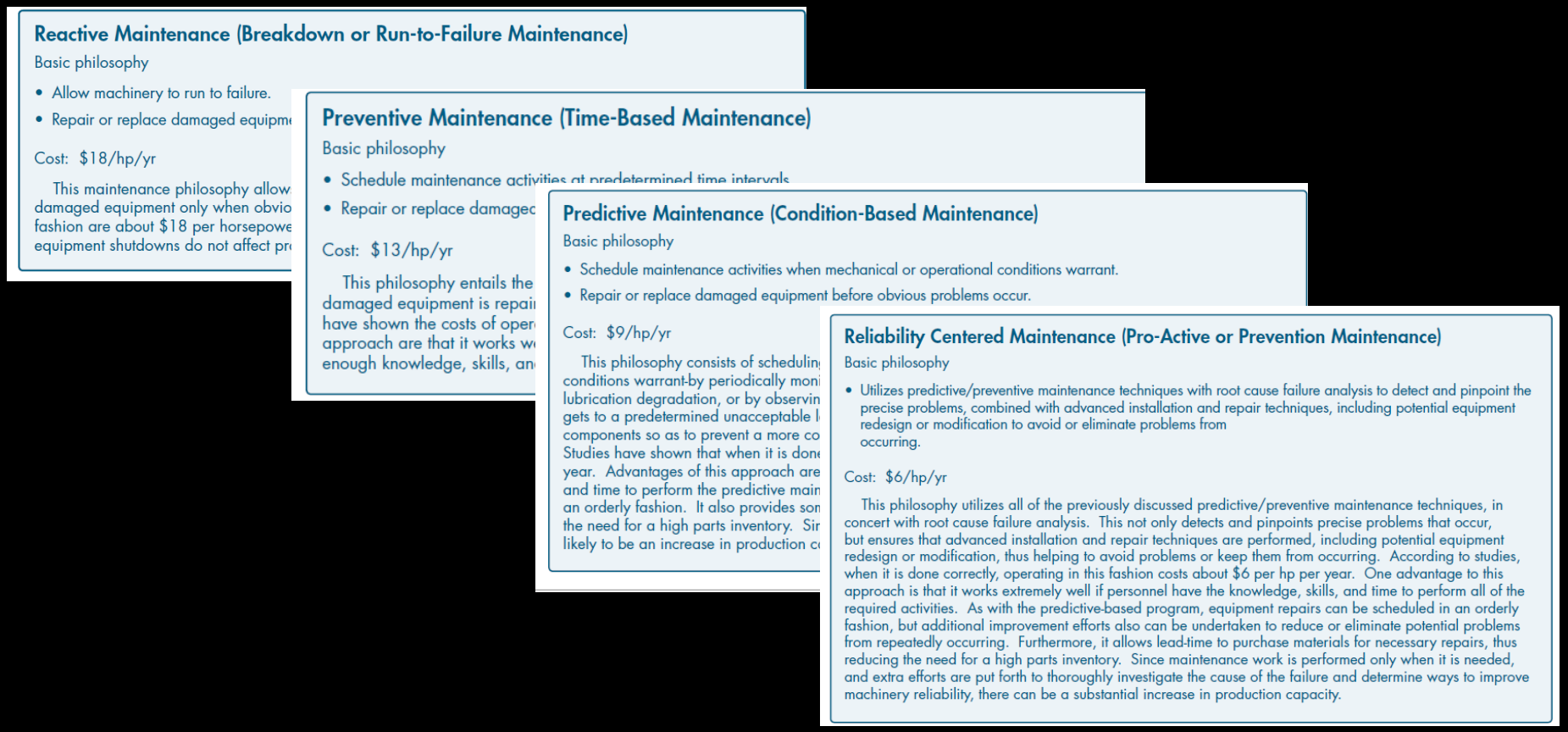
BIM enabled **= 36 hrs**

- 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 equipm

Cost: $18/hp/yr

This maintenance philosophy allow
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 damagec

Cost: $13/hp/yr

This philosophy entails the
damaged equipment is repai
have shown the costs of oper
approach are that it works w
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 schedulin
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. Sir
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 !

BIM Vision

- Design /Maintenance collaboration
  - ☑ O& M strategic Plan
    - Share O&M strategy with A/E's
    - Develop O&M standards for designs
    - Maintenance to educate A/E's on access requirements
    - Reduce "Means & methods" --- > BIM tools

Thank you!

Questions?

Birgitta Foster
btfoste@sandia.gov

BIMworkx.com