Enhancing Building Maintenance Practices with Data Analytics

Facilities Management
THE UNIVERSITY OF IOWA

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UI Facilities Management FDD Program

Enhancing Building Maintenance Practices with Data Analytics

- Why do we use data analytics?
- What is **F**ault **D**etection and **D**iagnostics?
- High-level overview of the Uiowa FDD Program
- Introduction to key players involved in the FDD response team
- Walk through an example of a typical fault response workflow
- Illustration of benefits
- What’s next?

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Weak Signals

"The intuition about how a machine is operating on a factory floor used to come from working there thirty years and being able to detect a slightly different sound signature emanating from the machine, telling us something is not exactly right. That is a weak signal. Now with sensors, a new employee can detect a weak signal on the first day of work – without any intuition."

Thank You for Being Late
An Optimist's Guide to Thriving in the Age of Accelerations
Thomas L. Friedman

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2003 **Typical Room Comfort Control Operation Parameters in 2003**

1. Terminal Air Box Control with Hot Water Reheat (Type A):
    a. Each zone has a TAB with a hot water reheat coil, reheat coil control valve, and DDC controller. Install a single point temperature sensor 2'–0" downstream of the reheat coil. Install a wall mounted temperature sensor to maintain space temperature of 72°F (adj.). See drawings for temperature sensor requirements.
    b. Terminal air boxes shall be set in occupied or unoccupied control via a space occupancy sensor. If the TAB is in occupied mode, the box shall open to at least minimum air flow. Space temperature shall be maintained as described herein. If the TAB is in unoccupied mode, it shall be allowed to modulate closed. The box and valve shall only modulate open to maintain a minimum winter setback temperature of 65°F (adj.), and a maximum summer set up temperature of 80°F (adj.).
    c. The occupancy sensor shall set the TAB to unoccupied after fifteen minutes (adj). to avoid "false–offs."
    d. At full cooling, the TAB shall be fully open. The reheat coil control valve shall be closed.
    e. On a fall in space temperature, the TAB shall modulate closed until space setpoint is maintained, or until it reaches its minimum position. The reheat coil control valve shall be closed.
    f. On a further fall in space temperature, the TAB and the reheat coil control valve shall modulate open in unison until setpoint is maintained or until specified maximum heating airflow is reached.
    g. If heating water system temperature is 5°F (adj.) below setpoint, on a call for heating, the TAB shall remain at its minimum airflow setting.

Three modes of operation-room for intuition

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2018 **Room Comfort Control Operation Parameters for Voxman**

D. VARIABLE AIR VOLUME TERMINAL UNITS WITH REHEAT and SLAB HEATING and COOLING with TRACKING SEQUENCE FOR ALL STUDIOS PROVIDED WITH PROCESS EXHAUST AIR:

1. General
   a. The DDC panel shall index each space between occupied and scheduled unoccupied modes.
   b. Provide all sensors with adjustable set point. The space temperature set point shall be adjustable at the sensor within a range as specified at the DDC panel.
   c. Provide monitoring of the discharge air temperature at each terminal unit.
   d. Slab system mode to be determined b… manifold cabinet.
   e. During the hours of primary or second… the space temperature dead band sha… Occupancy and Temperature Set poi… any space in the same area, the spac… range.
   f. Upon receipt of signal that any operab… monitoring contact, all components as… position until the window is indicated t…
   g. EVAVs that are required to be full ope… not considered to be required for proc… specifically track the exhaust airflow.
   h. The automatic temperature control sy… maintain pressure relationships in the… more supply variable volume terminal… variable volume terminal unit. The sy… air flow tracking.
   i. Whenever exhaust is active to the room, tracking controls shall modulate the supply terminal unit(s) as required to maintain an approximate differential of .05" adjustable between the supply air flow to and the exhaust air flow from the room, with the doors in the closed position. Refer to airflows on plans to determine required direction of airflow.
      1) The initial airflow differential is indicated per the airflows provided on the plans; however the actual airflow shall be determined during balancing for each room.
      2) Required supply air flows shall be determined during balancing based on providing a differential air flow between exhaust air flow and supply air flow, as required to maintain the pressure differential as noted above.
   j. For rooms with dedicated process exhaust fans, status of the exhaust fan as well as dust collector DC-7 shall be monitored and the position of the supply air VAV box shall modulate as required to provide make up air. Refer to exhaust fan sequence of operation.
   k. W231 kiln room will be provided with differential pressure monitoring at the doors to the adjacent corridor to modulate the exhaust air flow to maintain the space slightly negative. Interlock the operation of the natural gas fired equipment in W231 KILN ROOM and W251 SCULPTURE STUDIO with the provision of mechanical air combustion supply to open the associated SVAV to the minimum position required for combustion air (1,200 cfm or each room) to prevent main burner operation when the mechanical air supply system is not in operation. A differential pressure sensor shall be provided to monitor airflow across the SVAV as proof of combustion airflow. DDC contractor to coordinate with equipment suppliers as required for interface with electronic controllers provided …

2. In occupied mode, the room tracking operation for each space shall be as follows:
   a. For those studios with process exhaust, the exhaust air terminal units shall modulate open or exhaust fans shall start on indication that exhaust is required. Indication may be via a manual timer, current sensor indicating equipment served is on or occupancy sensor. Refer to notes provided above and on the exhaust VAV terminal unit and the exhaust fan for specific indication required. For rooms with timer, label timer EXHAUST ON/OFF
   b. For those studios with process exhaust that are indicated to be occupied but no process exhaust is in use, SVAV shall modulate open to provide minimum level of ventilation airflow as indicated per SVAV schedule and modulate the reheat coil control valve to provide temperature neutral air.
   d. If space temperature increases two degrees above space set point and the slab system is in cooling mode, the two way valve on the slab cooling system shall cycle on. The space cooling set point shall be reset up two degrees and the slab system valve will continue to cycle as required to maintain slab system set point.
   e. If the space temperature increases to two degrees above the slab cooling space set point, the VAV terminal unit DAT set point shall reset down and the reheat coil control valve will modulate as required. If the reheat coil control valve is completely closed, the exhaust airflow will increase as required to provide additional cooling airflow as required to maintain slab cooling set point.
   f. If the space temperature drops to two degrees below the slab cooling set point, the two way control valve to the slab cooling system shall be cycled closed and the space temperature set point shall be reset down two degrees.
   g. If the space temperature drops to two degrees below space set point and the slab system is in heating mode, the two way valve on the slab heating system shall cycle on. … be reset down two degrees and the slab system valve will … ed to maintain slab system set point.
   … rops two degrees below the slab heating set point, the reheat … dulate open as required to maintain the slab heating set point. … lve is completely open, the exhaust airflow will increase as … nal heating airflow as required to maintain slab cooling set …
   … rops two degrees below the slab heating set point, the space … l be reset back up two degrees and the two way valve on the … ycle closed.
   … de, the space temperature set point shall be reset to a wider … follows:
   … the outdoor and exhaust air dampers shall remain closed and … g system control valve shall cycle to maintain setback set …

More modes of operation, more data points, more “weak signals”

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"Experienced workers knew how to process weak data. But now with Big Data, with a much finer grain of fidelity we can make **finding a needle in the haystack the norm - not the exception**. And we can augment the human worker with machines so they work as colleagues and enable them to process weak signals together and overnight become like a thirty year veteran."

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- Understanding what has happened in the past, what is happening now, and what will probably happen is foundational for predictive analytics.
- We already have the data and the expertise!
- Predictive analytics is bridging the gap traditionally provided by Institutional Knowledge.

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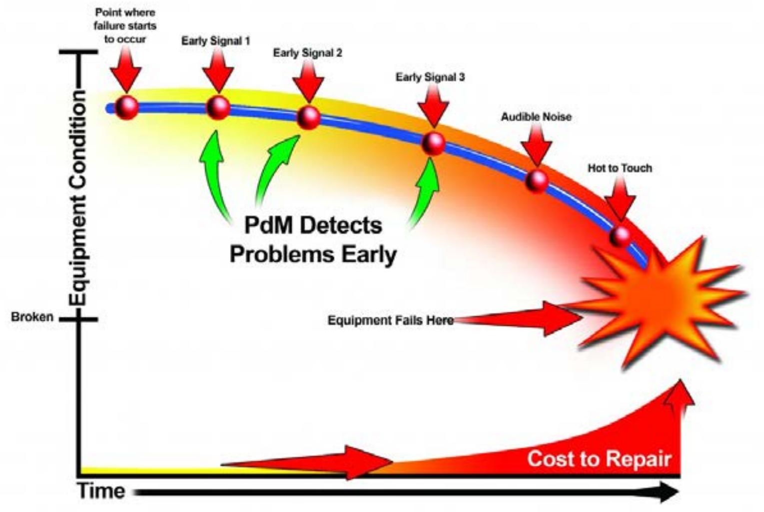
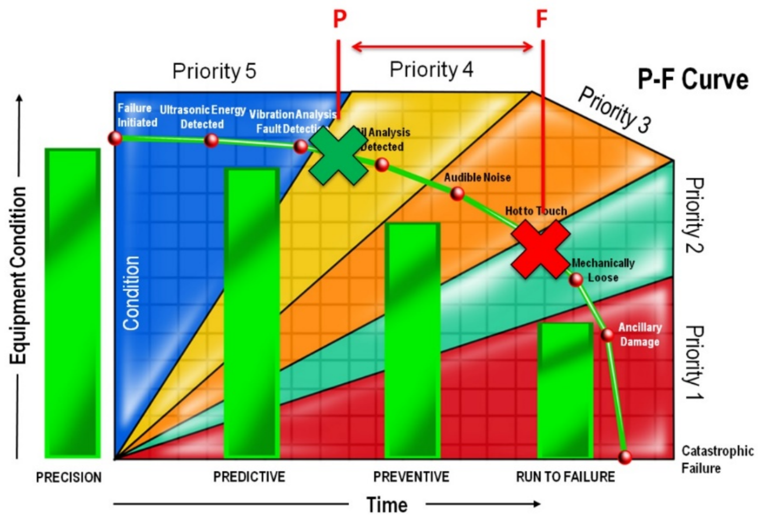
Early warning signs, often in the form of “Weak Signals” provides the basis for predicting impending system failure.

Predicting impending failure, and preventing that failure, mitigates business continuity risk and financial risk.

The dollar outlay shifts from productivity losses, repair costs and wasted energy to investments in infrastructure and technology and active monitoring.





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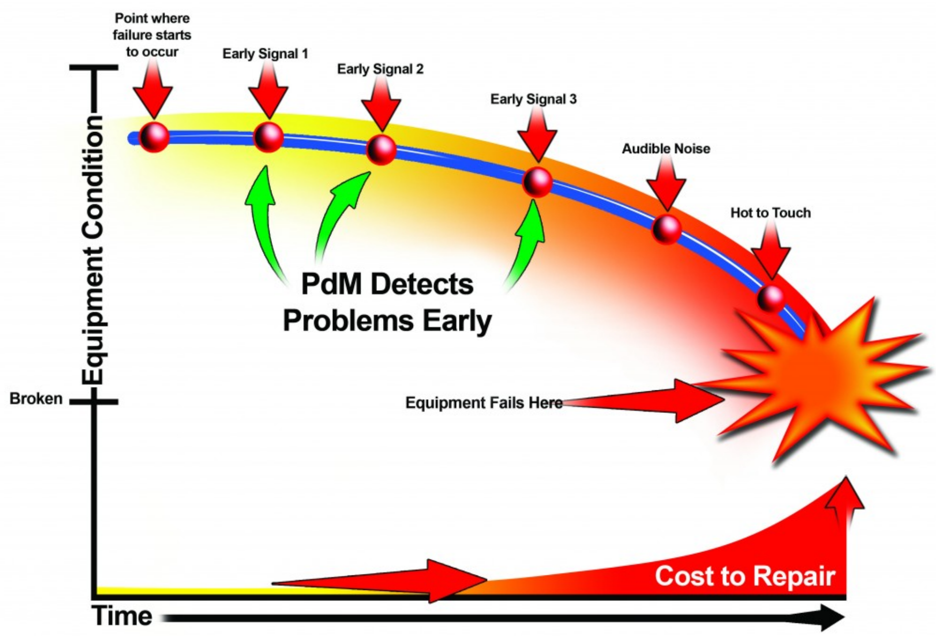
Managing Risk & Costs

The dollar outlay shifts from productivity losses, repair costs and wasted energy to investments in infrastructure and technology and active monitoring.



Fault Detection and Diagnostics

What is it?

Fault Detection and Diagnostics **(FDD)** is a software tool used to

PROACTIVELY discover building system problems and identify optimization opportunities…

BEFORE they lead to alarms, excessive waste of resources, occupant discomfort or system failure.

Fault Detection and Diagnostics

Key Tenants of Uiowa's FDD Program

- We leverage our internal expertise to prioritize and perform the majority of the work.
- We use existing data infrastructure, mostly through our Building Automation Systems, OSISoft Pi and our Computerized Maintenance Management System (AiM).
- Compliments overall FM goal to support proactive and predictive maintenance.

Fault Detection and Diagnostics

Program Timeline

1. **September 2014**
   Started a pilot to self-perform an on premises FDD implementation in a newly constructed lab building

2. **September 2015**
   Investigated working with an integrator for a campus-wide FDD solution

3. **February 2016-June 2016**
   Issued an RFP to select an FDD solution for 20 General Fund Buildings

4. **October 2016-January 2017**
   Selected an FDD solution and on-boarded 20 buildings with a software as a service, cloud-based solution.

20 Buildings

Academic, Lab, Office, Recreational, etc.

KGS Buildings Clockworks FDD Software

49,000 Points

5 min interval collection

All Major HVAC Equipment

AHUs, HW/CHW Systems, Pumps, VAVs

4 Building Automation Systems

Andover Continuum, Schneider StruxtureWare, JCI Metasys, Pi OPC

Onboarding time

3 months for all buildings to be live and performing fault detection

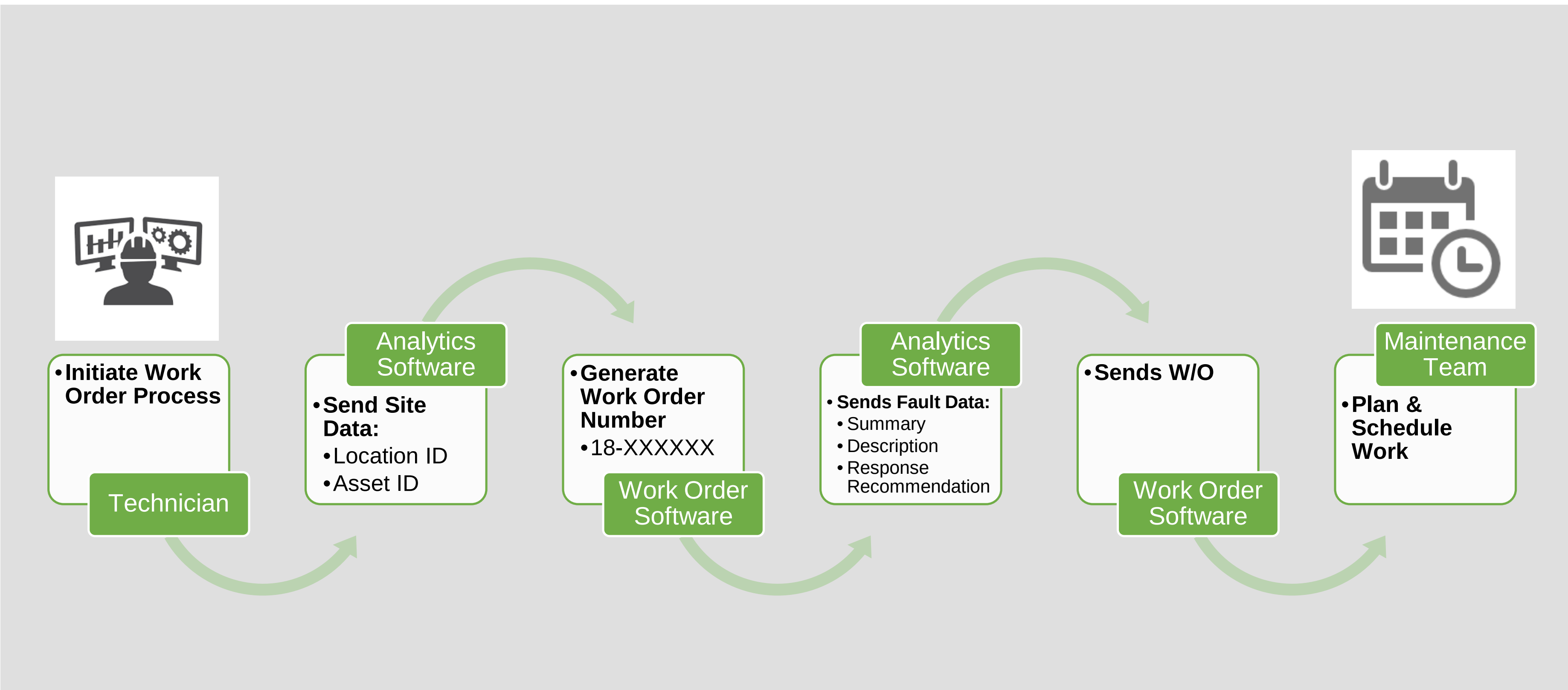
Fault Detection and Diagnostics

Buildings currently online

College of Medicine Administration Building	Biology Building East	Adler Journalism Building	Campus Recreation and Wellness Center
College of Public Health Building	Blank Honors Center	Boyd Law Building	Chemistry Building
Pappajohn Biomedical Discovery Building	Voxman Music Building	Spence Laboratories of Psychology	Pomerantz Center
Dental Science Building	Hancher Auditorium	University Services Building	Trowbridge Hall
Carver Biomedical Research Building	Stuit Hall	Medical Laboratory	Calvin Hall

Fault Detection and Diagnostics

Work order automation helps facilitate the work and “tell the story”



Analytic **R**esponse **G**roup

Multidisciplinary team
Meets 4 mornings per week
Prioritizes, plans & coordinates response

First Responders

- Experienced HVAC technicians
- Interact with tool full time
- Field troubleshoot and point person for maintenance fixes

2 FTE

Controls Support

- Experienced controls programmers (1 point person)
- Assist with analytics issues & troubleshooting, adjust programming as needed

1 FTE

Analytics

- BLS Managers
- Technical support for FDD
- Review metrics and report successes

As Needed

Priority and Planning

- BLS Managers
- Prioritize and plan ARG activities
- Coordinate and plan FDD projects

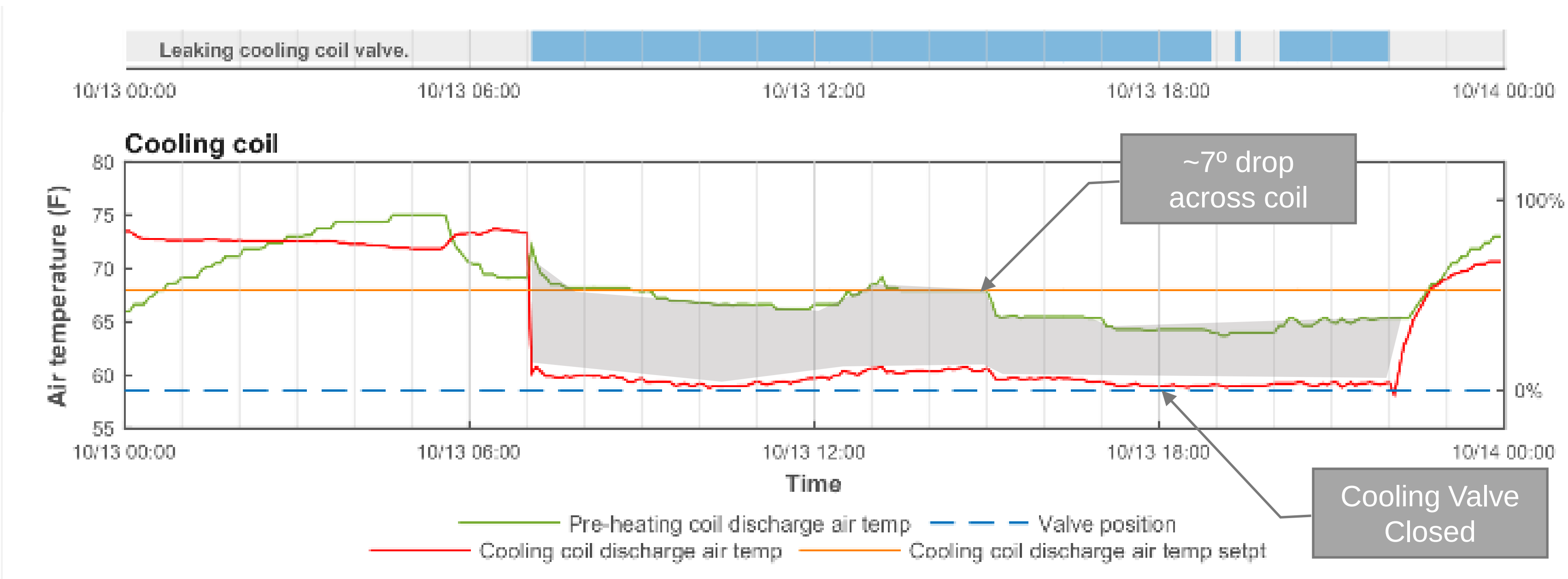
As Needed

Fault Response Workflow

Issue identified and troubleshooting begins 10/13/17

Building	Equipment	Analysis	Start Date	Notes Summary	Tasks	Cost	E	C	M
Boyd Law Building	BLB-AHU-3 (Air Handler)	AHU Coils	10/13/2017	Leaking cooling valve.	0	$22	8	0	6

First Responders do a quick “desktop” validation of the fault using software



Fault Response Workflow

Direction given and work order generated 10/13/17

CLOCKWORKS

Summary: BLB FDD AHU-3 Leaking cooling valve.
Building Name: Boyd Law Building
Equipment Name: BLB-AHU-3
Analysis Name: AHU Coils
Issue Date: 10/13/2017
Interval: Daily
Reporter: Jeffrey-dwyer@uiowa.edu
Assigned: Jeffrey-dwyer@uiowa.edu
Status: Completed
Date Completed: 10/17/2017 12:08 PM, (UTC Offset: -6, Time Zone: Central Standard Time)
Description: Leaking cooling valve.
Recommendations: Check valve and sensor
Actions: Cooling valve was leaking through and preheat steam valve was leaking
Work Type: Unassigned
Work Order Number: 18-549000
Annual Avoidable Cost: 7,054 USD
Annual Avoidable Cooling Use: 15,220 TON-hrs
Annual Avoidable Electric Use: 183,020 kWh
Date Created: 10/1[illegible]/2017 9:50 AM, (UTC Offset: -6, Time Zone: C
Last Modified: Jeffrey-dwyer@uiowa.edu, 10/17/2017 12:08 PM (U

Notes entered in Clockworks are pushed to the work order description within AiM

The technician initiates a request for a work order within Clockworks, which generates a work order in the CMMS (AiM)

AiM Work Order KATHLEEN About Logout

Search

Work Order	Description	Extra Description	Property	Created By	Date Created	Type
18-549000	AHU Coils 2017/10/13 BLB FDD AHU-3 Leaking cooling valve. (More)	Leaking cooling valve. Check valve and sensor	0377	FDD	Oct 16, 2017 12:00 AM	BLDG MAINT

Fault Response Workflow

Work completed and Work Order closed 11/9/17

AiM Work Order KATHLEEN About

Search

Entry Date	Created By	Name	Note Type	Notes
Nov 09, 2017 03:20 PM	JDWYR		CLOSEOUT	Adjusted cooling valve and replaced heating valve from pnumatic to electric.

Analytic is no longer flagging

Building	Equipment	Analysis	Start Date	Notes Summary	Tasks	Cost	E	C	M	Actions
Boyd Law Building	BLB-AHU-3 (Air Handler)	AHU Coils	11/13/2017		0	$0	0	0	0	
Boyd Law Building	BLB-AHU-3 (Air Handler)	AHU Coils	11/14/2017		0	$0	0	0	0	
Boyd Law Building	BLB-AHU-3 (Air Handler)	AHU Coils	11/15/2017		0	$0	0	0	0	
Boyd Law Building	BLB-AHU-3 (Air Handler)	AHU Coils	11/16/2017		0	$0	0	0	0	
Boyd Law Building	BLB-AHU-3 (Air Handler)	AHU Coils	11/17/2017		0	$0	0	0	0	

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Institutional Benefits

- ***Proactive Maintenance:*** Our team has greater visibility into hidden equipment issues, and receives an automated, prioritized “to do” list.
- ***Prioritized Insights:*** Greater direction for completing work due to prioritization metrics. We now perform root-cause analysis to determine the necessary resolution for each fault—maximizing time and resources.
- ***Measured Impact:*** We now can track our success and justify our internal staffing and vendor support. Our work, now captured through AiM, illustrates impact, and is one more piece of the puzzle to identify time and resource needs.

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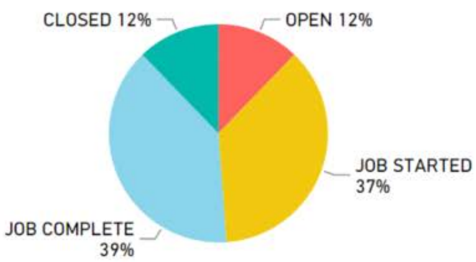
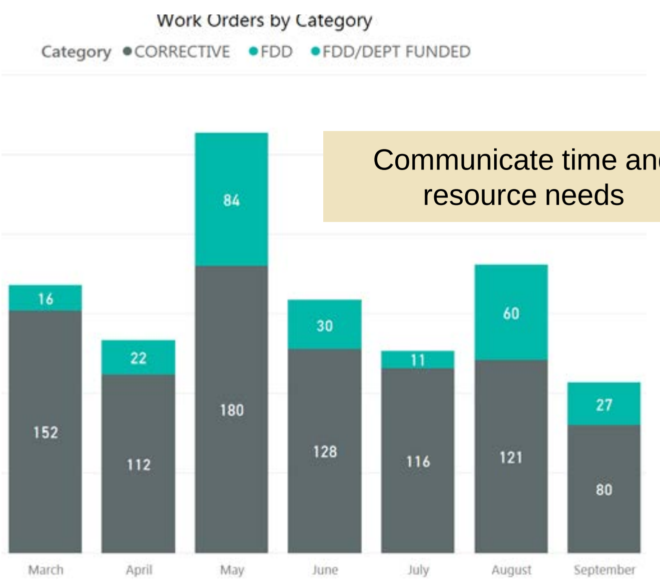
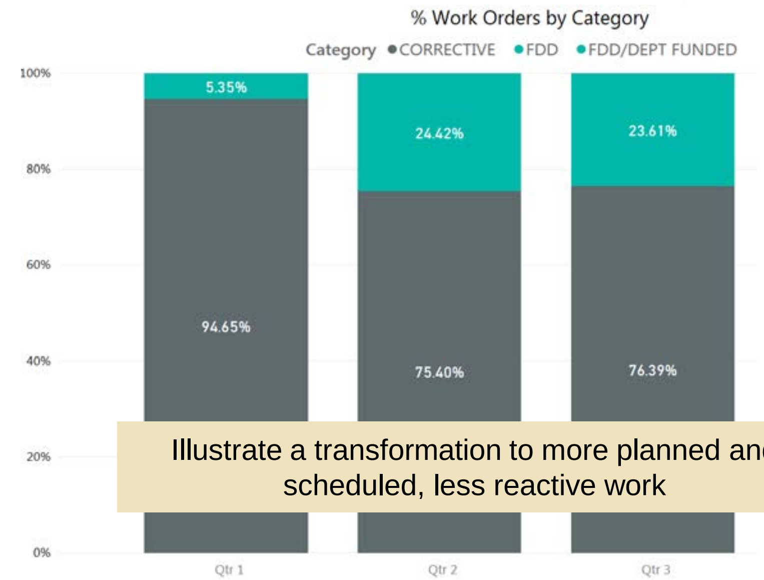
Data is captured in our CMMS for enhanced KPI Measurement



Show progress in starting and closing out issues



Communicate time and resource needs



Illustrate a transformation to more planned and scheduled, less reactive work

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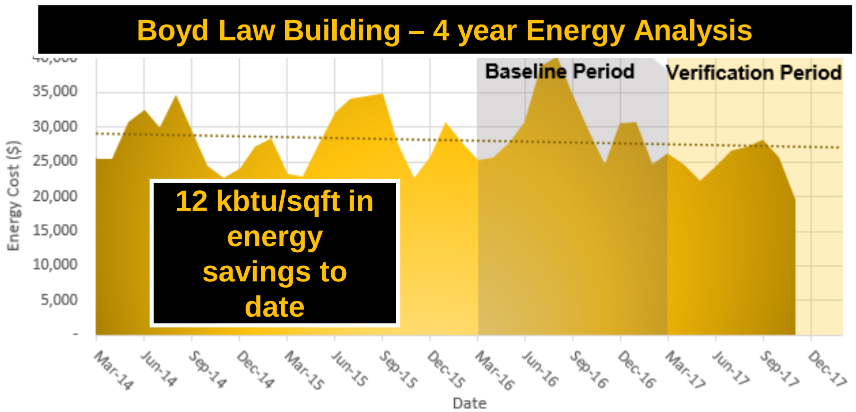
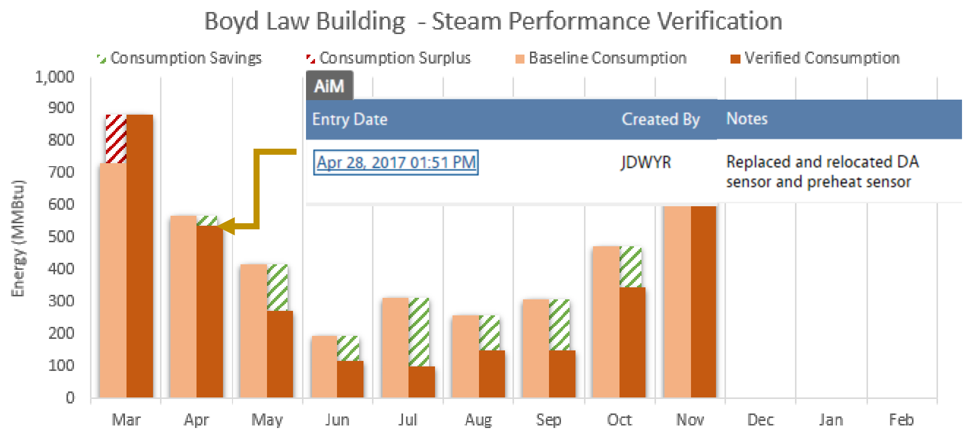
Data is captured in AiM to help with Measurement & Verification



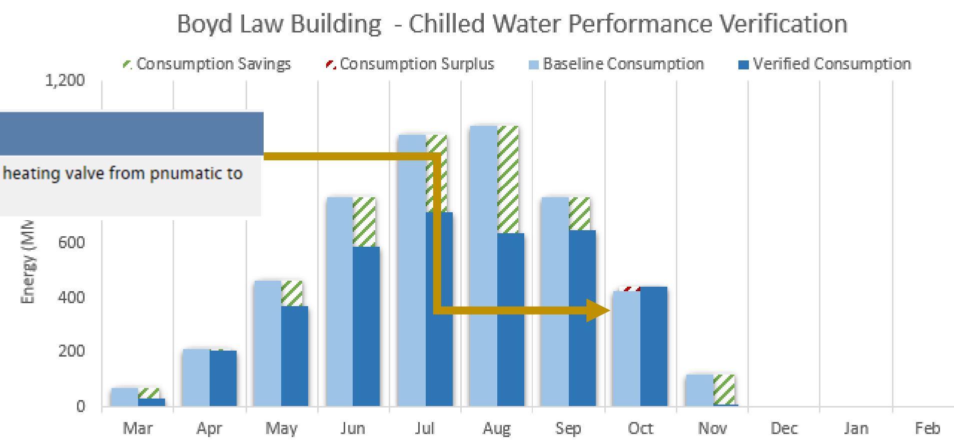


AiM

Entry Date	Created By	Notes
Apr 28, 2017 01:51 PM	JDWYR	Replaced and relocated DA sensor and preheat sensor

AiM

Entry Date	Created By	Notes
Nov 09, 2017 03:20 PM	JDWYR	Adjusted cooling valve and replaced heating valve from pnumatic to electric.



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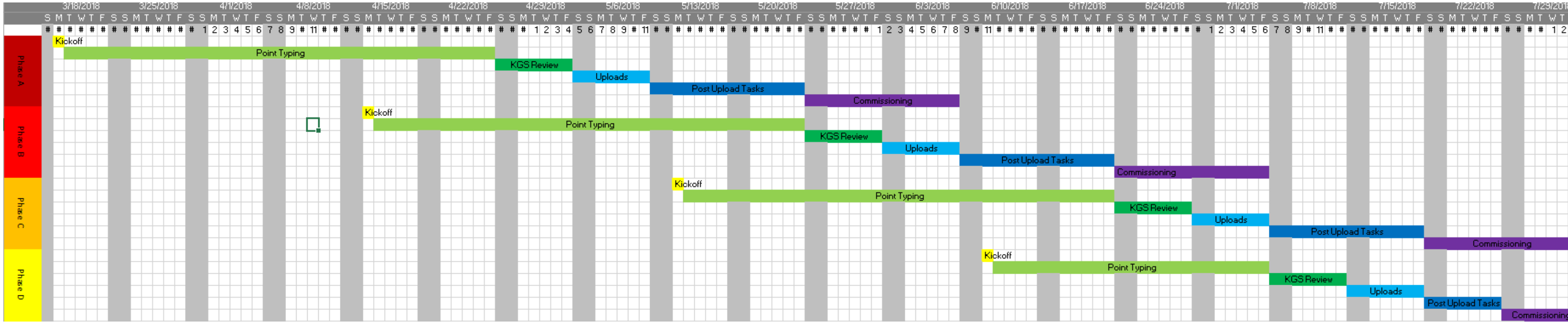
What's Next?

- Onboarding 29 additional buildings over the next 5 months
- Expanding the FDD response process to include more frontline staff involvement
- Investigating the use of the tool for new construction commissioning



Questions?

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