Get It Right the First Time

A Case Study on Monitoring-based Commissioning for New Construction

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A Woman Business Enterprise (WBE)

UMass Amherst

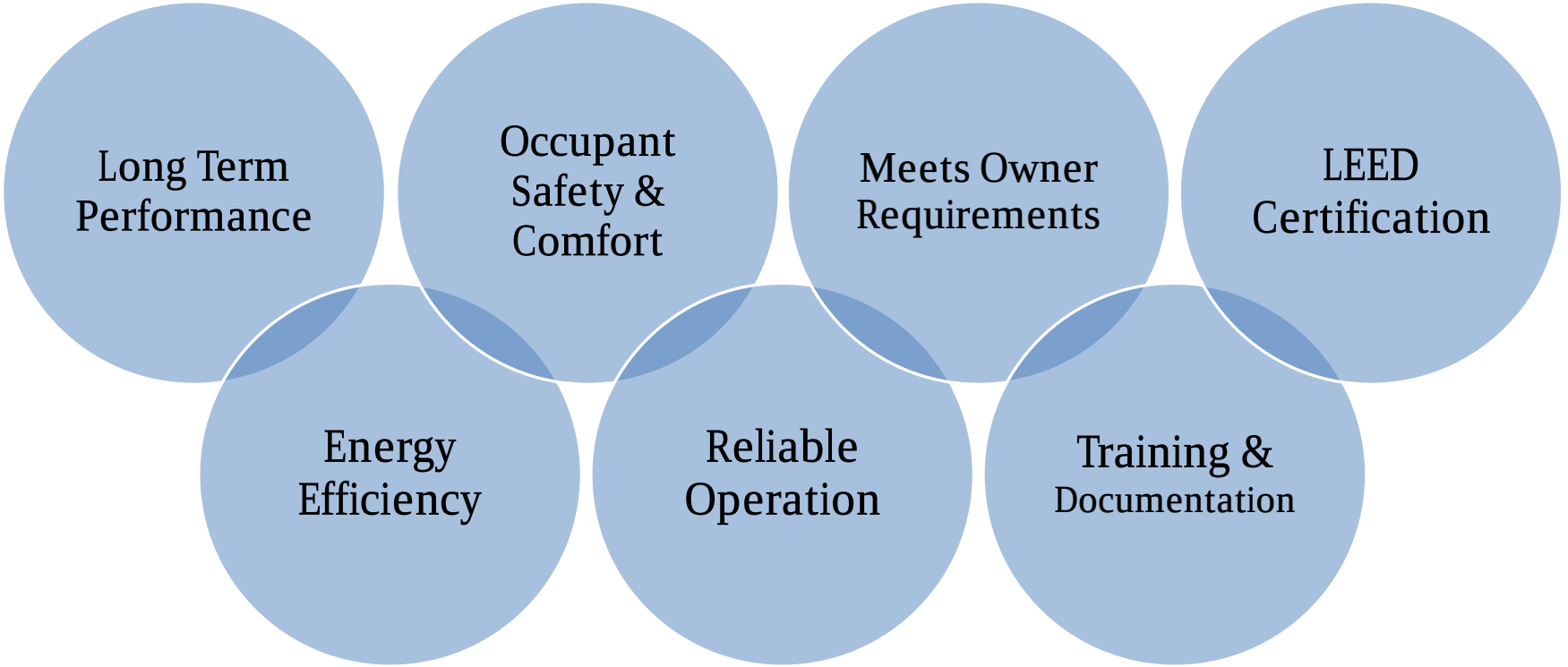
Physical Sciences Building

Learning Objectives

- Understand the limitations and risks that exist with “conventional” new construction commissioning
- Understand the capabilities of modern Monitoring-based Commissioning (MBCx) software and how it can be leveraged for new construction laboratory commissioning
- Discover why MBCx software is so effective during the project turnover phase
- Learn the benefits and impacts to different stakeholders of adding MBCx software to a new construction commissioning program

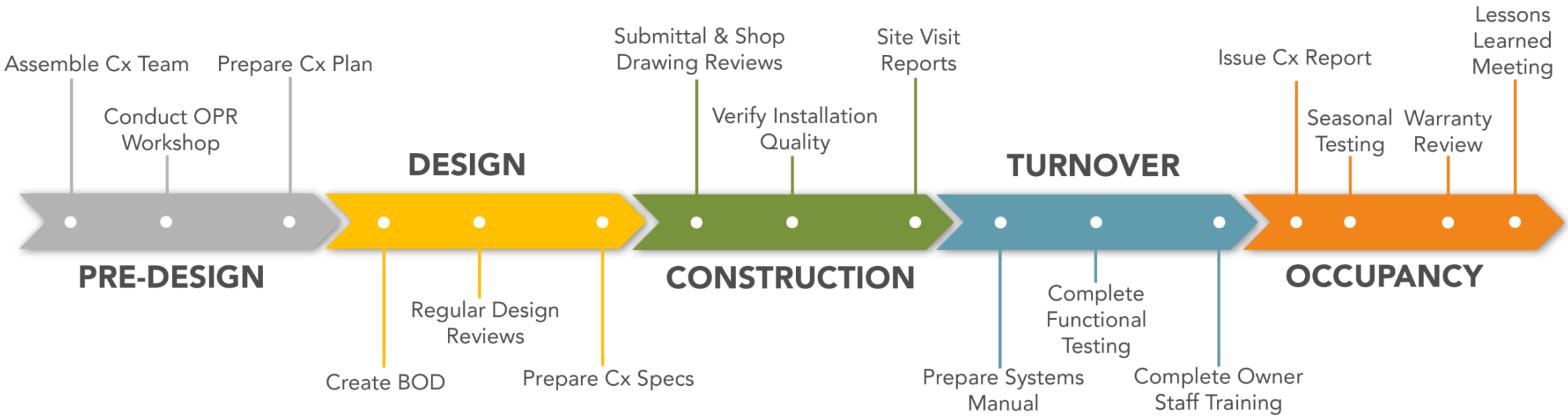
New Construction Commissioning

Commissioning is a continuous process that, when executed properly, helps ensure that building equipment, systems, and envelope perform as intended by the design team and meet the needs of the Owner, occupants, and facilities maintenance staff.



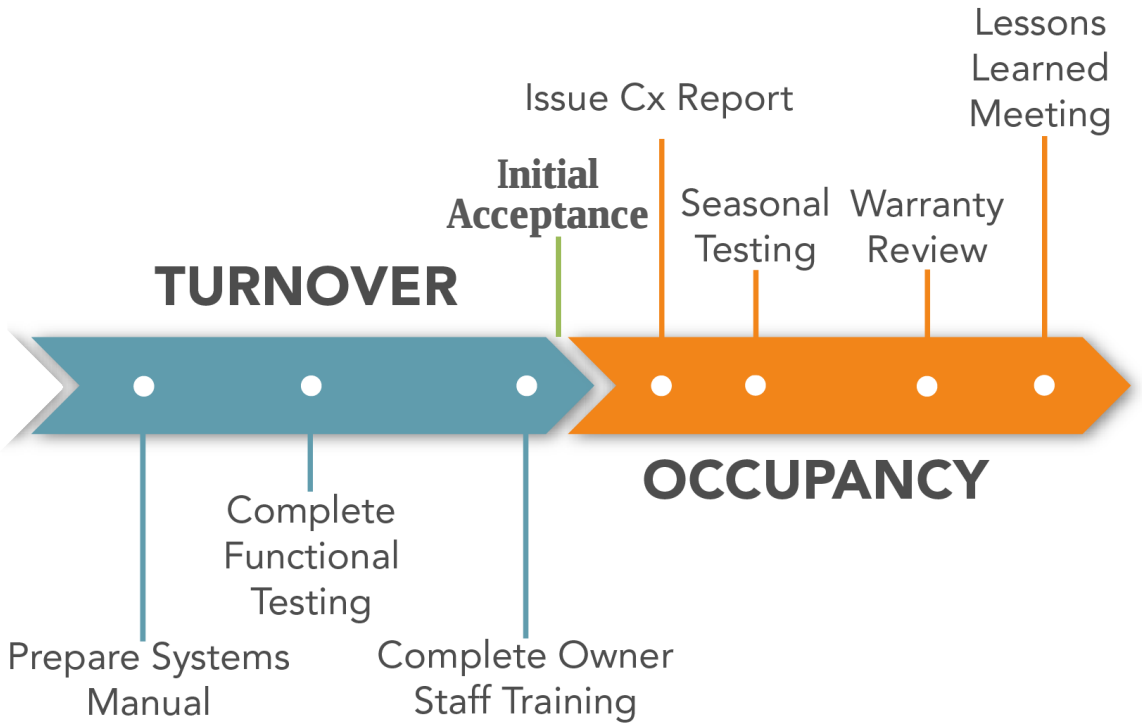
Commissioning & Project Turnover

- Turnover is the systematic transition from construction to occupancy & use
- Physical completion of construction & transfer of knowledge
- Owner formally assumes the responsibilities of operation and maintenance
- Cx & Turnover process continues post-occupancy to complete all punch list items, perform seasonal commissioning, and hold close-out meetings



The Reality of Building Turnover

- Commissioning ends with Cx report and 'final' punch list submission
- Seasonal trend log reviews and end of warranty reviews don't happen or are not comprehensive
- This phase does not receive the necessary level of focus, oversight, and commitment

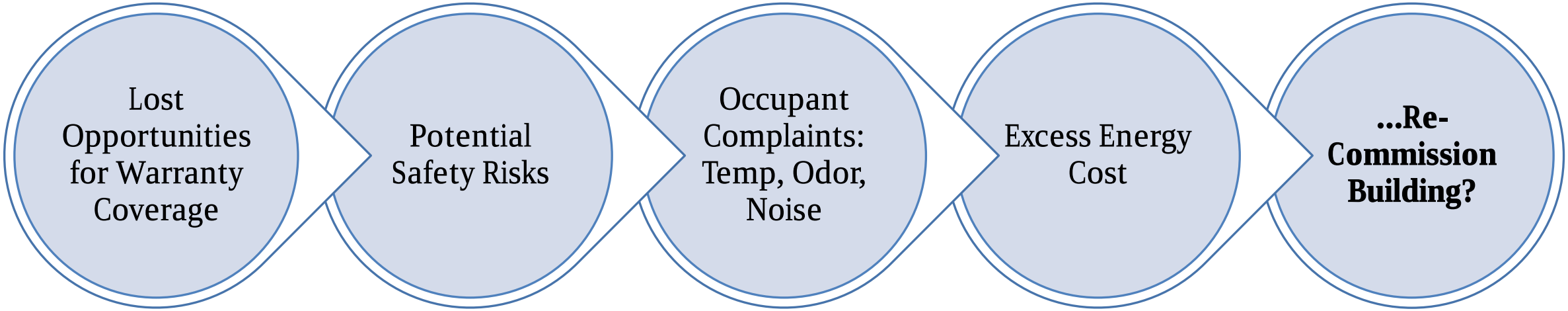


Why is Commissioning Not Successful?

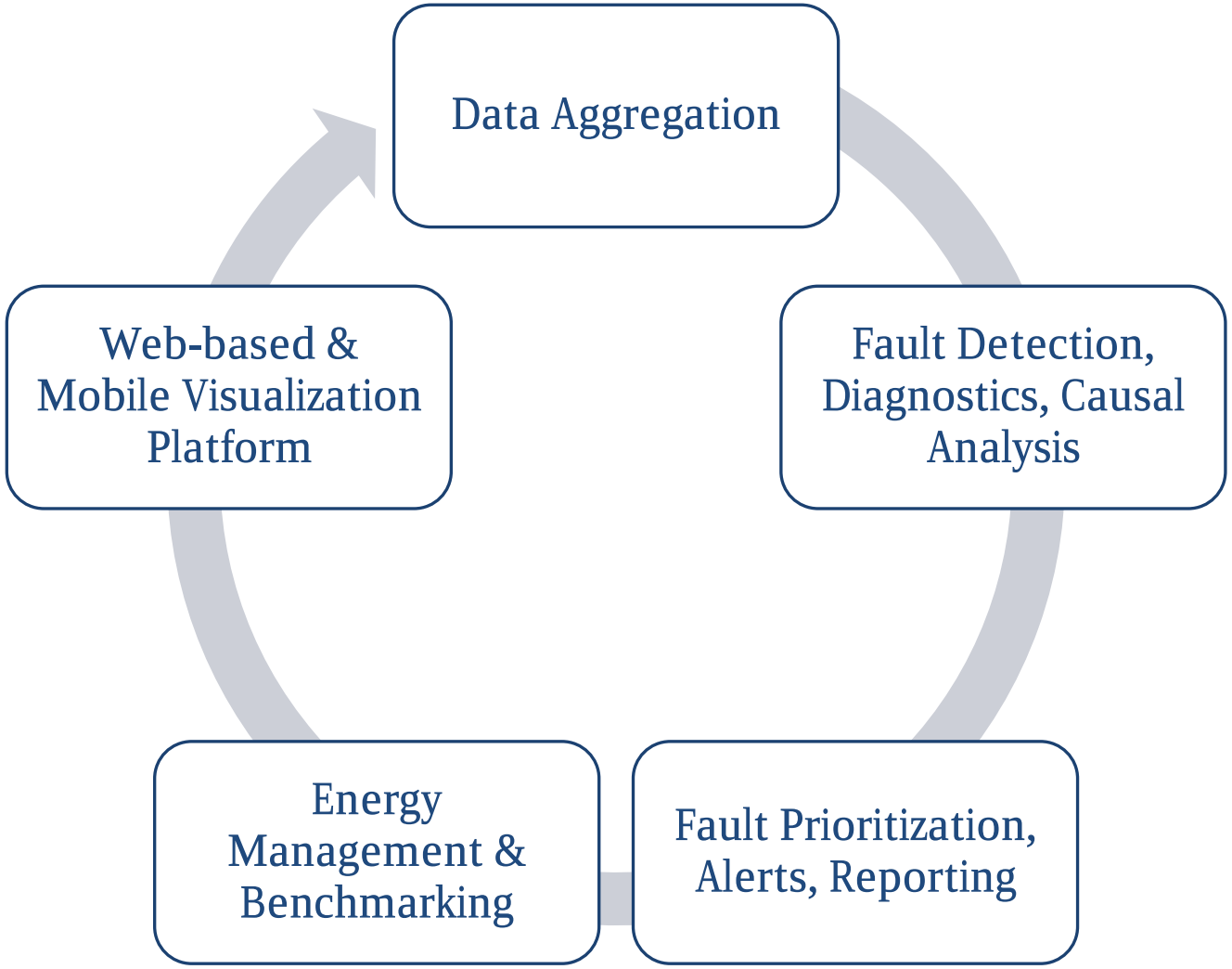
- Vague or incomplete specifications
- Limited scope, insufficient budget allocation, or “low bid” for commissioning
- Weak or inadequate functional performance tests
- Ineffective communication, lack of leadership, or accountability
- Constrained or accelerated schedules, especially at the end of construction

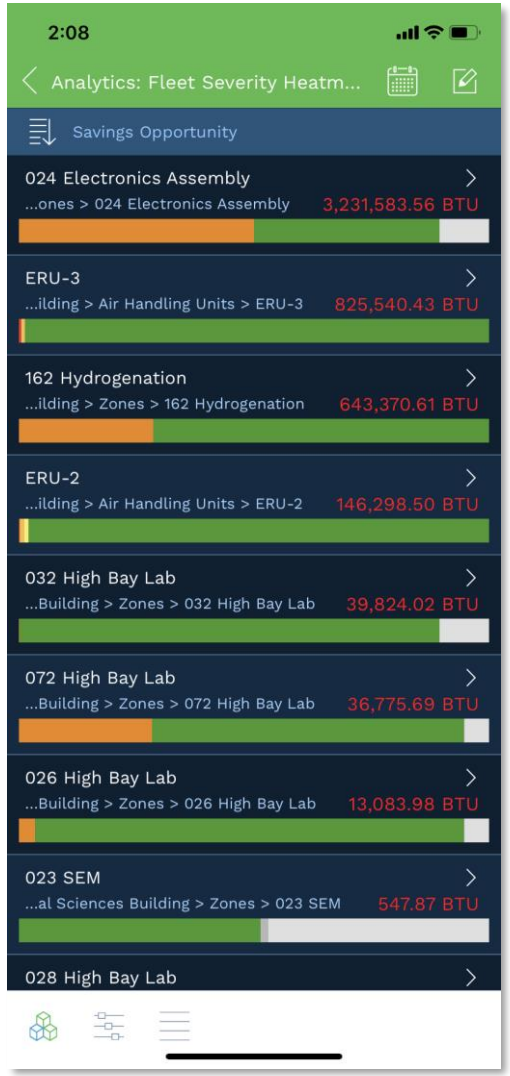
Turnover & Warranty Phase Trend Log Review Cost Example		
Building Floor Area	90,000	ft2
HVAC Equipment Quantity	350	AHUs, Terminal Devices, Fume Hoods, Zones, HXs, etc.
Sample Rate	100%	
Trend Log Review & Reporting Hours	0.5	hours each, average
Quantity Trend Log Reviews	3	Initial + 2 additional seasons
Total Hours	525	hours, total
Labor rate	$150	/ hour
Initial & Seasonal Trend Log Review Cost	$78,750	
Cost per Square Foot	**$0.88**	/ ft2

Impacts of Incomplete Commissioning



Monitoring-Based Commissioning (MBCx)





The Value of MBCx in New Construction Cx

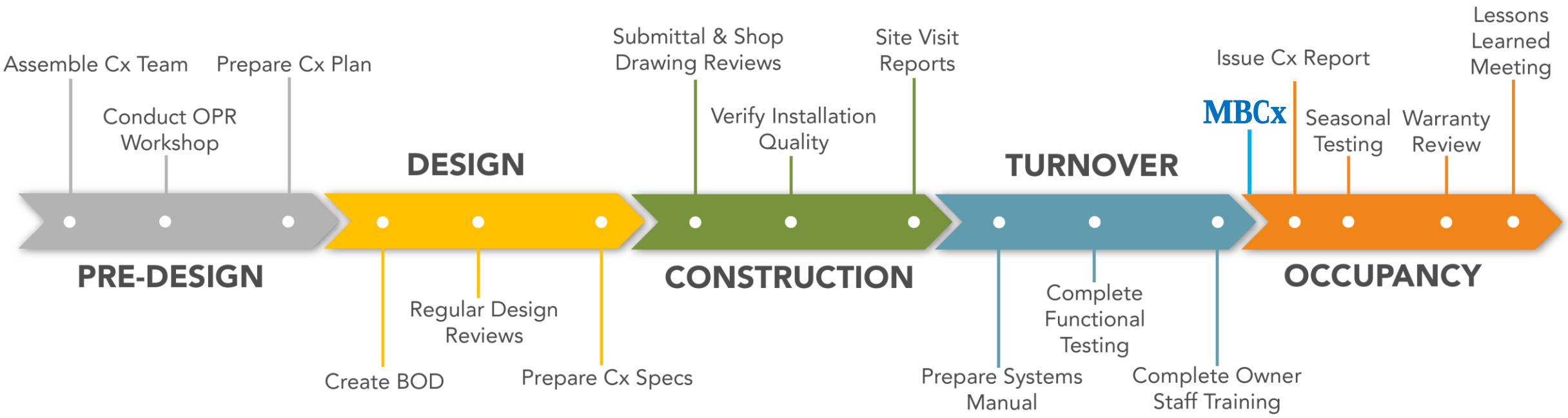
MBCx provides an opportunity to build a more successful Cx program

1. Continuous analysis of equipment and system performance, efficiency, comfort, and safety during the warranty period (and beyond)
2. All systems and equipment are monitored. No sampling.
3. Uncovers issues not caught by many written functional performance tests and assigns priority with avoidable costs
4. Alerts construction team and Cx agent to new issues immediately or on-demand
5. Transparency and accountability; Entire project team has access to system. Findings provide supporting evidence to go after warranty issues.

Case Study: UMass Amherst
Physical Sciences Building

- 90,000 GSF
- 20 faculty-led research groups
- 3 make-up air units with heat recovery
- 47 lab zones
- 90 fume hoods
- Initial occupancy in spring 2018
- Warranty period through May 2019
- LEED Gold Certified

Case Study: UMass Amherst
MBCx Deployed 4 Months After Occupancy



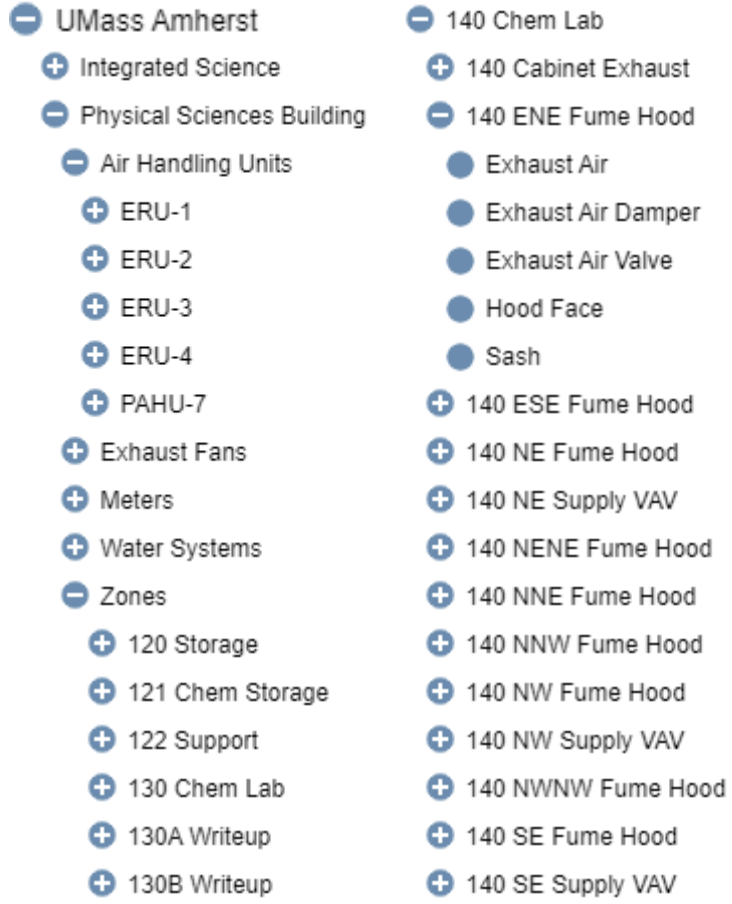
Case Study: UMass Amherst
Equipment Monitored

- All airside HVAC equipment including air handlers, terminal devices, hoods, and lab controls
- Chilled and hot water loops, pumps, domestic hot water
- Electrical sub-meters

Equipment Types	Quantity	Quantity Analytics, each	Total Analytic Instances
UMass Amherst Physical Sciences Building (PSB)			
Energy Recovery Units	3	28	84
Lab Zones	48	4	192
General Exhaust Boxes	45	7	315
Supply VAV Boxes	133	15	1,995
Fume Hoods	90	12	1,080
Snorkel, Cabinet Exhaust	12	7	84
Zone Exhaust Fans	15	3	45
AC Units	7	1	7
Hydronic Loops	4	15	60
Heat Exchangers	6	1	6
Pumps	11	3	33
Electric Meters	11	-	-
Total	**385**	**96**	**3,901**

Case Study: UMass Amherst
MBCx Software Deployment Process

- Reviewed latest record drawings, TAB reports, Cx report including FPT results, control sequences of operation, building automation system graphics
- Mapped 10,600 building automation system points using MBCx software standardized naming convention
- Configured nearly 100 analytics to mine 385 systems and equipment for issues and opportunities

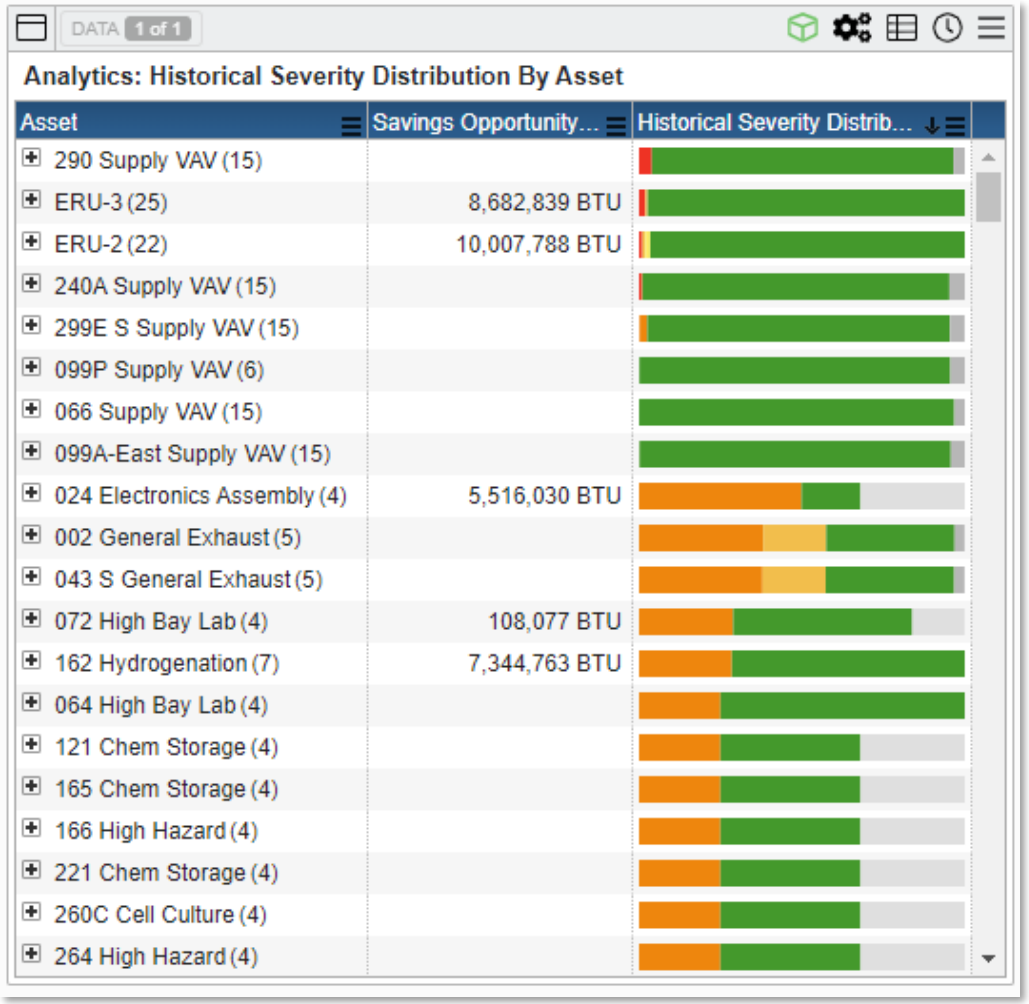


Case Study: UMass Amherst
Initial Results – 4 Weeks

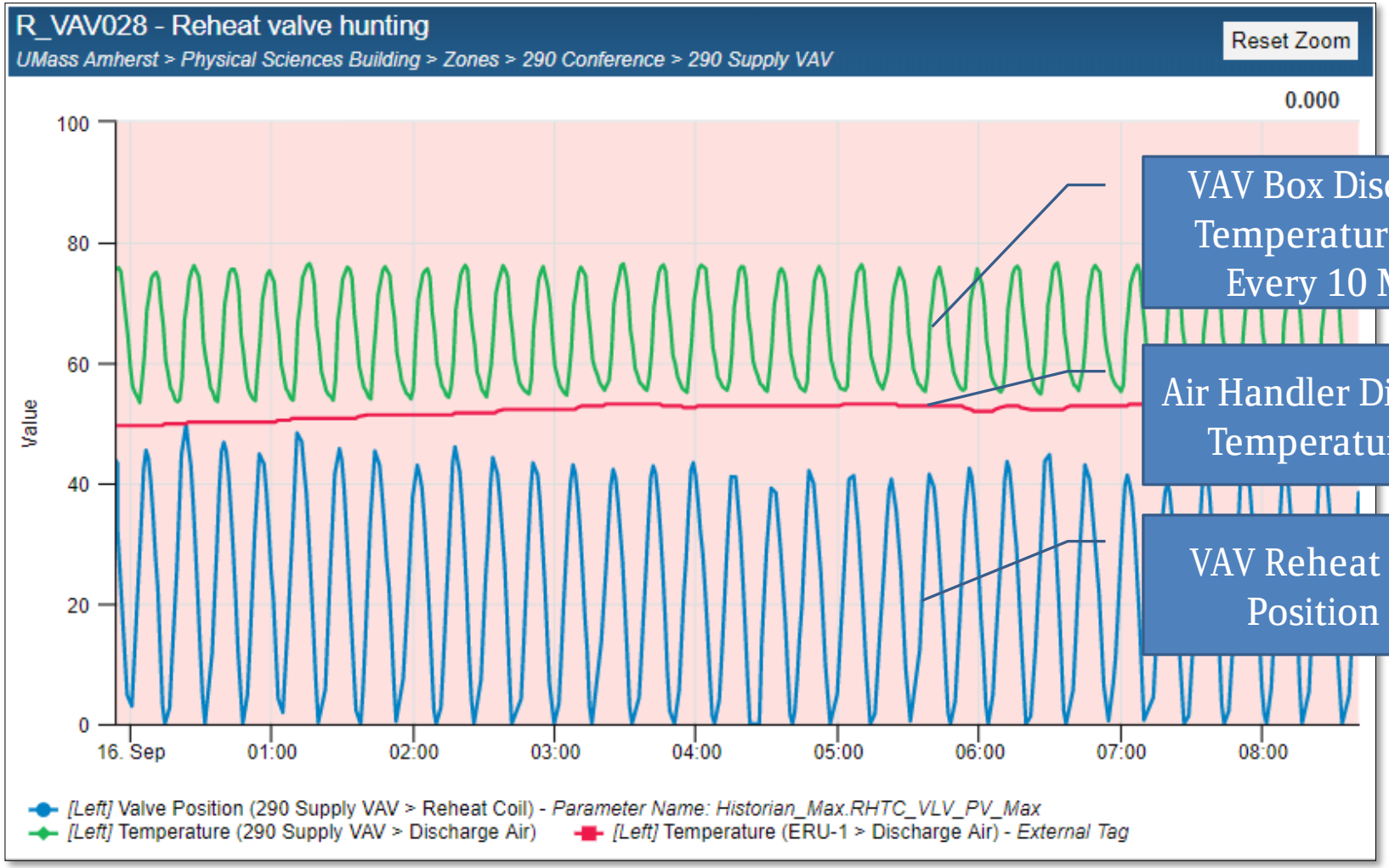
Initial Results - 43 Unique Issues

- 10 of 47 labs (21%) with improper pressurization
- 6 Labs operating well above design min ACH
- Broken fume hood sash position sensors
- Valve and damper hunting
- Broken communication between lab controllers and supervisory controllers – 'flat lined' points
- Inefficient ERU heat recovery control

<u>Most classified as issues covered under warranty</u>



Case Study: UMass Amherst
Valve and Damper Hunting



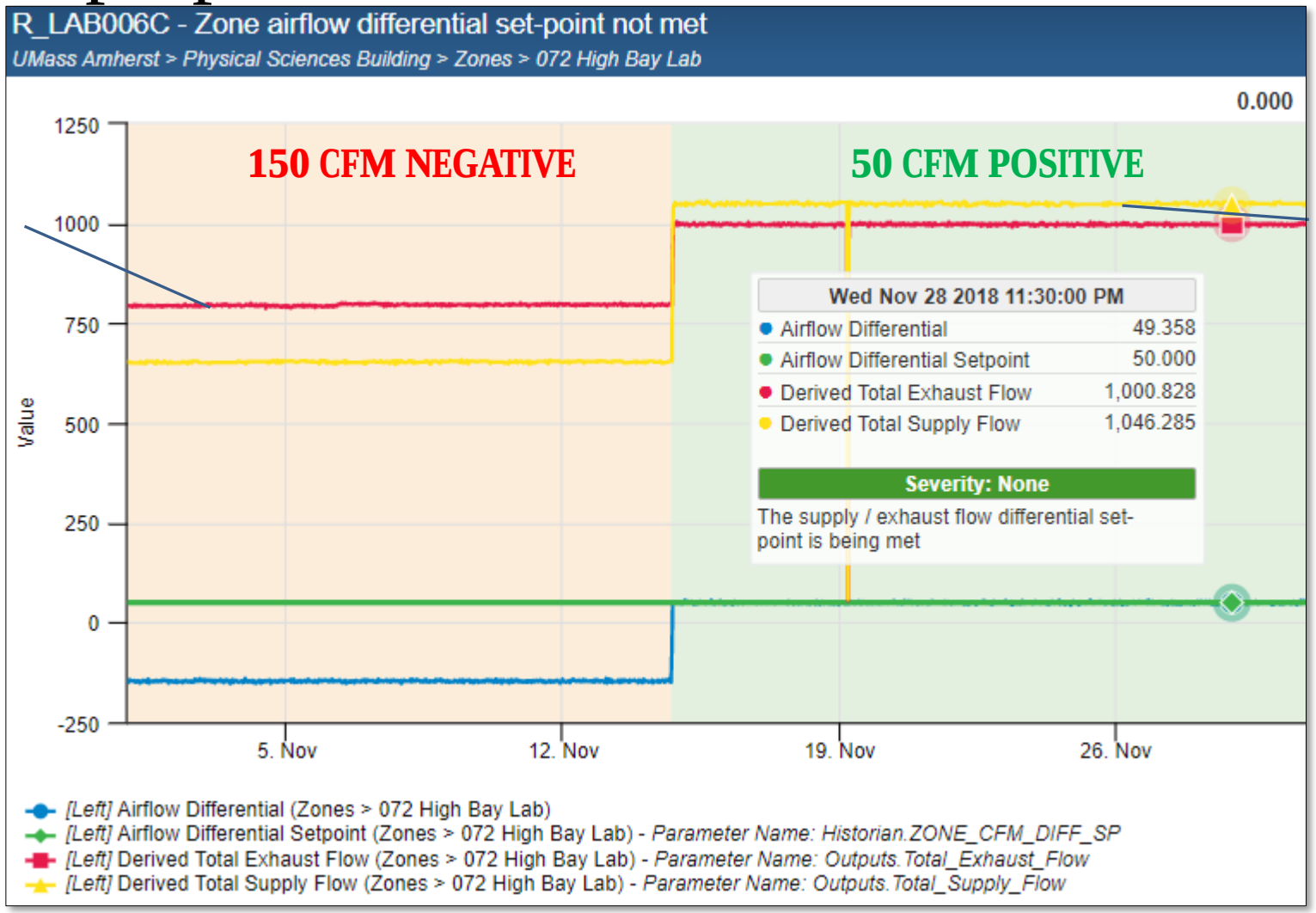
VAV Box Discharge Air Temperature 55-76°F Every 10 Minutes

Air Handler Discharge Air Temperature Stable

VAV Reheat Coil Valve Position 0-50%

Case Study: UMass Amherst
Improper Lab Pressurization – Clean Room

Exhaust Flow: 775 cfm
Supply Flow: 625 cfm

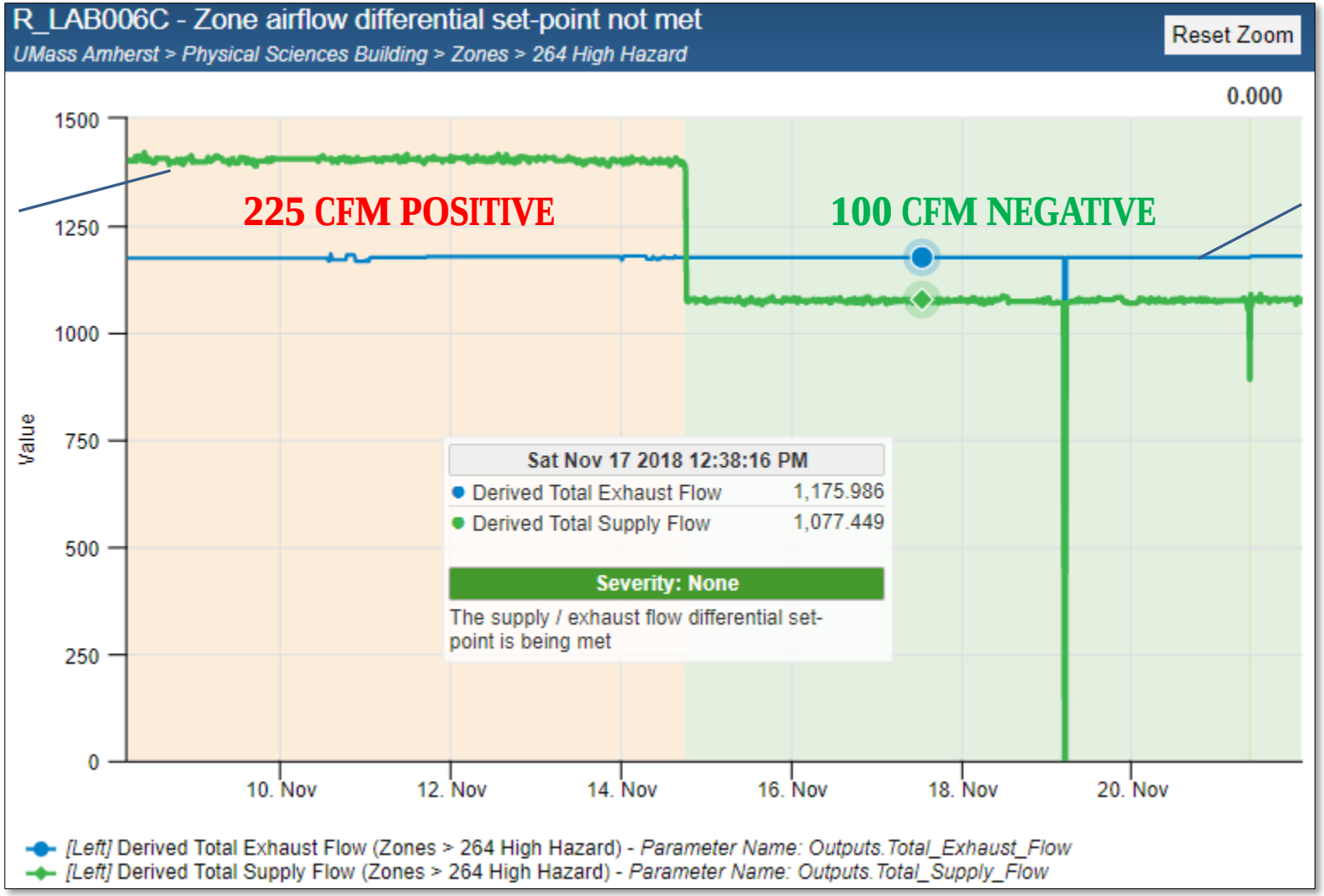


Exhaust Flow: 1,000 cfm
Supply Flow: 1,050 cfm

Case Study: UMass Amherst

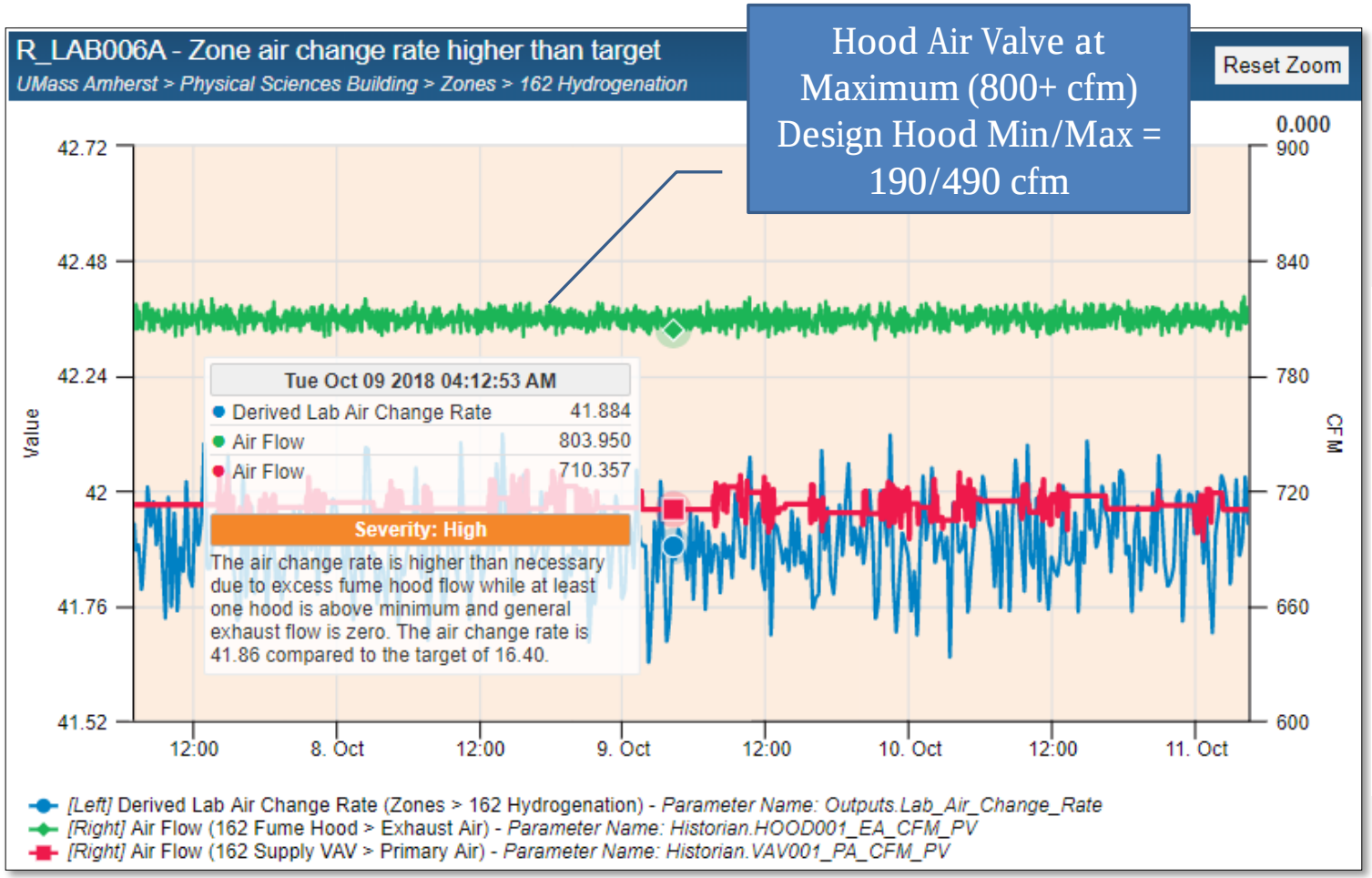
Improper Lab Pressurization – 'High Hazard' Chem Storage

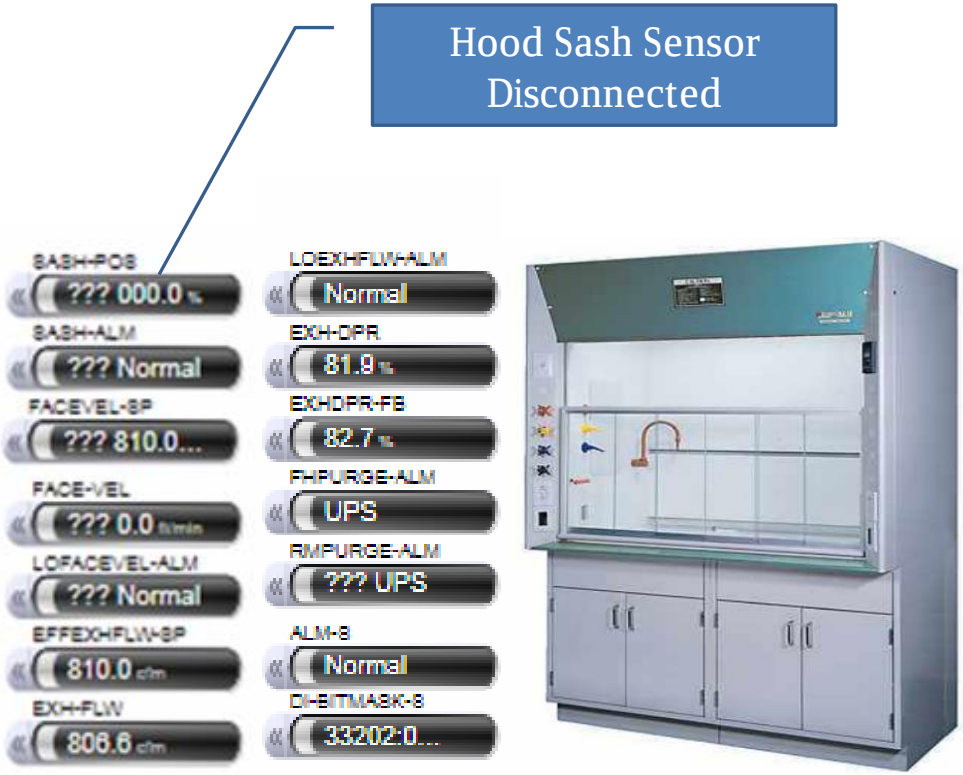
Exhaust Flow: 1,175 cfm
Supply Flow: 1,400 cfm



Exhaust Flow: 1,175 cfm
Supply Flow: 1,075 cfm

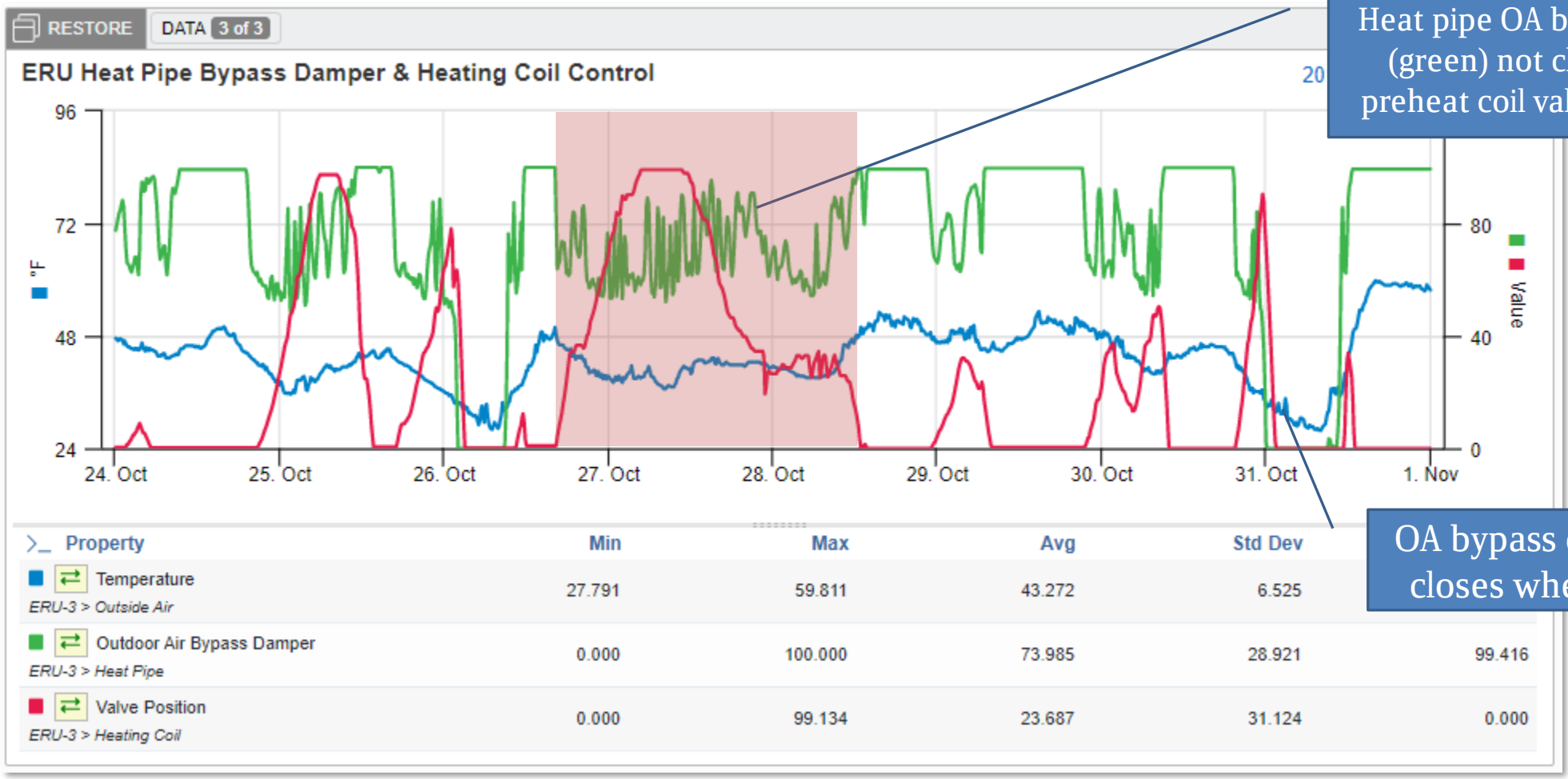
Case Study: UMass Amherst
Failed Fume Hood Sash Sensor – High Lab ACH





Case Study: UMass Amherst

Ineffective Energy Recovery Unit Heat Pipe Operation

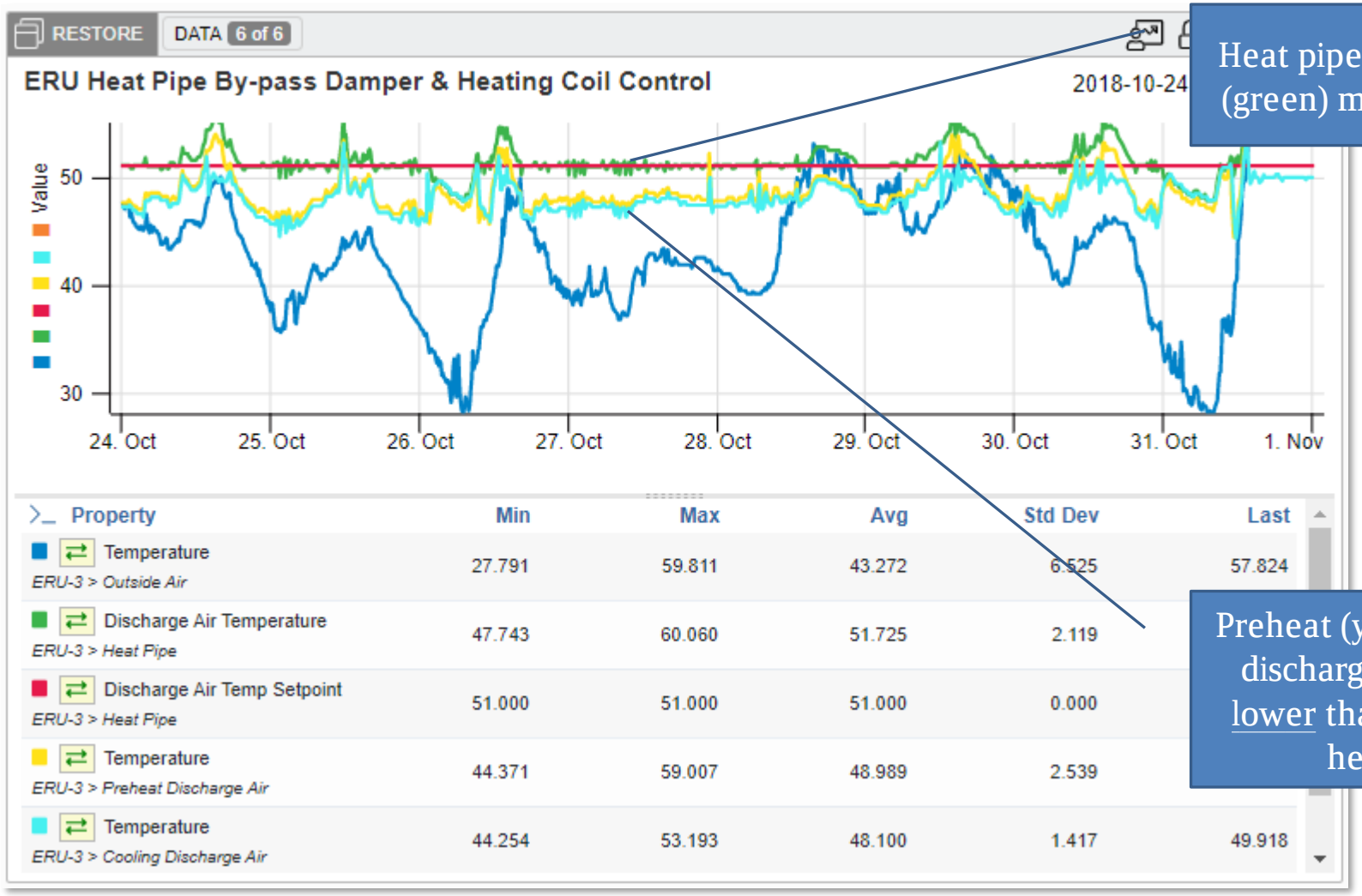


Heat pipe OA bypass damper (green) not closing while preheat coil valve (red) open

OA bypass damper only closes when OAT < 33

Case Study: UMass Amherst

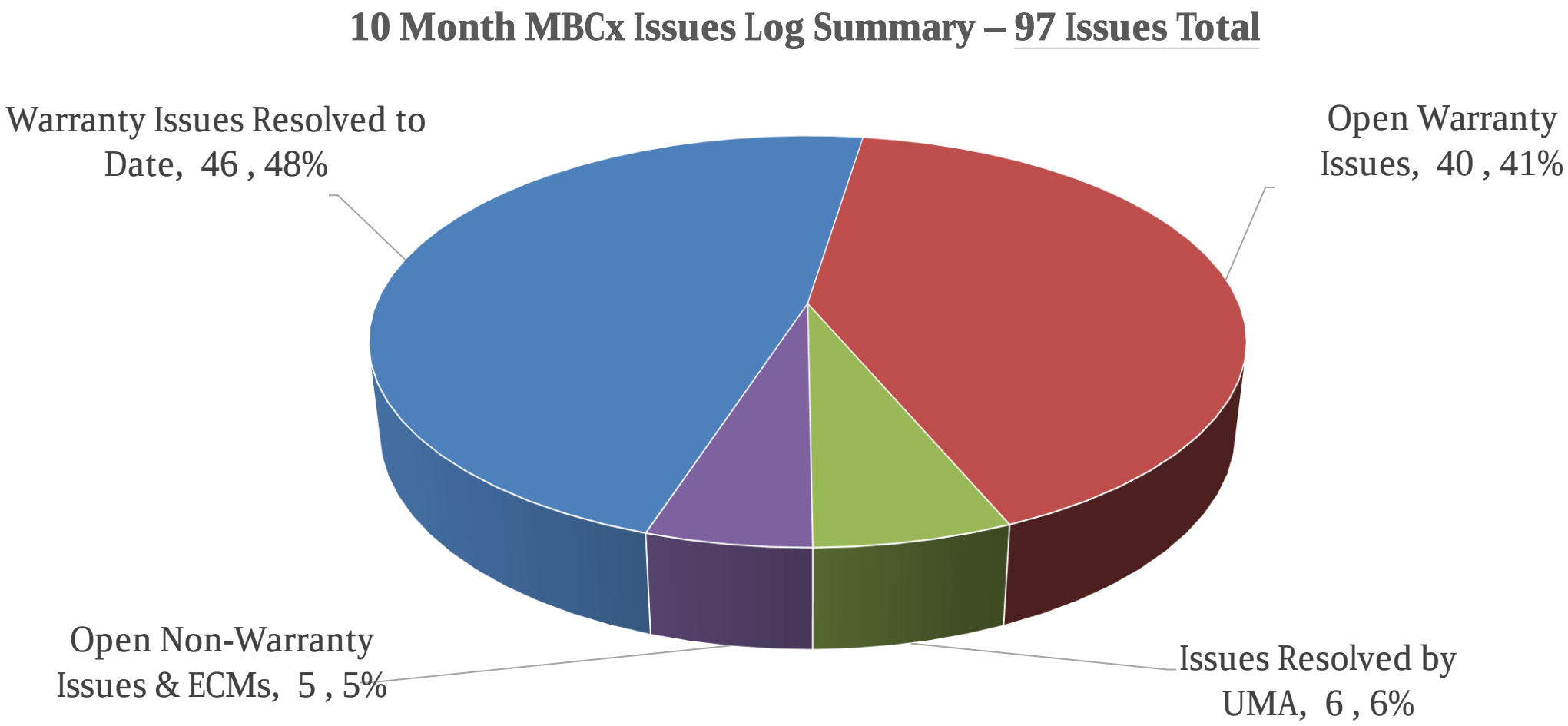
Ineffective Energy Recovery Unit Heat Pipe Operation



Heat pipe leaving air temperature (green) meeting set-point of 51°F

Preheat (yellow) and cooling (red) discharge air temps both 4-5°F lower than heat pipe temp with heating valve open

Case Study: UMass Amherst
Results at End of Warranty Period



Case Study: UMass Amherst
Top Findings & Energy Cost Savings

Top Findings with Energy Cost Savings at end of 10 Months

Top Findings with Energy Savings		Annual Electric Savings	Annual CHW Savings	Annual Steam Savings	Annual Cost Savings
#	-	kWh	ton-hrs	Mlbs	$
1	Resolve High Minimum ACH	44,754	10,815	463	$15,548
2	Improve ERU Heat Pipe Control	0	6,765	469	$9,957
3	Repair GEX Airflow Controls	24528	2,964	228	$7,807
4	Replace Hood Sash Position Sensors	15,217	3,677	158	$5,287
5	Improve ERU Static Pressure Reset	25,405	0	0	$3,049
6	Improve CHW Loop dP Reset	5,752	0	0	$690
Totals		**115,656**	**24,221**	**1,318**	**$42,338**

Case Study: UMass Amherst
Summary of Benefits

Physical Plant / Facilities Maintenance

- Nearly 100 issues impacting energy use, long term equipment reliability, comfort, and safety identified. Over 50% resolved to date.
- Smoother, more transparent building turnover. Increased communication and collaboration.

Department of Construction Management (DCM)

- >90% of issues identified covered under equipment and installation warranty
- Improved communication and overall relationship with Physical Plant

Environmental Health & Safety

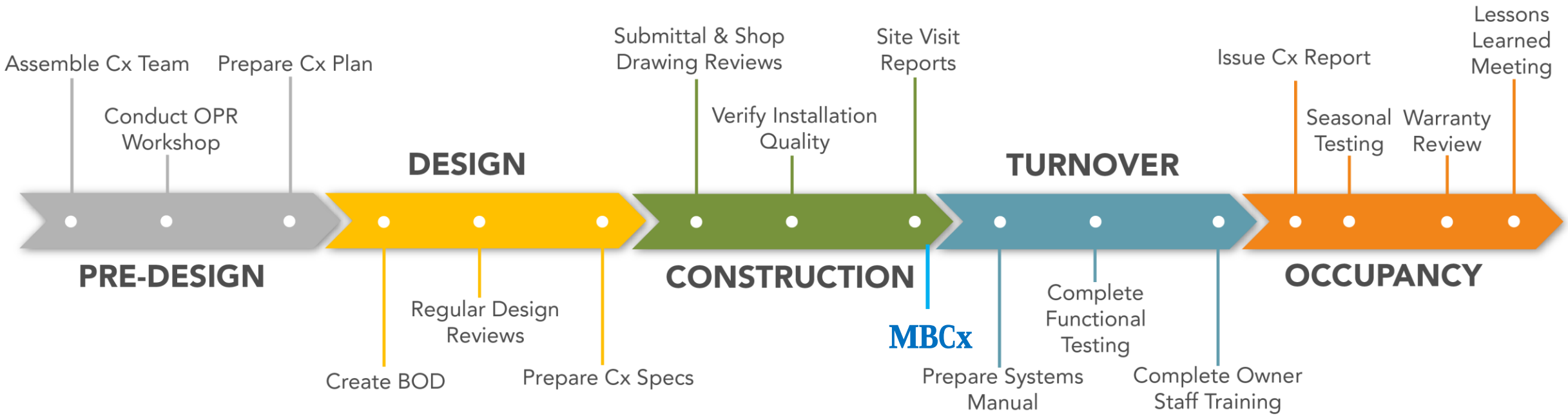
- Better understanding of and confidence in lab HVAC & controls performance, fume hood use/performance
- Potential risks to occupant safety flagged and resolved

LEED Measurement & Verification Team

- Access to equipment and metering trend logs, visualization and analysis tools for M&V

Case Study: UMass Amherst
Lessons Learned & Future Plans

- Increase dialog between General Contractor, Commissioning Team, and MBCx Team
- Deploy and leverage MBCx earlier in the new construction commissioning process
- Integrate MBCx as part of commissioning specifications & standard Cx processes
- Continue using MBCx post-warranty to maintain benefits



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Questions

Case Study: UMass Amherst
EH&S Summary Views

Calculated Lab Air Change Rate

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List View: Derived Lab Air Change Rate

Name	Equipment	History	Value	Status
Derived Lab Air Change Rate	Zones > 162 Hydrogenation		42.461	High Lab ACH
Derived Lab Air Change Rate	Zones > 035 Chem Prep		15.116	Normal
Derived Lab Air Change Rate	Zones > 029 Chem Prep		15.077	Normal
Derived Lab Air Change Rate	Zones > 240 Chem Lab		14.482	Normal
Derived Lab Air Change Rate	Zones > 140 Chem Lab		14.392	Normal
Derived Lab Air Change Rate	Zones > 130 Chem Lab		13.523	Normal
Derived Lab Air Change Rate	Zones > 032 High Bay Lab		12.311	Normal
Derived Lab Air Change Rate	Zones > 150 Chem Lab		11.073	Normal
Derived Lab Air Change Rate	Zones > 224 Support		10.683	Normal
Derived Lab Air Change Rate	Zones > 250 Chem Lab		10.519	Normal
Derived Lab Air Change Rate	Zones > 120 Storage		8.538	Normal
Derived Lab Air Change Rate	Zones > 072 High Bay Lab		7.880	Normal
Derived Lab Air Change Rate	Zones > 160 Support		7.875	Normal
Derived Lab Air Change Rate	Zones > 026 High Bay Lab		7.705	Normal
Derived Lab Air Change Rate	Zones > 122 Support		7.394	Normal

Fume Hood Sash Position

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List View: Fume Hood Sash Position

Name	Equipment	History	Value	Status
Percent Position	162 Fume Hood > Sash		100.000	Sash 100% Open
Percent Position	230 WW Fume Hood > Sash		18.880	Sash Partially Open
Percent Position	230 WNW Fume Hood > Sash		16.596	Sash Partially Open
Percent Position	130 NW Fume Hood > Sash		12.609	Sash Partially Open
Percent Position	250 ENE Fume Hood > Sash		9.706	Sash Closed
Percent Position	250 EE Fume Hood > Sash		9.060	Sash Closed
Percent Position	250 WW Fume Hood > Sash		9.027	Sash Closed
Percent Position	240 SWSW Fume Hood > S...		8.286	Sash Closed
Percent Position	240 SE Fume Hood > Sash		8.105	Sash Closed
Percent Position	240 SESE Fume Hood > Sash		7.721	Sash Closed
Percent Position	250 E Fume Hood > Sash		6.680	Sash Closed
Percent Position	240 SSE Fume Hood > Sash		6.134	Sash Closed
Percent Position	130 NE Fume Hood > Sash		5.934	Sash Closed
Percent Position	150 WW Fume Hood > Sash		5.669	Sash Closed
Percent Position	130 WNW Fume Hood > Sash		5.637	Sash Closed