2021 I²SL Annual Conference

Revitalizing Lab Buildings:

Florida State University Breathes New Life Into Existing Lab Systems

9.28.2021
Jim Stephens, FSU
Tyler Dykes, AEI



AEI Affiliated Engineers

Learning Objectives

- Recognize the need and business case for engaging in retro-commissioning efforts for existing lab facilities.
- Understand the risks to personnel in the building, research programs, and building systems inherent to this type of project.
- Establish a structured approach to planning tasks, assessing systems, and optimizing the performance of existing lab facilities.
- Define success criteria and evaluate the technical skills, tools, and expertise that are necessary to execute this type of effort.

Discussion Topics

- Background and Scope
- Process
- Implementation
- Case Studies & Results



FSU: A Preeminent Florida University

SUSTAINABLE CAMPUS
FLORIDA STATE UNIVERSITY

FOUNDED IN
1851

TOTAL STUDENTS
41,867

TOTAL OF
375
BUILDINGS

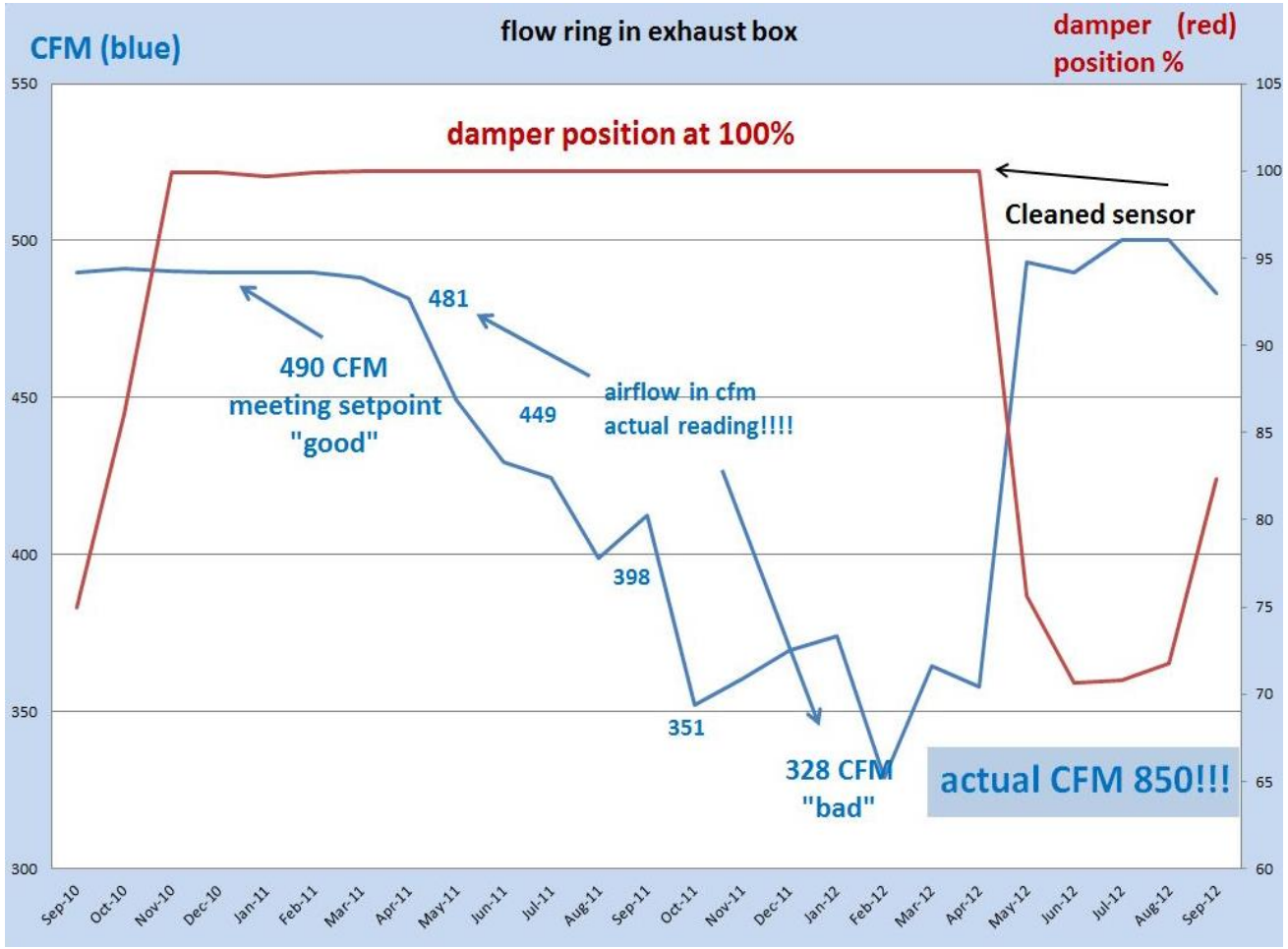
TALLAHASSEE CAMPUS
477 ACRES



Courtesy: Florida State University News

FSU Lab ACH Retro-Commissioning

- **Project Drivers**
  - Reduce Energy Use
  - Confirm & Improve Lab Performance
  - Streamline Maintenance
  - Ensure Reliability and Safety
- **Tasks**
  - Benchmark Existing Conditions
  - Affirm New Air Change Rates
  - Implement Adjustments & Corrections
- **Special Considerations**
  - Proper Air Balance
  - Perceived Thermal Comfort
  - Peripheral Effects on Equipment
  - Smart Labs



Lab Design Expertise

#1 Science & Technology Laboratories Engineering Firm
BUILDING DESIGN +CONSTRUCTION 2020

#1 Science + Technology Engineering Firm
BUILDING DESIGN +CONSTRUCTION 2019

TOP 5 Science+Technology Engineering Firm
BUILDING DESIGN +CONSTRUCTION 2018

#1 Science+Technology Engineering Firm
BUILDING DESIGN +CONSTRUCTION 2017

TOP 10 University Engineering Firm
BUILDING DESIGN +CONSTRUCTION 2021

TOP 10 Engineering Firm
BUILDING DESIGN +CONSTRUCTION 2021

50M sf of research buildings

5M sf of containment space

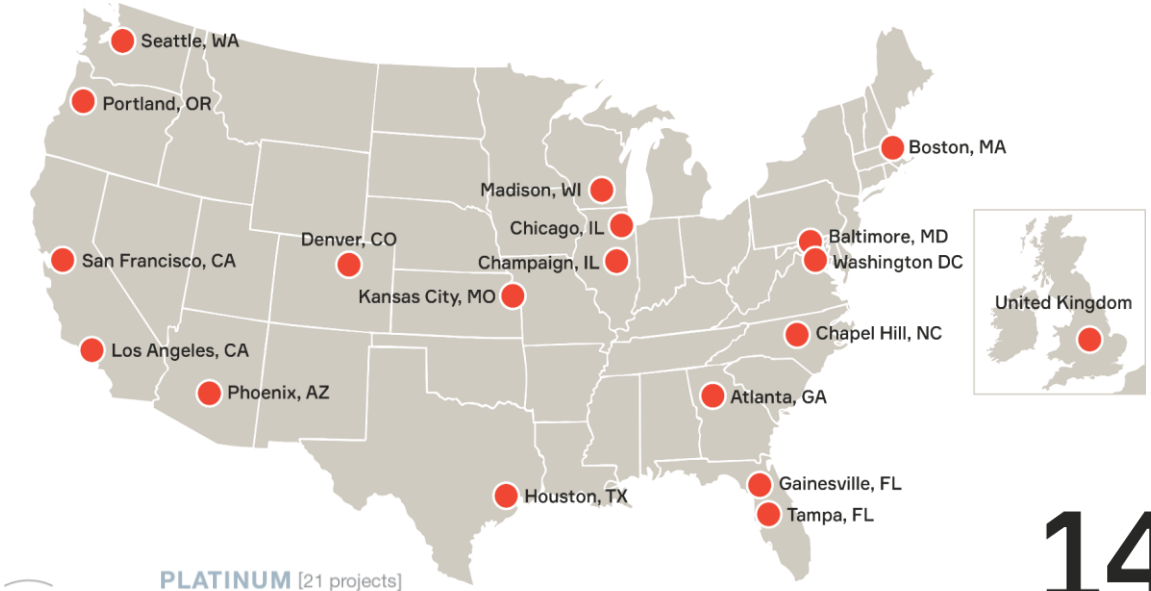
10M sf of vivarium

9.5M+ sf of GMP facilities

19 offices

700+ employees

40+ years of experience



FOYA Facility of the Year Awards Honorable Mention



Nephron Pharmaceuticals
New Manufacturing and Research Facility
Cayce, South Carolina



Takeda Pharmaceutical
Integrated Plasma Manufacturing Complex
Social Circle, Georgia

292 LEED® PROJECTS

205 PROJECTS PURSUING LEED®

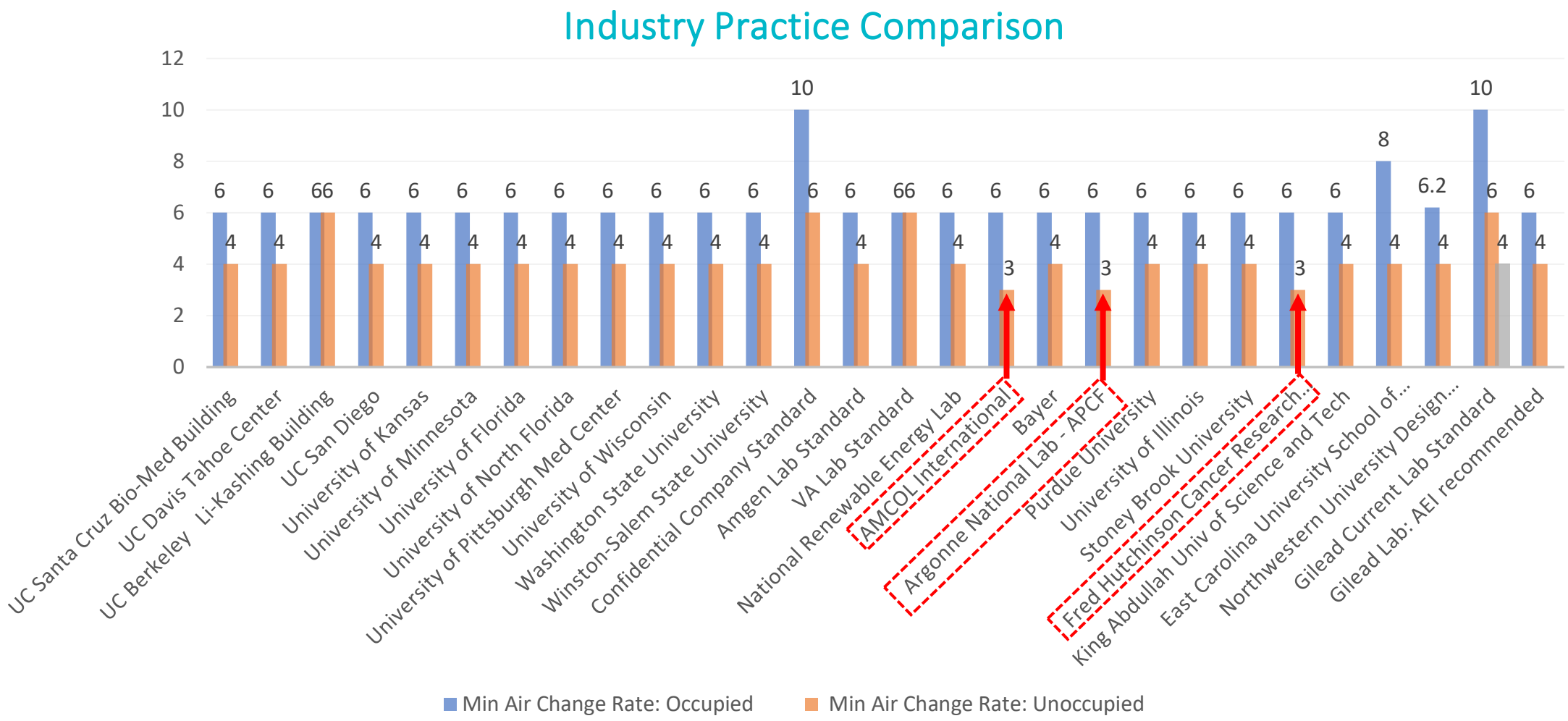
PLATINUM [21 projects] 8,835,000 sf
GOLD [145 projects] 24,813,000 sf
SILVER [88 projects] 11,398,000 sf
CERTIFIED [38 projects] 3,142,000 sf

HIGHER EDUCATION/ RESEARCH ENR REGIONAL BEST PROJECT 2017
Engineering News-Record
Biomedical Sciences Partnership Building

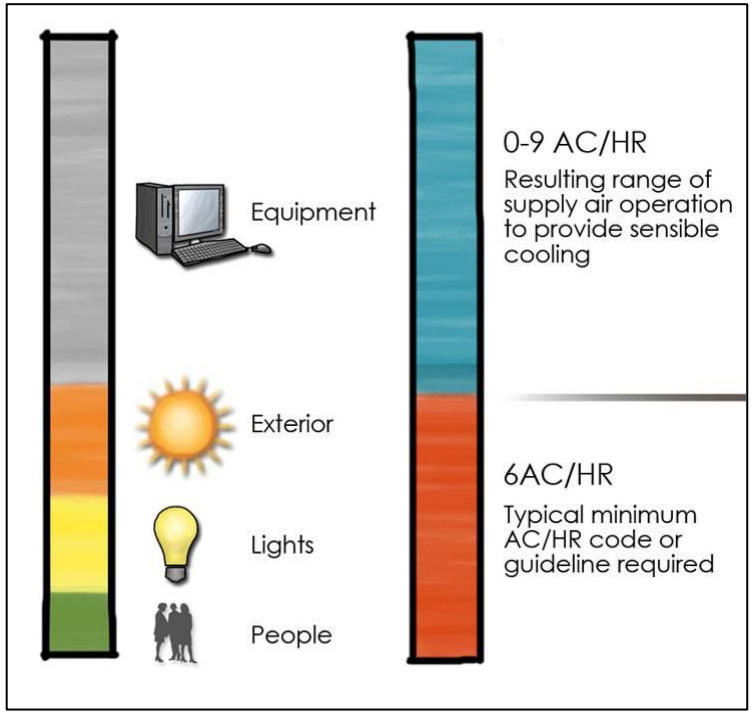
14 Lab of the Year awards
R&D Magazine

TOP 10 MEP Giants
2016, 2017, 2018, 2019, 2020, 2021
Consulting - Specifying Engineer

Progression In Air Change Rates



Right-sizing For Different Types of Labs





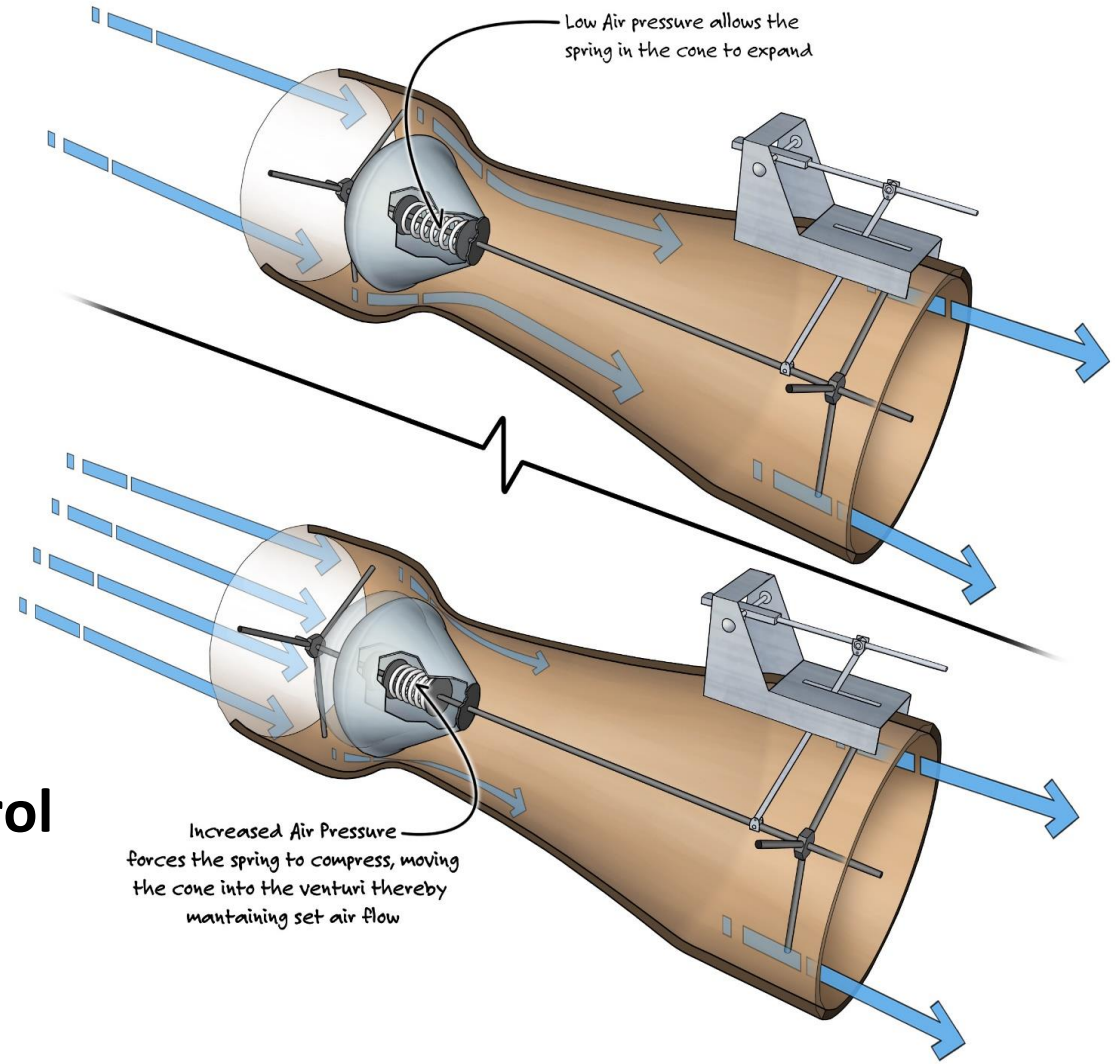




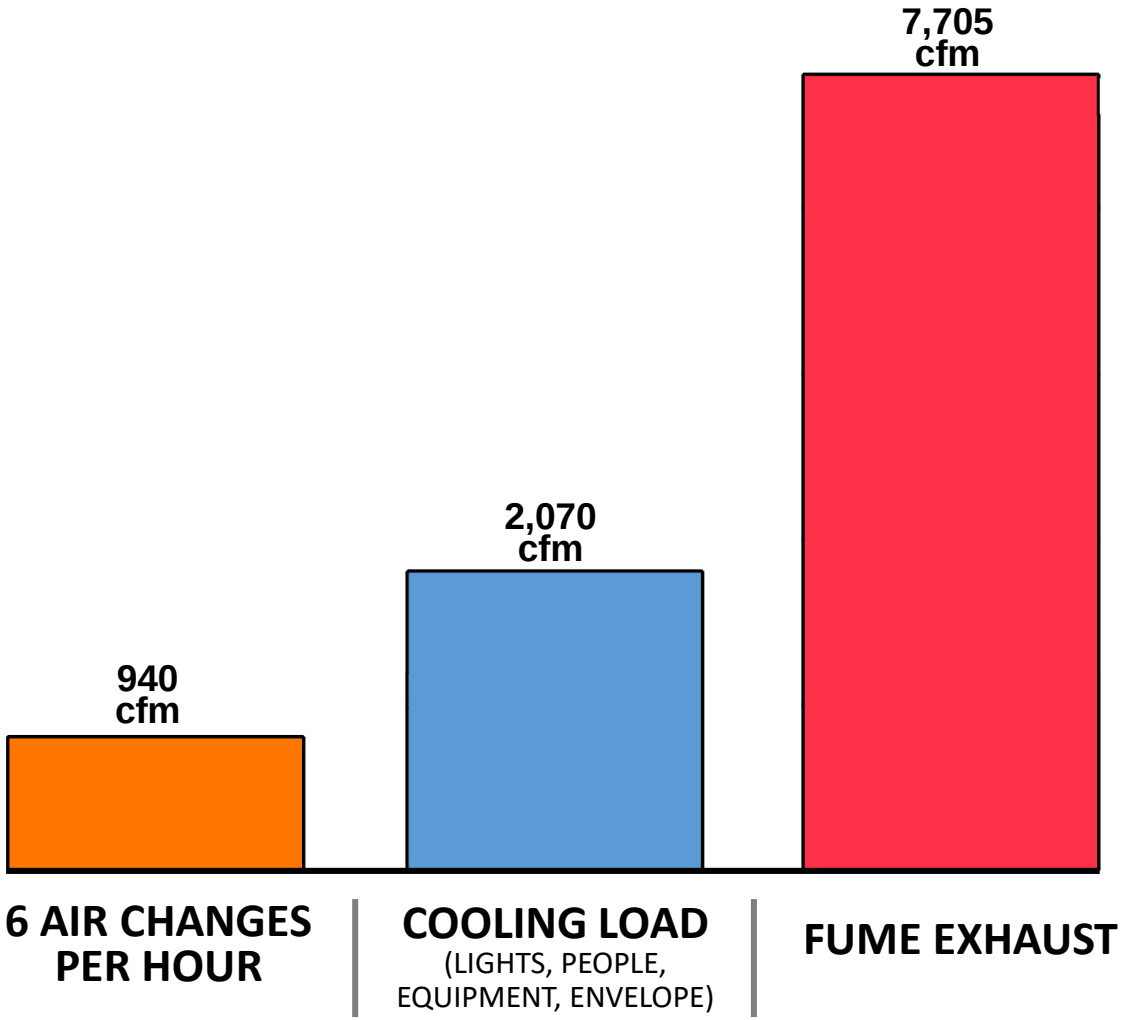
Variable Air Volume

Two-Position Air Flow Control

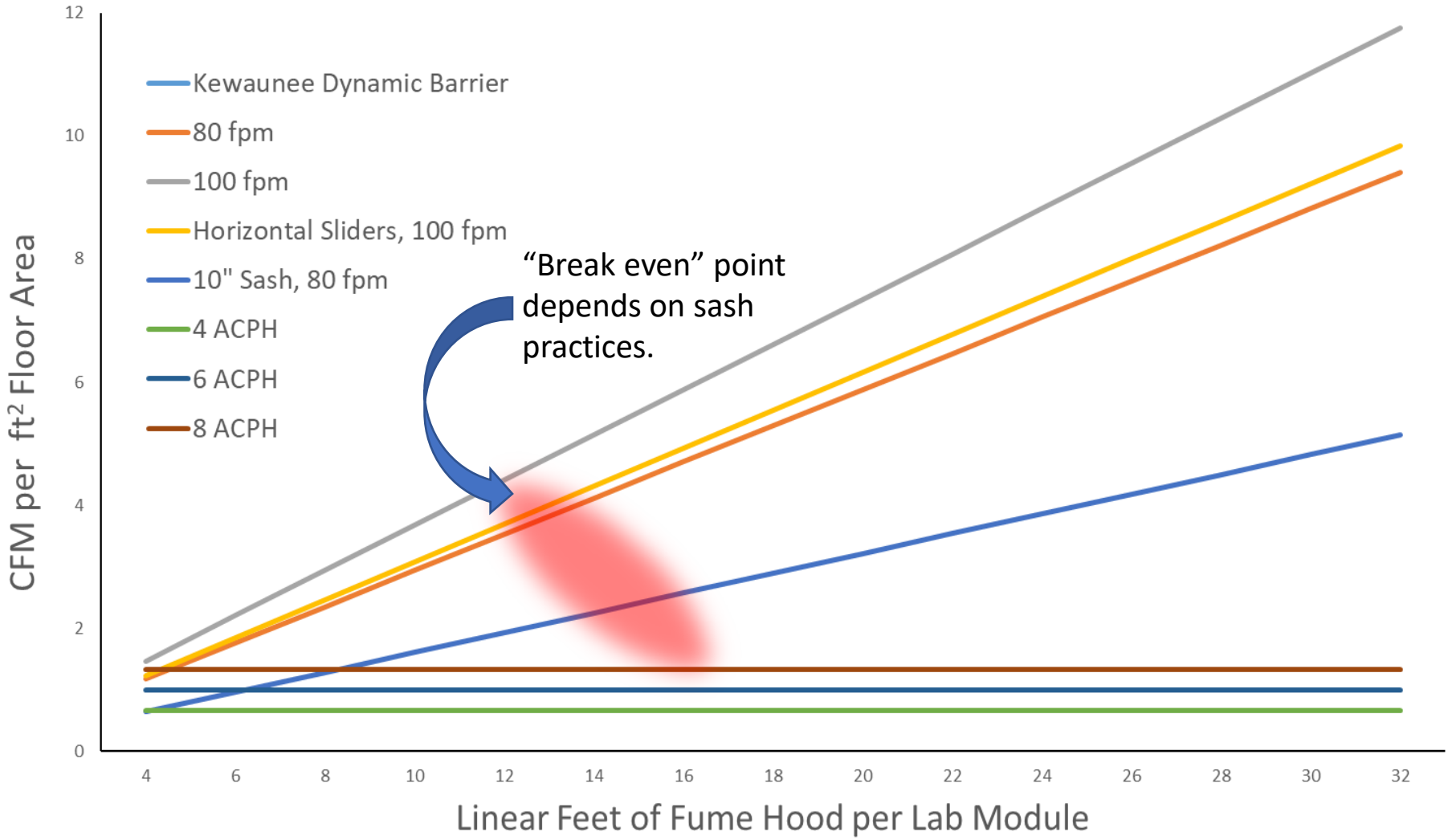
- **Case study**
  - 135,000 GSF
  - Teaching and medium intensity lab building
  - $102k premium for fully modulating VAV compared to 2-position
  - $25k annual energy savings
  - 4 year simple payback
  - 5% reduction in 25-year life cycle cost
- **Either requires pressure independent control**



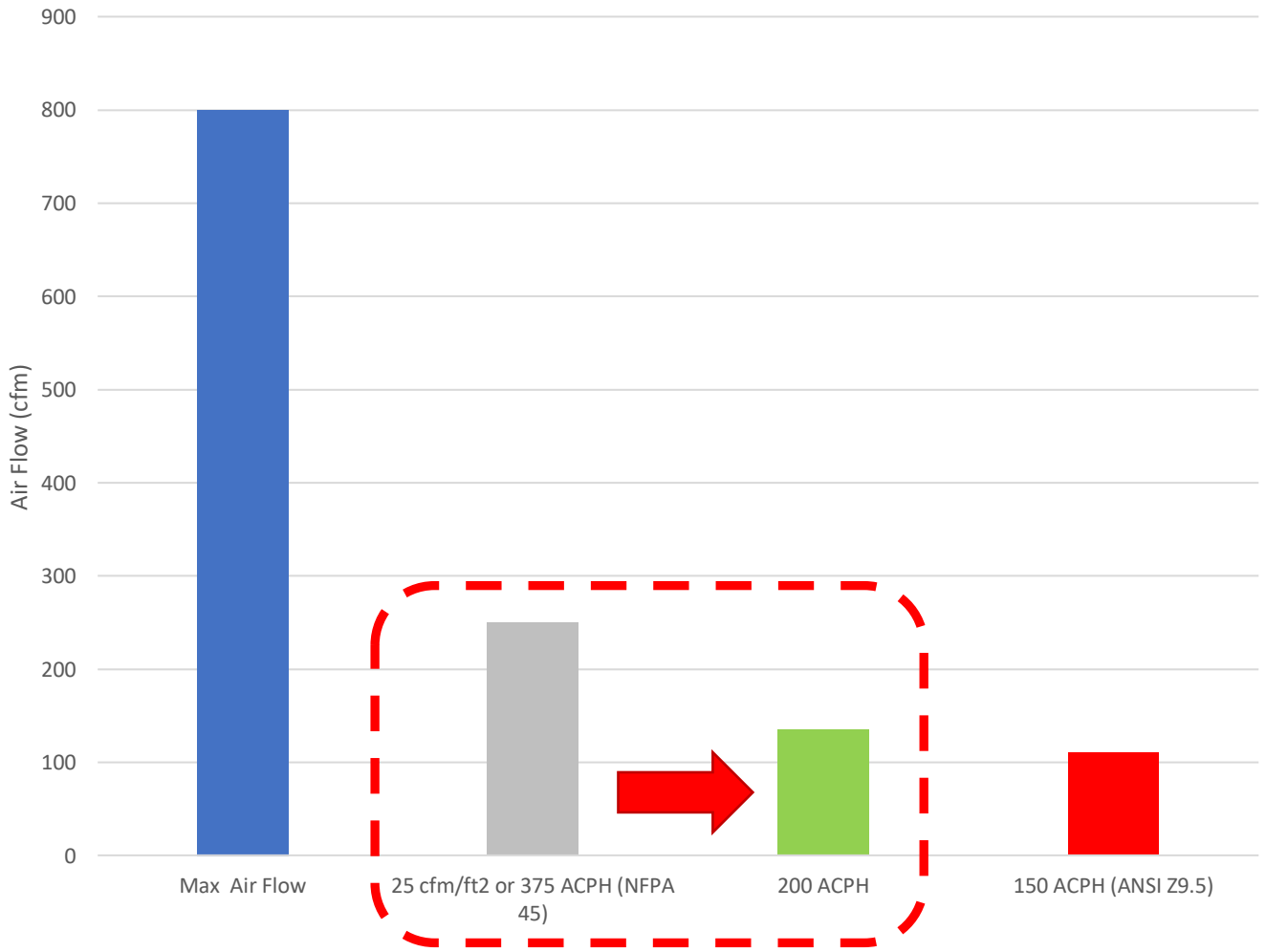
Effects Of Fume Hood Density



Effects Of Fume Hood Density



Effects of VAV Fume Hoods



Additional Considerations

- Thermal Load
- Facility Balance
- Impact to Non-Lab Areas
- Outside Air
- Original Design vs Current Usage
- Equipment Turndown
- System Effects

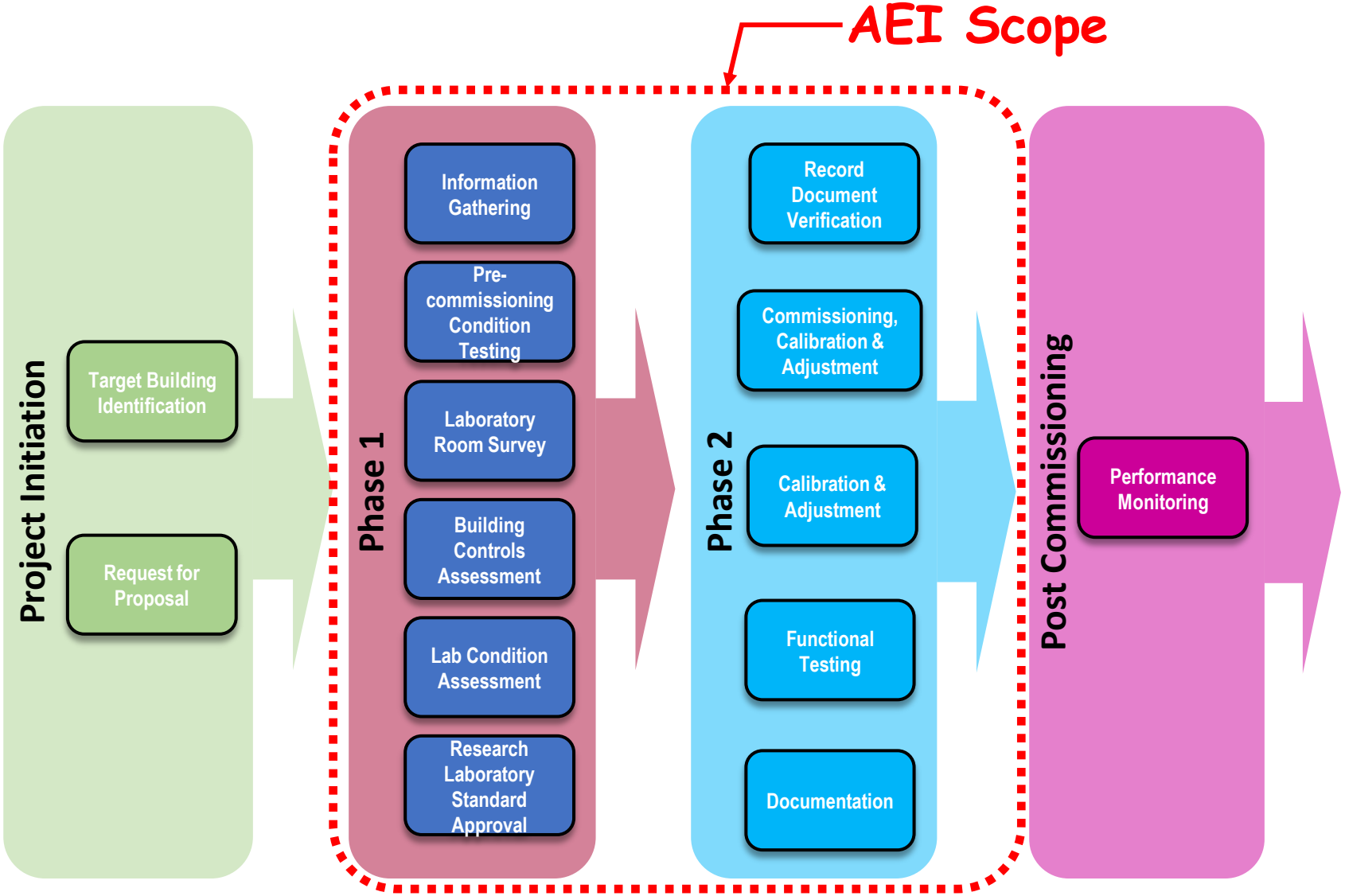


Implementation

- **Optimize Time in Each Lab**
  - Current Documentation
  - Preliminary Checklist and Test
  - Combine Visual Inspections with Testing
- **Minimize Impact to Lab and Facility**
  - Reduce Testing Time
  - Avoid Disruptive Activities
- **Maximize Schedule**
  - Organize Effort by Facility
  - Organize Effort by System (AHU/Exhaust)



Procedure


AEI Scope
Project Initiation
Target Building Identification
Request for Proposal
Phase 1
Information Gathering
Pre-commissioning Condition Testing
Laboratory Room Survey
Building Controls Assessment
Lab Condition Assessment
Research Laboratory Standard Approval
Phase 2
Record Document Verification
Commissioning, Calibration & Adjustment
Calibration & Adjustment
Functional Testing
Documentation
Post Commissioning
Performance Monitoring

Schedule/Planning

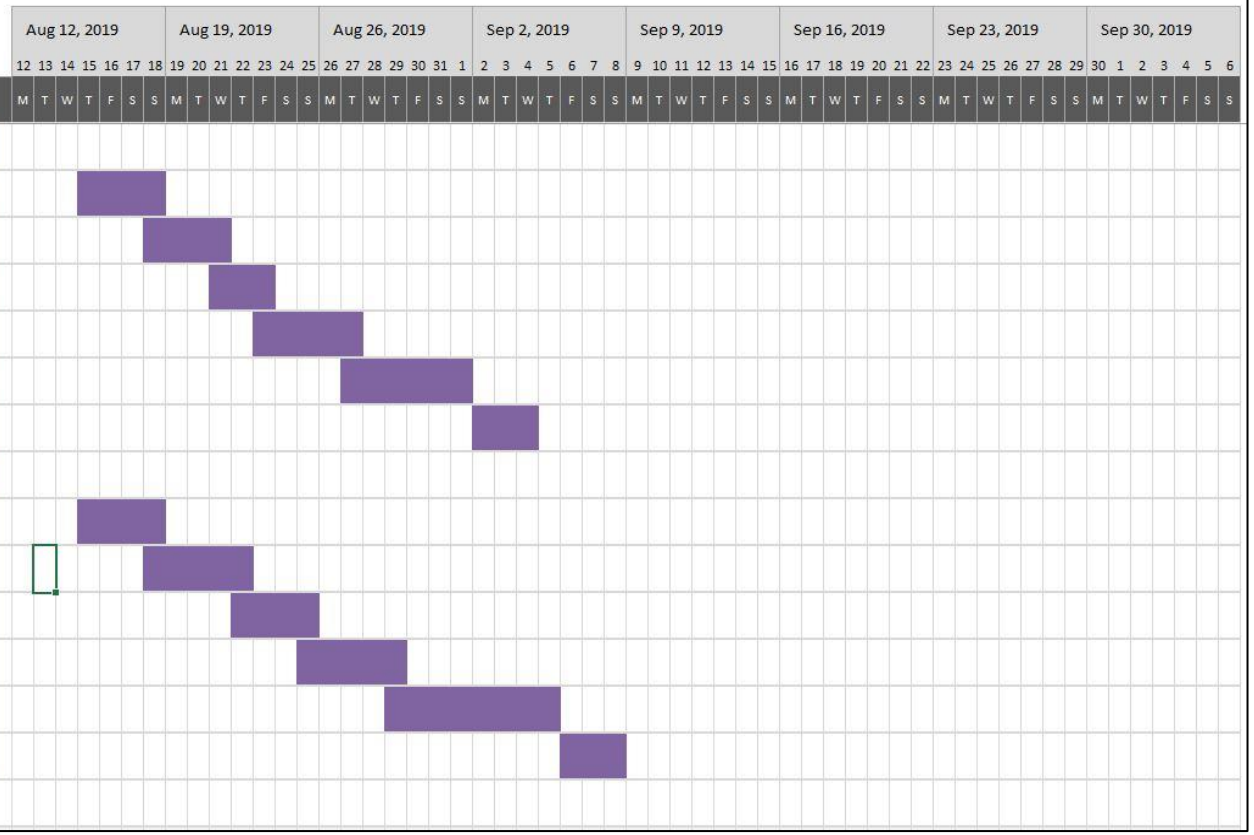
FSU Labs

Affiliated Engineers

Project Start: Thu, 8/15/2019

Display Week: 1

TASK	ASSIGNED TO	PROGRESS	START	END
Lab or Facility 1				
Planning	Watts	0%	8/15/19	8/18/19
Assessments	Field Team 1	0%	8/18/19	8/21/19
Light Cx	Field Team 1	0%	8/21/19	8/23/19
Design evaluation	Design Team 1	0%	8/23/19	8/27/19
Implementation	Field Team 1	0%	8/27/19	9/1/19
Reporting	Field Team 1	0%	9/2/19	9/4/19
Lab or Facility 2				
Planning	Watts	0%	8/15/19	8/18/19
Assessments	Field Team 2	0%	8/18/19	8/22/19
Light Cx	Field Team 2	0%	8/22/19	8/25/19
Design evaluation	Design Team 2	0%	8/25/19	8/29/19
Implementation	Field Team 2	0%	8/29/19	9/5/19
Reporting	Field Team 2	0%	9/6/19	9/8/19



Benchmarking Existing Conditions

Research Laboratory Standard

Utilities and Engineering Services

Building: King Life Sciences Date: 4/16/2020
Lab Number: 2014

The Research Laboratory Standard for each laboratory is a tool to assist Florida State University in maintaining high levels of safety and operational performance for its research facilities. The Research Laboratory Standard is a record of critical control points that maintain environmental conditions based on the specific materials and equipment being used in each laboratory. The intent of this process is to provide a controlled environment where process variables are known and variance is minimized, leading to a higher quality of research. This cannot be done without the communication and cooperation of EH&S, the research department, and Utilities and Engineering Services. **Any changes to flow parameters need to be approved by EH&S.**

		DESIGN	ACTUAL	TARGET Max	TARGET Min
Air changes per hour (ACH)	*Occupied*	10.2	9.7	10.4	6.2
	Unoccupied	7.3	-	7.4	4.8
Total Supply Air flow (cfm)	*Occupied*	1300	1326 *1300*	1300	700
	Unoccupied	876	-	876	490
Total Exhaust Air flow (cfm)	*Occupied*	1505	1338 *1400*	1500	900
	Unoccupied	1081	-	1076	690
Lab type					
Number of fume hoods		1	1	1	
Total fume hood exhaust (cfm)	*Max/Min*	550	460 *540*	500	400
Number of general exhaust valves		2	2	2	
Total general exhaust (cfm)	*Occupied*	1505	471 *360*	1000	90
	Unoccupied	1075	-	575	90
Other exhaust (cfm)			407 *500*	375	0
Room area (ft²)		886.0	866.9	866.9	
Ceiling height (ft-in)		10	10'	10'	
Room volume (ft³)		8860	8669	8669	
Volume of Cabinets, Very Large Equipment (ft³)		-	383.0	-	
Room air balance offset (cfm)		-205	-12	-200	
Room temperature set point (°F)		73.0	73.0	73.0	
Room temperature tolerances**	*Max/Min*				
Room humidity tolerances**	*Max/Min*				

** only applicable for research requiring specific constraints *BAS setpoints in italics.*

EH&S Approvals

Per Florida State University policy, EH&S has reviewed the target parameters for conformance to the appropriate ventilation rates accepted by both the University and applicable safety codes. The selected rates are based on the types of equipment utilized in the spaces as well as the type of research.

Environmental Health & Safety Representative Date

Facilities Acknowledgement

The target settings as approved by EH&S are also approved by Utilities and Engineering for implementation. No setting changes will be made to the system without the creation of a replacement standard that has been approved by EH&S.

Lab Program Manager Date

Thermal Comfort Verification Survey

Affiliated Engineers

In which area of the building is your space located?
☐ North ☐ East ☐ South ☐ West

Are you within 15 feet of an exterior wall? ☐ Yes ☐ No

Are you within 15 feet of a window? ☐ Yes ☐ No

Please rate the overall thermal comfort in your space:

-3	-2	-1	0	1	2	3
Very Dissatisfied						Very Satisfied

Please rate the thermal comfort in your space during warm or hot weather:

-3	-2	-1	0	1	2	3
Too Cold			Comfortable			Too Hot

Please rate the thermal comfort in your space during cool or cold weather:

-3	-2	-1	0	1	2	3
Too Cold			Comfortable			Too Hot

If you experience thermal discomfort (temperature and humidity), which of the following best describes it?
☐ Morning ☐ Afternoon ☐ Weekends ☐ Monday Mornings ☐ Always

If you experience thermal discomfort (temperature and humidity), which of the following best describes it?

☐ Too much/ too little air movement
☐ Heat from office equipment
☐ Vented air is too hot
☐ My workspace is hotter than other areas
☐ Hot floors and walls
☐ Thermostat is inaccessible/controlled by others
☐ Incoming sunlight heats up space
☐ Drafty windows
☐ Vented air is too cold
☐ My workspace is colder than other areas
☐ Cold floors and walls
☐ Other (Please explain below)

How satisfied are you with the air quality in your space?

-3	-2	-1	0	1	2	3
Very Dissatisfied						Very Satisfied

Overall, does the air quality enhance or interfere with your productivity?

-3	-2	-1	0	1	2	3
Interferes						Enhances

If you are dissatisfied with the air quality in your work area, is it: ☐ Stuffy/Stale ☐ Odorous

FSU Research Lab Standard Thermal Comfort Survey

Retro-Commissioning Tools

- Real time access to Documentation
- Free access to ALL active parties
- Unlimited reference file storage
- Streamlines tracks
- Documents issue and resolution
- Instant progress dashboard views
- Owner control over content

DASHBOARD

Overview

Affiliated Engineers Commissioning Practice | FSU Laboratory ACH-Recommissioning | 20370-00

Design Issues 0	Checklists 108	Tests 126	Equipment 3
	Accepted, Ready for FPT 99.07%	In Progr / Acceptance Recommended / Deficient Partial	Startup Complete 100%

Construction Issues 311	Checklist Lines 3634	Test Lines 4760	Tasks 0
Open 28.29% / Closed 71.06%	Yes 59.32% / No 25.56%	Yes 83.21%	

Design Issues 0

Status	Count	Percentage
Open	0	0%
In Progress	0	0%
Resolved	0	0%
Closed	0	0%

Construction Issues 311

Status	Count	Percentage
Open	88	28.29%
In Progress	2	0.64%
Resolved	0	0%
Closed	221	71.06%

Checklists 108

Status	Count	Percentage
Assigned	0	0%
In Progress	1	0.92%
Ready for GC Review	0	0%
Ready for CxA Review	0	0%
Accepted, Ready for FPT	107	99.07%

Checklist Lines 3634

Answer	Count	Percentage
Yes	2156	59.32%
No	929	25.56%
N/A	537	14.77%
	12	0.33%

Tests 126

Status	Count	Percentage
Assigned	5	3.96%
In Progress, No Recommendation	29	23.01%
Acceptance Recommended	64	50.79%
Deficient, Partial Retest Required	28	22.22%
Deficient, Complete Retest Required	0	0%
Deficient, Multiple Test Attempt Failures	0	0%

Test Lines 4760

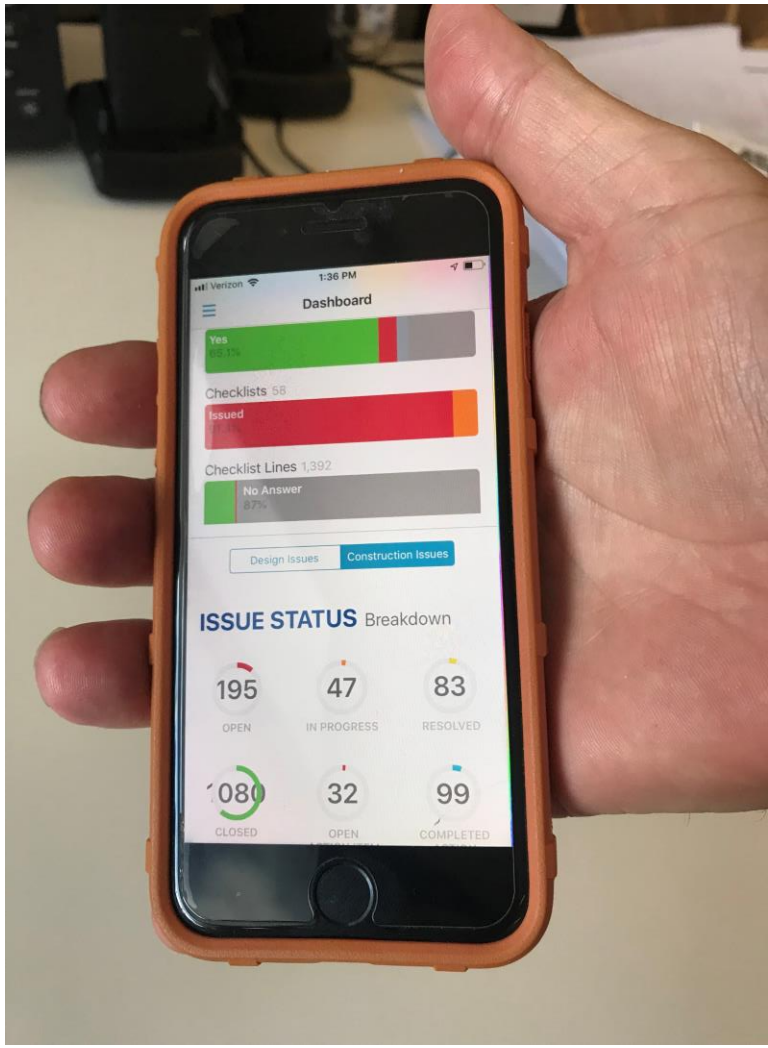
Answer	Count	Percentage
Yes	3961	83.21%
No	217	4.55%
N/A	380	7.98%
	202	4.24%

Equipment 3

Status	Count	Percentage
Scheduled	0	0%
Received / Inspected / Stored	0	0%
Installation in Progress	0	0%
Installation Complete	0	0%
Startup Complete	3	100%

Tasks 0

Status	Count	Percentage
Not Done	0	0%
Done	0	0%



Documentation

CHECKLIST

#67 3067A - FSU Lab VAV

Affiliated Engineers Commissioning Practice | FSU Laboratory ACH-Recommissioning | 20370-00

ACCEPTED, READY FOR FPT

Type Installation Verification
Asset 3067A

Lines 36

		LAB CONFIGURATION	
✓	1	Configuration for application is correct in accordance with project records	
✓	2	Configuration for application is correct in accordance with manufacturer records	
✓	3	Sensors associated with the LTU as described in the Sensor Verification section	
		MAINTENANCE	
✓	4	Confirm no water leaks	
✓	5	Confirm strainers have been maintained	
✗	6	Controller is functional and error free.	
		ROOM AND SENSOR VERIFICATION	
✗	7	Supply air flow is within calibration tolerance Airflow 172 CFM Actual 302 CFM	
✗	8	Supply air valve modulates to maintain setpoint	
✗	9	Exhaust air flow is within calibration tolerance Airflow 324 CFM Actual 415 CFM.	
✗	10	Exhaust air valve modulates to maintain setpoint	
✓	11	Room temperature sensor is within calibration tolerance Temperature 74.25 actual 73.6	
½	12	Room humidity sensor is within calibration tolerance	
✓	13	Room Offset/pressure is within tolerance	
✓	14	Supply temperature sensor is within calibration tolerance Temperature 58 actual 60	
		ALARMS & GRAPHICS VERIFICATION	
✓	15	Alarms function per design	

Checklists | Printed on 06/04/2020 | Page 114 of 708

TEST

#76 3067A - Air Change Test & Acceptance Phase 2

Affiliated Engineers Commissioning Practice | FSU Laboratory ACH-Recommissioning | 20370-00

IN PROGRESS, NO RECOMMENDATION

Assigned To Affiliated Engineers, Inc. - Gainesville
Asset 3067A

Attempts Most Recent

Attempt No. 1 IN PROGRESS, NO RECOMMENDATION — Status set by Michael Watts on 4/7/2020.

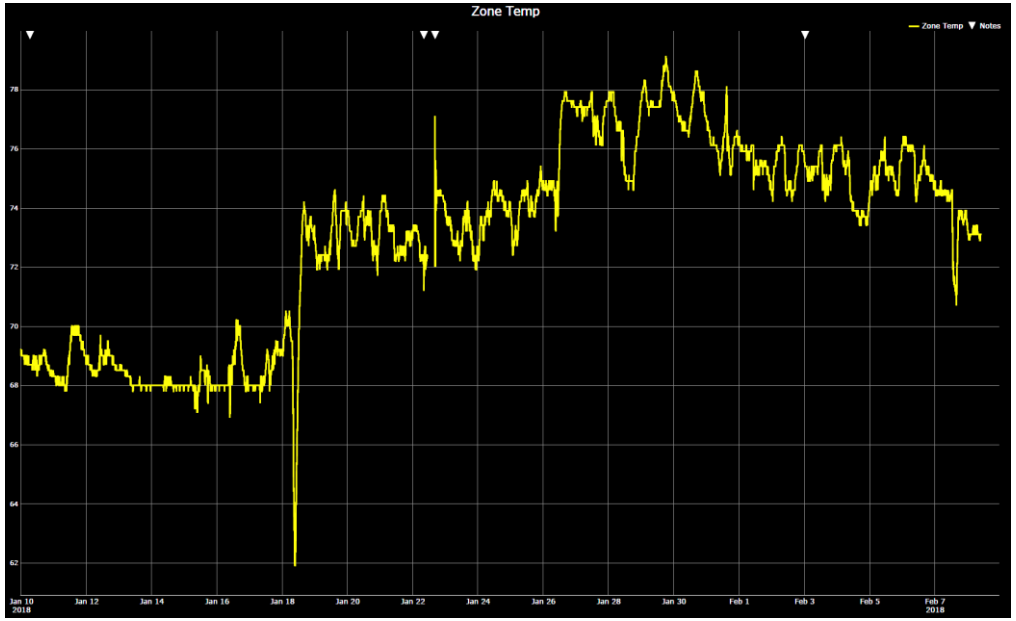
THIS TEST IS TO CONFIRM (1) AIR CALIBRATIONS ARE COMPLETE, (2) INITIAL CONDITIONS ARE DOCUMENTED, (3) AIR FLOW SETPOINTS ARE ADJUSTED, (4) ROOM IS STABLE AND OPERATING AT TARGET CONDITIONS, AND (5) FINAL CONDITIONS ARE DOCUMENTED (APPLICATION 2459)

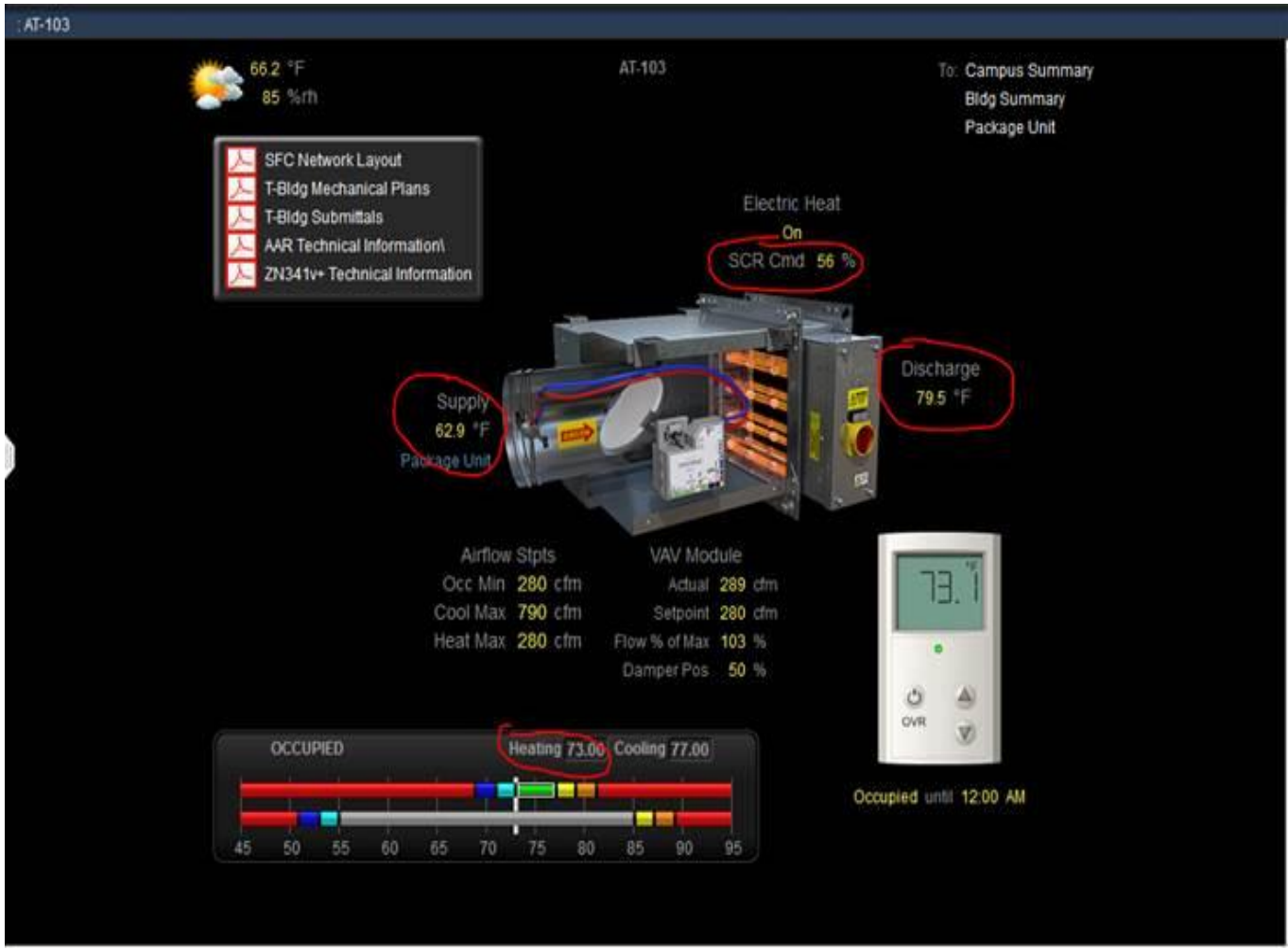
		AIR FLOW CALIBRATIONS
YES	1	Verify airflows are calibrated (Airflow Calibration Test is complete)
YES	2	Verify room pressure is satisfactory for the conditions
YES	3	***Accepted***
		INITIAL CONDITIONS - ON THE BAS TAKE SNIPPETS OF THE INITIAL CONDITIONS AND SAVE TO THE PROJECT FOLDER UNDER THE ROOM NUMBER FOR INITITAL CONDITIONS
YES	4	Room Graphic
N/A	5	Snorkel Exhaust Graphic
N/A	6	Fume Hood Graphic
YES	7	Record Room Temperature (point 4) Temperature - Space 74.25 °F
YES	8	Record Room Temperature Setpoint (point 13) Temperature - Space Setpoint 74 °F
YES	9	Record % Heating (point 49) Position Command 100 % coil da-t 90.5 degf
YES	10	Record % Cooling (point 79) Command - Loop Output 0 %
YES	11	***Accepted***
		AIR FLOW CHANGES SECTION
YES	12	Verify the RLS sheet has the target airflows and is approved to use
		ON THE BAS, CHANGE THE FOLLOWING AIRFLOW SETPOINTS TO TARGET AIRFLOWS ON THE RLS:
YES	13	Point 31 - Occ Sup Max Airflow - Cooling Maximum Supply Setpoint 220 CFM
YES	14	Point 32 - Occ Sup Min

Tests | Printed on 06/04/2020 | Page 372 of 708

Implementation

- Functional Testing
- Performance Verification
- Documentation
- Trending





King Life Sciences Background

- **Completed in 2008**
- **181,000 Gross Square Feet**
- **Five Floors**
- **Biological Science Department**
- **Interdisciplinary Life Science Education and Research**
  - Wet and Dry Labs
  - Wet Teaching Labs Convertible to Research Labs
  - Auditorium, Classrooms and Offices

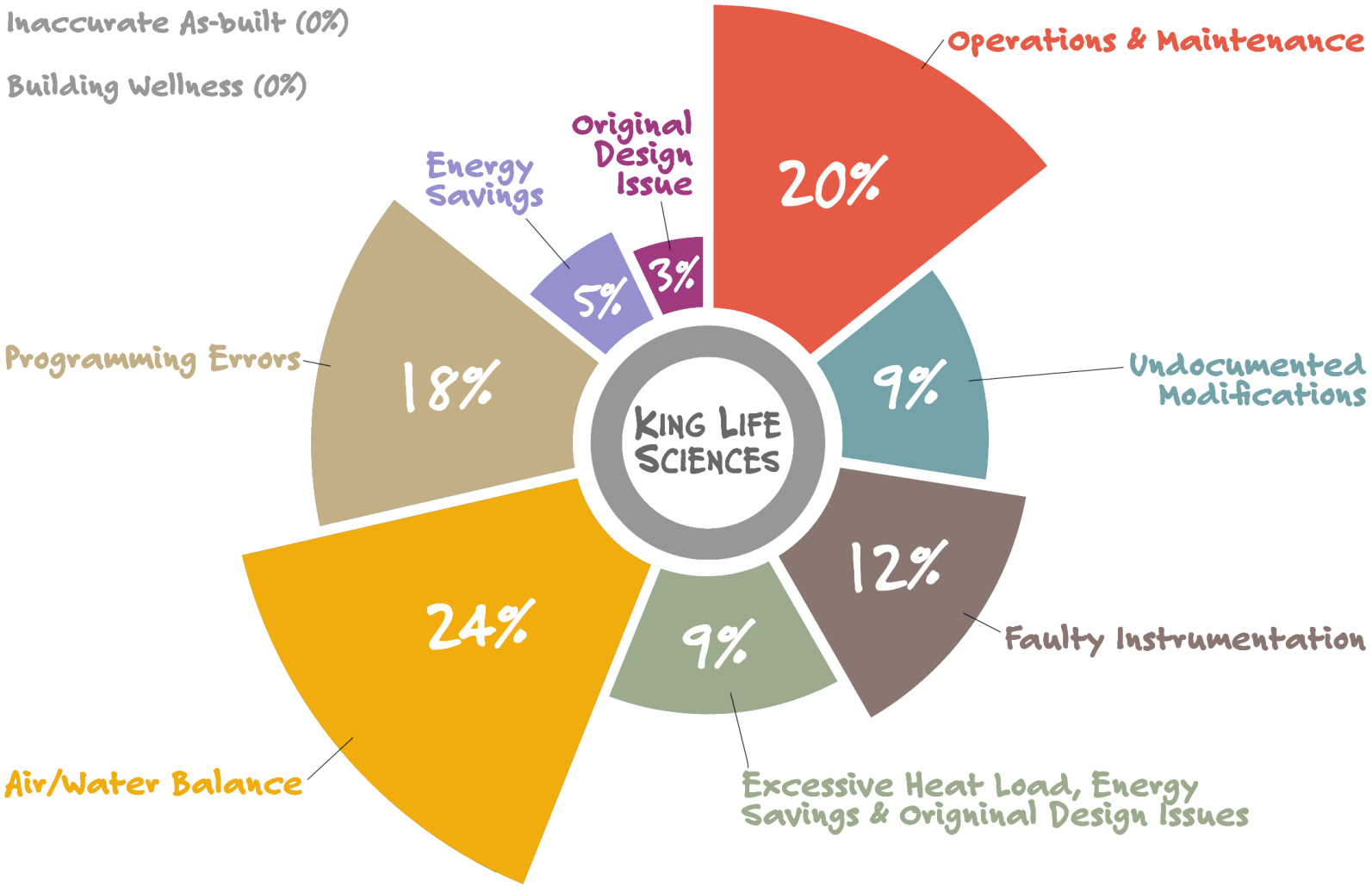


King Life Sciences Results

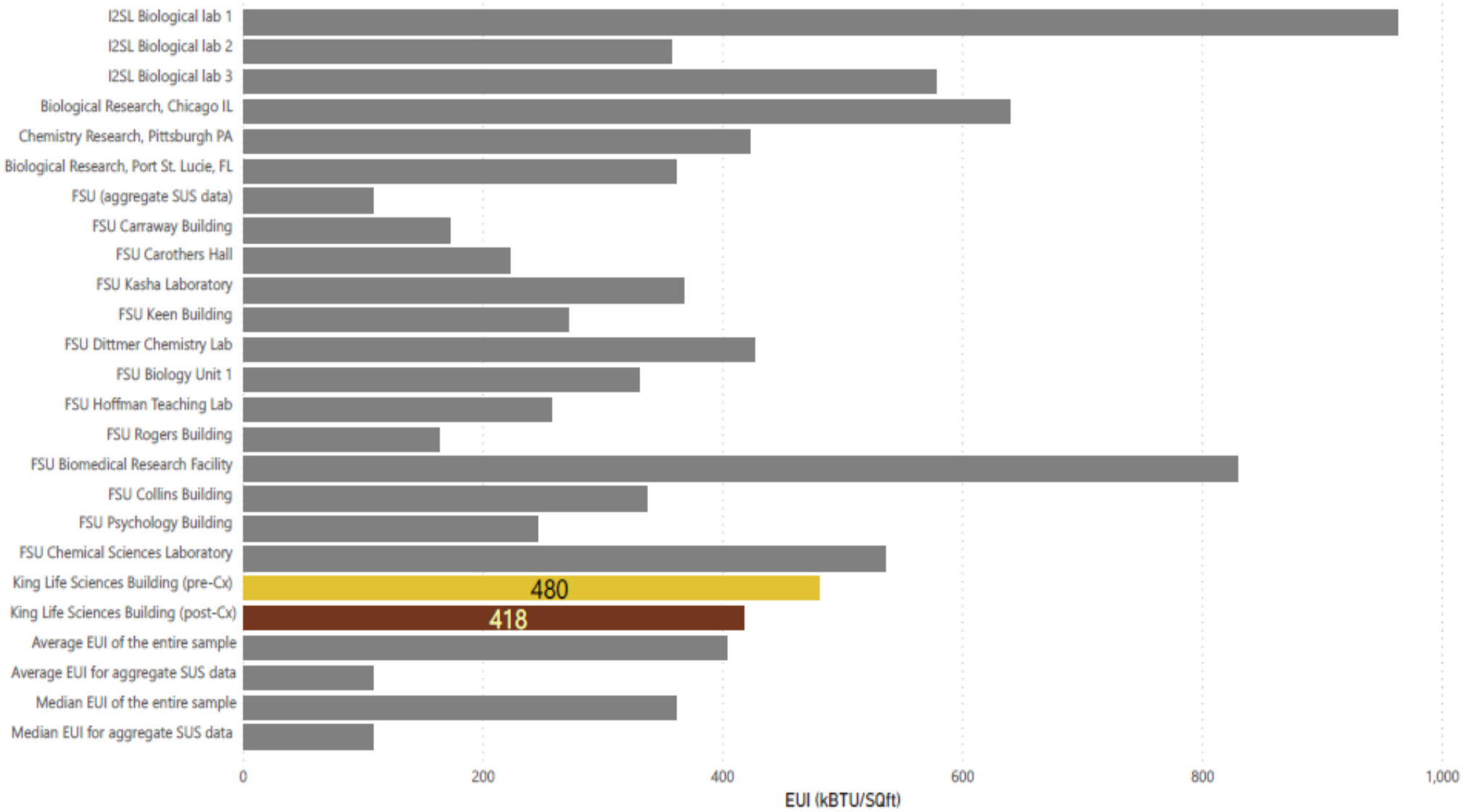
- ***Excessive Heat Load:*** Current load in area exceeds original design intent (refrigerators, freezers, computers, other heat producing equipment in excess of what was originally planned for)
- ***Energy Savings:*** Energy conservation measure
- ***Building Wellness*:** Opportunity to improve indoor air quality, or to prevent future indoor air quality issue
- ***Undocumented Design Modifications:*** Undocumented additions or modifications to the HVAC systems that will impact system operations
- ***Operation and Maintenance:*** Issues that are due to the operational settings of systems or additional maintenance needs that can be resolved by the Facilities/Maintenance staff through a work order
- ***Air Balance/Water Balance:*** Test & Balance effort needed to correct issue
- ***Programming Incomplete/Errors:*** Issue found within the building automation software
- ***Design Issues:*** Issue found with original design compared to current best practices
- ***Future Capital Improvement:*** Opportunity outside the scope of the project
- ***As-builts:*** Actual installation varies from as-built documentation
- ***Control Instrumentation:*** Components out of calibration, or not working properly; this includes controllers, field panels, etc.

King Life Sciences Results

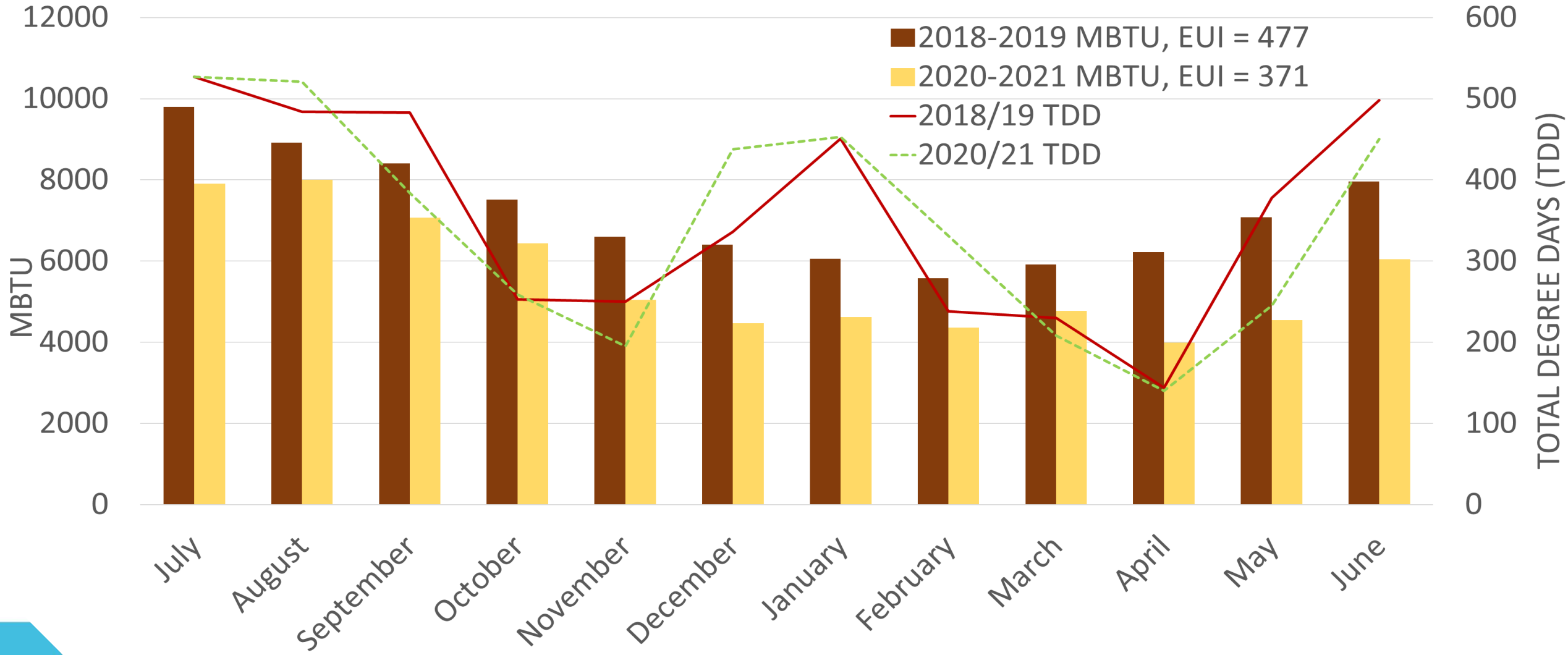
221 of 311 issues resolved



King Life Sciences Predicted Results



King Life Sciences Actual Results



College of Engineering Background

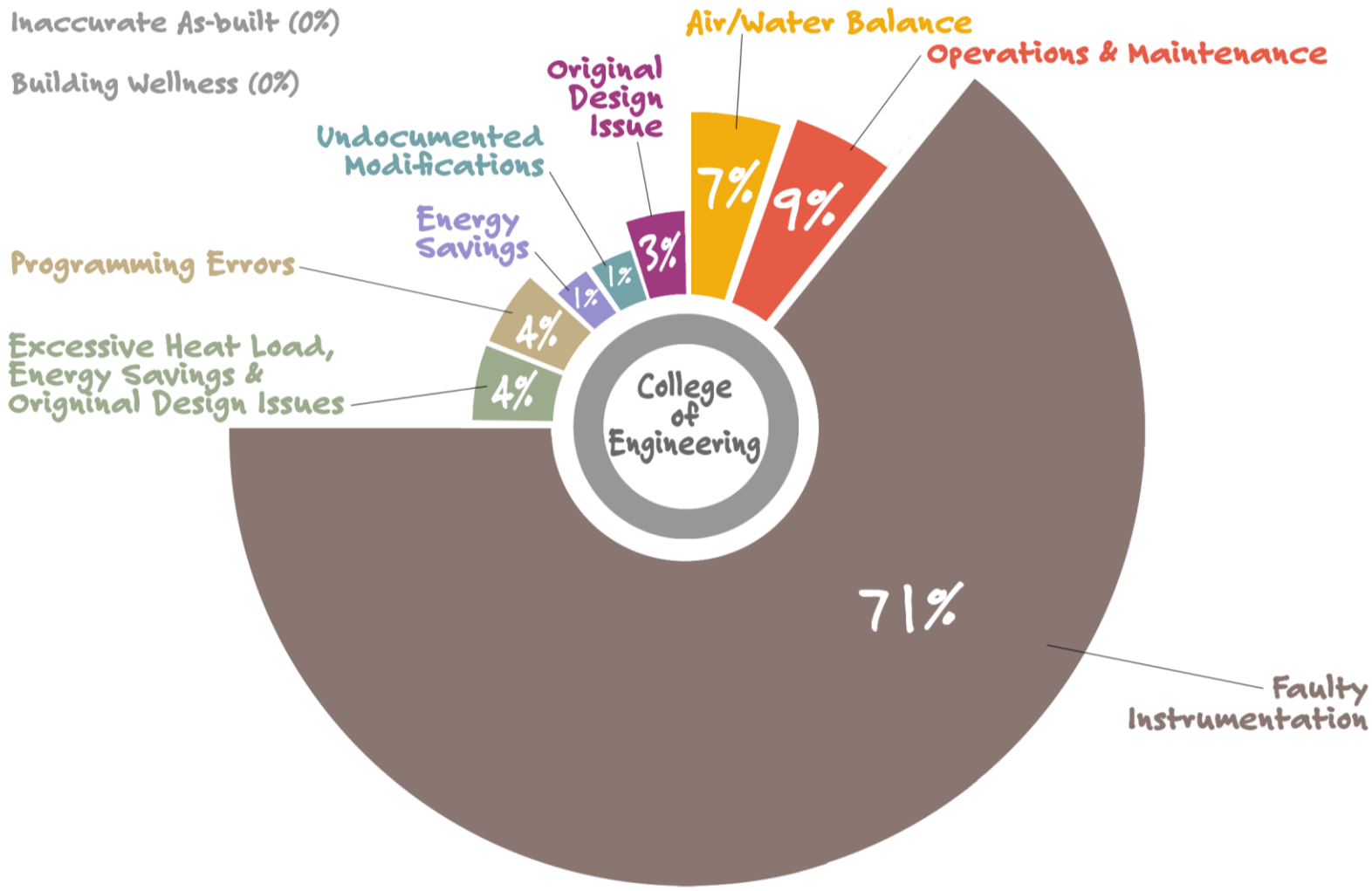
- **Building A Completed in 1988**
  - 127,000 Gross Square Feet
- **Building B Completed in 1998**
  - 98,000 Gross Square Feet
- **Three Floors**
- **Interdepartmental Academics and Research**
  - Chemical/Biomedical
  - Civil/Environmental
  - Electrical and Computer
  - Industrial & Manufacturing
  - Mechanical



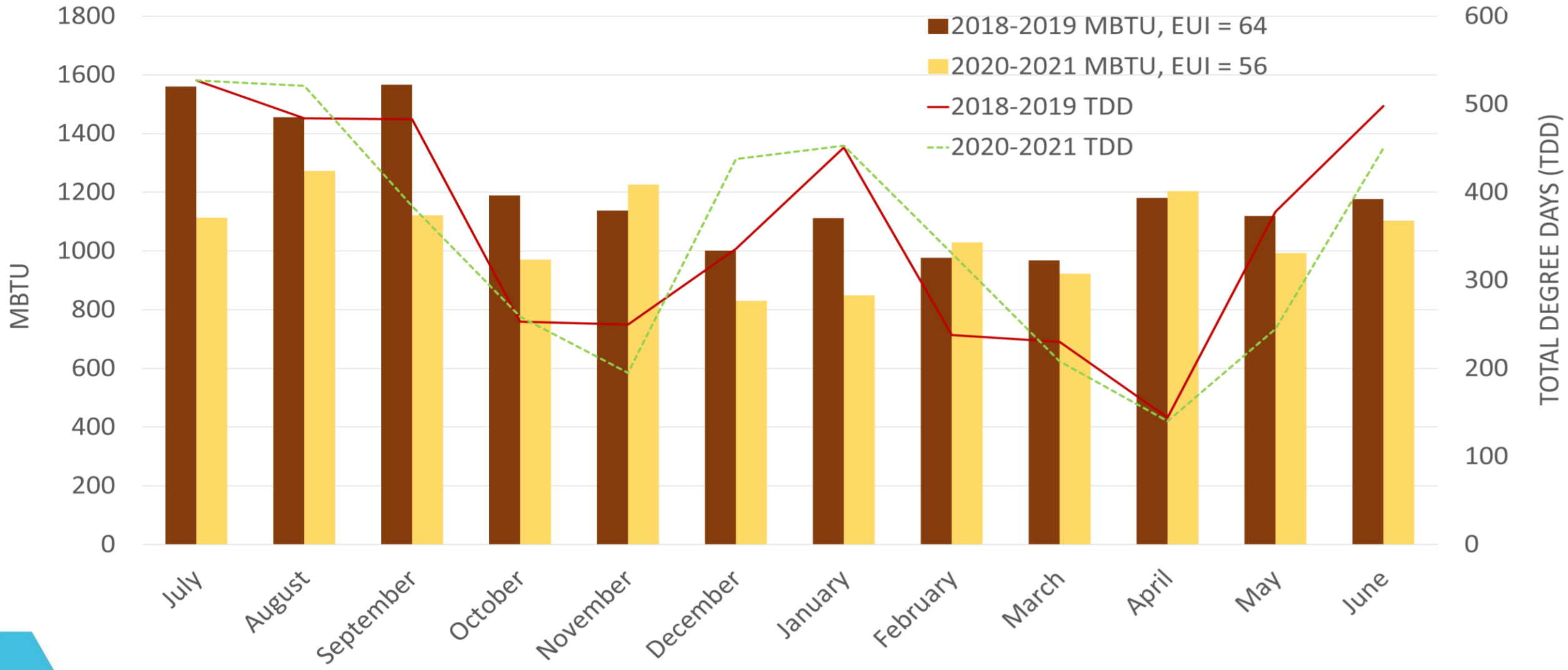


College of Engineering Results

47 of 148 issues resolved



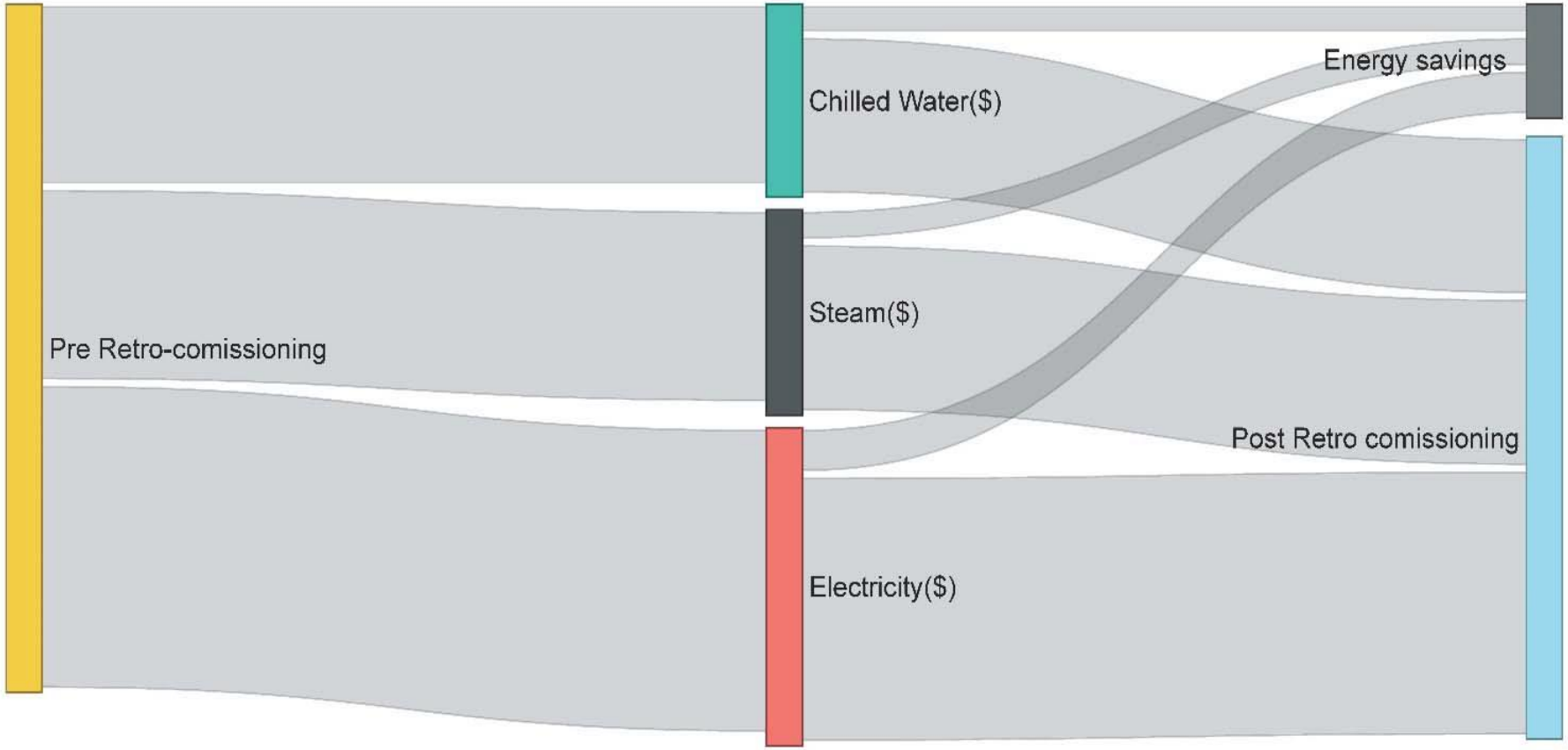
College of Engineering Actual Results



Lessons Learned

- **Importance of stakeholder team, led by Utilities & Maintenance**
  - Gain buy-in from occupants
  - Manage Perceptions and Behavioral Change
- **Pre-screen buildings with retro-commissioning team to maximize value and streamlines process**
- **Curate good record documents and merge prior to any field work - maximizes efficiency**
- **Pre-define a plan for resolving issues outside the scope of retro-commissioning, according to categories; allows back-checking without the need to re-mobilize**
  - Work Orders
  - RFPs for quick-response service providers
  - Maintenance projects
  - Capital projects
- **Consider adding Phase 3 for Documentation, Benchmarking, and Record Document Revisions**
- **Consider adding Post-Occupancy Phase**

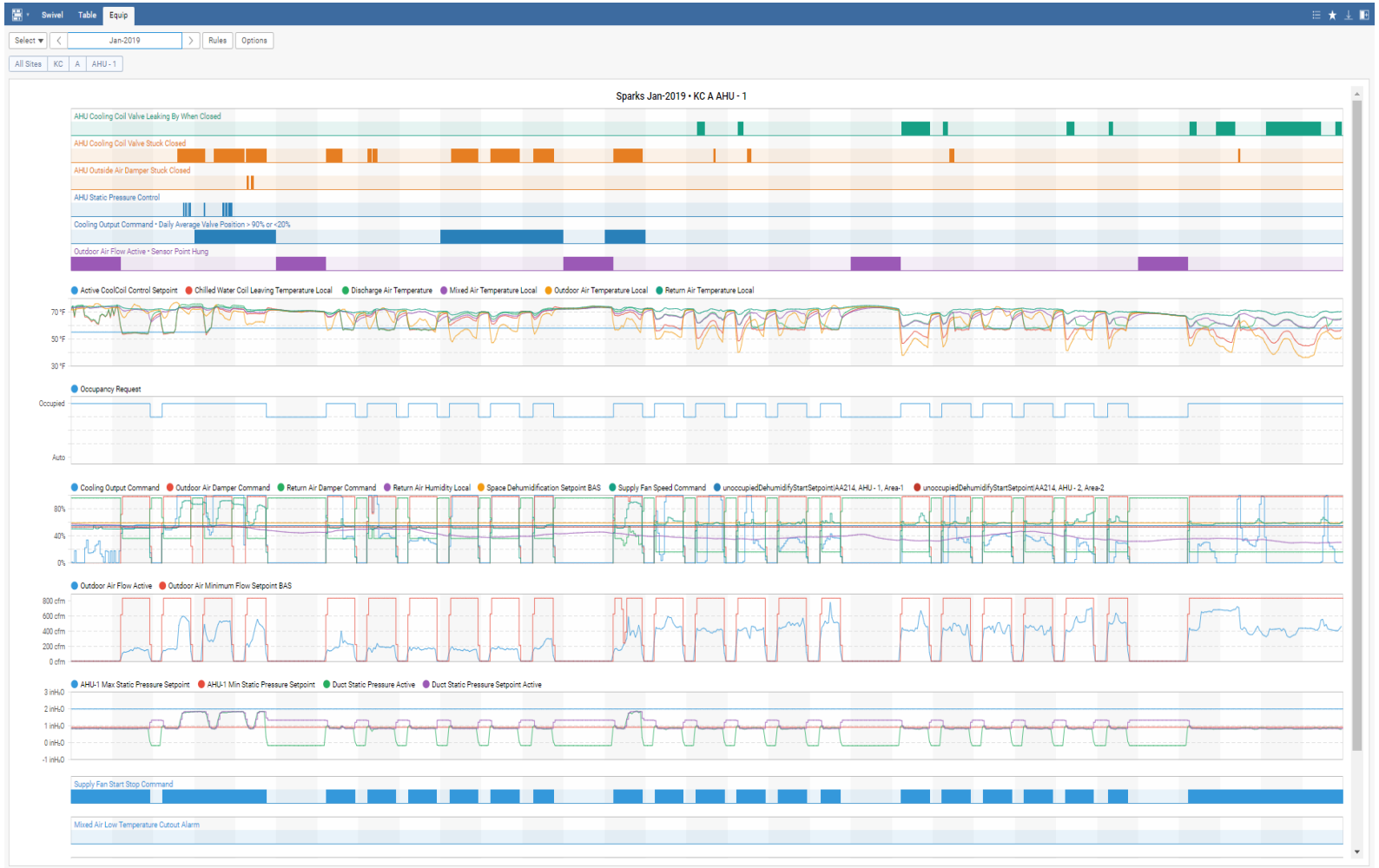
Granularity



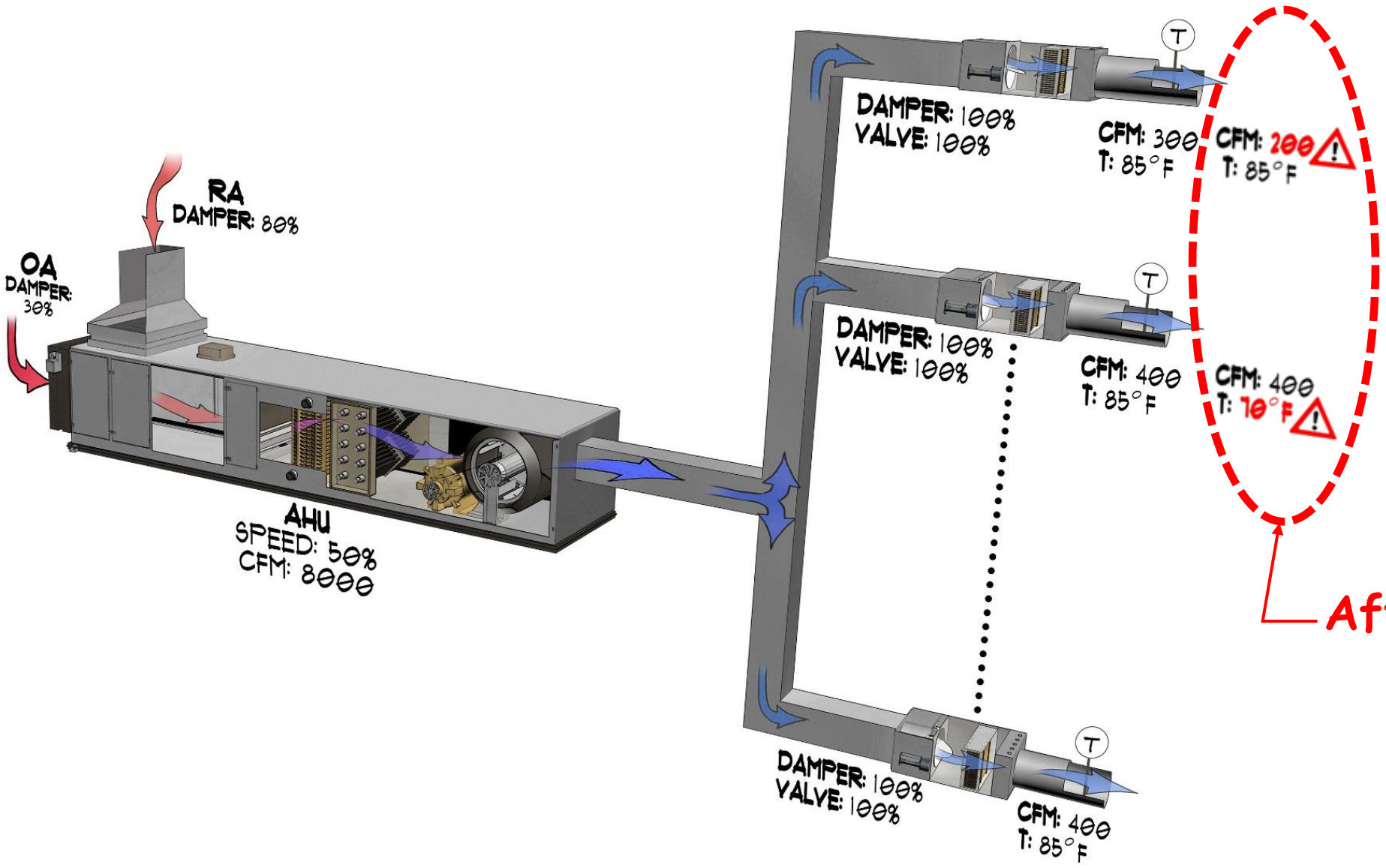
Fault Detection

Sky Spark Rule Set

- AHU OA Damper Stuck Closed
- AHU OA Damper Stuck Open
- AHU Simultaneous Heating and Cooling
- AHU Cooling Coil Valve Stuck Closed
- AHU Cooling Coil Valve Stuck Open
- AHU Heating Coil Valve Stuck Closed
- AHU Heating Coil Valve Stuck Open
- AHU Controlled Device Stability
- AHU Static Pressure Control
- Chiller Design Temperature Delta
- Chiller High Pump DP Reset
- Cooling Tower Approach Temp
- Air Terminal Damper Stuck Closed
- Air Terminal Damper Stuck Open
- Air Terminal High Reheat Utilization
- Equipment Running In Unoccupied Mode
- Sensor Point Hung



Automated Commissioning



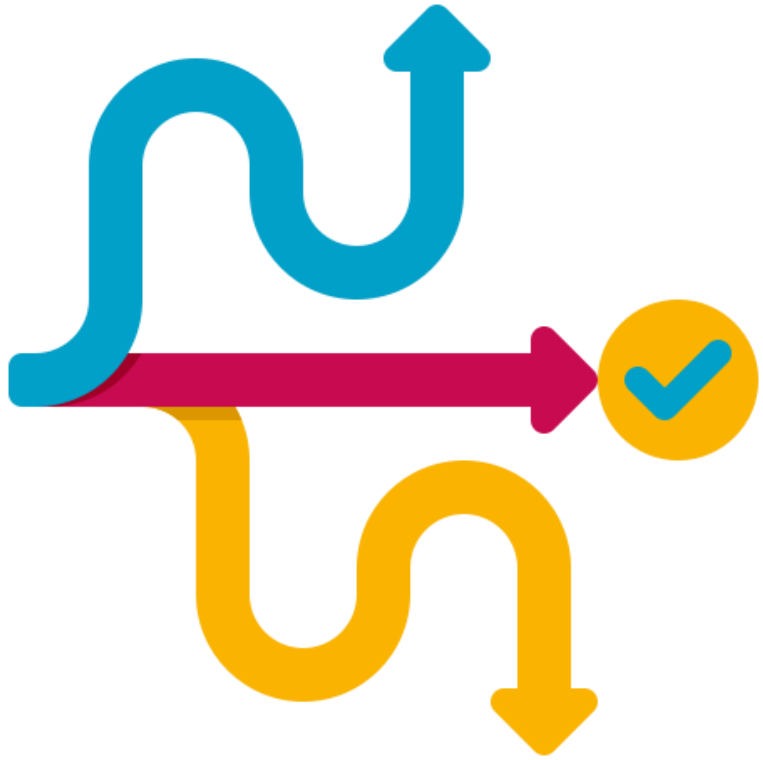
Behavioral Change

- **Low-temperature Storage**
  - Inventory management
  - Preventative maintenance
  - Procurement
- **Sash Management Programs**
- **Harvard “Shut the Sash” Case Study**
  - Normalized goals from lab to lab based on number of hoods, usage patterns, and air flow rates
  - Integrated with building controls to track performance of users
  - Monthly and bi-annual rewards
  - 30% reduction in fume exhaust levels
  - Highly recognizable



Conclusion

- **Process**
- **Results, 3-5 year payback**
- **Mitigate component failures and limited availability of skilled labor with:**
  - Simplicity in System Design
  - Periodic Retro-commissioning
  - Additional Staff Training
  - Smart Building Systems
- **The most efficient lab is the one that you don't have to RE build.**



Questions?

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