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Ventilation Management in Laboratories: Big Energy Savings and Improved Safety

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Energy
Exchange

Better Buildings[®]
SUMMIT

Airflow Management for High Performance Labs and Critical Control Environments

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President



Exposure Control Technologies, Inc.

919-319-4290

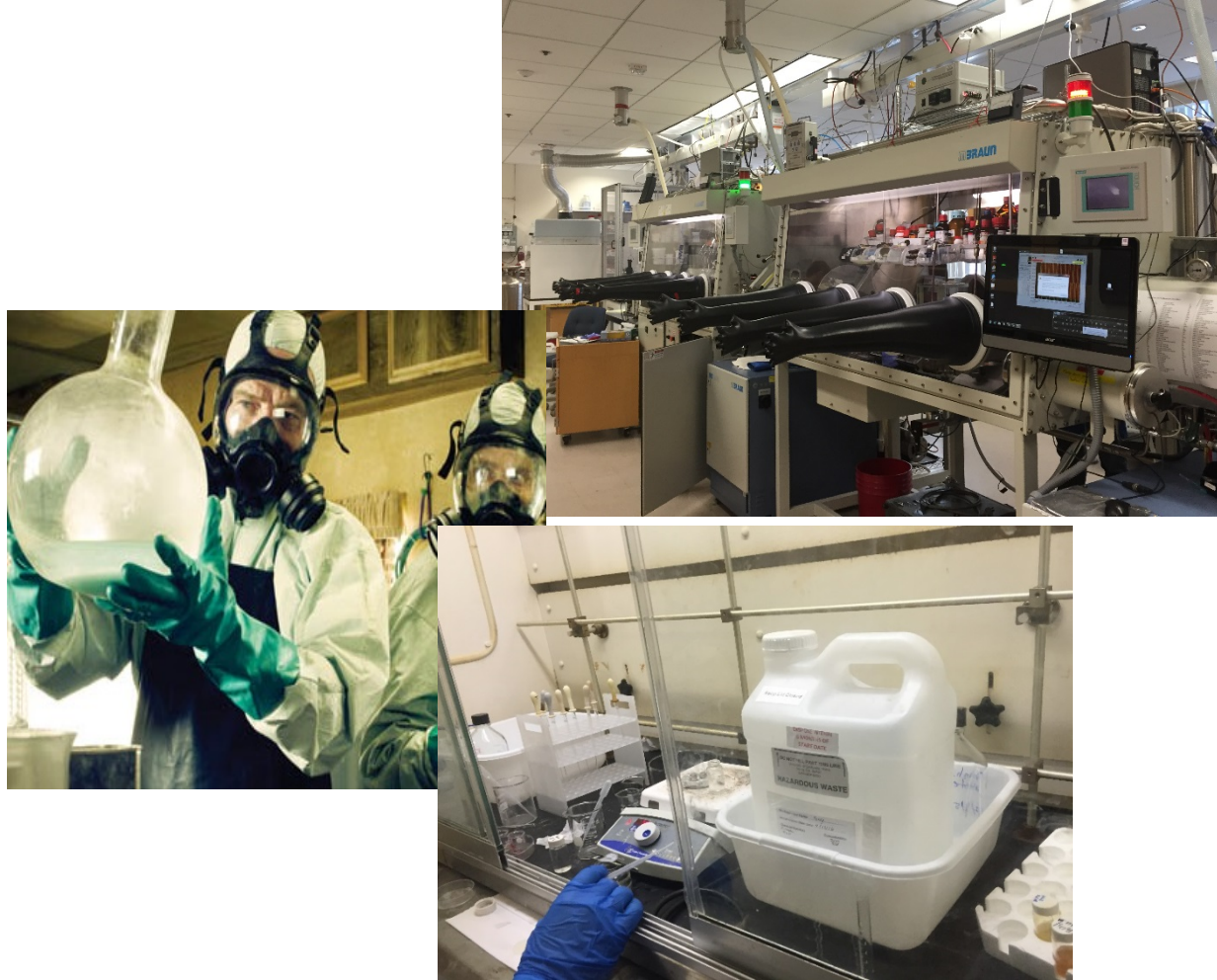
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Labs are specially designed to provide safe and controlled environments that promote science

Hazards

- Chemical
- Biological
- Radiological
- Physical

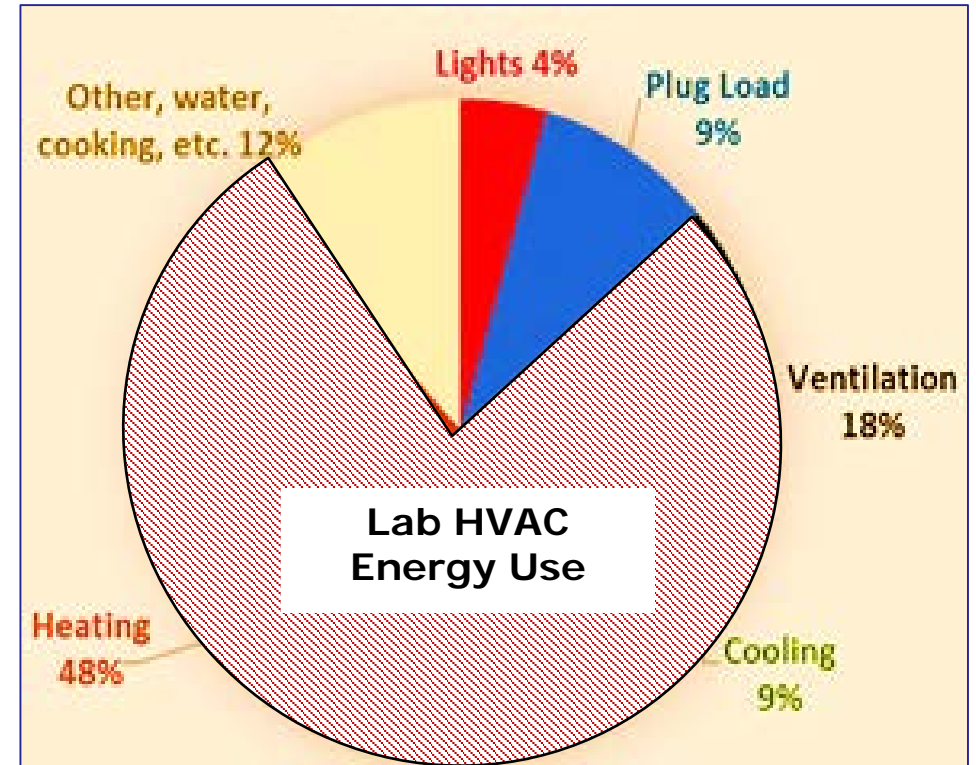


Laboratory buildings are expensive and complicated

- Average Size of Lab Building $\approx 100,000 \text{ ft}^2$
- Cost of Construction_(USA) \approx \$45 Million to \$100 Million
- Energy Cost \approx \$700,000/year (Avg. \$7 per ft^2)

45% to 85% of the energy is consumed by Fume Hoods and the Lab HVAC Systems

- Lab HVAC and Fume Hoods \approx 30% of Construction Cost
- Fume Hood Installation \approx \$25,000 - \$50,000 each
- Fume Hood Annual Cost \approx \$2,400 – \$5,000 per year



As much as 50% of HVAC energy is wasted by excess airflow, inefficient fume hoods and improper modulation of flow

Improperly designed and aging labs can adversely affect safety, energy use, operating costs and research results

- Fail to meet occupant needs
- Poor control of environmental conditions
- Increased risk and potential for liability
- Inefficient and costly to operate
- Poor retention and recruitment of talent
- Escalating Deferred Maintenance

Building System	Percentage costs of the	
	DM Costs	total DM costs
HVAC	\$132,917,184	35%
Electrical	\$79,750,310	21%
Exterior Systems	\$49,369,239	13%
Interior Systems	\$41,773,972	11%

Success requires a combination of efforts

- **Design and Mechanical Attributes**

- High performance fume hoods
- Variable Air Volume Systems
- High efficiency mechanical systems
- Building information and control systems

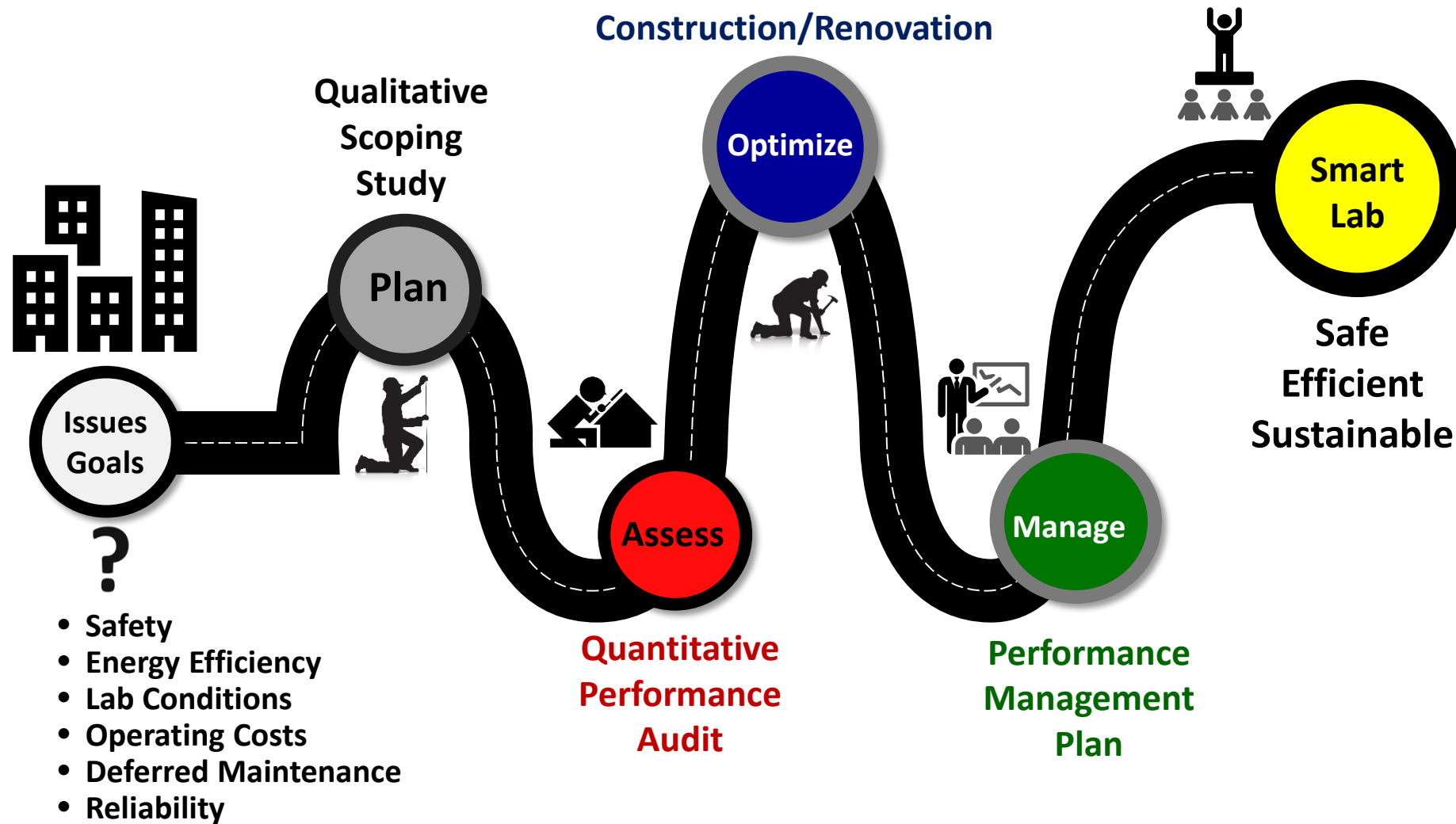
- **Management and Leadership**

- Occupant Information and Floor Plans
- Ventilation Safety Demand Assessment
- System Diagrams and Airflow Specifications
- Airflow Management Program (AMP)
- LVMP Manager / Coordinator



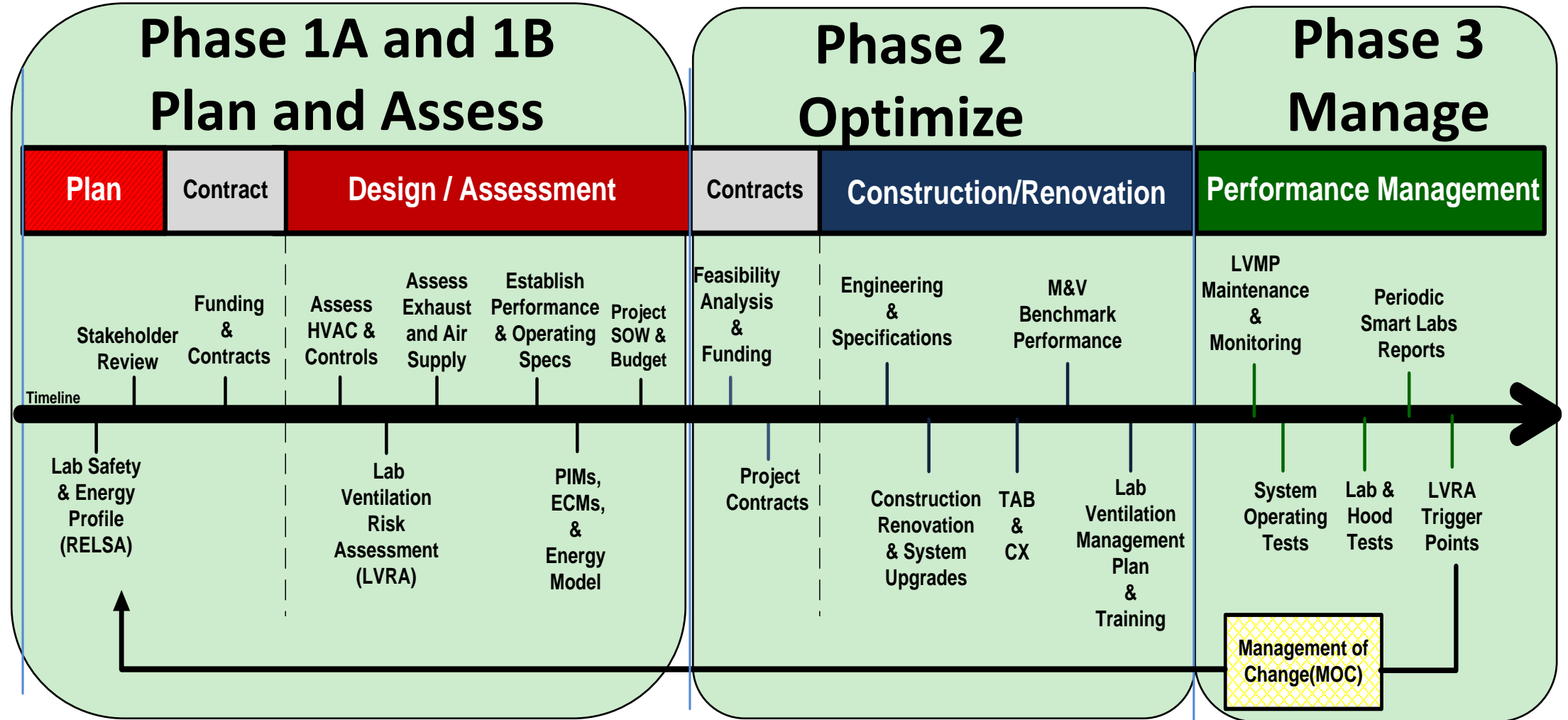
Lab Ventilation Management Plan

Smart Labs™ provides a roadmap to success

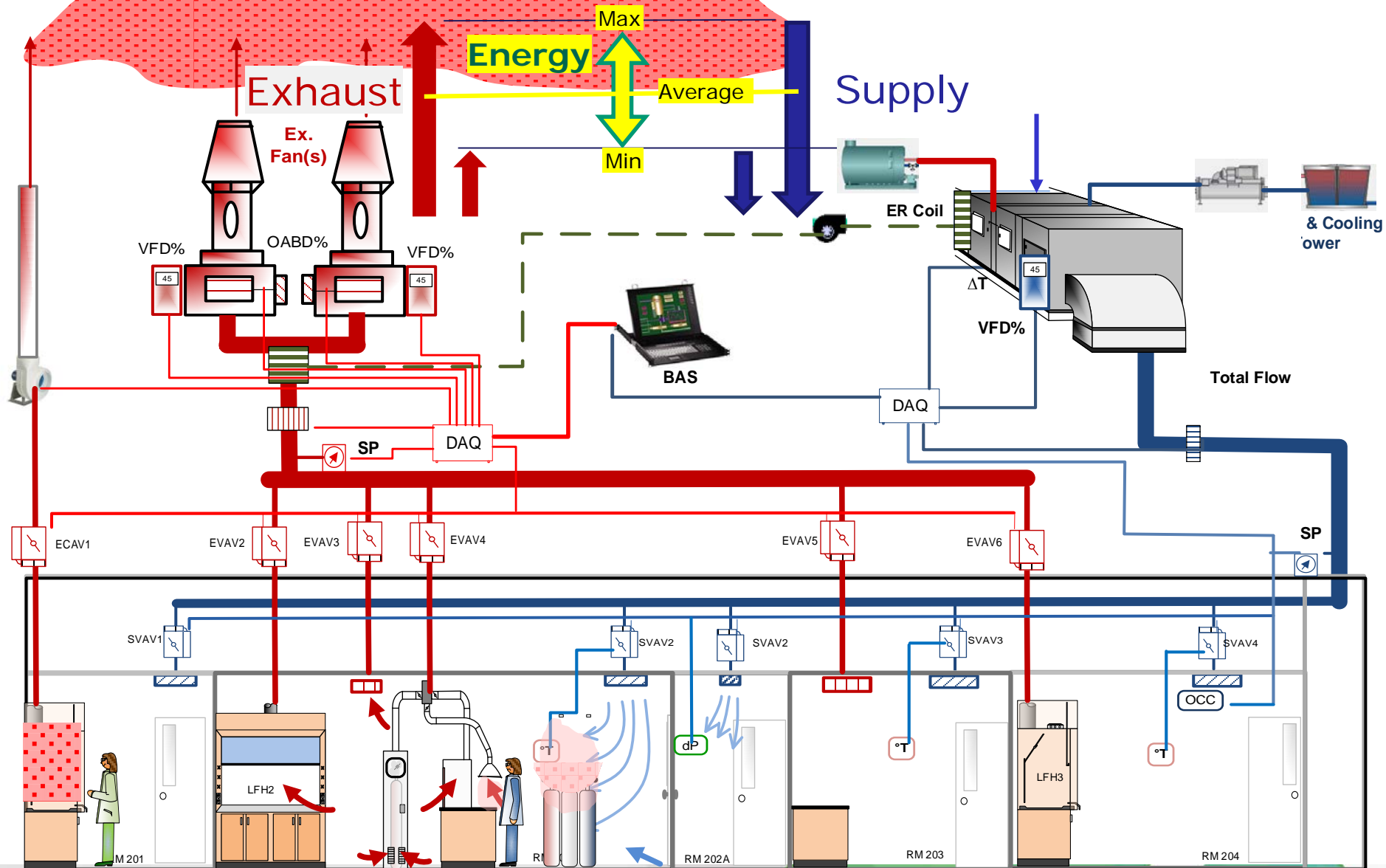


Roadmap to Smart Labs™

High Performance Ventilation Systems



Ventilation drives both safety and energy use



The Demand for Ventilation establishes the design and operating requirements

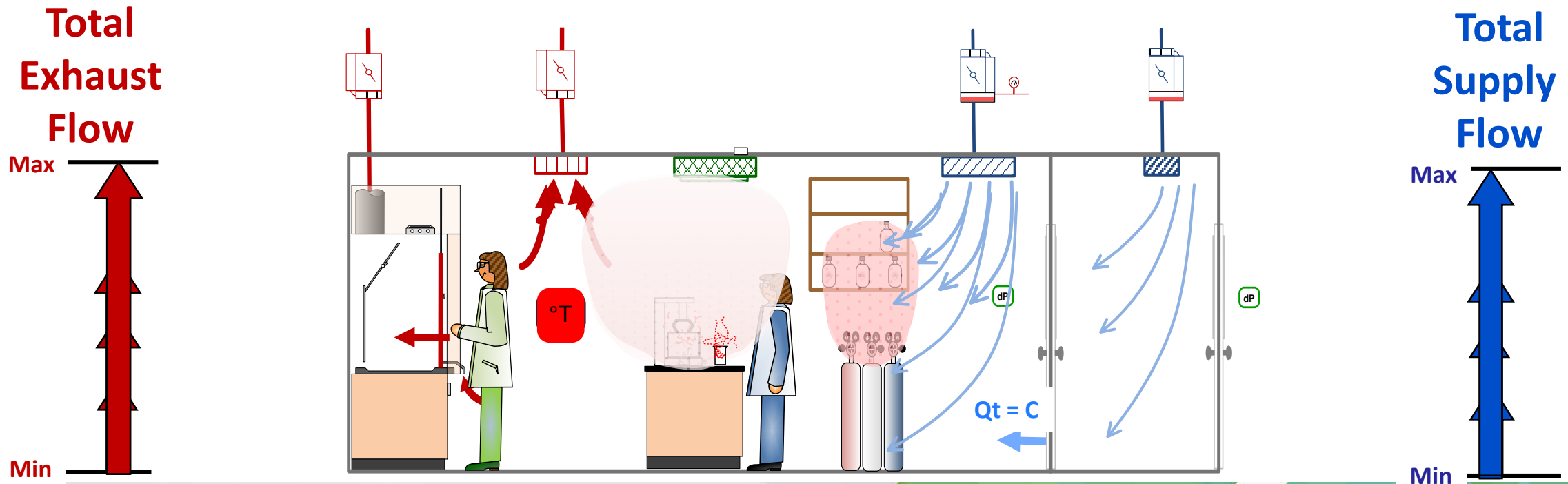
- **Safety (Risk)**
 - Fume Hood Flow
 - Contaminant Removal (ACH)
 - Isolation (Lab Pressurization)
- **Comfort & Productivity**
 - Temperature
 - Humidity
- **Occupancy & Utilization**



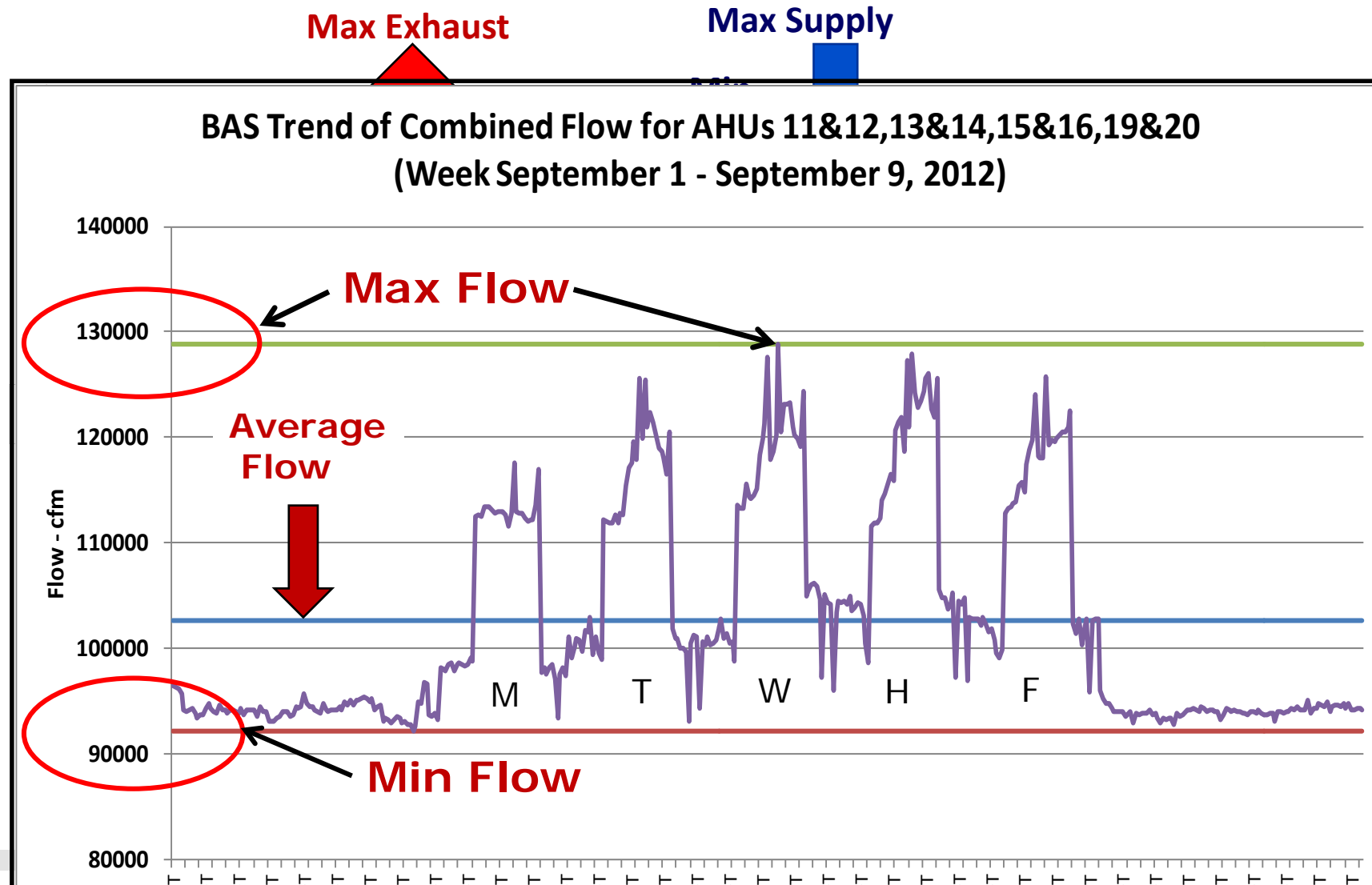
Minimum flow and range of modulation required to meet the safety and functional requirements of the occupants

The Airflow Control System is intended to modulate flow to meet the demand for ventilation

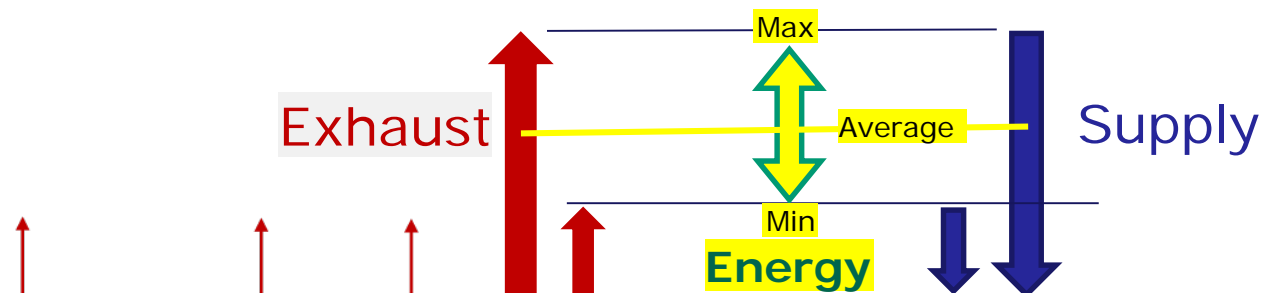
- Unoccupied Lab - Sashes Closed - Min. Conditioning Required
- Occupied Lab - Sashes Closed - Max Conditioning Required
- Occupied Lab - Sashes Open - Min Conditioning Required
- Occupied Lab - Sashes Open - Max Conditioning Required



The range of modulation should match occupancy and utilization of the labs and hoods



Operation and energy consumption should correlate with demand



Demand \Rightarrow Operation \Rightarrow Energy

Energy Airflow Efficiency
BTU/ft² \Rightarrow \$/ft² \Rightarrow cfm/ft² \Rightarrow \$/cfm

Maximum savings are achieved by reducing total airflow and improving system efficiency

High performance requires understanding the demand for ventilation, appropriate airflow specifications and ensuring proper operation

How Much Flow
is Required?

Where is the
Flow Required?

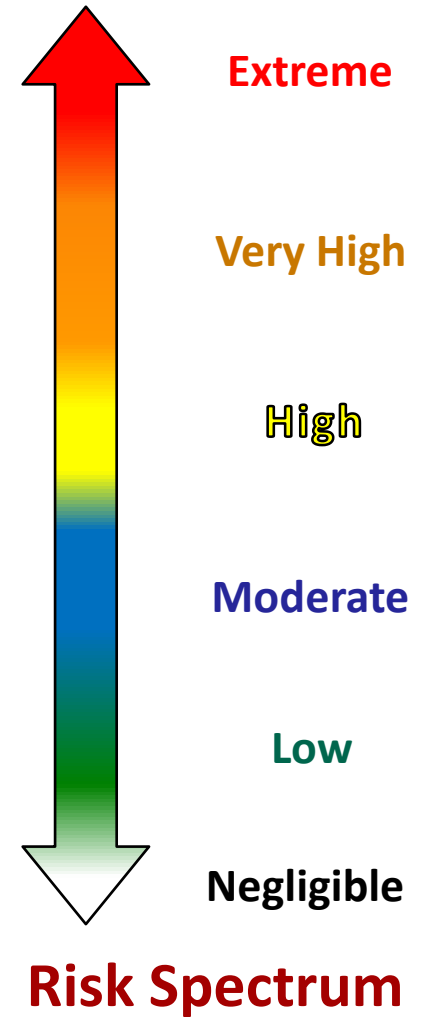
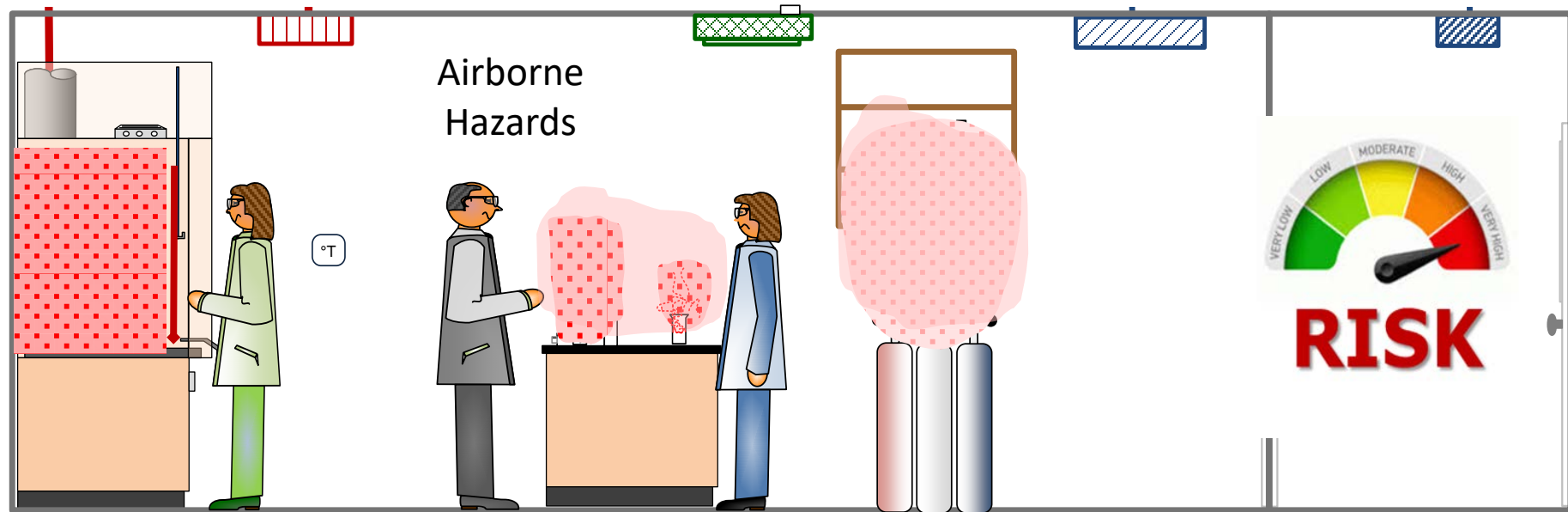
When is the
Flow Required?

3Flow™

The demand for ventilation is a function of risk, use of the lab and the functional needs of the occupants

Airborne Hazards and Processes

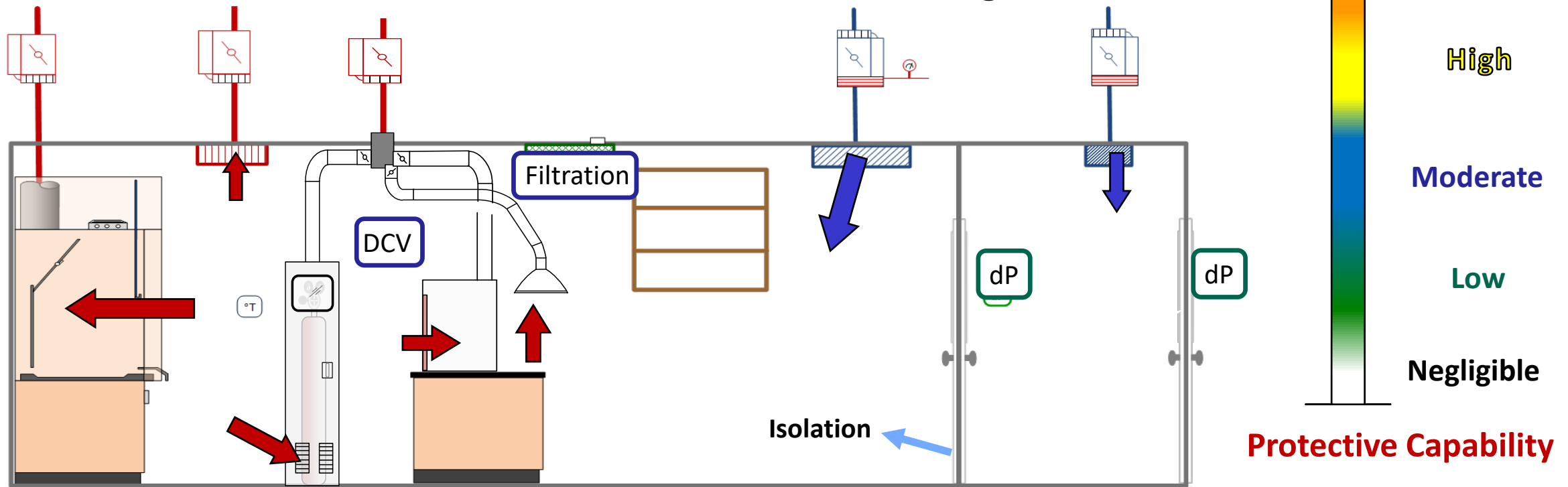
- Exposure Control Level
- Quantity
- Potential for Generation
- Concentration Profile



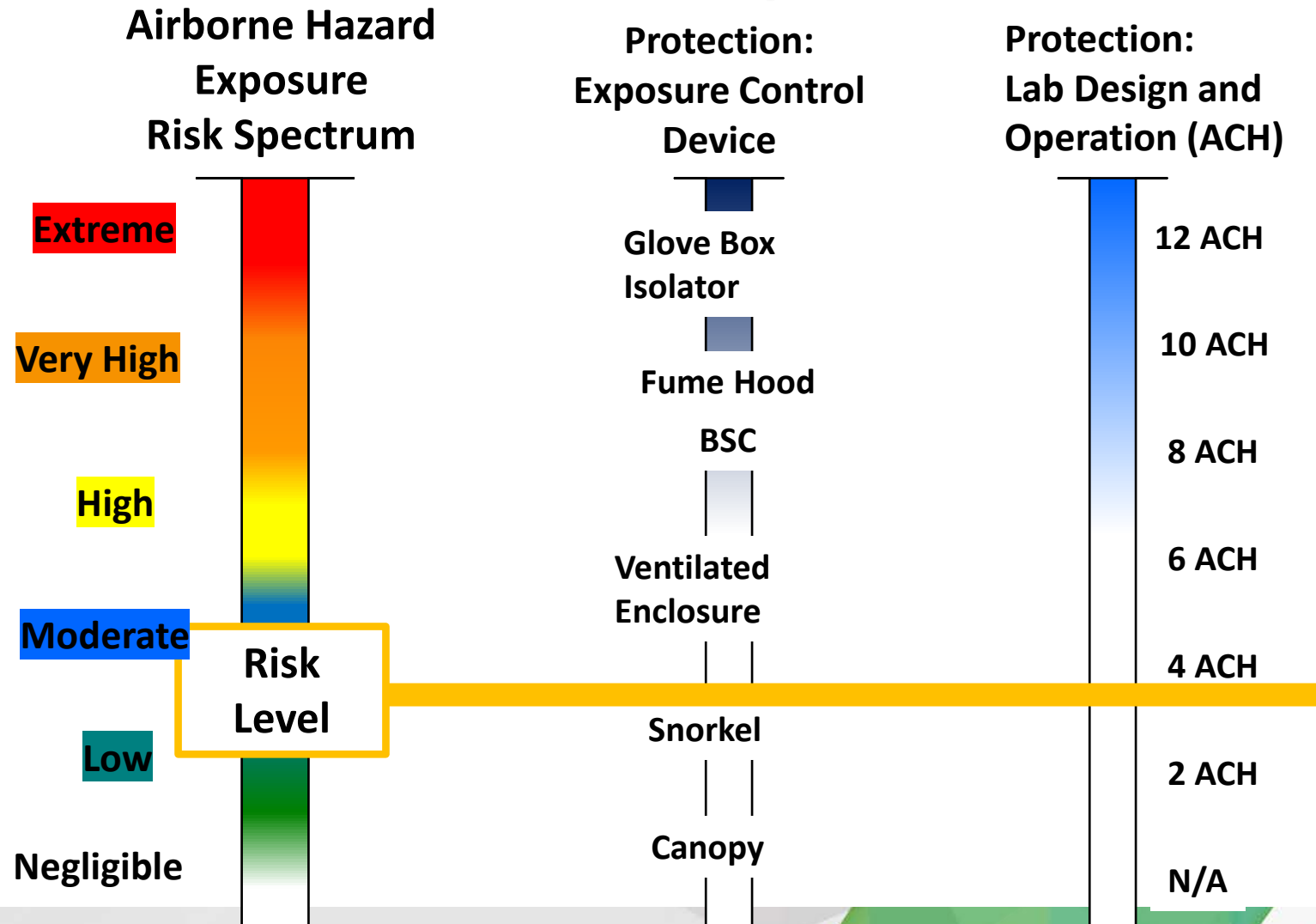
The level of protective capability is a function of the design attributes, configuration and operation

Level of Protective Capability

- Type of Exposure Control Devices
- Quality and Quantity of Airflow
- Sensors, Controls and Monitoring



Risk is mitigated by lab design attributes, operating specifications and work practices

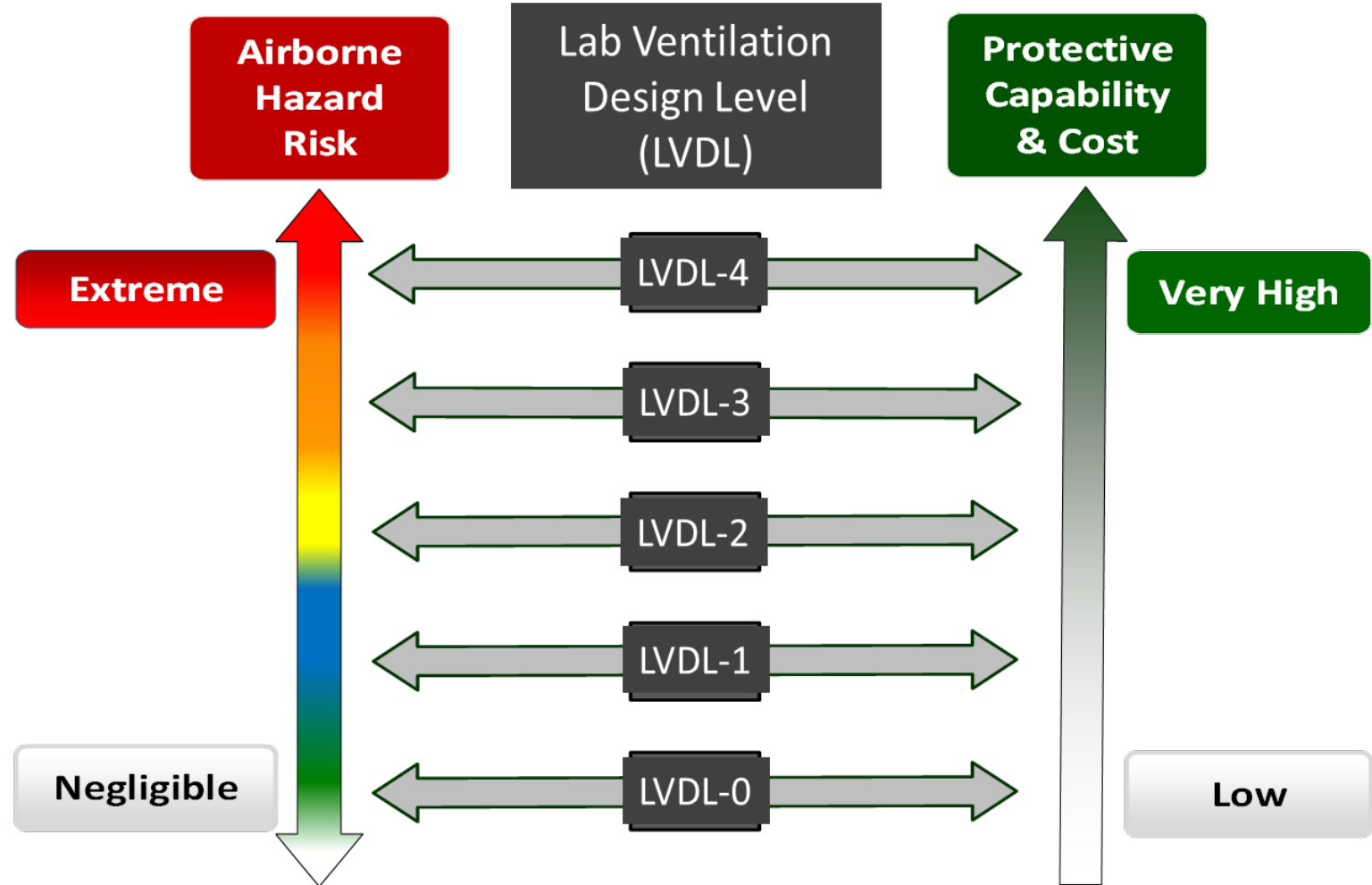


ASHRAE – Classification of Lab Ventilation Design Levels

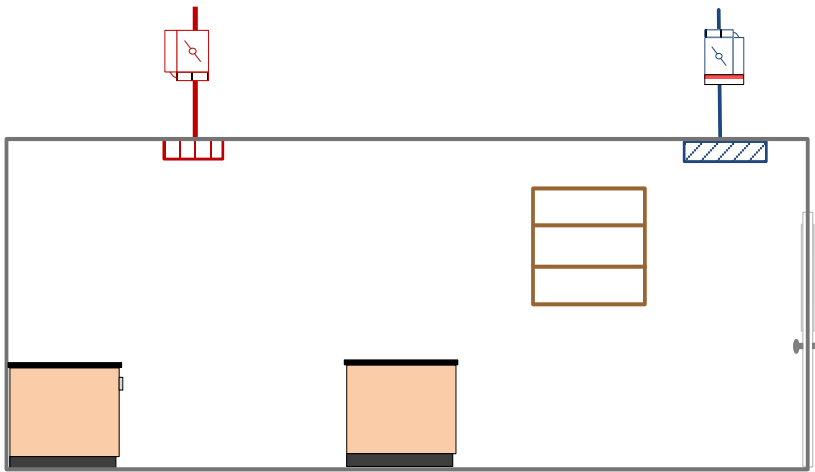
Classification of Laboratory Ventilation Design Levels

Developed by
ASHRAE Technical Committee 9.10, Laboratory Systems
Laboratory Classification Subcommittee

In partnership with
American Chemical Society
Division of Chemical Health and Safety
and
American Industrial Hygiene Association
Laboratory Health and Safety Committee

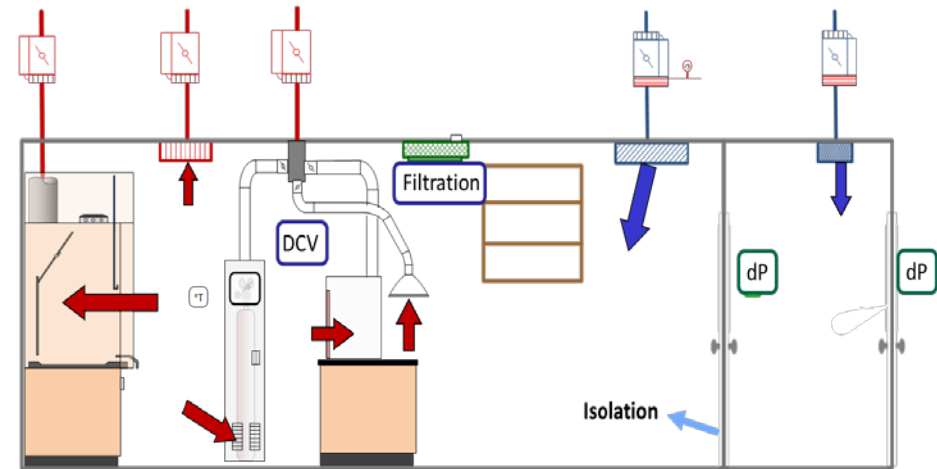


The Lab Ventilation Design Levels (LVDLs) describe the physical attributes and operating parameters that provide levels of protection



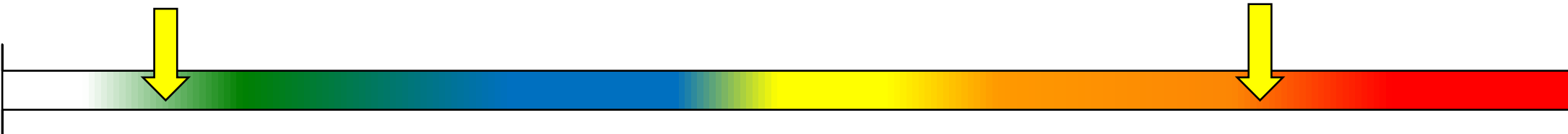
LVDL-0

- Limited Isolation
- No Exposure Control Devices
- No Filtration or Redundancy
- Low Airflow and Possible Recirculation

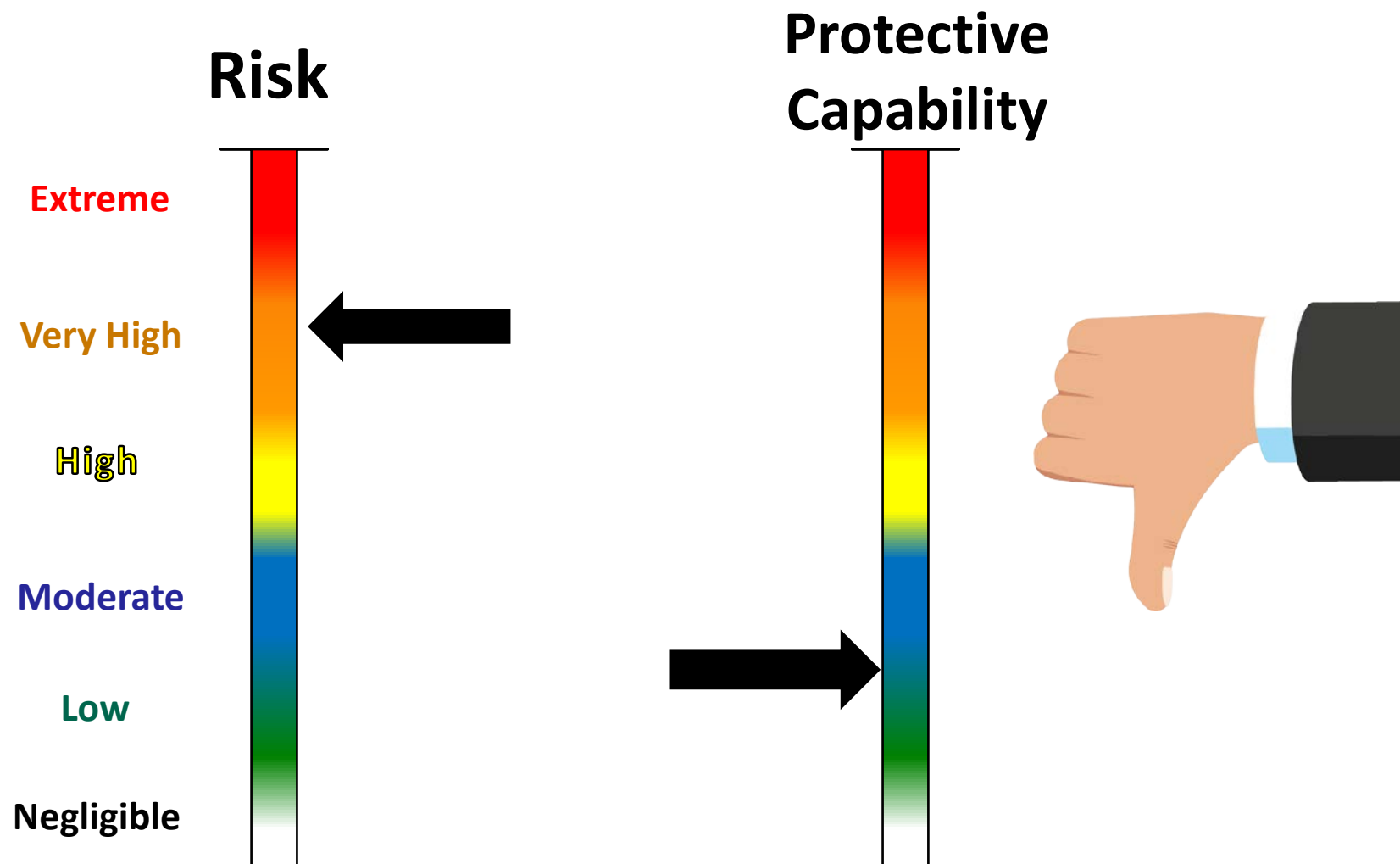


LVDL-4

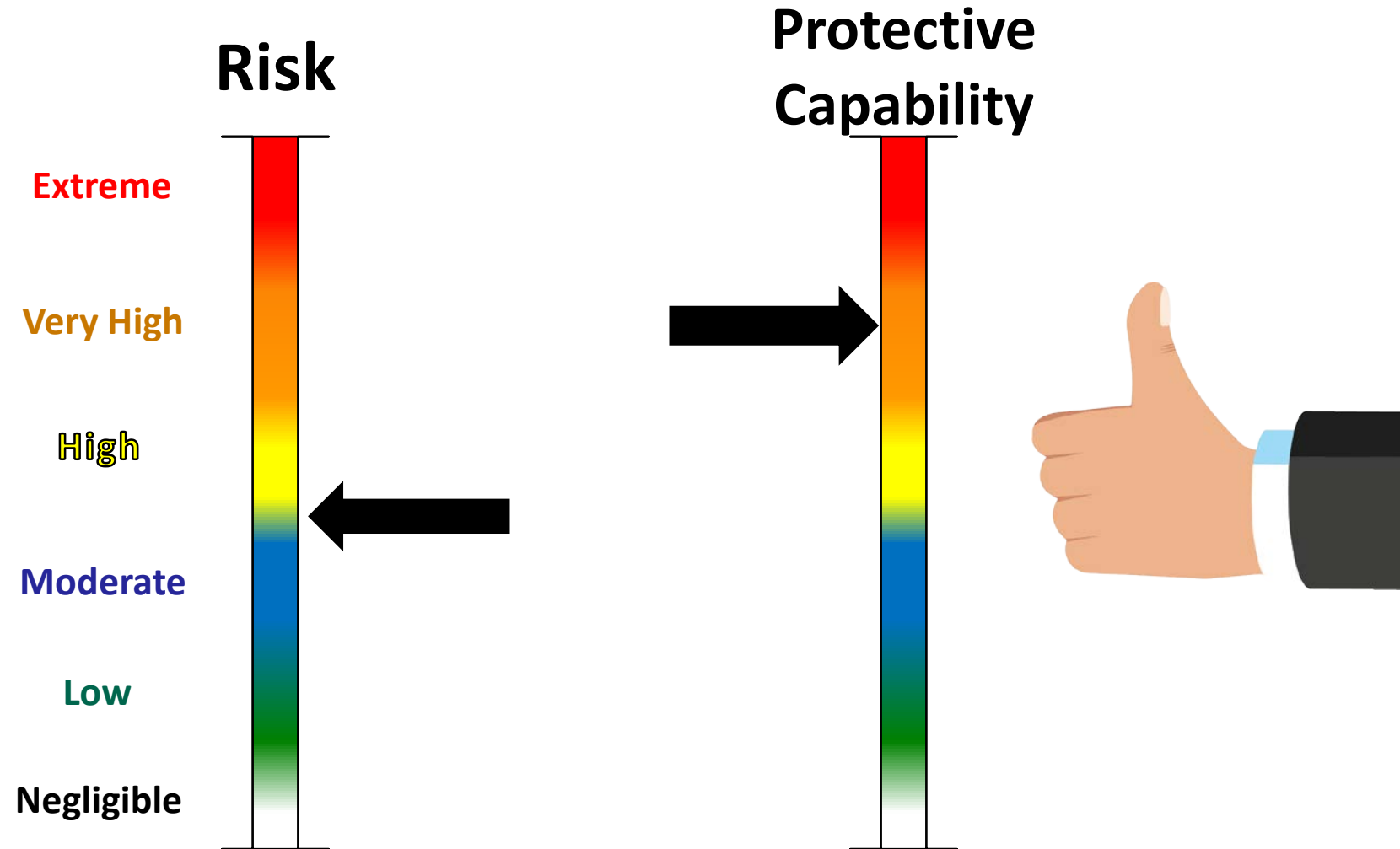
- Physical isolation and pressure control
- Fume Hoods and Special ECDs
- Filtration, Redundancy, Backup
- Effective Ventilation and High Airflow



Is the protective capability of the space sufficient to mitigate the risk of exposure ?



Is the protective capability of the space sufficient to mitigate the risk of exposure ?



The protective capability must exceed the demand for ventilation

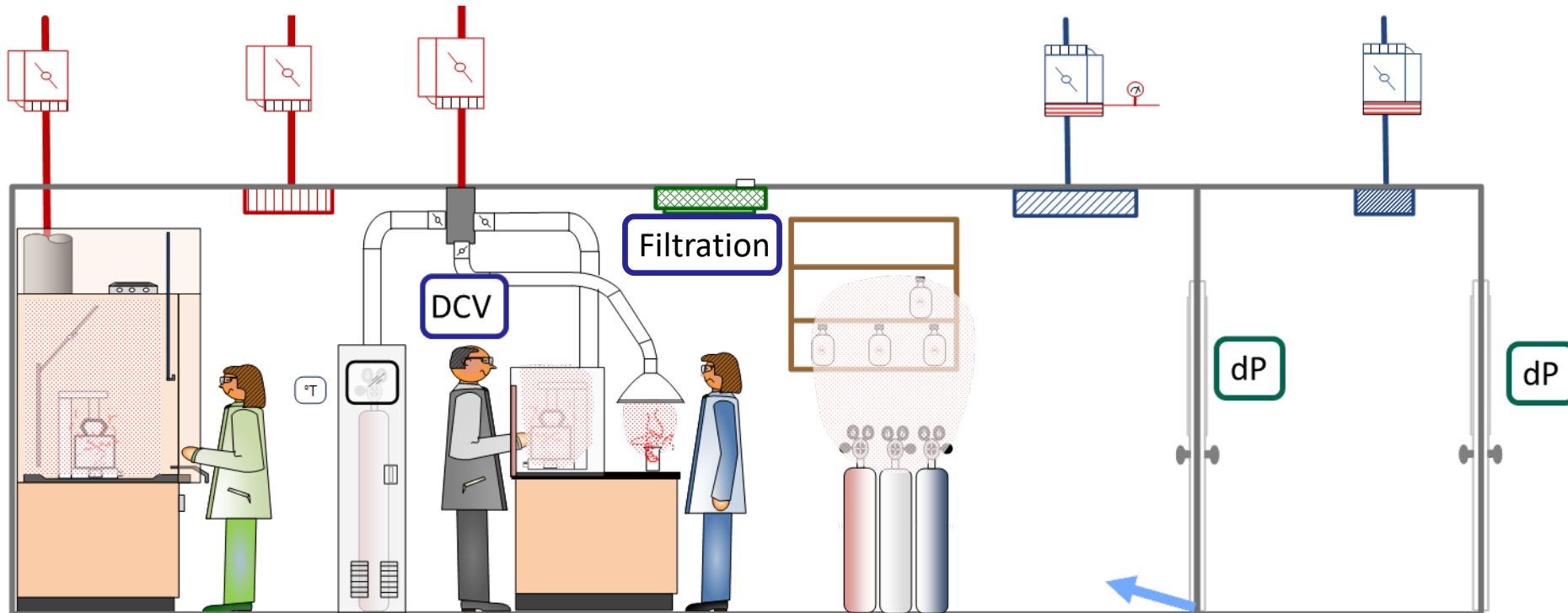
Protective Capability

- Design
- Configuration
- Operation

\geq

Demand for Ventilation

- Airborne Hazards (Risk)
- Conditioning
- Utilization



A Lab Ventilation Risk Assessment (LVRA) determines the demand for ventilation and the required protective capability of the space

- Survey Laboratories
 1. Assess Exposure Control Devices (ECDs)
 2. Assess Lab Environment
- Categorize Risk Using Control Bands
- Determine Hazard Emission Scenarios
- Establish Performance Requirements
- Derive Recommended Operating Specifications
 - Minimum Fume Hood Flow
 - Minimum Laboratory ACH
 - Exhaust Stack Discharge Requirements



The LVRA is used to assign Risk Control Bands that represent Hazard Emission Scenarios



Risk Control Band	Description
0	Negligible
1	Low
2	Moderate
3	High
4	Very High
5	Extreme

Hazard Emission Scenario

- Exposure Limit (concentration)
- Quantity
- Potential Generation Rate
- Concentration Profile

Risk Factors for Labs are identified, rated and weighted for assigning Risk Control Bands and Operating Specifications

Utilization - Airborne Hazards and Processes

- Chemical Hazard Rating
- Quantity of Hazardous Material
- Chemical Generation Potential
- Methods of Generation and Source Locations
- Potential for Change

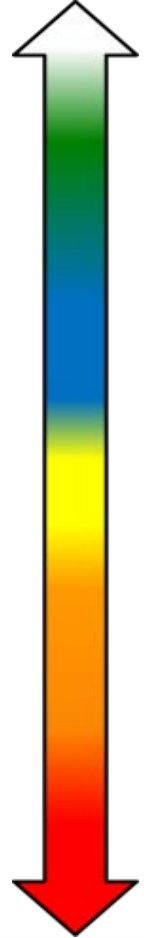
Lab Design and Operation

- Appropriate ECDs
- Ventilation Effectiveness (Sweep)
- Isolation and Controls



Score carding risk factors enables RCB assignment

Negligible

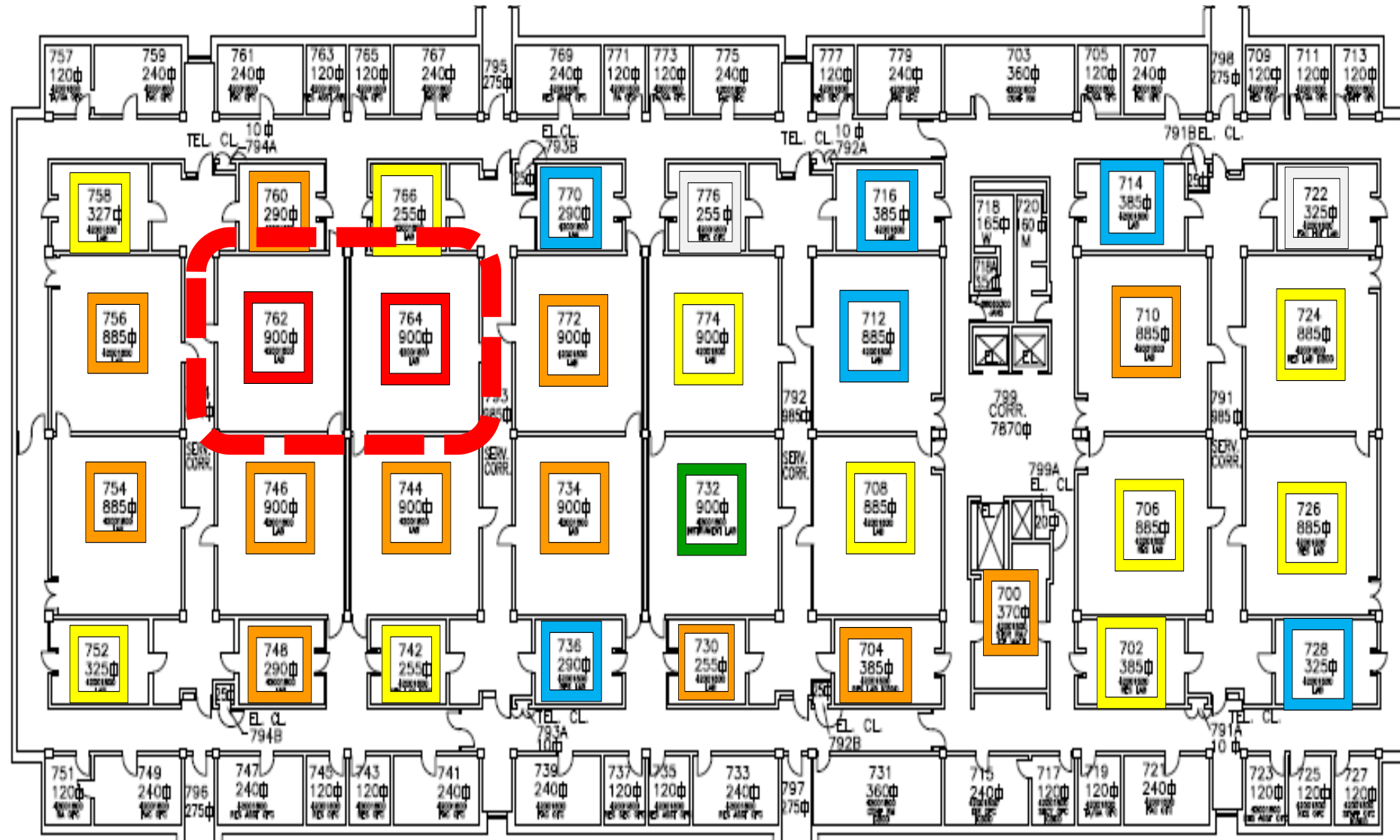


Extreme

Total Score	Control Band	Description
< 16	0	Negligible
16-40	1	Low
41-64	2	Moderate
65-88	3	High
89-120	4	Very High
121-160	5	Extreme



RCBs differentiate labs and identify areas of concern



Risk Control Bands are associated with minimum design and operating specifications

Ratings, Weightings and RCBs Adjusted per Site Requirements
Unocc Set back Recommendations

LVRA – Risk Control Bands and Lab Operating Specifications						
Laboratory Specifications	Risk Control Band					
	0	1	2	3	4	5
Minimum Effective Occupied ACH	N/A	2	4	6	8	10
Recirculation of Lab Air	Yes	Yes	Filtered	Internal	Internal	No
Lab Pressurization “w.g.	Neutral	Neutral	< -0.005	< -0.01	< -0.05	= > -0.05
Room Monitor	N/A	N/A	N/A	Review	Yes	Yes
Airlock/Vestibule	N/A	N/A	N/A	N/A	N/A	Yes
Enthalpy Wheels	Yes	Yes	Review	Review	No	No
Min Effective Unoccupied ACH	N/A	1	2	3	4	N/A
Emergency Purge Mode	No	No	No	No	Review	Yes

New technologies have been developed for safer more efficient and more sustainable labs

Fume Hood upgrades:

- Better containment
- Lower flow

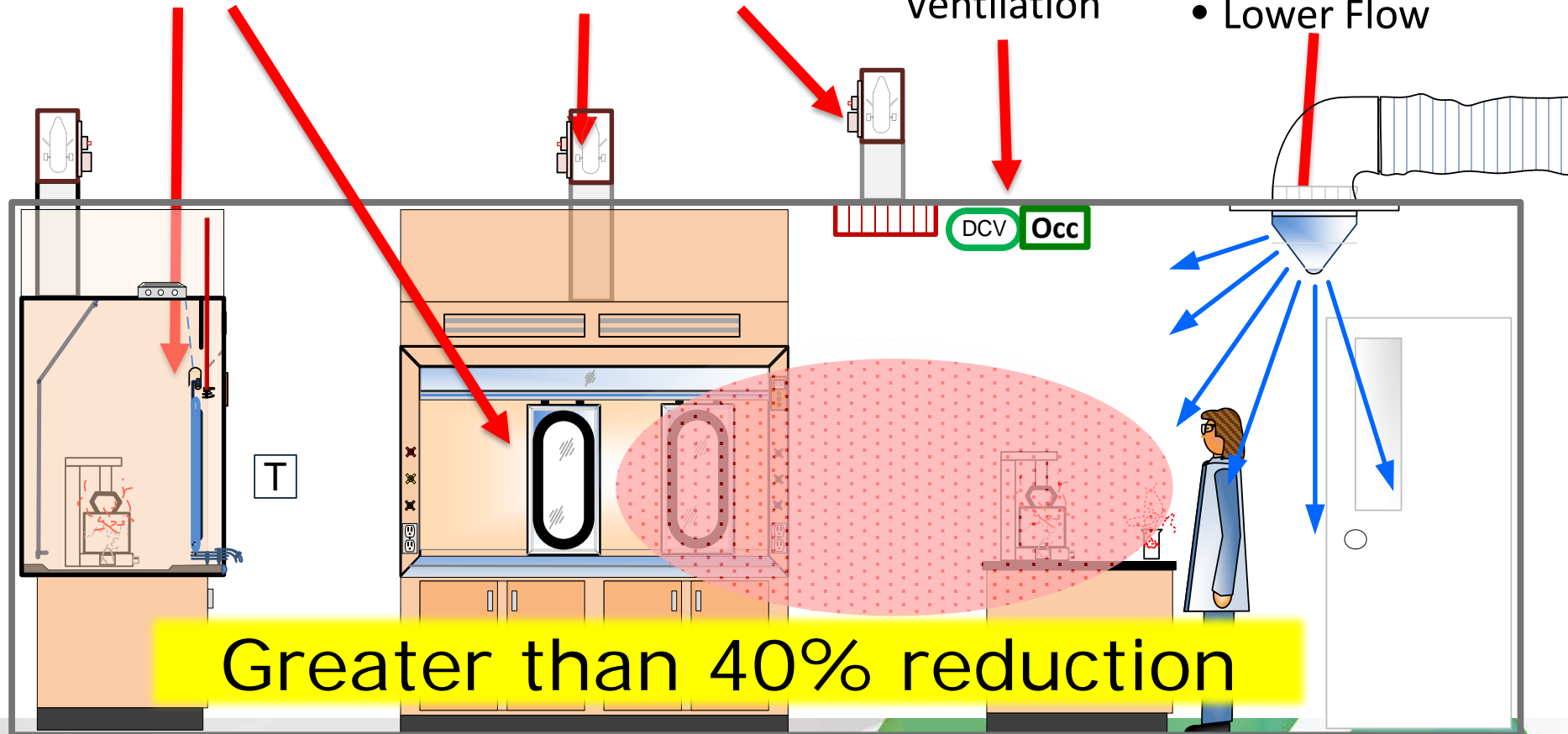
VAV Valves:

- More Accurate
- Better Control

Demand
Control
Ventilation

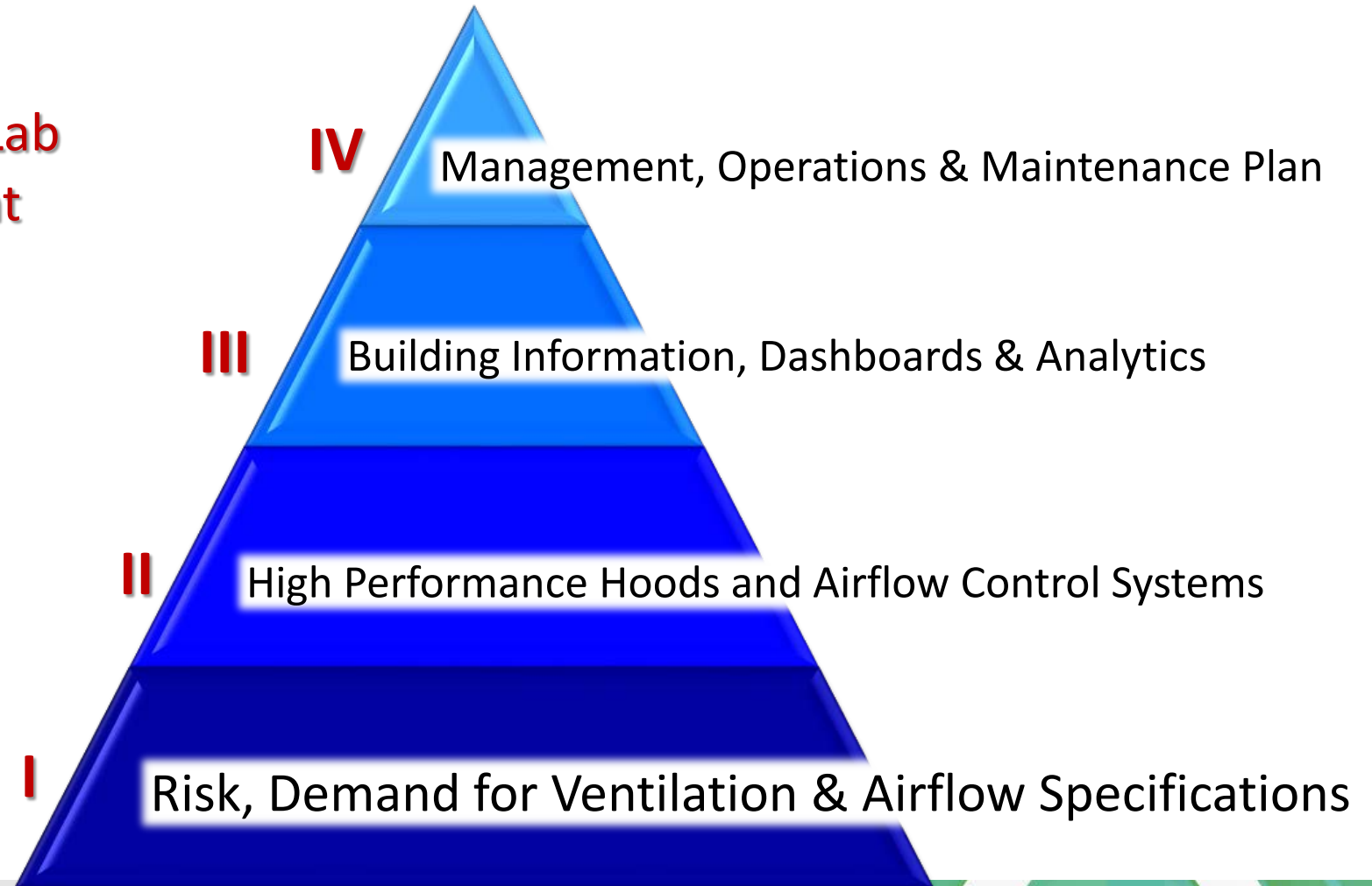
High VEFF Diffusers

- Better Distribution
- Lower Flow



A Lab Ventilation Management Program (LVMP) provides the structure to achieve and maintain safe, energy efficient and sustainable labs.

Key Components of an Lab Ventilation Management Program (LVMP)

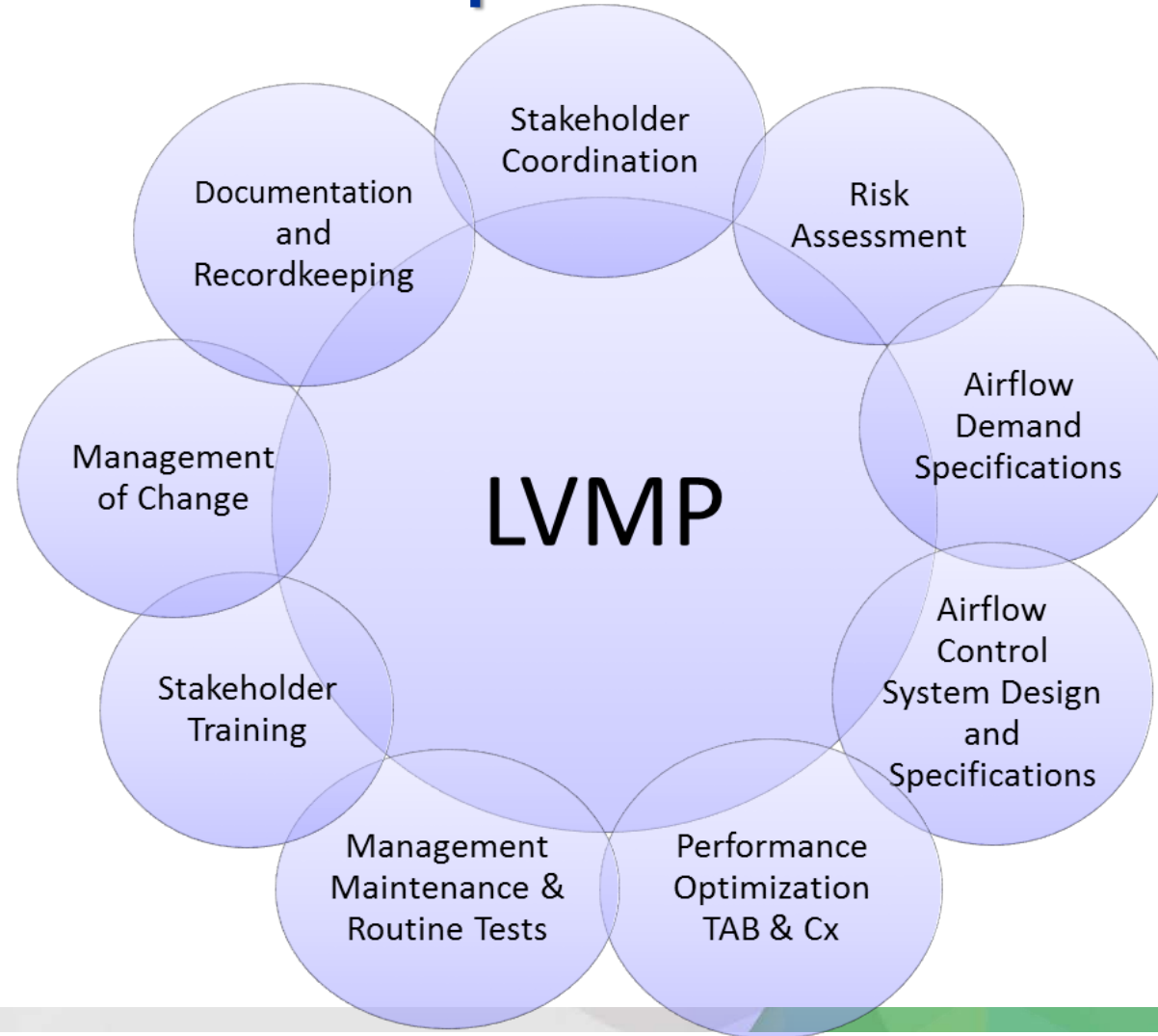


Lab Ventilation Management Program (LVMP) is a Coordinated Team Effort

- **Stakeholder and LVMP Team (In-house and Contractors)**
 - Facilities and Energy Engineers
 - Environmental Health and Safety
 - Lab Staff Representatives
 - HVAC Systems Engineer
 - Laboratory Hood Specialist
 - Building Controls Operator
 - Mechanical Maintenance
 - TAB Contractor
 - Commissioning Contractor
- **LVMP Manager/Coordinator**



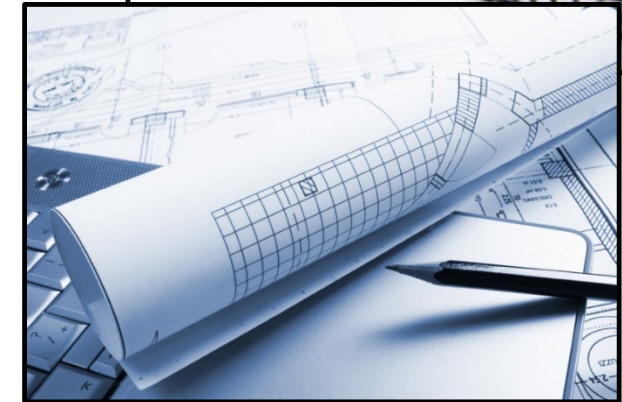
Lab Ventilation Management Program is comprised of multiple elements



Operating Manual for Building Systems

Performance Management Plan

- Lab Ventilation Risk Matrix
- Accurate Drawings / Diagrams
- Equipment Inventories and Information
- Appropriate Flow Specifications
- Control Sequences and Parameters
- Key Performance Indicators and Metrics
- Standard Operating Procedures
- Adequate Training for Stakeholders and Staff



Protect Return On Investment

The LVMP provides training for all stakeholders

- Program Managers & Supervisors
 - Facilities Engineering
 - Operations and Maintenance
 - EH&S
 - Lab Management

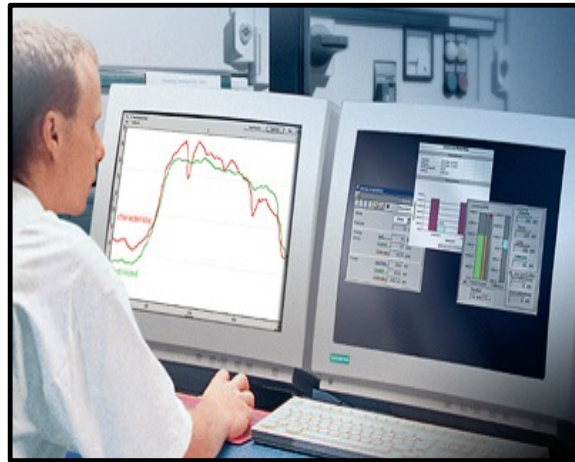


LVMP Manager Coordinator

- Maintenance



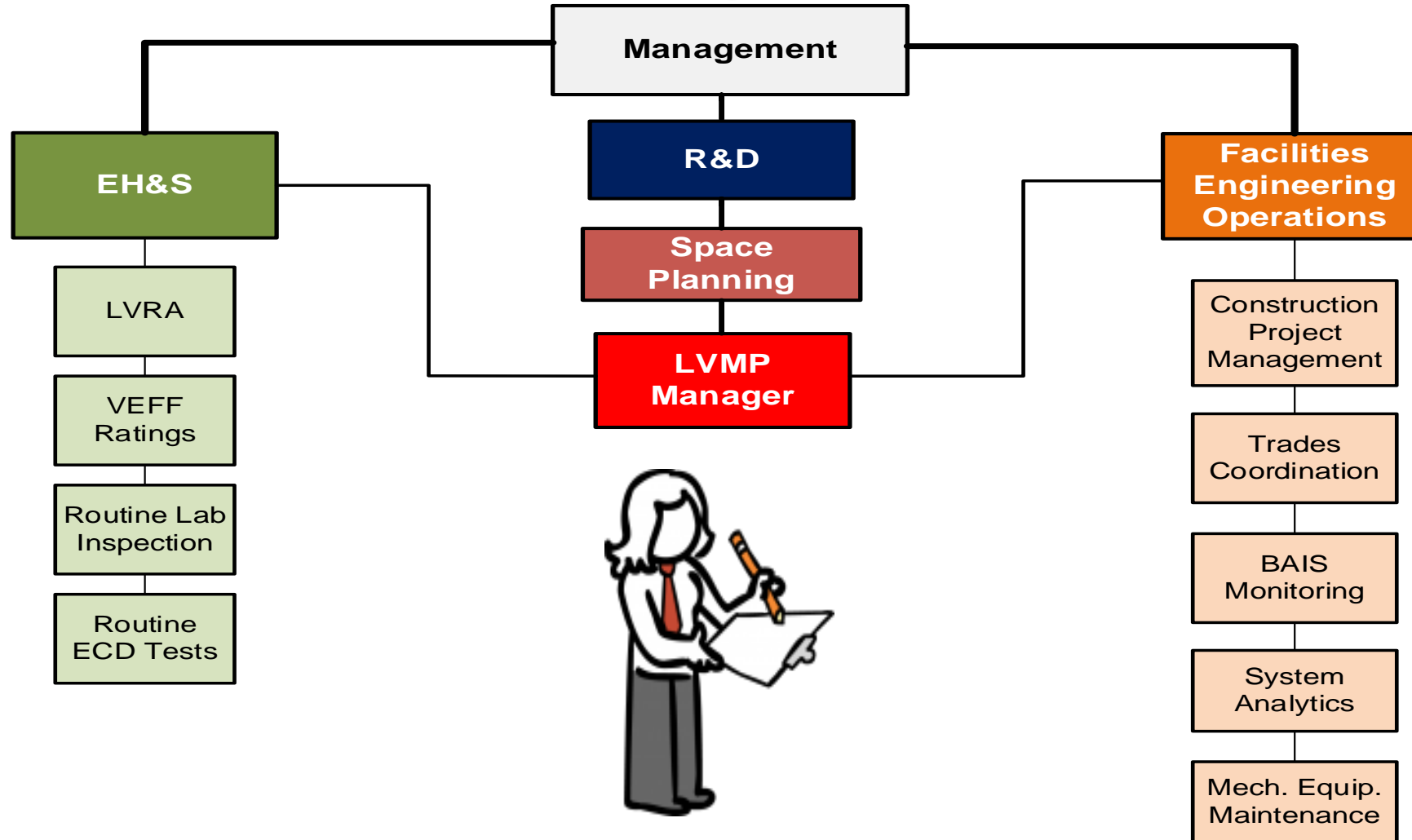
- Building Operators



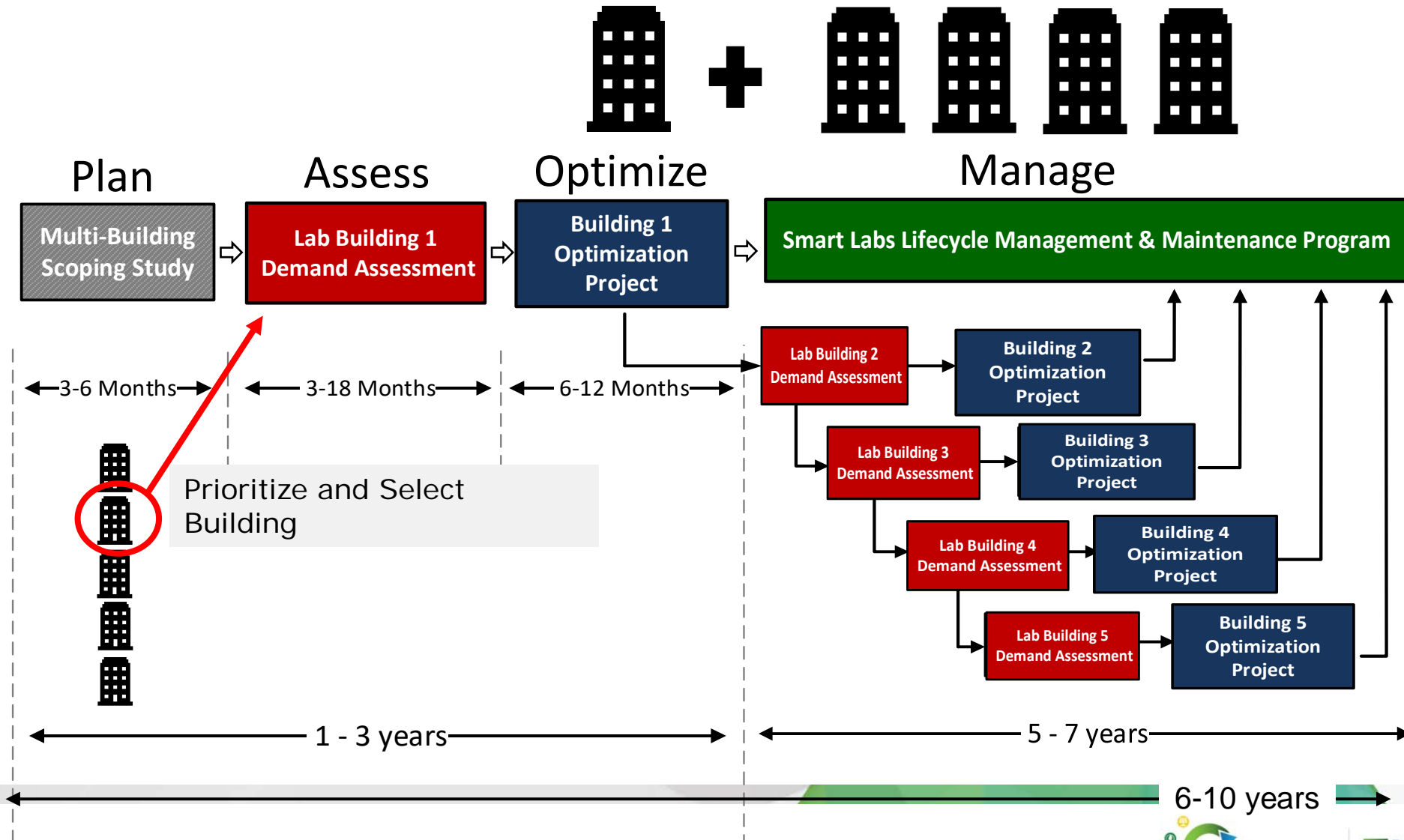
- Lab Personnel



The LVMP Manager integrates and coordinates the efforts of key stakeholders

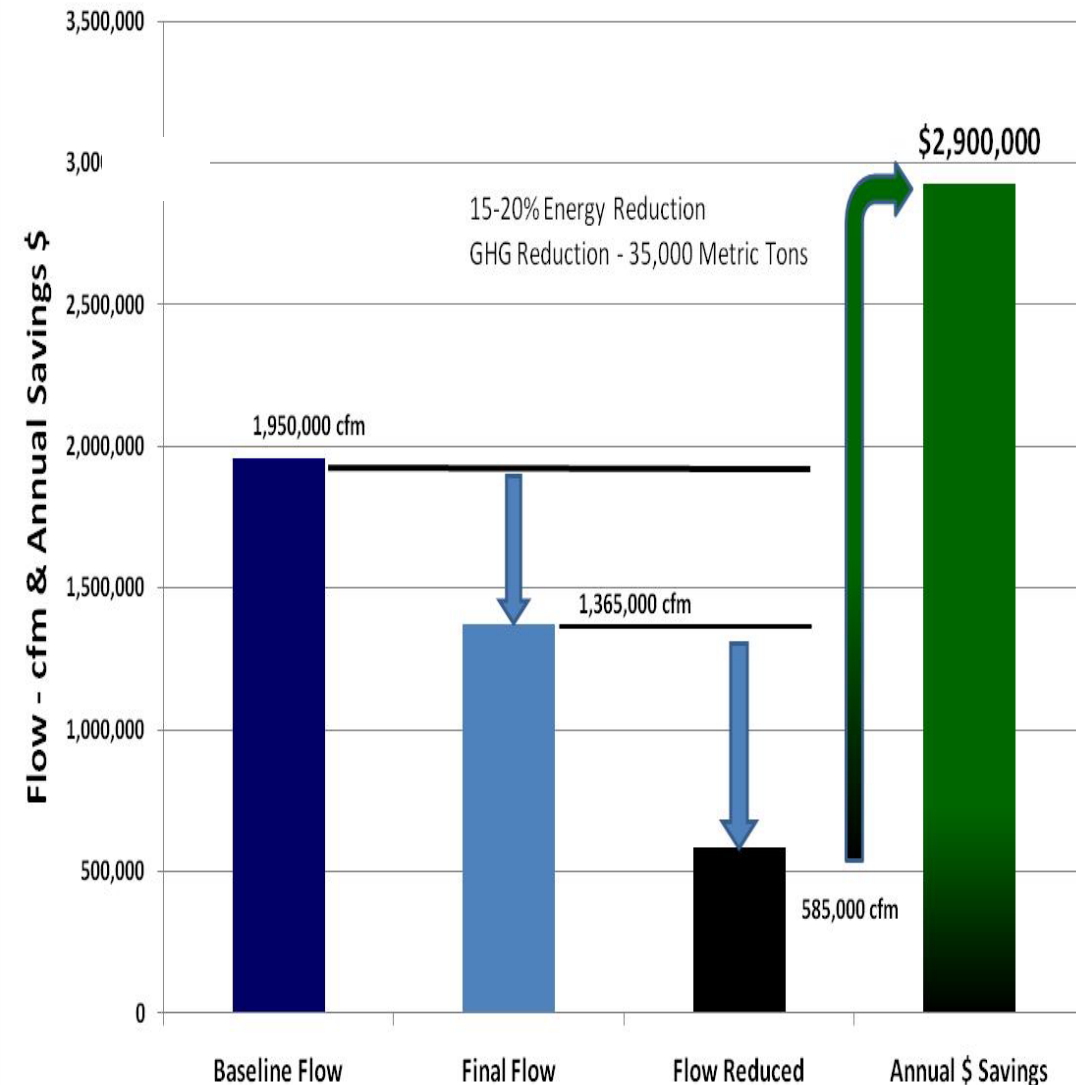


The roadmap accelerates implementation, reduces risk and yields more predictable results



The Roadmap to Smart Labs™ – Proven Results

- **Safer Labs**
- **Dependable Performance**
- **Compliance with Standards**
- **Mitigate deferred maintenance**
- **Significant Energy Reduction**
 - > 500 Billion BTUs
 - > 150 Million kWh
- **Cost Savings**
 - > \$6 Million per Year
 - Typical Payback 1 - 5 years



New methods and technologies deliver benefits of predictably safer and more energy efficient labs

■ Government
■ Universities


■ Chemical
■ Biotechnology

■ Pharmaceutical
■ Industry



Indiana University Health





The right flow in the right place at
the right time!™



Thank You!

Questions

Thomas C. Smith



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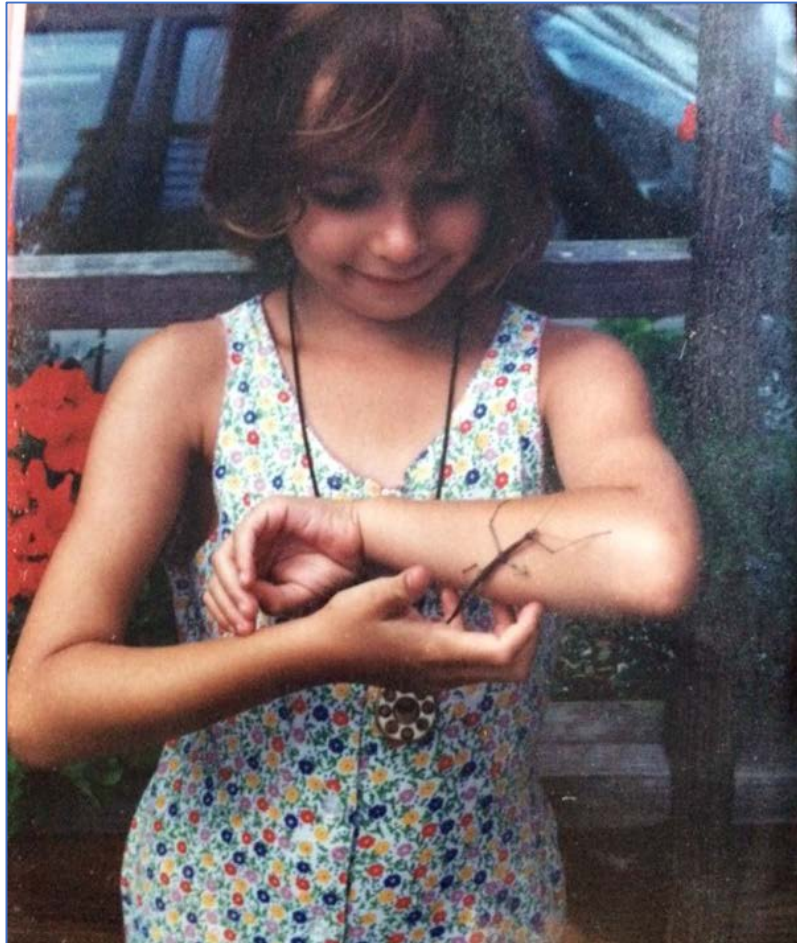
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How to Create a Ventilation Management Program

A Case Study: Tips and Tricks at
Los Alamos National Laboratory



Genna Waldvogel

LVMP Coordinator and Civil & Environmental Engineer
Los Alamos National Laboratory

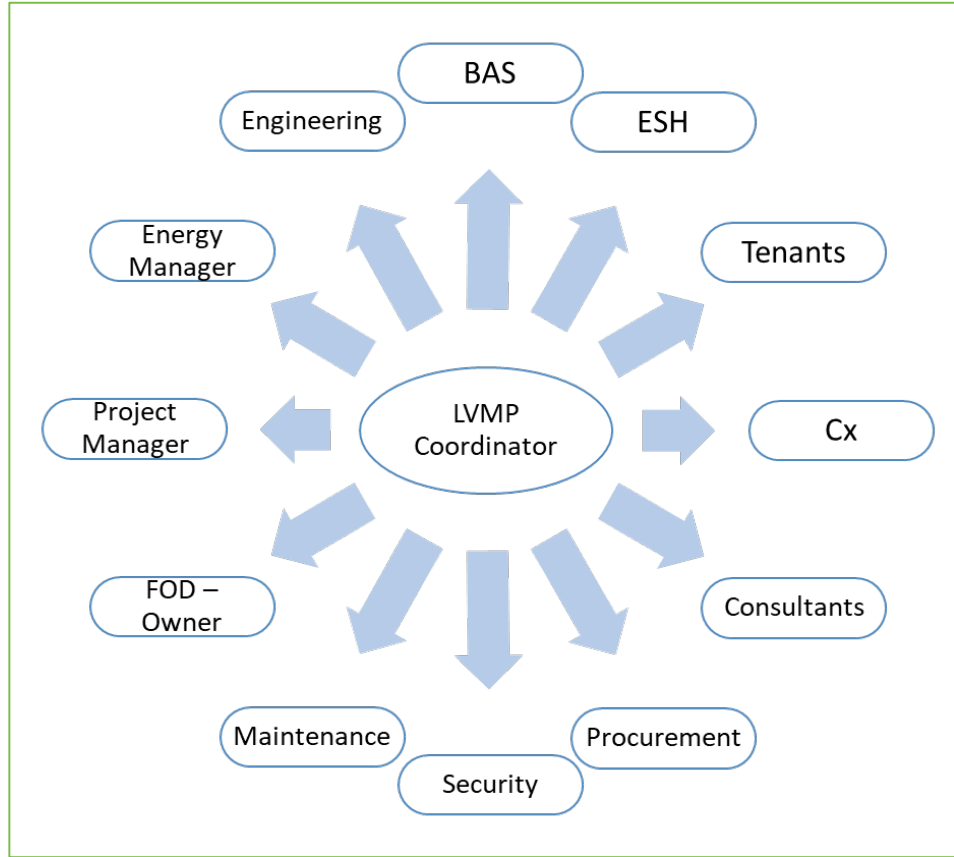


Quick Overview of Presentation


- LANL's Smart Lab Core Team
- Focus Facilities
- Case Studies:
 - 35-0085 – Biochemistry
 - 48-0107 – Radiochemistry
- Future Work for Ventilation Management

Smart Labs Core Team

Smart Labs Core Team- Common Goal & Roles and Responsibilities



Laboratory Ventilation Management Program Success

- We created Roles and Responsibilities for all LVMP members and for all phases 
- We have created communication between all team members, including laboratory tenants:
 - We have involved tenants with Status Update Board and Weekly meetings



- We had training: (ESH, IH, Maintenance, Cx, BAS)
 - LVRA
 - HVAC Systems and Laboratory Test Analysis
 - Implementing Building Management Plan (BMP)



- We have developed:
 - Preventive Maintenance Plan
 - Hibernation Protocol
 - An Exposure Assessment with Risk Control Banding (in process)
 - Fume Hood Annual Certification Process Revisions and Hood Team (in process)
 - Fume Hood Database with connection to exhaust fans and all ID numbers being used



- CEREBRO:
 - Safety net to make sure chemicals and ACH match the risk control band for the space (in process)

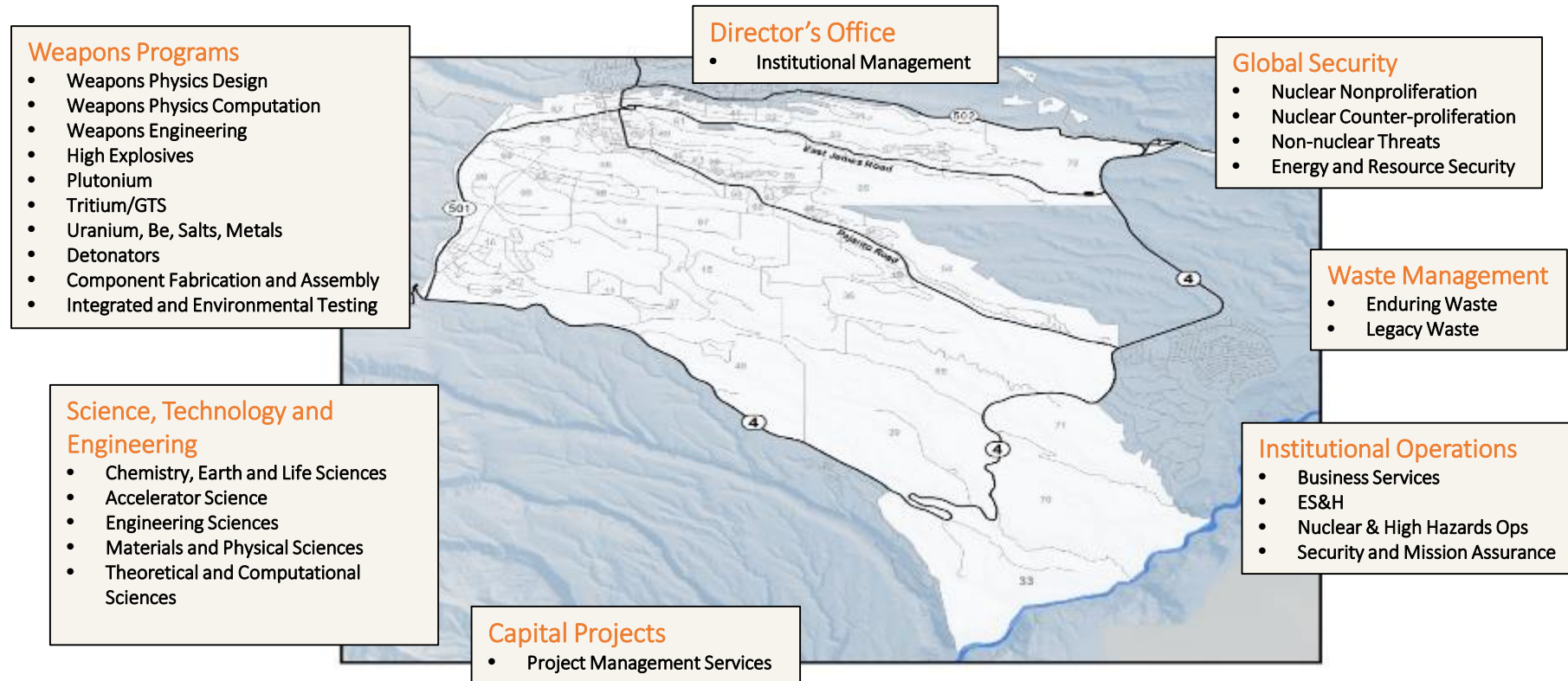


- We are tracking status for all buildings and metrics for all buildings



Focus Facilities

The Laboratory is an integrated and dynamic system of people, facilities, equipment, materials and services that supports our national security mission



36 square miles 47 technical areas 1,280 buildings/9M sq. ft. 11 nuclear facilities 268 miles of roads

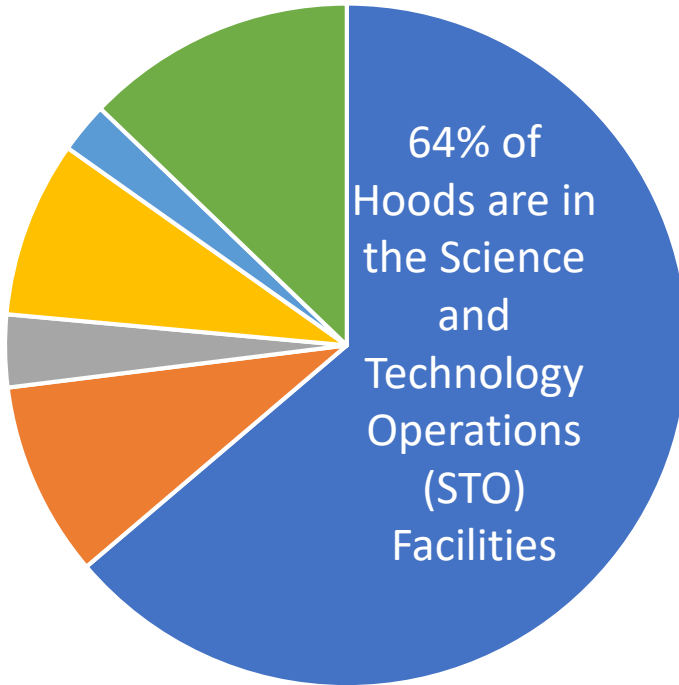
8,000 career employees 2,250 R&D scientists and engineers 350 postdocs 1,600 students at peak

\$2.5B budget 60% Weapons Program 4,700 projects 600 B&R codes

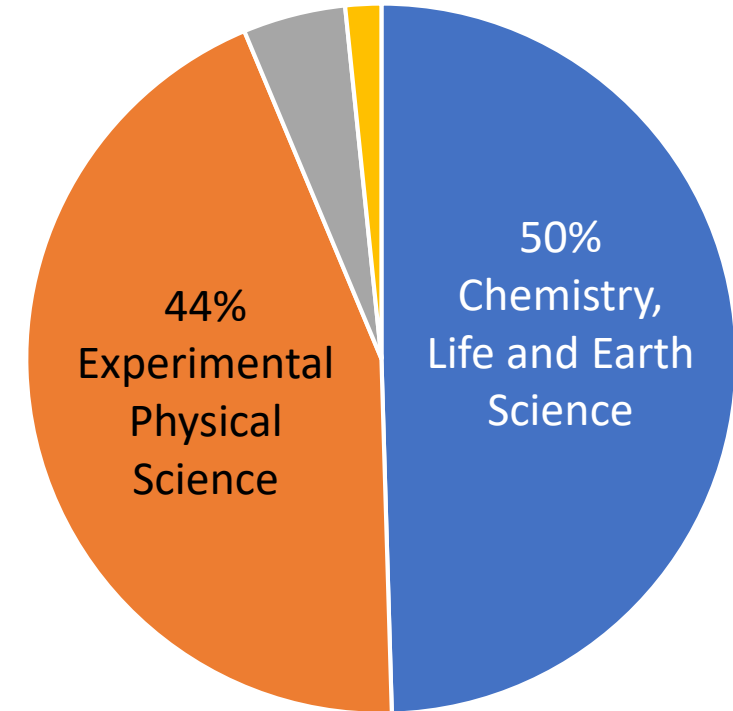
5 PADS 14 Directorates 80 Divisions

Fume Hoods at LANL

Fume Hood Distribution at LANL



STO Fume Hood Distribution



Development of a Laboratory Ventilation Management Program

- Selected 5 buildings to implement Smart Labs
- All existing buildings in various stages of needing maintenance, upgrades, and old/new lab equipment

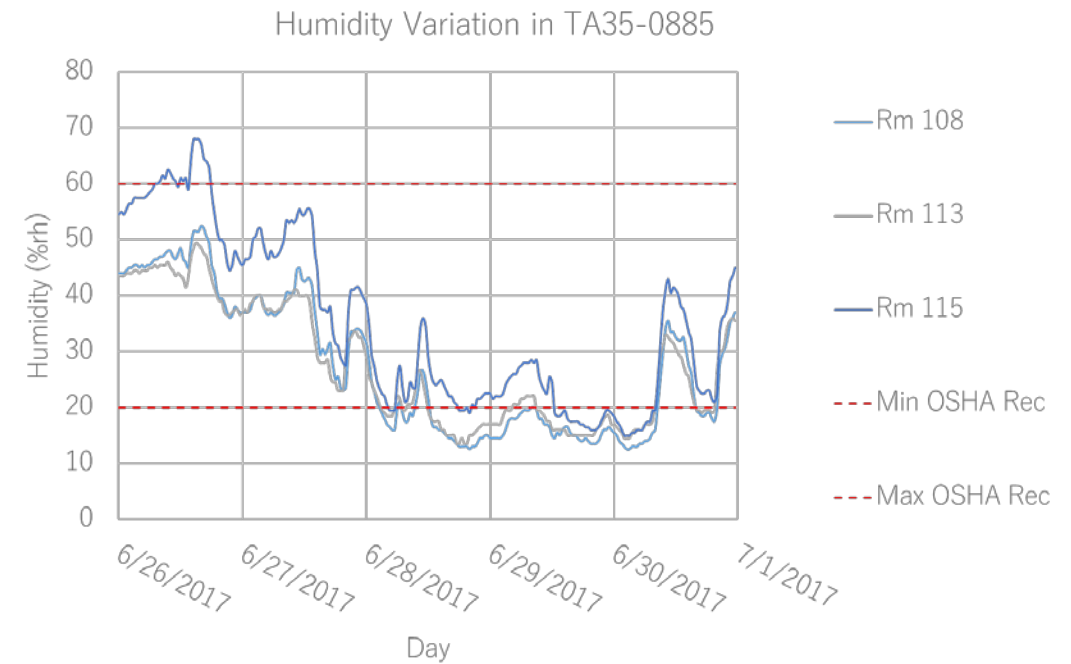
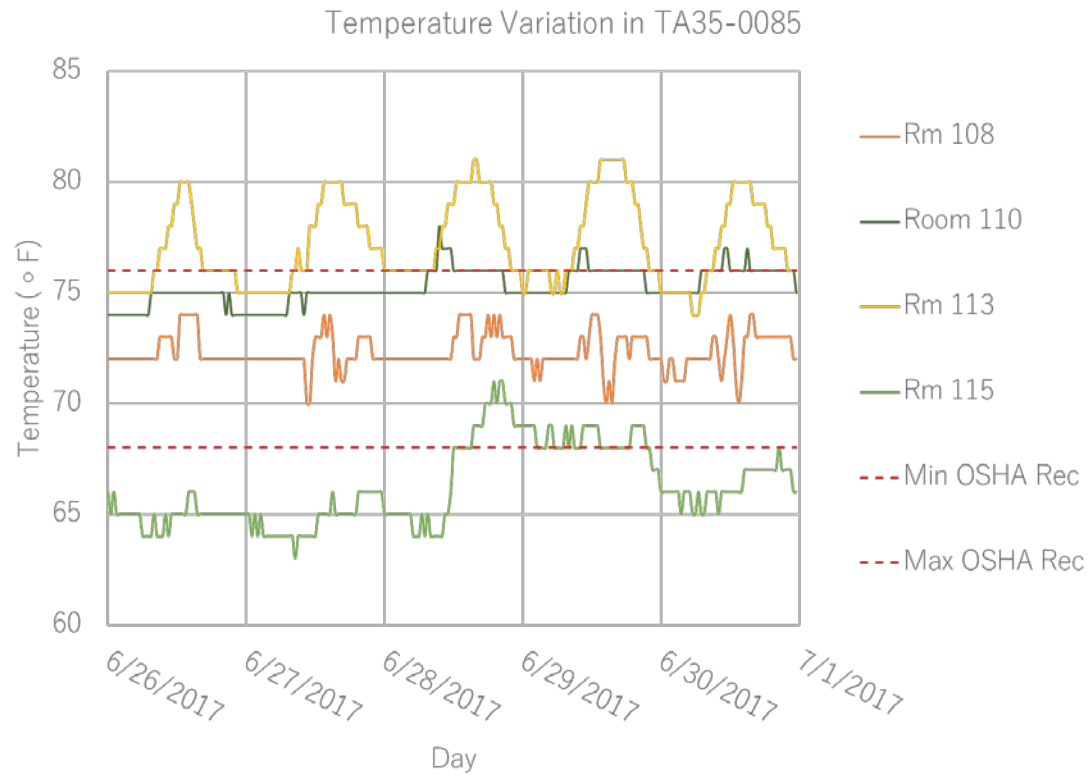
	Phase 1A - Plan						Phase 1B - Assessment								Phase 2 Optimization						Phase 3 Manage					
	Qualitative Scoping Study					Contracting	Quantitative Performance Audit							Contracting	Construction / Renovation / Upgrade Project					Contracting	Performance Management and Operations Plan					
	1A-A	1A-B	1A-C	1A-D	Deliverable		1B-A	1B-B	1B-C	1B-D	1B-E	1B-F	Deliverable		2-A	2-B	2-C	2-D	Deliverable		3-A	3-B	3-C	3-D	3-E	Deliverable
Building Name	Team & LVMP Program Development	Building Systems Survey & Inventory	Systems Condition Status Indicators	Appraise & Profile Buildings	Building Project Priority Plan	Funding, Bids, Contracts	Building Systems Documents	LVRA	System Operating Tests	Airflow & Operating Specifications	Energy and Operating Cost Model	Performance Improvement Measures (PIMs)	Scope of Work for Optimization	Funding, Bids, Contracts	Engineering & Specifications	Implement PIMs	TAB & CX	Benchmark Operation	Building Management Plan (BMP)	Funding, Bids, Contracts	Implement BMP Train Personnel	BAS Monitoring Analytics	Maintenance and Functional Tests	Lab Safety Surveys	Change Management	Performance Status Reports
03-1698	Yes	Yes	Yes	Yes	Yes		Yes	Yes	Yes	Yes	Yes	Yes	Yes		Yes	Yes	Yes									
★ 35-0085	Yes	Yes	Yes	Yes	Yes		Yes, but dated	Yes	Yes	Yes	Yes	Yes	Yes													
48-0001	Yes	Yes	Yes	Yes	Yes		Yes, but dated	Yes	Yes	Yes	Yes	Yes	Yes													
35-0213	Yes	Yes	Yes	Yes	Yes		Yes, but dated	Yes	Yes	Yes	Yes	Yes	Yes													
★ 48-0107	Yes	Yes	Yes	Yes	Yes		Yes		Yes	Yes		Yes			Yes	Yes	Yes	Yes								

- 03-1698:
 - Next Step: Benchmark operations and BMP
- 35-0085
 - Pilot Building
 - Controls Design In Process
 - Next Step: Design Implementation
- 48-0001:
 - Large RCx projects repairs
- 35-0213
 - BAS implementation
 - Large RCx project repairs
 - RCD for Smart Labs design and Implementation
- 48-0107:
 - Is it a Smart Lab?
 - Building Management Plan (BMP) creation

TA35-0085

Biochemistry Facility

Current Status - Unstable Conditions



Current Status – Risk Control Bands



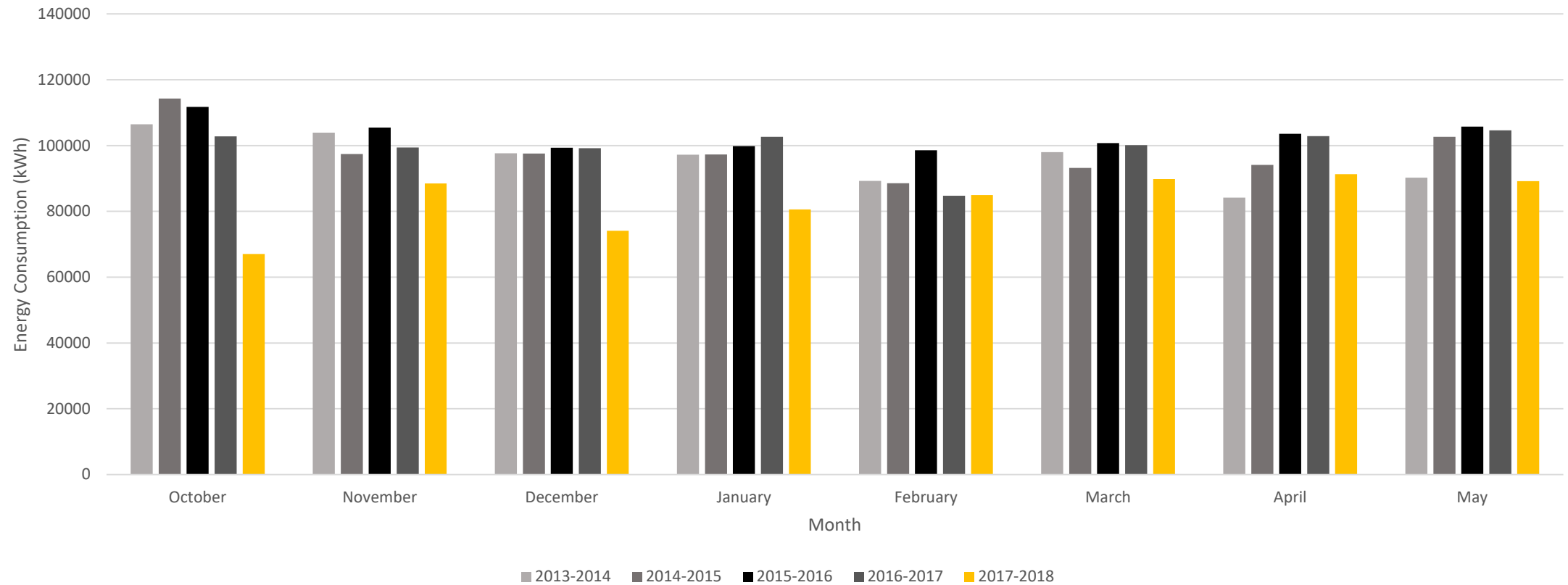
Table 1 Description of Risk Control Bands

Risk Control Band	Description
0	Negligible
1	Low
2	Moderate
3	High
4	Very High
5	Extreme



Current Status – Energy Metering

Yearly Comparison of 35-0085 Energy Consumption Without New Appliances



Current Projects

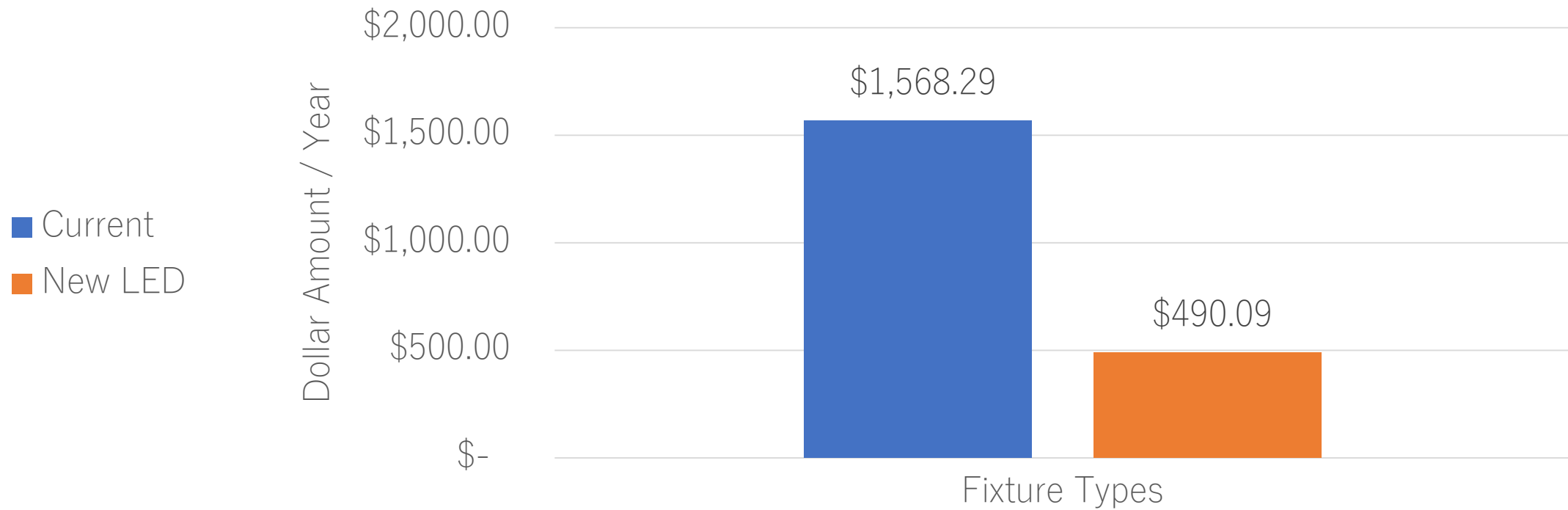
Hood ID	Height 1	Height 2	Total Savings	Height 3	Total Savings	Height 4	Total Savings	Height 5	Total Savings	Height 6	Total Savings	Height 7	Total Savings	Height 8	Total Savings
19540	10	13	30%	6	-40%	4	-60%	5.5	-45%	6	-40%	6	-40%	4	-60%
19550	7	10	43%	5	-29%	5.5	-21%	6.5	-7%	7	0%	10	43%	5	-29%
19560	4	1	-75%	2	-50%	3.5	-13%	2	-50%	2	-50%	1	-75%	0	-100%
19570	3	2	-33%	3	0%	2	-33%	2.4	-20%	2	-33%	1	-67%	3	0%
19580	6	28	367%	18	200%	6	0%	6	0%	1	-83%	12.5	108%	3.5	-42%
19590	5.5	6	9%	4	-27%	4.5	-18%	3.2	-42%	15	173%	13.5	145%	5.5	0%
19600	10	10	0%	7	-30%	7	-30%	8.5	-15%	8	-20%	10.5	5%	10	0%
19610	22	22	0%	8	-64%	6.5	-70%			6	-73%	10	-55%	7.5	-66%
19620	6	17	183%	11	83%	7	17%	3.5	-42%	5	-17%	4	-33%	5	-17%
19630	5	10	100%	5	0%			3.5	-30%	5	0%	3.5	-30%	3	-40%
19640	8	6.5	-19%	9	13%	8	0%	7.3	-9%	6	-25%	7	-13%	7.6	-5%
19650	8	7	-13%	5	-38%	9.5	19%	9	13%	9	13%	6.5	-19%	6	-25%
19660	8	0.5	-94%	0	-100%	0	-100%	0	-100%	3	-63%	3	-63%	3	-63%
19670	10	9	-10%	3	-70%			7.8	-22%	9	-10%	9.5	-5%	9	-10%
19680	10	17	70%	9	-10%	8	-20%	9.5	-5%	9.2	-8%	19	90%	9	-10%
19690	11	13	18%	7	-36%	9	-18%	10	-9%	9	-18%	12	9%	8.2	-25%
19700	6	5	-17%	5	-17%	3	-50%	4	-33%	0	-100%	7.5	25%	2.3	-62%
19710	11	18	64%	7	-36%	10	-9%	3	-73%	3	-73%	10	-9%	12	9%
19720	18	10	-44%	6	-67%	5.5	-69%	5.5	-69%	5.5	-69%	5.5	-69%	6	-67%
Average	8.9	10.8	22%	6.3	-29%	5.8	-34%	5.4	-39%	5.8	-34%	8	-10%	5.8	-35%



Current Projects



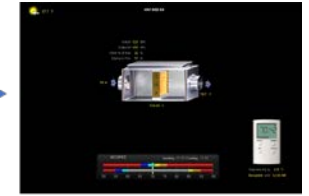
Price of Fixtures per Year



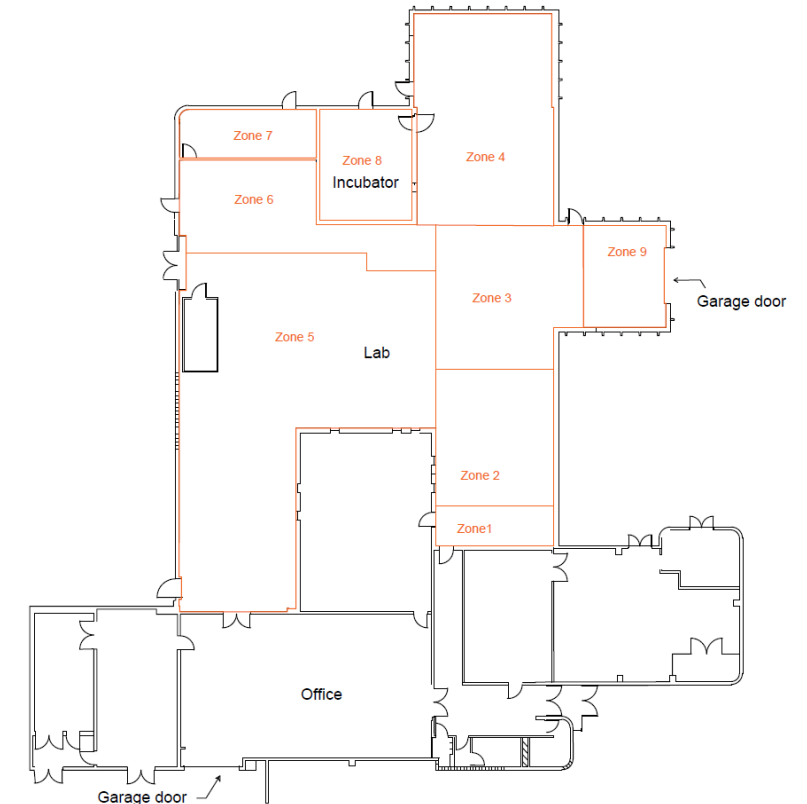
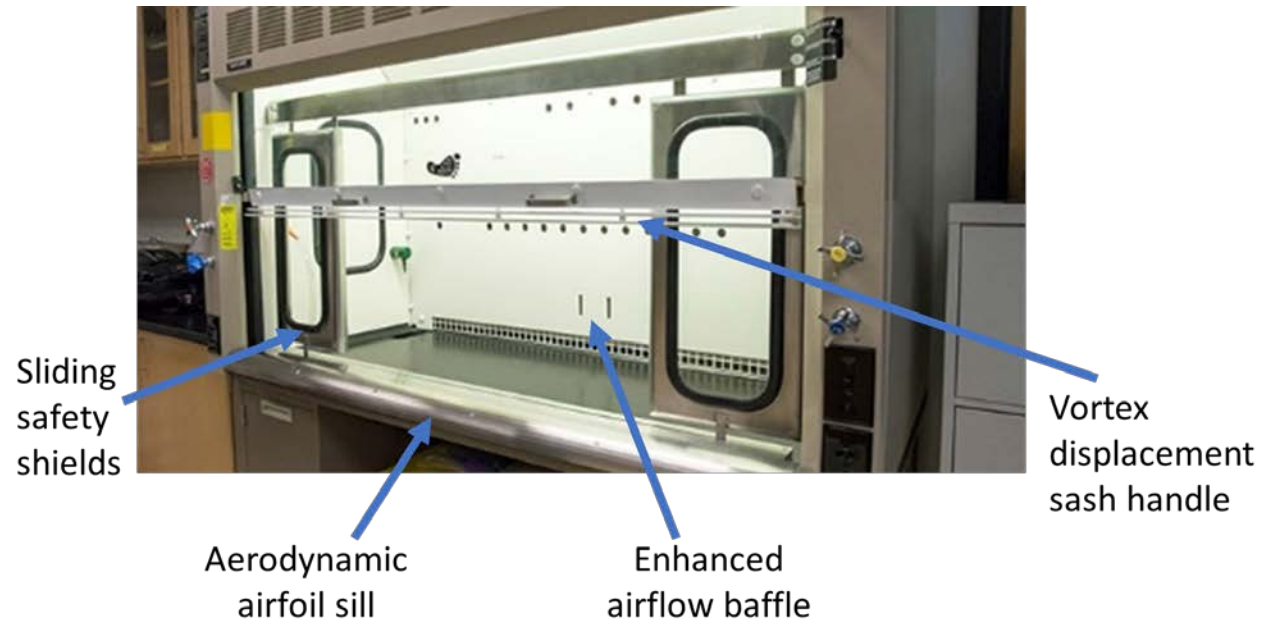
Future Projects – Engineering



Pneumatic Controls



Digital Controls



TA48-0107

Radiochemistry Facility

Current Status – Recently Renovated



Current Status – Energy Metering

48-0107 Electric

GSF = 3,225



Current Projects



Building Management Plan TA 48-0107

Table 1. Estimated time, cost, and savings estimate comparison

Cost Description	Estimated Cost	Estimated Savings
Sash Stickers Installation	\$ 100.00	\$ 10,400.00
Manifolded Exhaust Stacks and Balance of Ventilation System:	\$ 157,500.00	\$ 15,153.18
Automated Time/ Motion sensors for Lighting	\$ 1,000.00	\$ 946.08
Estimated Totals:	\$ 158,600.00	\$ 26,499.26
Estimated Payoff Time:	~6 years	

ROI for Smart Lab Upgrades



Future Projects



Demand for Ventilation Assessment Report



Laser Laboratory Building (35-0085)

Los Alamos National Laboratory

Los Alamos, New Mexico

Final Report

April 17, 2017



Exposure Control Technologies, Inc.
231-C East Johnson Street
Cary, NC 27513
www.exposurecontroltechnologies.com

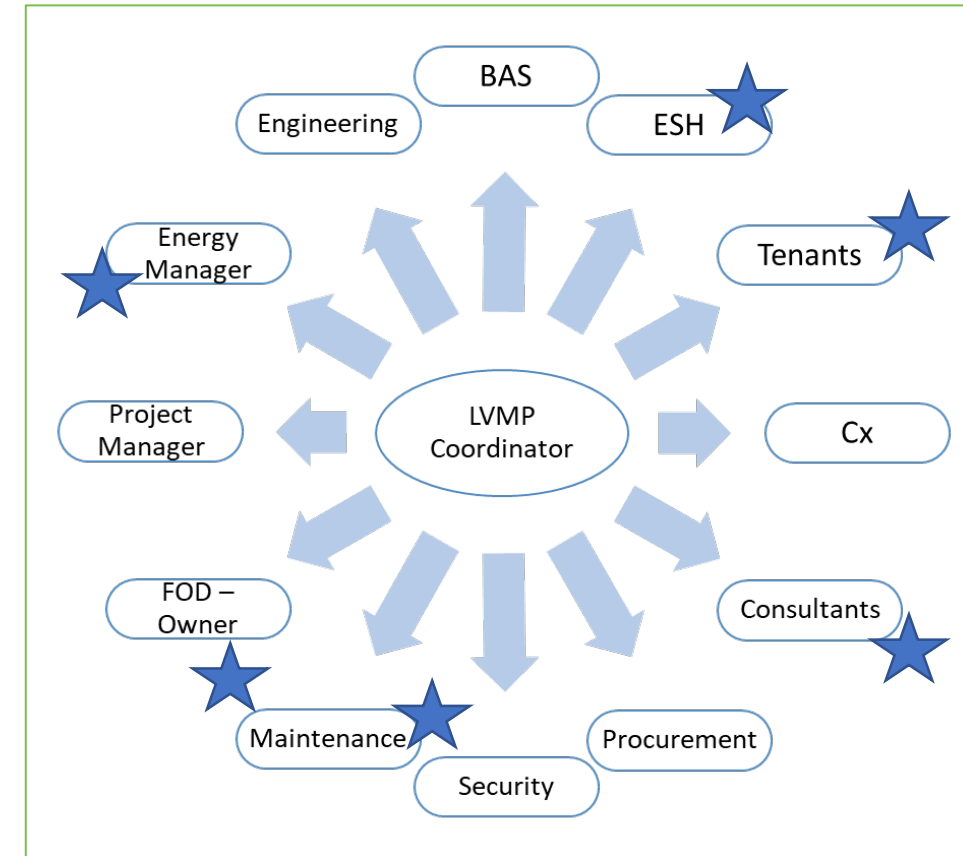


Future Work

Ventilation Management

Future Projects

- Annual Preventative Maintenance
- Annual Risk Control Banding
- Continue Weekly Meetings with Tenants
- Fume Hood Team Pilot
- Hibernation Protocol Pilot
- CEREBRO Pilot



Questions?

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