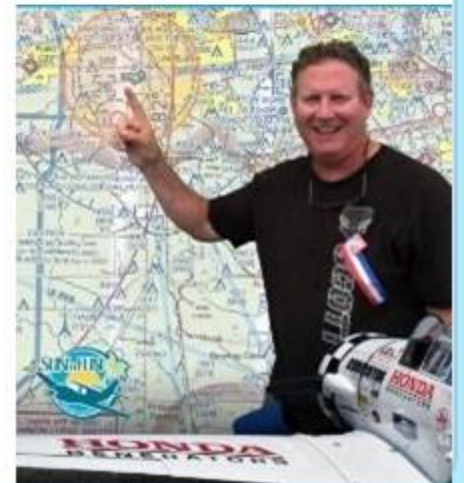


Practical Application of Upper-Room UVGI Systems

Paul Arthur Jensen, PhD, PE, CIH
Final Approach Inc



Keeping Public Spaces Safe:
Ultraviolet Germicidal Light for
Air Disinfection in the era of
COVID-19
13 March 2021

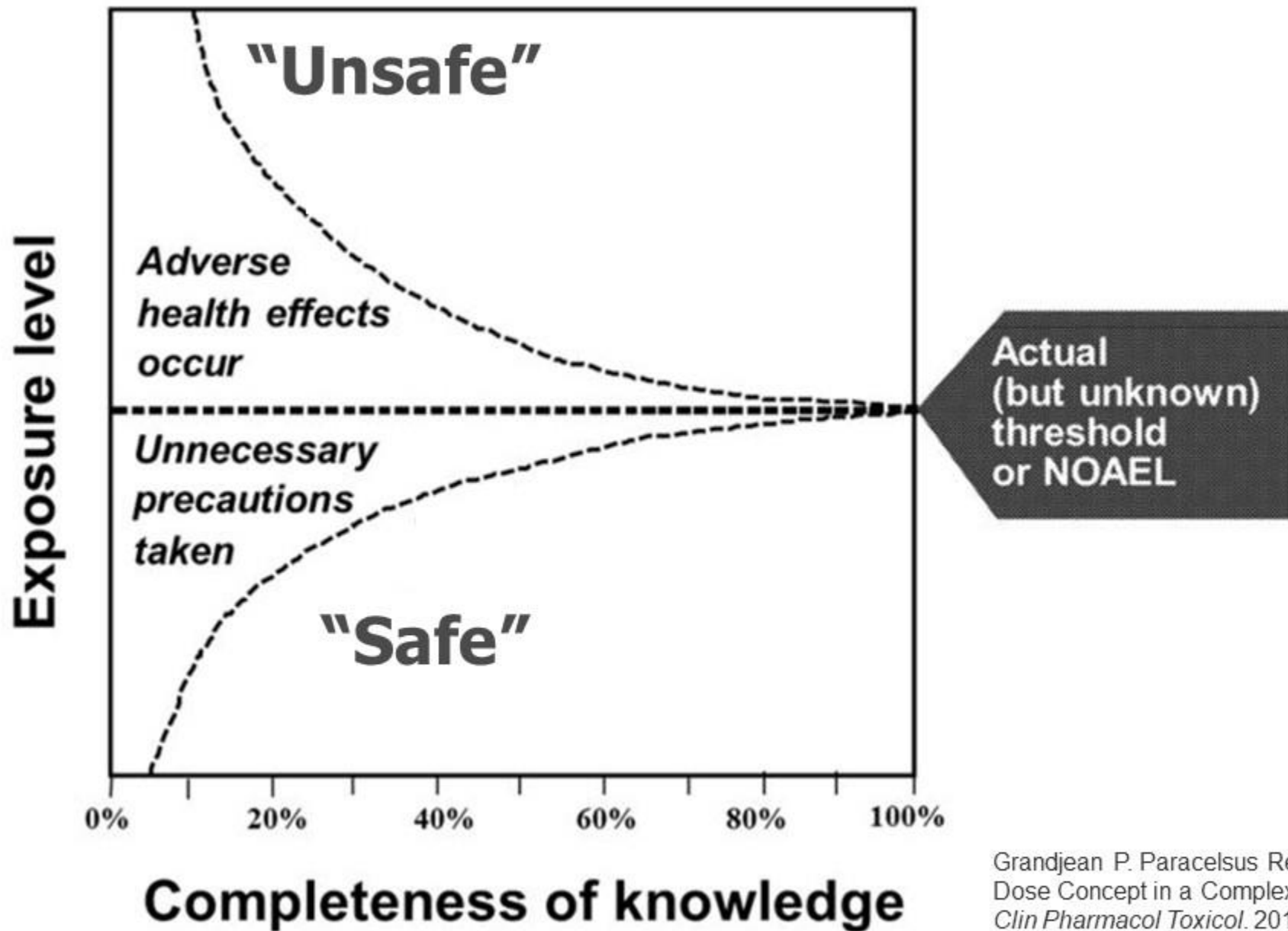


What is there that is not poison? All things are **poison** and nothing is without poison. Solely the dose determines that a thing is not a poison.

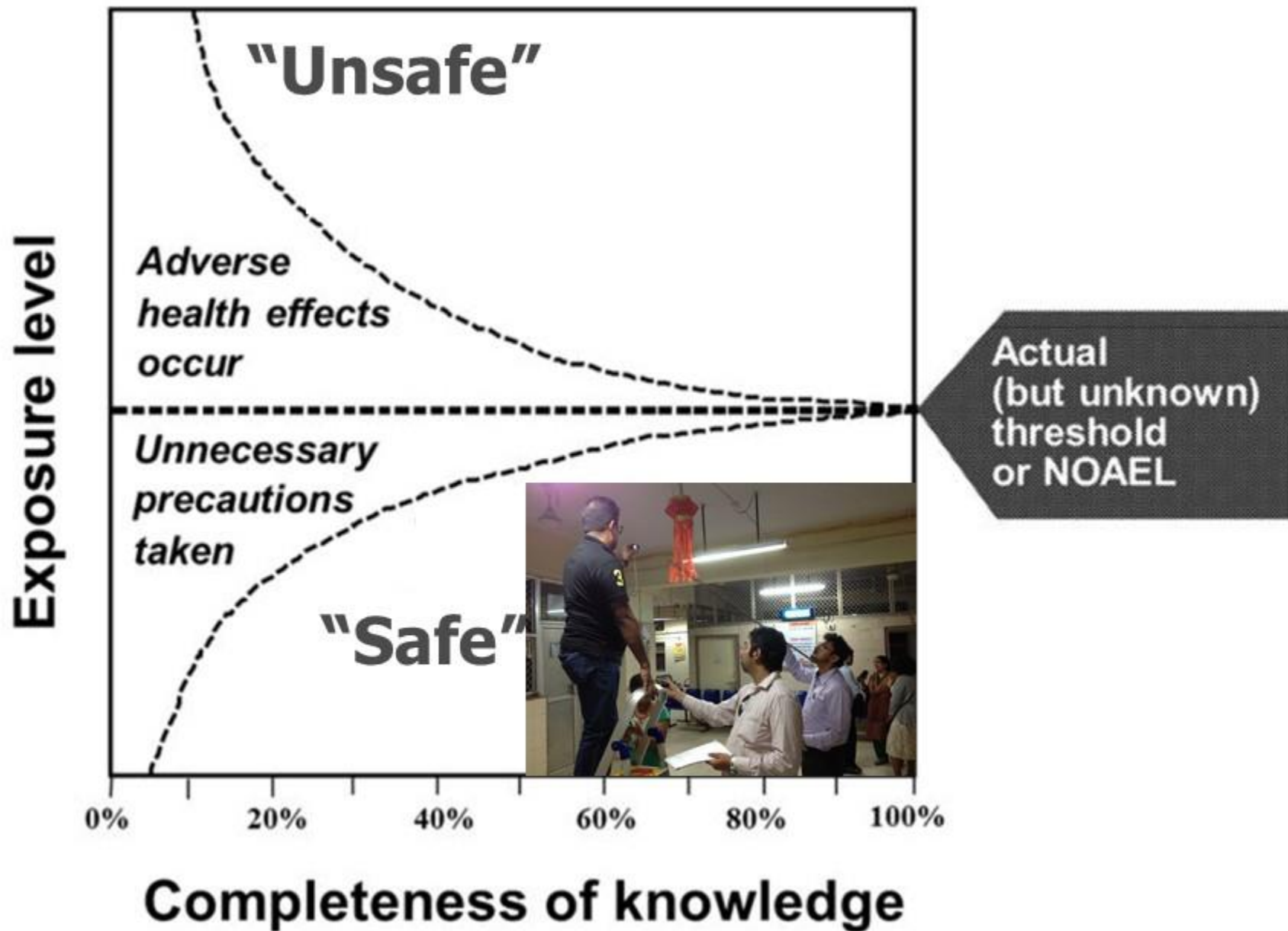
—Paracelsus
(1493–1541)

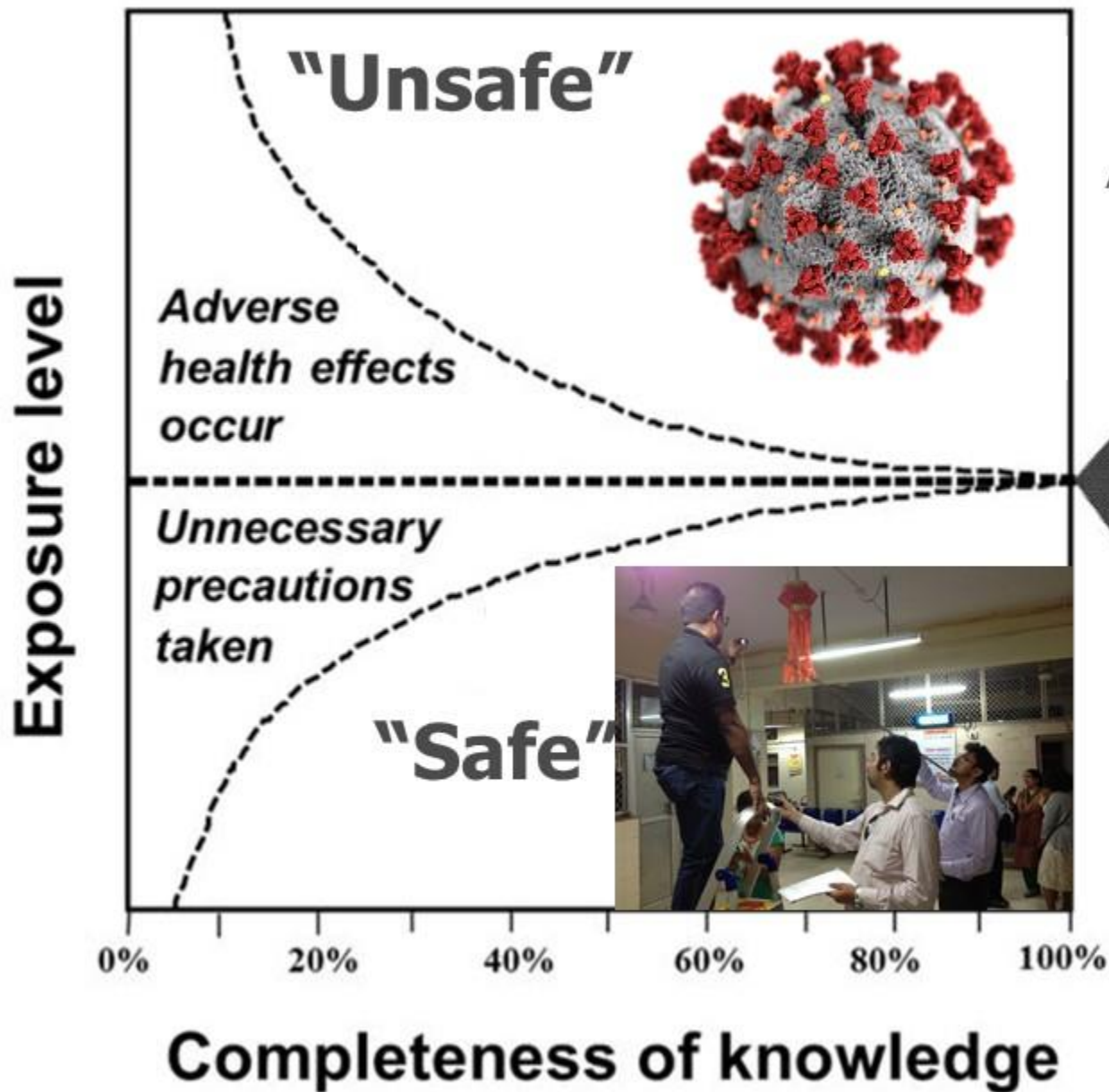


Grandjean P. Paracelsus Revisited: The Dose Concept in a Complex World. *Basic Clin Pharmacol Toxicol.* 2016;119(2):126-132. doi:10.1111/bcpt.12622



Grandjean P. Paracelsus Revisited: The Dose Concept in a Complex World. *Basic Clin Pharmacol Toxicol.* 2016;119(2):126-132. doi:10.1111/bcpt.12622



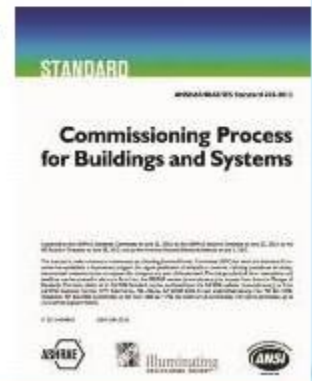


Alissa Eckert, MSMI, Dan Higgins, MAMS, CDC



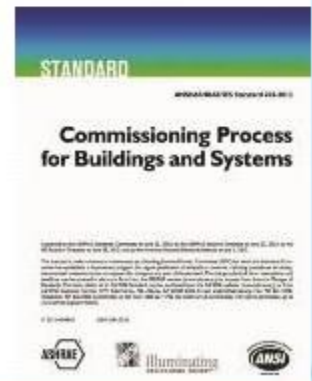
ANSI / ASHRAE / IES 202-2018: Commissioning Process For Buildings And Systems

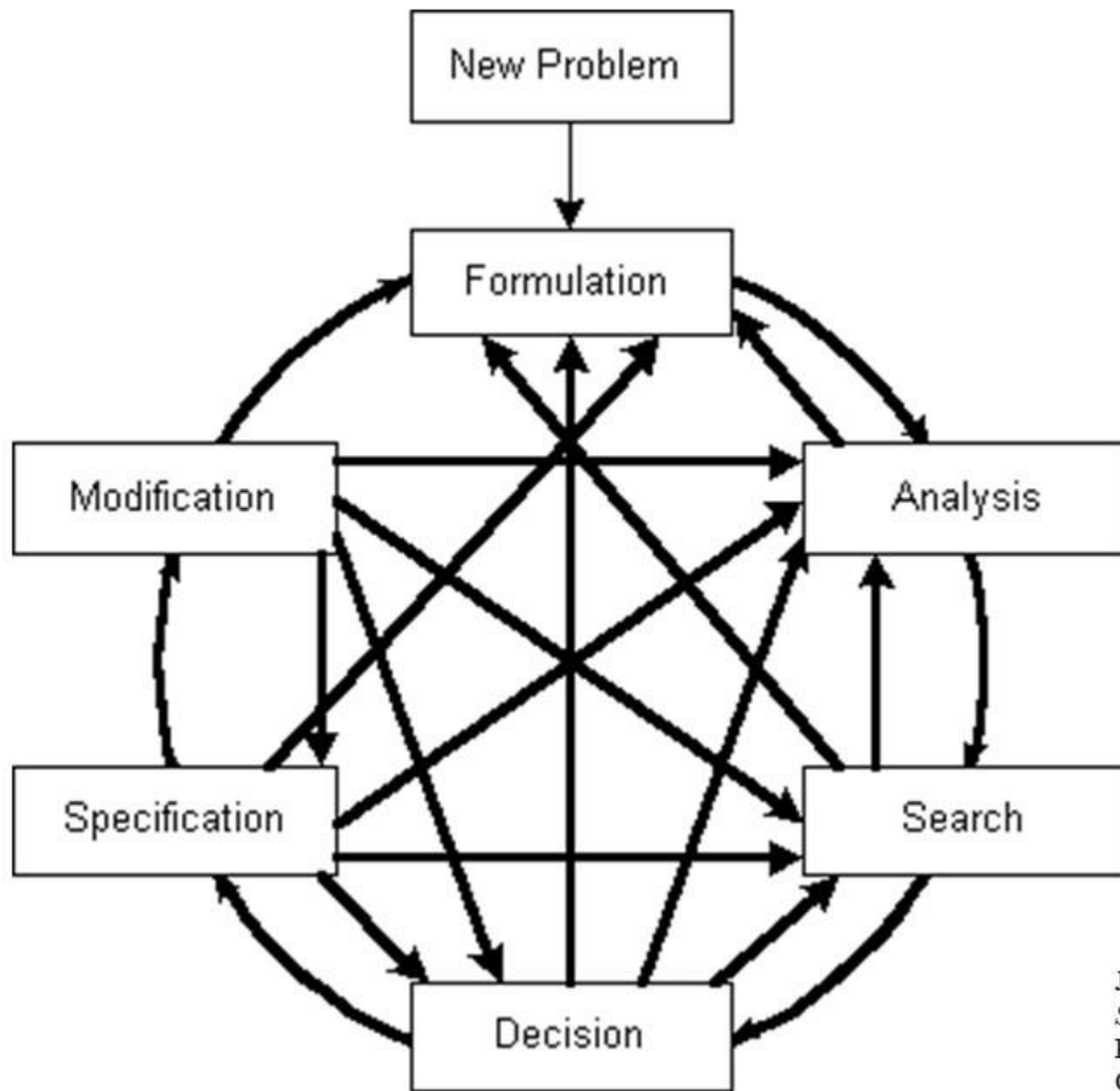
Provides procedures, methods and documentation requirements for each commissioning activity for project delivery, from predesign through occupancy and operations, to ensure building “performs” as desired!



ANSI / ASHRAE / IES 202-2018: Commissioning Process For Buildings And Systems

- Overview of Commissioning **Process** Activities,
- Description of each process step's minimum activities
- Minimum documentation requirements, and
- **Acceptance requirements (performance).**





Jensen RW, Tonies CC
Software Engineering,
Prentice Hall, Englewood
Cliffs, NJ, 1979, p.22)

The Salvation Army's Center of Hope

1001 N Pennsylvania Ave
Oklahoma City, OK 73107





N Pennsylvania Ave

sylvania Ave



 +52°

AOI 48



Risk Assessment

- Microorganisms/diseases of concern
 - Coronavirus
 - TB
 - Influenza
 - TB/Coronavirus, TB/influenza, Coronavirus/influenza
- Clients - Epidemiology
- Infection Prevention and Control Plan
(policies & practices fully implemented)



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Facebook © 2021

MAY
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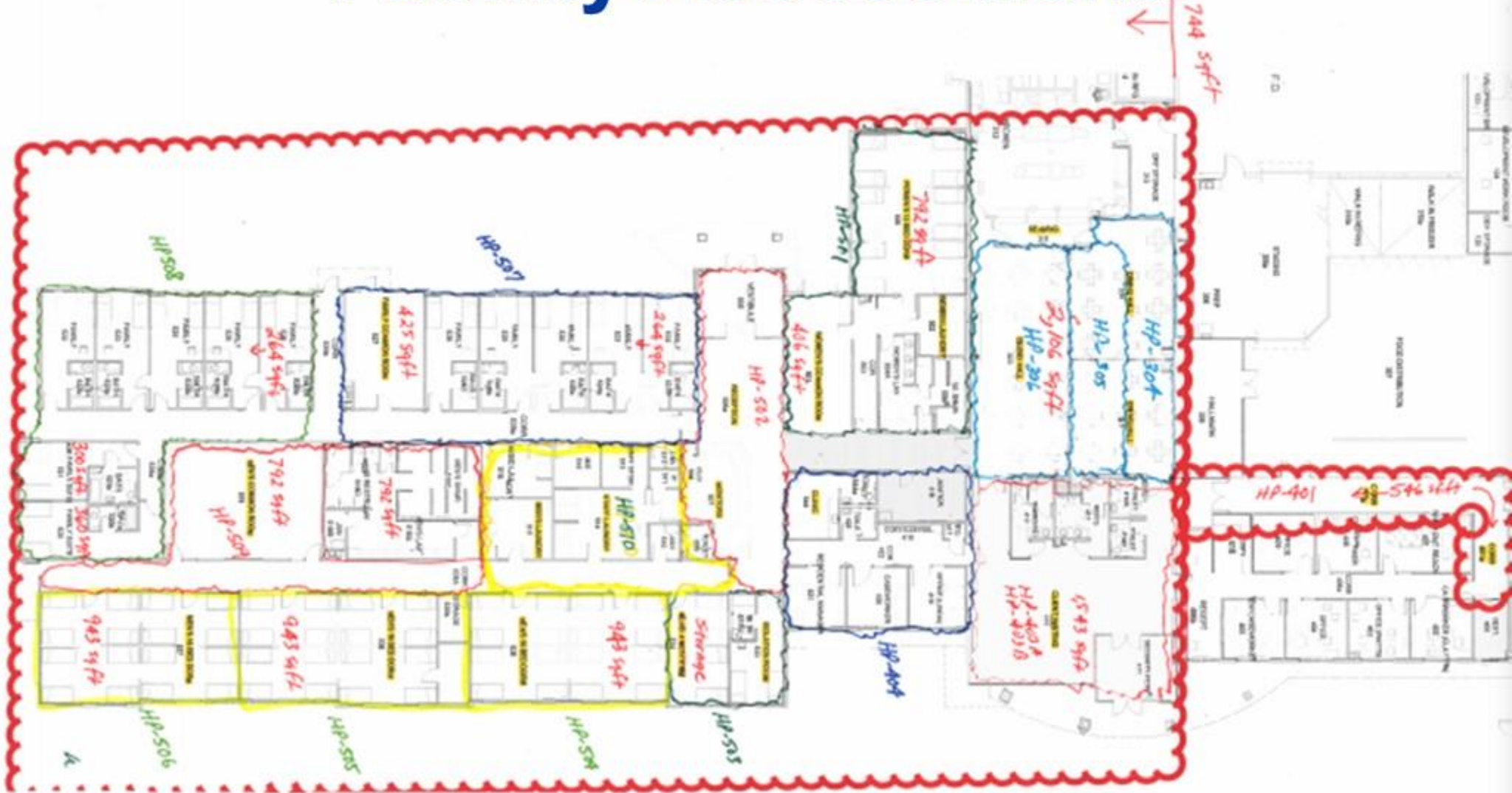
Homeless Encampment Public Testimony
Hearings (Series 1 of 4)

Antioch, Contra Costa County, California USA

TSA, OKC

- Meals
- Food packets
- Utility & rent assistance
- Temporary housing
- Transition housing
- Winter shelter

Facility Assessment



Facility Assessment

- Feasibility of implementation of UR UVGI systems
 - Ceiling height
 - Physical
 - Effective
 - Limitations due to activities in spaces
 - Electricity
 - Air mixing
 - Ceiling or wall fans
 - HVAC system

Prioritization

Priority	Room Name
1	Dining Room
1	Clinic Room
1	Family Common Room
1	Men's Common Room
1	Men's Dorm Room #1
1	Men's Dorm Room #2
1	Men's Dorm Room #3
1	Shelter Reception (corridor)
1	Shelter Reception (main area)
1	Social Services Reception
1	Women's Common Room
1	Women's Dorm Room
1	Pantry Corridor (exit)
1	Pantry Corridor (main)
2	Case Workers' Corridor
2	Case Workers' Office #1
2	Case Workers' Office #2
2	Case Workers' Office #3
2	Chapel
3	Staff Laundry Room
3	Pantry Main Room
3	Pantry Sorting Room
?	Tornado Shelter

Initial Room Evaluation

Priority	Room Name	Room Volume (m ³)
1	Dining Room	503
1	Clinic Room	33
1	Family Common Room	124
1	Men's Common Room	209
1	Men's Dorm Room #1	234
1	Men's Dorm Room #2	234
1	Men's Dorm Room #3	234
1	Shelter Reception (corridor)	83
1	Shelter Reception (main area)	224
1	Social Services Reception	282
1	Women's Common Room	103
1	Women's Dorm Room	198
1	Pantry Corridor (exit)	30
1	Pantry Corridor (main)	123
2	Case Workers' Corridor	50
2	Case Workers' Office #1	33
2	Case Workers' Office #2	33
2	Case Workers' Office #3	33
2	Chapel	688
3	Staff Laundry Room	76
3	Pantry Main Room	856
3	Pantry Sorting Room	129
?	Tornado Shelter	550

Initial Dose Calculation

Priority	Room Name	Room Volume (m ³)	Calculated Dosage (W)
1	Dining Room	503	6.04
1	Clinic Room	33	0.39
1	Family Common Room	124	1.49
1	Men's Common Room	209	2.50
1	Men's Dorm Room #1	234	2.81
1	Men's Dorm Room #2	234	2.81
1	Men's Dorm Room #3	234	2.81
1	Shelter Reception (corridor)	83	0.99
1	Shelter Reception (main area)	224	2.69
1	Social Services Reception	282	3.38
1	Women's Common Room	103	1.24
1	Women's Dorm Room	198	2.37
1	Pantry Corridor (exit)	30	0.36
1	Pantry Corridor (main)	123	1.47
2	Case Workers' Corridor	50	0.60
2	Case Workers' Office #1	33	0.39
2	Case Workers' Office #2	33	0.39
2	Case Workers' Office #3	33	0.39
2	Chapel	688	8.26
3	Staff Laundry Room	76	0.91
3	Pantry Main Room	856	10.26
3	Pantry Sorting Room	129	1.55
?	Tornado Shelter	550	6.60

Initial Luminaire Selection

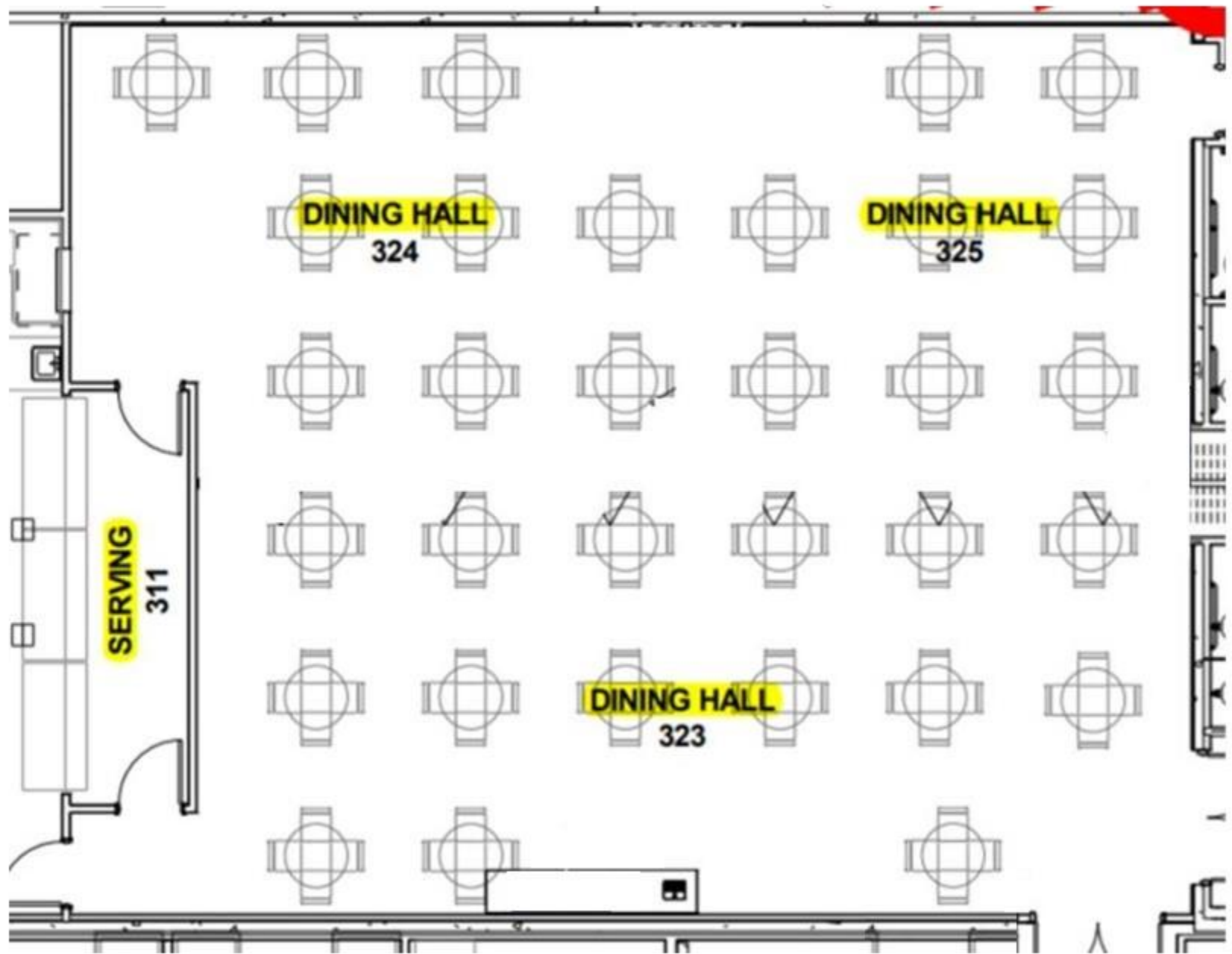
Priority	Room Name	Room Volume (m ³)	Calculated Dosage (W)
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2	Case Workers' Office #2	33	0.39
2	Case Workers' Office #3	33	0.39
2	Chapel	688	8.26
3	Staff Laundry Room	76	0.91
3	Pantry Main Room	856	10.26
3	Pantry Sorting Room	129	1.55
?	Tornado Shelter	550	6.60

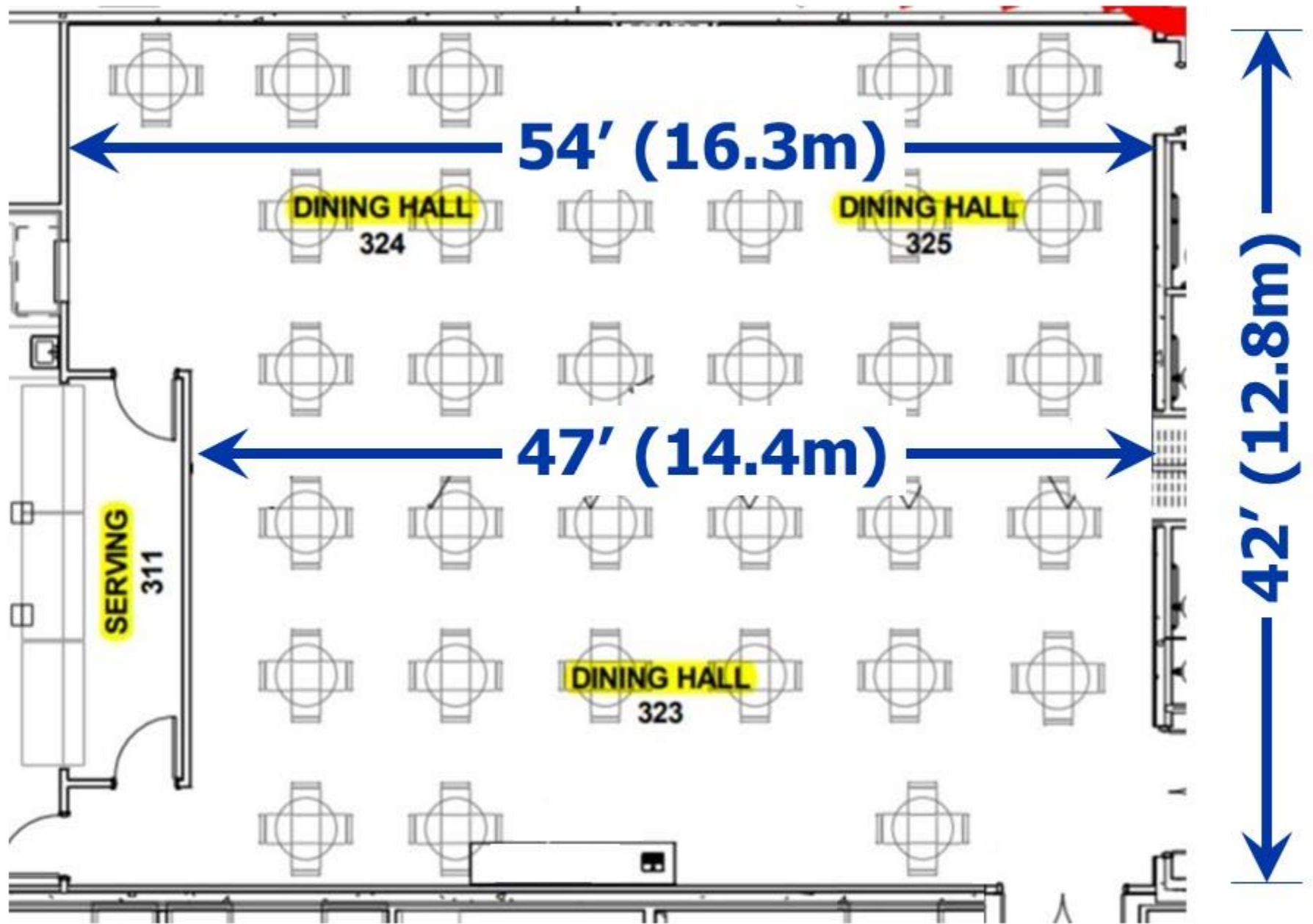
Mini	UVC Output =	0.35 W
Stratus	UVC Output =	0.71 W
Max	UVC Output =	1.21 W
Stratus Open	UVC Output =	3.71 W
Max Open	UVC Output =	6.25 W

Initial Luminaire Selection

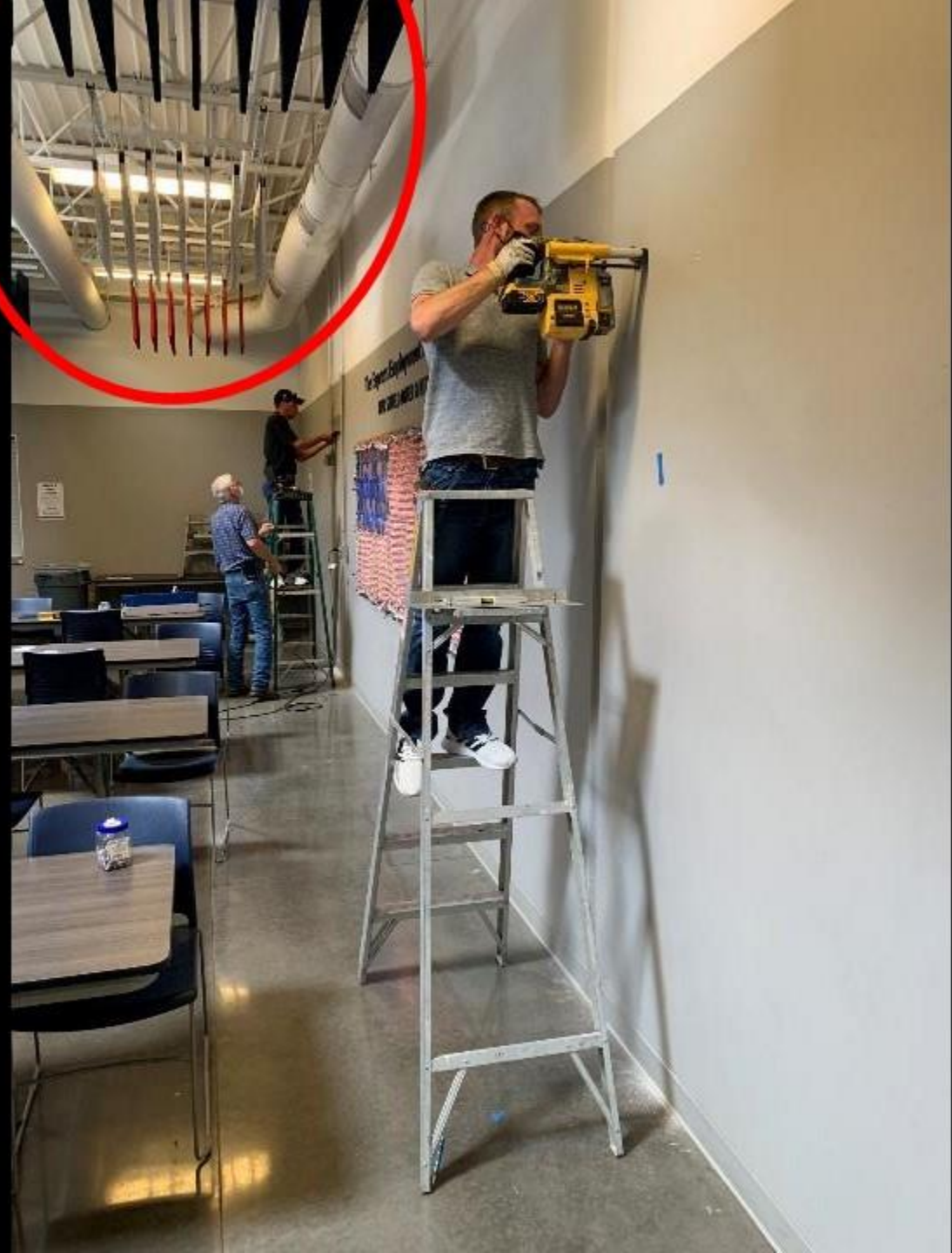
Priority	Room Name	Room Volume (m ³)	Calculated Dosage (W)	Cumulative Dosage (W)	Recommendation
1	Dining Room	503	6.04	6.05	5-Max
1	Clinic Room	33	0.39	0.35	1-Mini
1	Family Common Room	124	1.49	1.42	2-Stratus
1	Men's Common Room	209	2.50	2.42	2-Max
1	Men's Dorm Room #1	234	2.81	2.42	2-Max
1	Men's Dorm Room #2	234	2.81	2.42	2-Max
1	Men's Dorm Room #3	234	2.81	2.42	2-Max
1	Shelter Reception (corridor)	83	0.99	0.70	2-Mini
1	Shelter Reception (main area)	224	2.69	2.77	1-Mini & 2-Max
1	Social Services Reception	282	3.38	3.63	3-Max
1	Women's Common Room	103	1.24	1.42	2-Stratus
1	Women's Dorm Room	198	2.37	2.13	3-Stratus
1	Pantry Corridor (exit)	30	0.36	0.35	1-Mini
1	Pantry Corridor (main)	123	1.47	1.40	4-Mini
2	Case Workers' Corridor	50	0.60	0.70	2-Mini
2	Case Workers' Office #1	33	0.39	0.35	1-Mini
2	Case Workers' Office #2	33	0.39	0.35	1-Mini
2	Case Workers' Office #3	33	0.39	0.35	1-Mini
2	Chapel	688	8.26	7.42	2-Stratus Open
3	Staff Laundry Room	76	0.91	0.71	1-Stratus
3	Pantry Main Room	856	10.26	11.13	3-Stratus Open
3	Pantry Sorting Room	129	1.55	1.42	2-Stratus
?	Tornado Shelter	550	6.60	6.61	4-Max, 2-Stratus, & 1-Mini

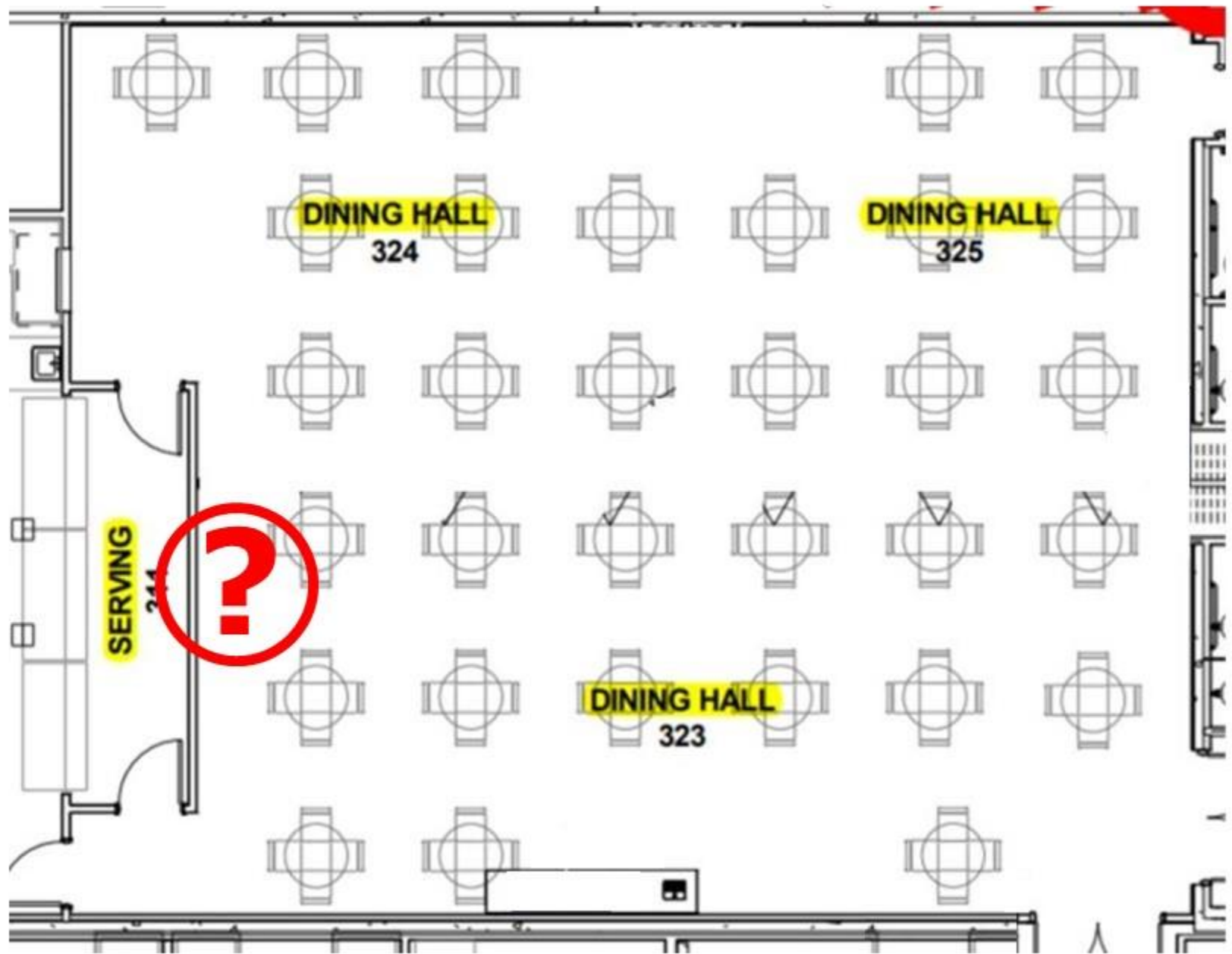
Initial Luminaire Layout

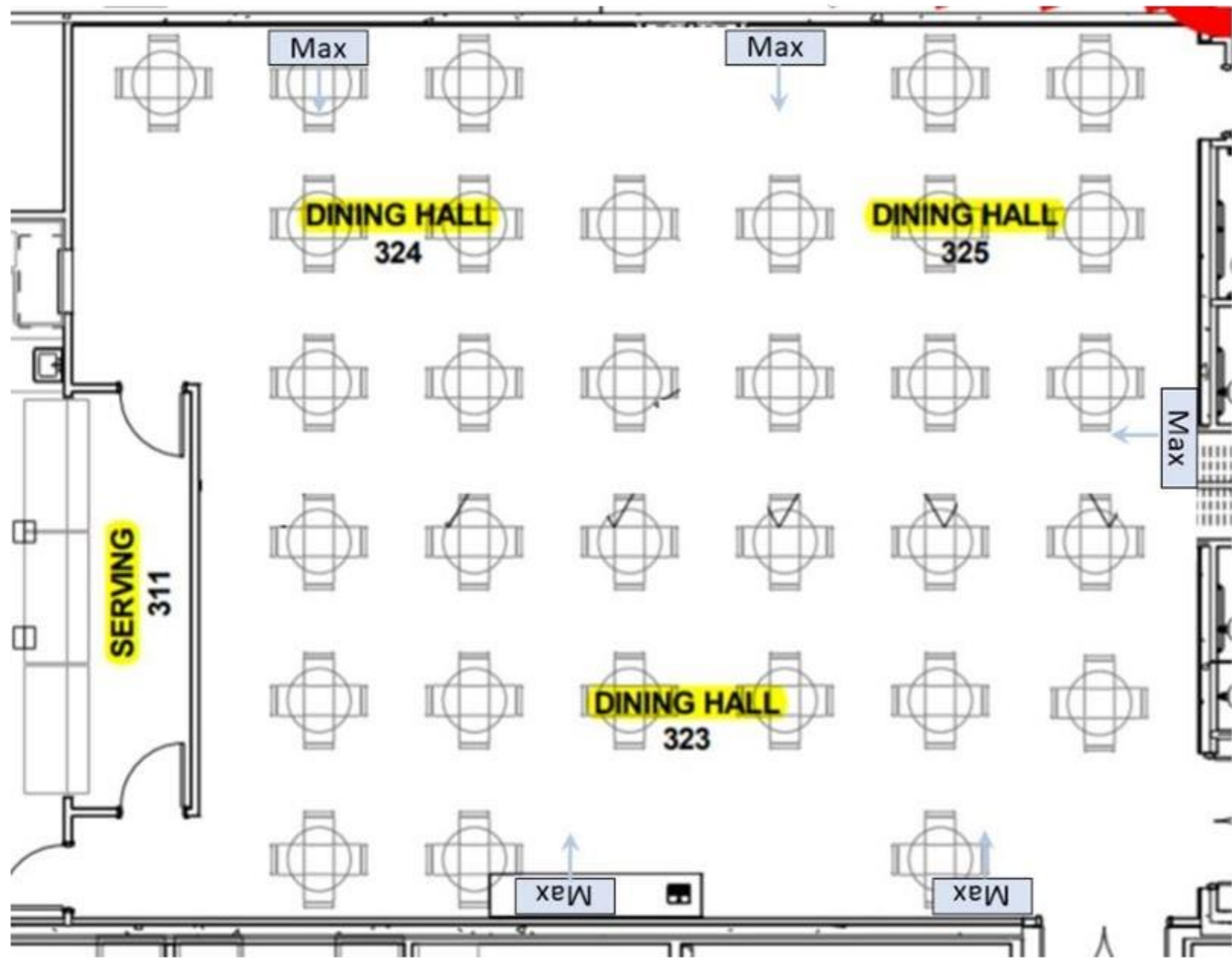


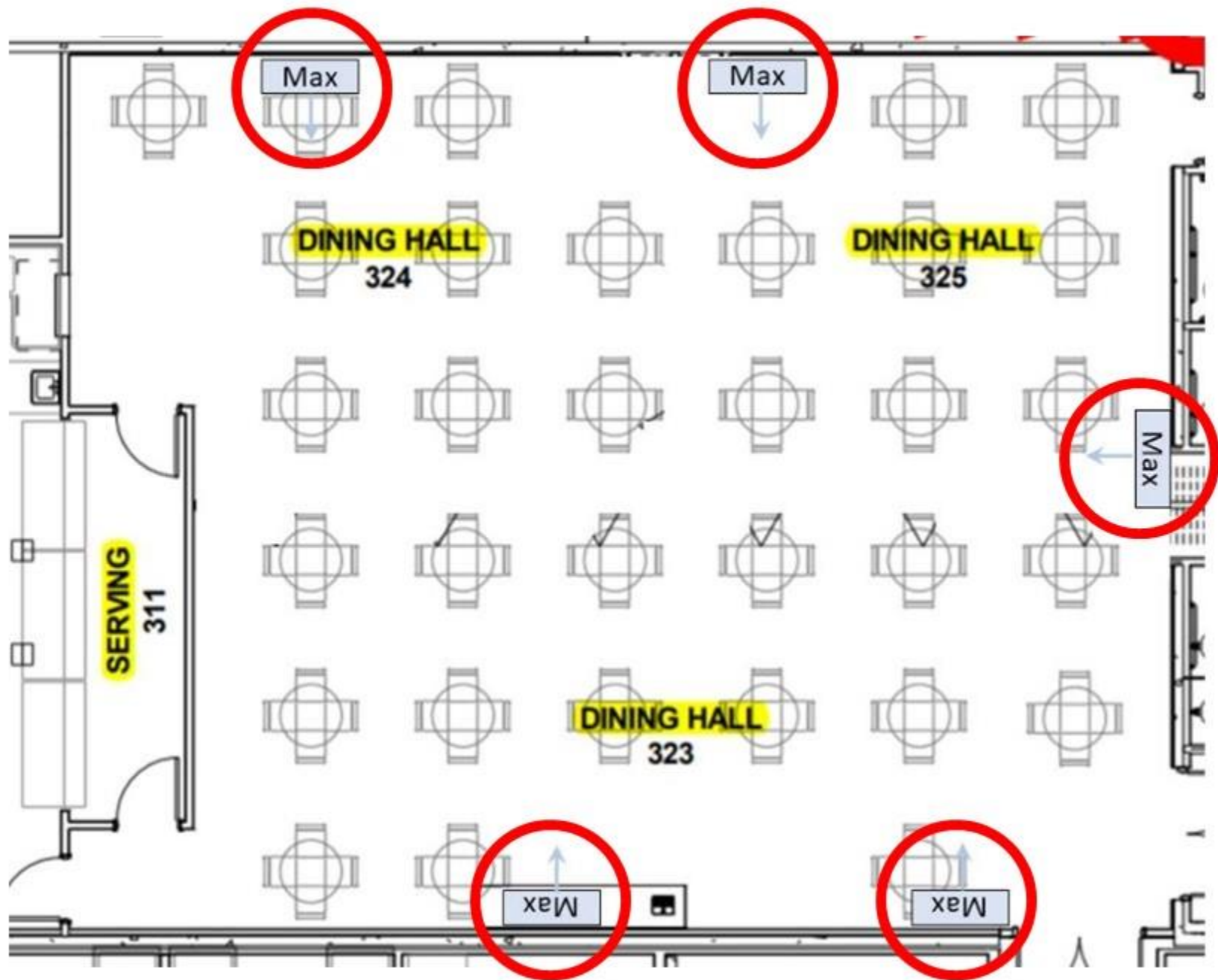












UVGI Luminaire Installation and Adjustment



ntier State Bank



The Express Employment Professionals
RED SHIELD DINER & KITCHEN





Final Acceptance Testing or Final Performance Testing

- This is NOT “commissioning”; rather, it is one step in the commissioning process!



42

43



42

43

5.5-5.9'
(1.68-1.80m)

42

43







0.390
µW/cm²

Operation and Maintenance

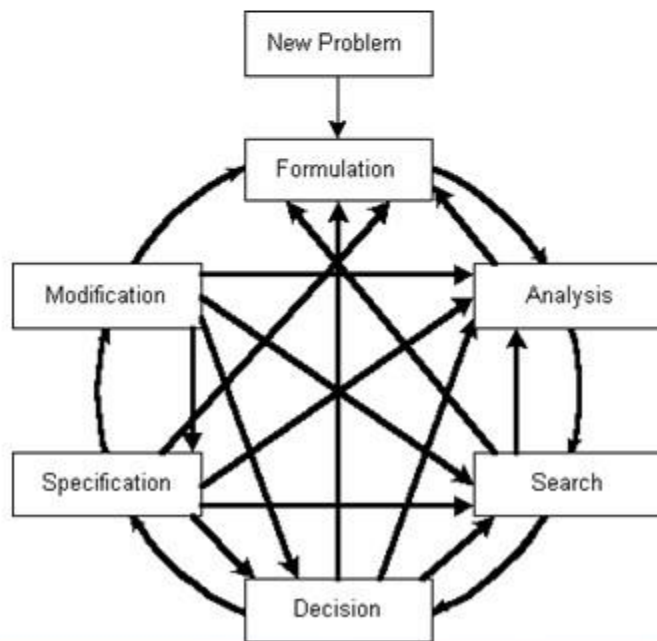






Change in Priorities

- Due to the limited Winter Shelter beds in OKC, TSA opened their Tornado Shelter for women during cold weather.

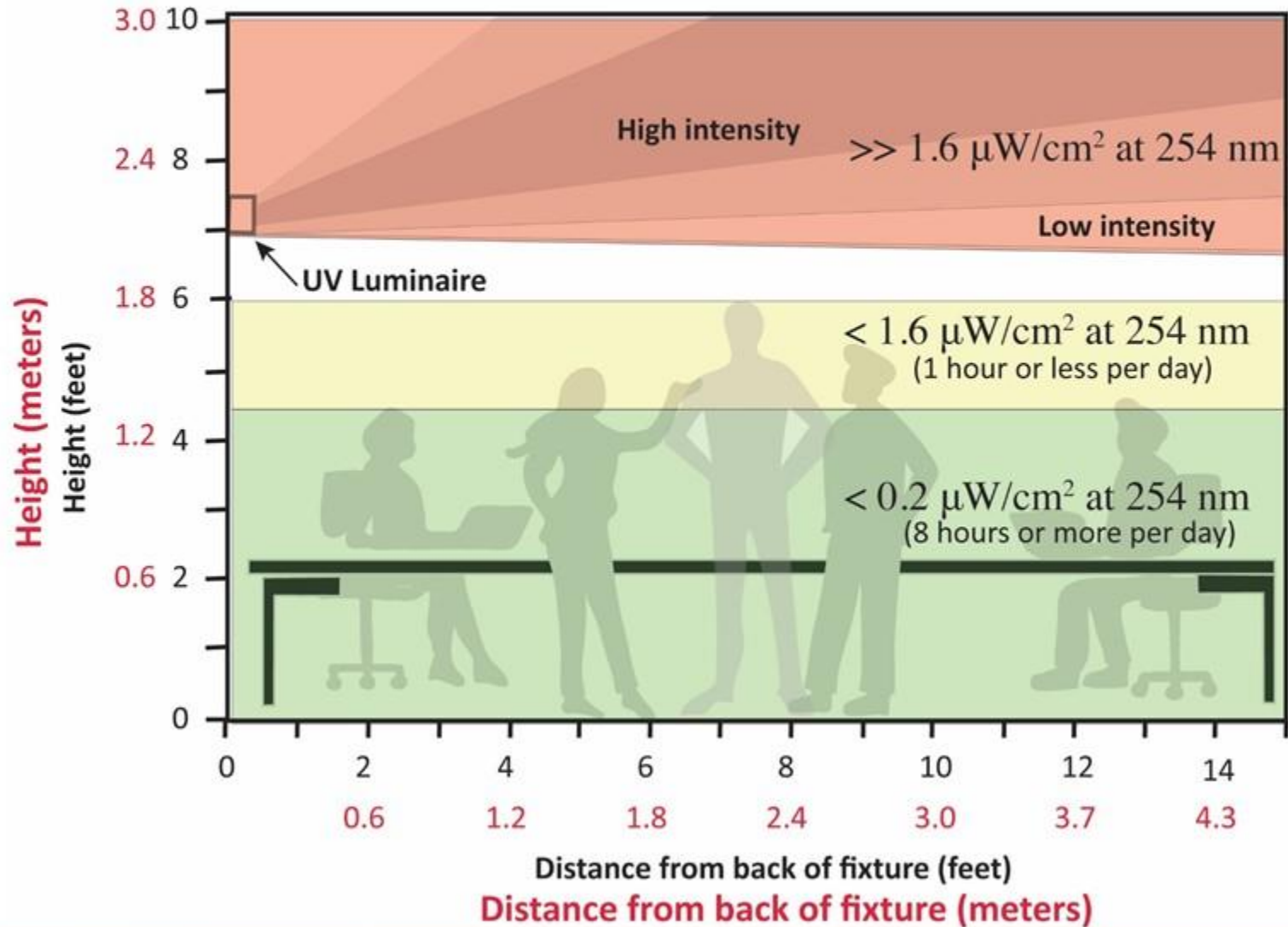








Air Mixing





PERGAMON

Atmospheric Environment 37 (2003) 405–419

ATMOSPHERIC
ENVIRONMENT

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Efficacy of ultraviolet germicidal irradiation of upper-room air
in inactivating airborne bacterial spores and mycobacteria
in full-scale studies

Peng Xu^a, Jordan Peccia^a, Patricia Fabian^a, John W. Martyny^b,
Kevin P. Fennelly^c, Mark Hernandez^a, Shelly L. Miller^{d,*}

^aDepartment of Civil, Environmental, and Architectural Engineering, University of Colorado, 428 UCR, Boulder, CO 80309, USA

^bTri-County Health Department, 4301 East 72nd Ave., Commerce City, CO 80022, USA

^cDivision of Pulmonary Medicine, National Jewish Medical and Research Center, 1400 Jackson St., Denver, CO 80206, USA

^dDepartment of Mechanical Engineering, University of Colorado, 427 UCR, Boulder, CO 80309-0427, USA

Received 1 February 2002; received in revised form 14 September 2002; accepted 21 September 2002



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Mixing vs. No Mixing

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Mixing vs. No Mixing

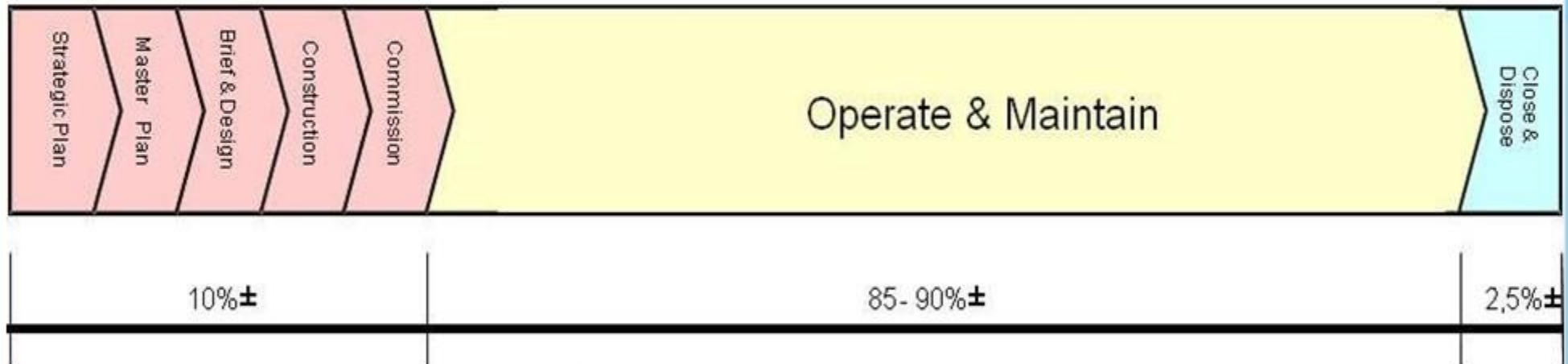
17 ACH vs. 3.4 ACH

oom air temperature). The inter-zonal airflow rate between the low
was an important factor in determining UVGI efficacy; under

Air Mixing

- Ceiling fans
- Wall fans
- Ventilation supply grilles

Lifecycle Costs

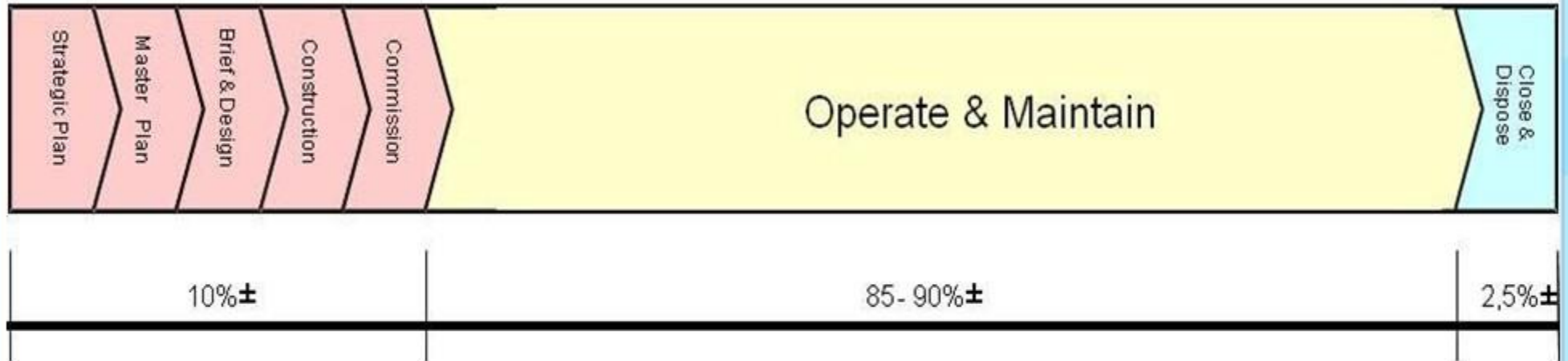


Graphic Courtesy of SA Parsons & G Abbott

Lifecycle Costs

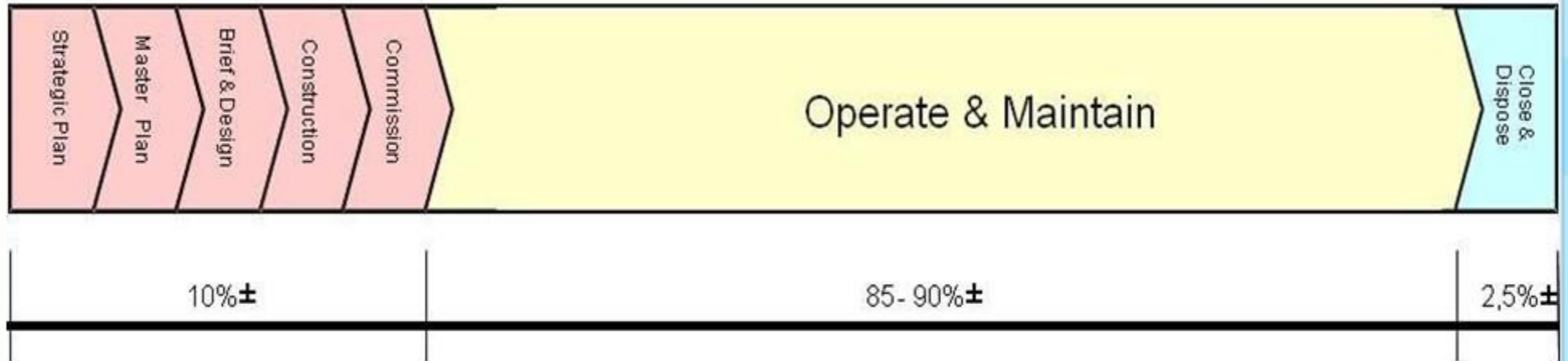
- Total cost over the life of the item
 - Planning & Procurement
 - Strategic Plan
 - Master Plan
 - Commissioning process
 - Design brief & design specifications
 - Construction/installation
 - Final acceptance/performance test
 - Operation & Maintenance
 - Close & Disposal

Lifecycle Costs



- Over the life of the UVC luminaire, how much will it cost to procure, install, operate, and maintain it?

Lifecycle Costs



- Over the life of the UVC luminaire, how much will it cost to procure, install, operate and maintain this luminaire?
- **2-5 times capital cost!**

Summary (1)

- UVGI lamps (254 nm)
- UVGI luminaires (fixtures)
- Room design & installation
- Room air mixing
- Final acceptance/performance testing (*final step in commissioning process before handover*)
- UVGI luminaire maintenance
- UVGI systems do NOT replace requirement for minimal fresh air!

Summary (2)

- Political commitment
- Rules and regulations supporting UVGI systems and part of the “package” of airborne infection control and prevention measures
- Guidelines to assist public and private entities and citizens in implementation of UVGI systems.
- End of the COVID-19 pandemic
- Better health for all

References (1)

Guidelines on Airborne Infection Control in Healthcare and Other Settings



April 2010
Directorate General of Health Services
Ministry of Health & Family Welfare
Nirman Bhawan, New Delhi

WHO guidelines on
tuberculosis infection
prevention and control
2019 update



THE
END TB
STRATEGY



World Health
Organization

References (2)

TECHNICAL INFORMATION SHEET

Disinfecting room air with upper-room (UR) germicidal UV (GUV) systems



What are UR GUV systems?
UR GUV (also referred to as ultraviolet germicidal irradiation or UVGI) systems combine the safe usage of GUV energy in the upper room with mechanical air mixing to disinfect large volumes of room air. (See Figure 1).

Why is UR GUV needed?
UR GUV is an affordable, effective and sustainable environmental control for reducing TB transmission in high TB transmission risk settings.

Are UR GUV systems recommended by WHO?
Yes, the updated WHO TB infection prevention and control guidelines¹ state "Upper-room germicidal ultraviolet (GUV) systems are recommended to reduce *M. tuberculosis* transmission to health workers, persons attending health care facilities or other persons in settings with high risk transmission." (Recommendation 5).

Studies on the effectiveness of GUV in two TB wards (one in Peru, the other in South Africa), found the reduction in risk of TB transmission was 70-80%.^{2,3}


Other studies show the varying levels of effectiveness of GUV in preventing airborne transmission of measles and other airborne pathogens.^{4,5}

How do we know if UR GUV systems are right for us?
Every facility should conduct a comprehensive airborne infection prevention and control (IPC) risk assessment by a trained facility IPC Team. This should be followed by development of a feasible and sustainable IPC plan to address and minimize the risks. Administrative controls must be given first priority, before considering other measures including UR GUV systems.⁶

ETT End Tuberculosis Transmission Initiative | **Stop TB Partnership**

ETT End TB Transmission Initiative

MAINTENANCE OF UPPER-ROOM GERMICIDAL ULTRAVIOLET (GUV) AIR DISINFECTION SYSTEMS FOR TB TRANSMISSION CONTROL



USAID FROM THE AMERICAN PEOPLE

Partner of the **Stop TB Partnership**

Thank you!

धन्यवाद!

ధన్యవాదాలు!

આભાર!

ధన్యవాదంಗಳು!



നന്ദി!

धन्यवाद!

ತುಲಾ ಪೆನ್‌ವಾಲ್ಡ್!

धन्यवाद!!

நன்றி!!