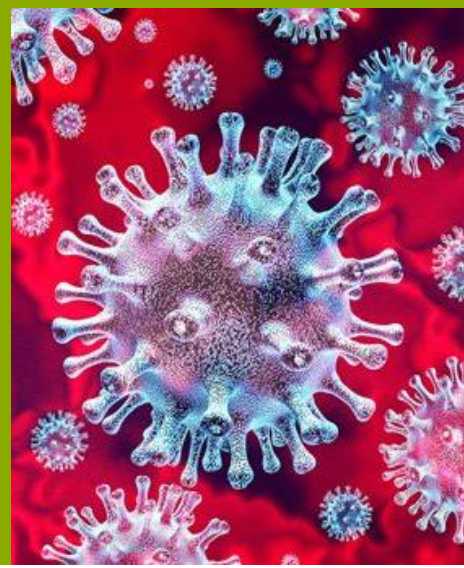
UPDATE: Recent US-Based Guidance for Healthcare Facilities To Prepare for COVID-19 Patients

Prepared for the China Chapter of I²SL

Daniel L. Doyle, PE, LEED AP
Chairman, Grumman/Butkus Associates
Board Member, International Institute for Sustainable Laboratories

April 28, 2020



Background and Sources

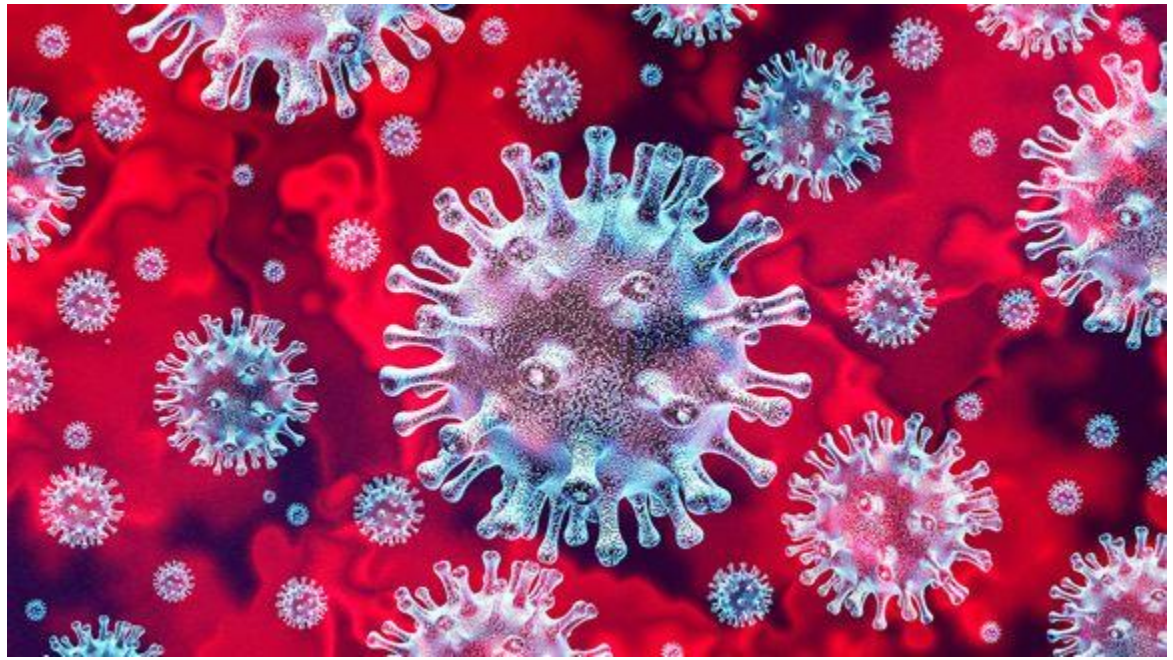
The guidance included in this presentation relies heavily on information obtained from:

- ASHE/ASHRAE Technical Committee for Healthcare (TEC 9.6)
- ASHRAE's Epidemic Task Force, chaired by William Bahnfleth
- See the Technical Committee 9.6 guidance (basis for this presentation): http://tc0906.ashraetcs.org/documents/COVID 2019 GUIDANCE ASHRAE Revised3-31-2020.pdf
- ASHE updates: https://www.ashe.org/COVID19resources

This presentation also represents the personal opinions of the presenter. ASHRAE, ASHE, and I²SL are not responsible for the use or application of this information. ***It is based in part on information developed in late March, but the situation continues to change rapidly.***

Pandemic COVID-19 and Airborne Transmission

What is the issue?



What Is ASHRAE's Role in This Pandemic?

ASHRAE, through its Environmental Health Committee, created the Epidemic Task Force, and has issued the following statements:

- Statement on airborne transmission of SARS-CoV-2:

  "Transmission of SARS-CoV-2 through the air is sufficiently likely that airborne exposure to the virus should be controlled. Changes to building operations, including the operation of heating, ventilating, and air-conditioning systems, can reduce airborne exposures."

- Statement on operation of heating, ventilating, and air-conditioning systems to reduce SARS-CoV-2 transmission:

  "Ventilation and filtration provided by heating, ventilating, and air-conditioning systems can reduce the airborne concentration of SARS-CoV-2 and thus the risk, of transmission through the air. Unconditioned spaces can cause thermal stress to people that may be directly life threatening and that may also lower resistance to infection. In general, disabling of heating, ventilating, and air-conditioning systems is not a recommended measure to reduce the transmission of the virus."

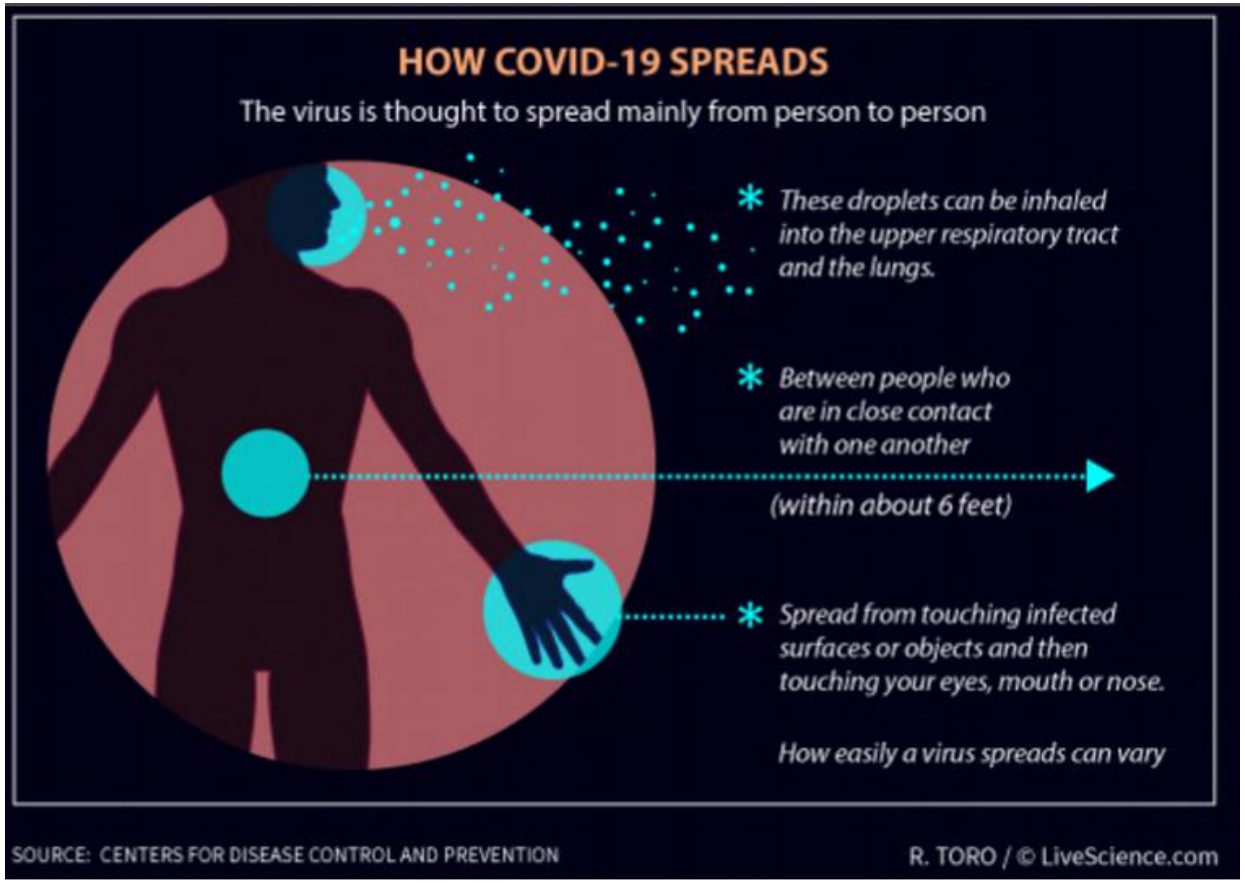
Pandemic COVID-19 and Airborne Transmission

Two important questions:

- What are the engineering interventions that may be applied to minimize the spread of the disease through air?
- How effective are those interventions at minimizing the spread of the disease?

Transmission

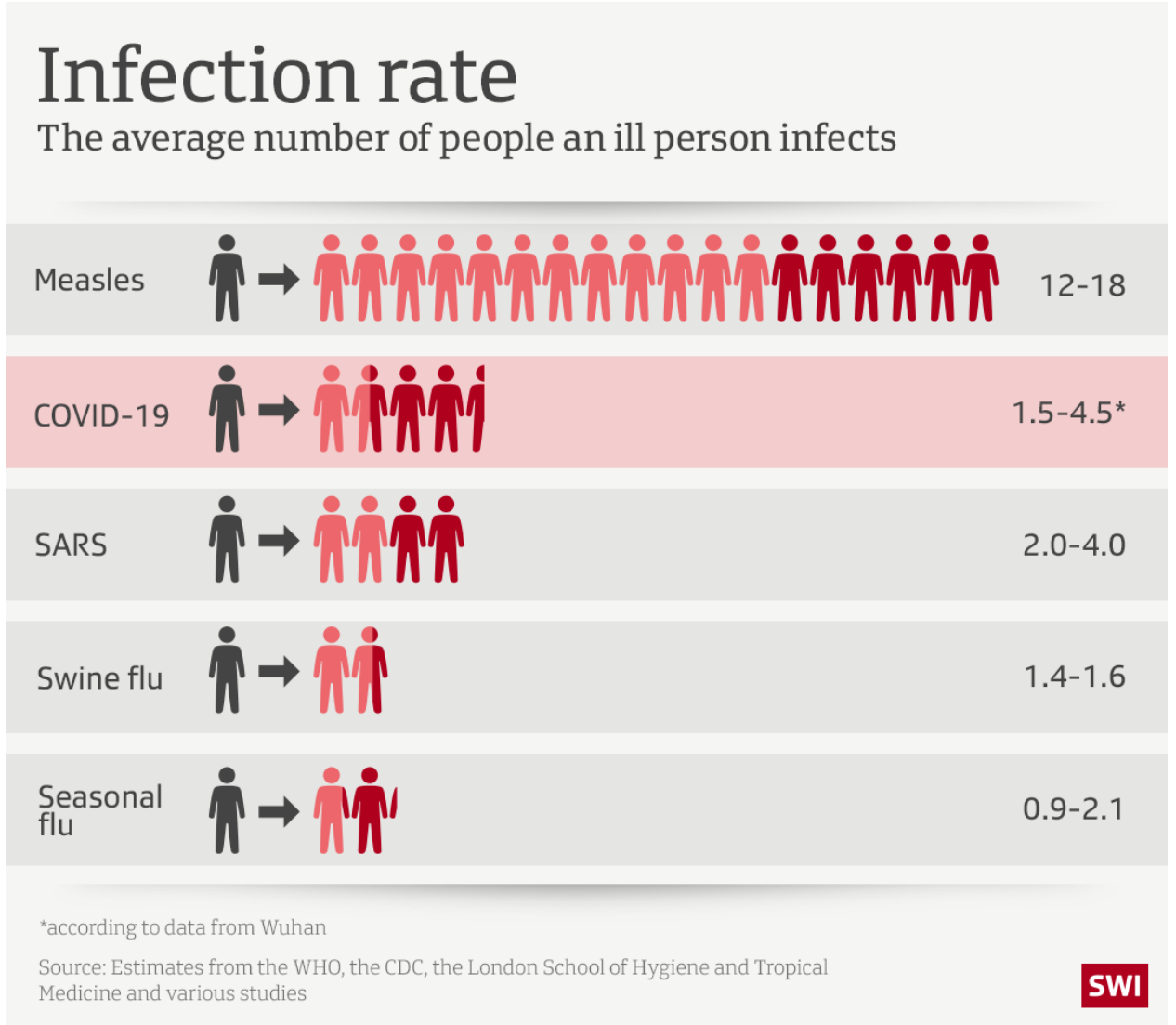
- COVID 19 is viable on surfaces for two to three days
- COVID 19 is viable aerosolized for at least three hours*
- See Aerobiology and HEPA filter sections for further information regarding airborne transmission risk



* https://www.statnews.com/2020/03/16/coronavirus-can-become-aerosol-doesnt-mean-doomed/

Transmission

- Transmission rate appears comparable to, but higher than, influenza
- Varies according to hygiene and mitigation efforts
- 25% of cases transmitted while asymptomatic (first 24 to 48 hours)
- People are thought to be most contagious when they are most symptomatic (sickest) – like in a hospital!



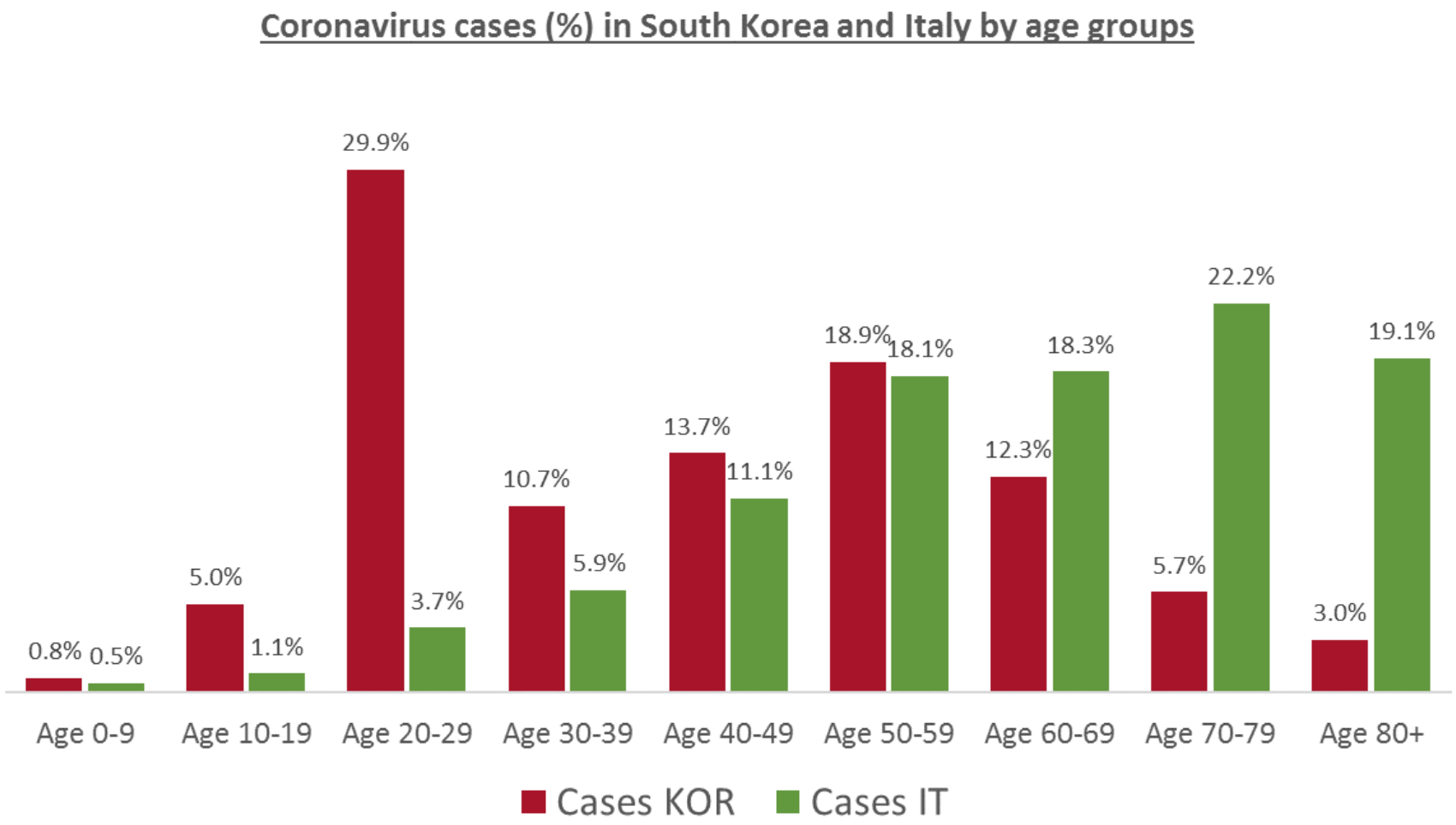
Populations

- At-risk populations frequently become more severe cases
- 15% of infected require **oxygen interventions**
- 3 to 4% mortality rate* vs 0.1% for influenza (30x higher). Actual rate unknown due to lack of information regarding actual number of people infected and undiagnosed.
- 80 years and older mortality rate is near 15% (70 = 8%, 60 = 3%)
- Nursing home / assisted living residents at high risk
- Others in confined spaces, such as prisons, at high risk

* If healthcare system becomes overwhelmed. Has been contained to about 1.0% mortality when rigorously managed (testing, quarantined, treatment regimes). Still 10x higher than influenza.

Transmission

- Young people may unknowingly have COVID and spread COVID



Hospital Space: Isolation

- Since COVID-19 emerged in most countries during their regular influenza season, most hospitals were already running at higher capacity. COVID influx has stretched normal conditions and, in some places, overcame available capacity. Officials have scrambled to develop alternatives for meeting patient needs.
- In the U.S. hospitals have airborne infectious isolation (A.I.I.) rooms, generally one to two per patient floor or suite. These rooms would normally be used for suspected COVID patients, along with patients who have other infectious conditions, such as tuberculosis.
- As COVID numbers have increased, some facilities find they have too few isolation rooms to house suspected patients.

Hospital Space: Isolation

- The general course of growth from suspected cases to a high number of cases is commonly shorter than the time frame for treatment and release of the "first-in" patients, so it is important to recognize that committing infectious isolation rooms to patients limits future flexibility
- The CDC is recommending that airborne infectious isolation rooms ONLY be used for COVID patients undergoing aerosol-generating procedures (AGP)
- Examples of AGP: Positive-pressure ventilation (BiPAP and CPAP), endotracheal intubation, airway suction, high-frequency oscillatory ventilation, tracheostomy, chest physiotherapy, nebulizer treatment, sputum induction, and bronchoscopy
- Work with clinicians to manage use of airborne infectious isolation rooms

Hospital Space: Dedicated COVID Units

- CDC has provided recent guidance that "facilities should consider designating entire units" to care for known or suspected COVID patients. These units would be staffed with dedicated healthcare personnel to limit exposure risk.
- Clinicians have advocated against cohorting suspected and confirmed patients in the same unit / suite, to avoid the potential for conversion
- Coordinate with clinical staff

Hospital Space: Emergency Departments and Care Facilities

- To manage patient influx and congestion, and to control the risk of exposure to healthcare workers, hospitals are restricting access to Emergency Departments to ambulatory patients only, and designating a specific area in the ED for respiratory cases
- Persons Under Investigation (PUI) capable of self-care are triaged outside the ED, either through drive-through or walk-up screening stations set up in tents or other temporary space, and advised to continue home care until test results are available
- Many nursing homes and assisted living facilities have implemented protective measures, including checking staff (before each shift) and visitors for flu-like conditions, temperature, and travel history. In many places, people are no longer allowed to visit at all.

AEC Action Plan

The architecture, engineering, and construction (AEC) industry can help communities prepare by:

- Sharing knowledge and information
- Answering questions and serving as a resource
- Being available to help when asked
- Being positive and reassuring

Main Steps for Health Facility Operators

- Verify performance of existing airborne infectious isolation (A.I.I.) rooms
- Verify performance of Emergency Department HVAC system
- Secure all HEPA units
- Understand surge/temporary patient segregation plan and deploy

Implementation

Engineers' primary function and expertise in preparation for COVID-19 is advising on HVAC systems, configurations, and modifications to support the safe segregation of suspected and confirmed patients within controlled air environments, whether true isolation or modified alternative arrangements, as best suits their needs

Basics

General parameters:

- Do no harm
- System arrangement should protect healthcare workers
- System arrangement should protect other patients
- Airflow from clean to less clean

Aerobiology

- COVID-19 patients will typically have respiratory conditions resulting in coughs, sneezes
- Virus believed to be commonly spread through contact exposures (sickened people touching door handles, countertops, etc.) and related cough/sneeze droplets collecting on these surfaces
- Aerosolized virus is a limited but possible vector of transmission*
- Recognize that virus may be aerosolized during toilet flush
  - Housekeeping may need to consider this condition

* See https://www.medrxiv.org/content/10.1101/2020.03.23.20039446v2 and https://www.livescience.com/coronavirus-can-spread-as-an-aerosol.html

Aerobiology: Hospital Approaches

- HVAC systems can protect healthcare workers and instill confidence by providing safe environment for their interactions with the most contagious patients, and reduce exposure when patients discharge contaminants during procedures
- Basic approaches
  - Airborne infectious isolation rooms require 12 air changes/hour, air exhausted directly (see ASHRAE Std 170)
  - Establish solutions beyond A.I.I. rooms as needed
  - Negative relative pressure helps contain contaminants
  - Air changes dilute contaminant level
  - Exhaust removes contaminants
  - Filtration removes contaminants

Basics: Keep It Simple

- Resource management
  - Recognize that you have limited time, so focus your efforts
  - Do not waste time, mental energy, or money without clear goals and plan
- Set goals
  - Work with clinicians
  - Establish minimum standards
  - Define key areas and designated rooms, suites
  - Maintain life safety precautions
  - Make a floor plan / map (ensure everyone knows the plan)
  - Set up space for staff to apply/discard PPE and wash

Passive Isolation

- As prescribed in CDC guidance*
- Most basic approach
  - One patient per room
  - Close the door
  - Implement related CDC safety protocols
- Work with clinicians, anticipate patient load and establish layered approach as needed

* https://www.cdc.gov/coronavirus/2019-ncov/infection-control/control-recommendations.html

Layered Approach

Hospitals should be aware of the clinical modes:

- Normal mode: Follow CDC guidelines (clinical plan my limit airborne infectious isolation rooms to patients receiving aerosol-generating procedures)
- Small-scale surge capacity mode: May be asked to create additional dedicated A.I.I. or temporary patient observation/segregation rooms with exhaust HEPA filtration and negative pressure
- Large-scale surge capacity mode: May be asked to establish dedicated wards/suite(s) and establish protocols with clinical and environmental action plans

Inform clinicians that temporary patient observation/segregation areas are not TRUE airborne infectious isolation rooms

Basics: HEPA

References to a "HEPA Unit" can mean:

- Portable HEPA machine

- Pre-assembled system

- Ad hoc assembly
  - HEPA filter in frame, preferably bag in/out but as needed/available
  - Off-shelf exhaust fan and associated power
  - Sealed connections, rack or wheel mounted

Filters

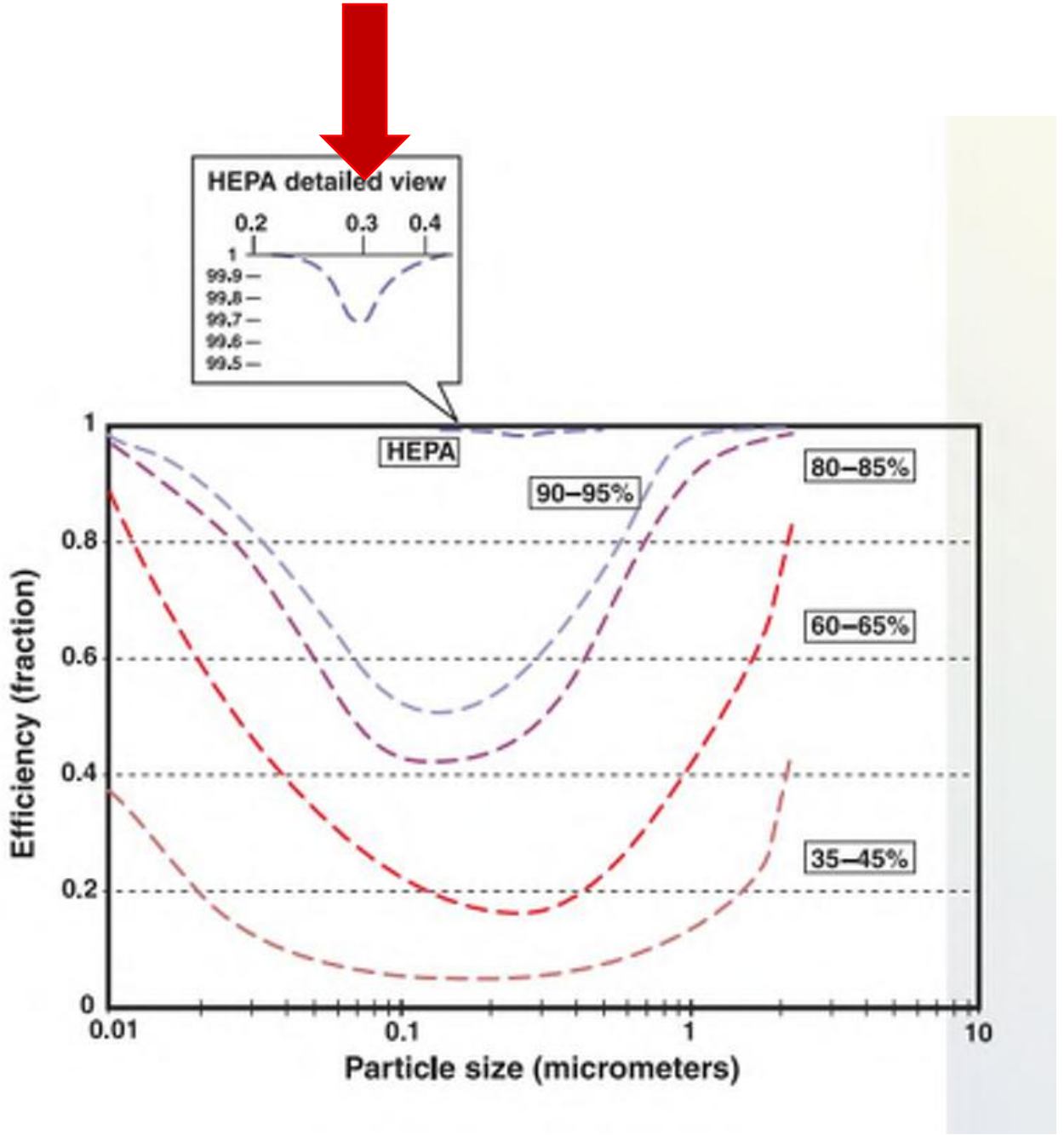
HEPA filters

- Virus particles can be 0.1 micron or smaller
- Infectious patient airborne discharges (cough/sneeze) are typically greater than 0.1 micron, as virus is passed on in liquid/mucus
- HEPA is at least 99.97% effective for 0.3-micron particles (next page)
- HEPA is an effective tool for contaminant removal

N95 mask filters

- N95 masks require fit testing and a competent pulmonary efficiency
- N95s are TESTED with 0.3-micron particles
- N95 is certified to filter at least 95% of airborne particles
- N95 is an effective tool for worker protection
- Sterilize for reuse: https://www.apsf.org/news-updates/potential-processes-to-eliminate-coronavirus-from-n95-masks

Basics: HEPA


HEPA detailed view
0.2
0.3
0.4
1
99.9
99.8
99.7
99.6
99.5
HEPA
90–95%
80–85%
60–65%
35–45%
Efficiency (fraction)
0
0.2
0.4
0.6
0.8
1
0.01
0.1
1
10
Particle size (micrometers)

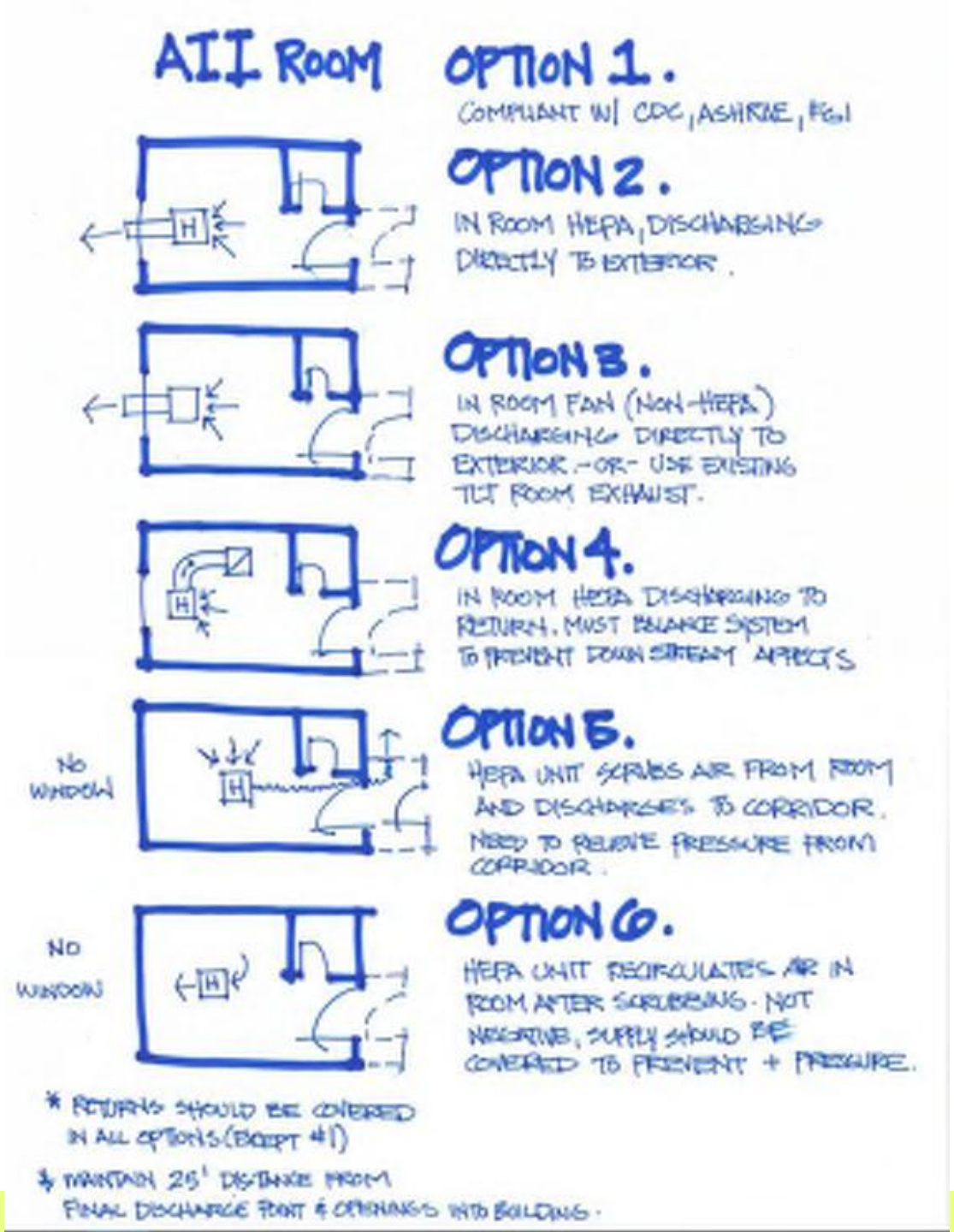
A.I.I. Room Approaches

Varied approaches; evaluate what works best for your existing conditions

Consider:

- Door closer
- Ability to monitor room pressure
- Limit patient transfers
- Ventilate and terminal clean before reuse

Hazard: Notify healthcare workers that HEPA units cannot be turned off once in place, as this may result an in unsafe condition with the room becoming positive pressure to the corridor

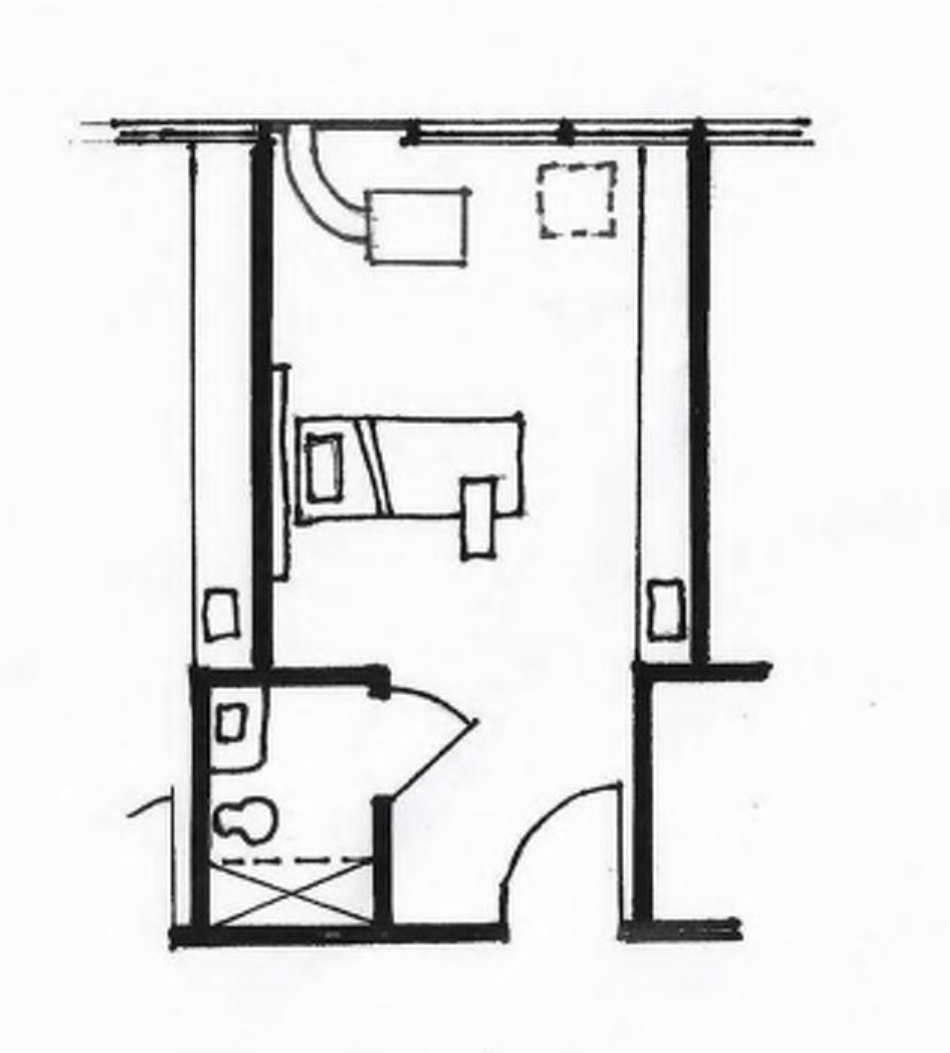


Examples: Patient Rooms

Small-Scale Surge

HEPA to outside:

- Single patient room with dedicated bathroom
- Seal off return air grill in patient room
- Place HEPA filtered negative air machine in patient room
- Duct through exterior to outside
  - Remove window and enclose opening
- Keep door to patient room closed
- Verify negative pressure before placing room in service, and monitor negative pressure while in service
- Limit patient transport and patient transfers
- Terminal cleaning after ACH removes potentially infectious particles

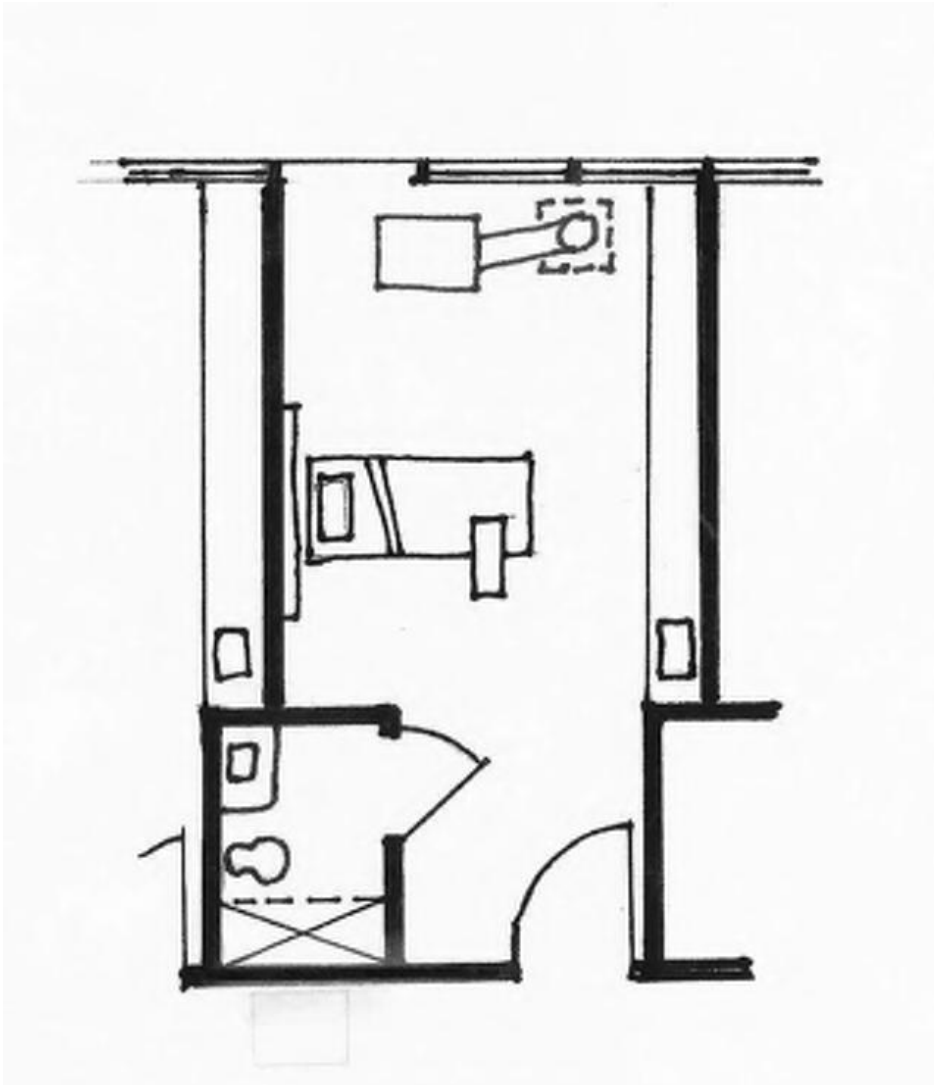


Examples: Patient Rooms

Small-Scale Surge

HEPA to return:

- Single patient room with dedicated bathroom
- Place HEPA-filtered negative air machine in patient room
- Duct to return air grill
  - Seal off remaining part of return air grill
  - Verify impact that this will have to the overall air handling system; choosing rooms closest to the air handler may reduce impact
- Keep door to patient room closed
- Verify negative pressure before placing room in service, and monitor negative pressure while in service
- Limit patient transport and patient transfers
- Terminal cleaning after ACH removes potentially infectious particles

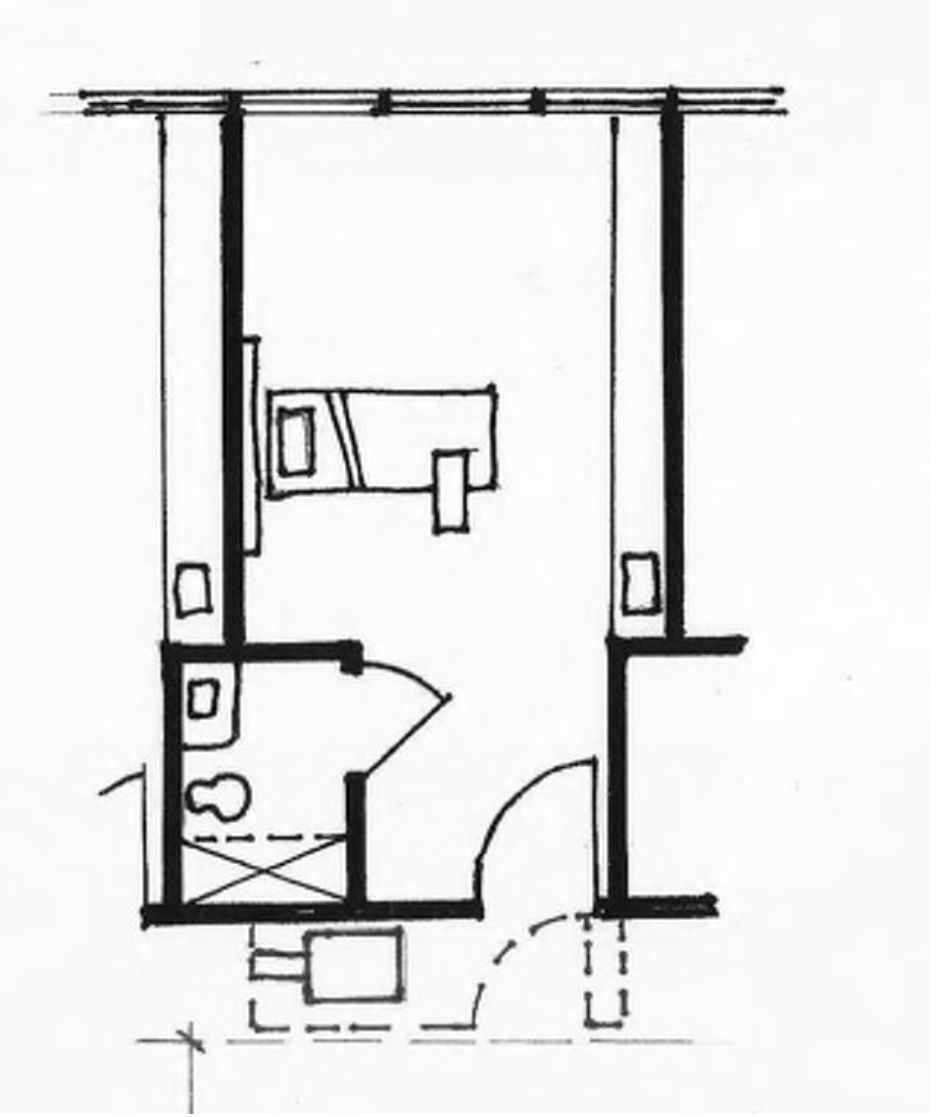


Examples: Patient Rooms

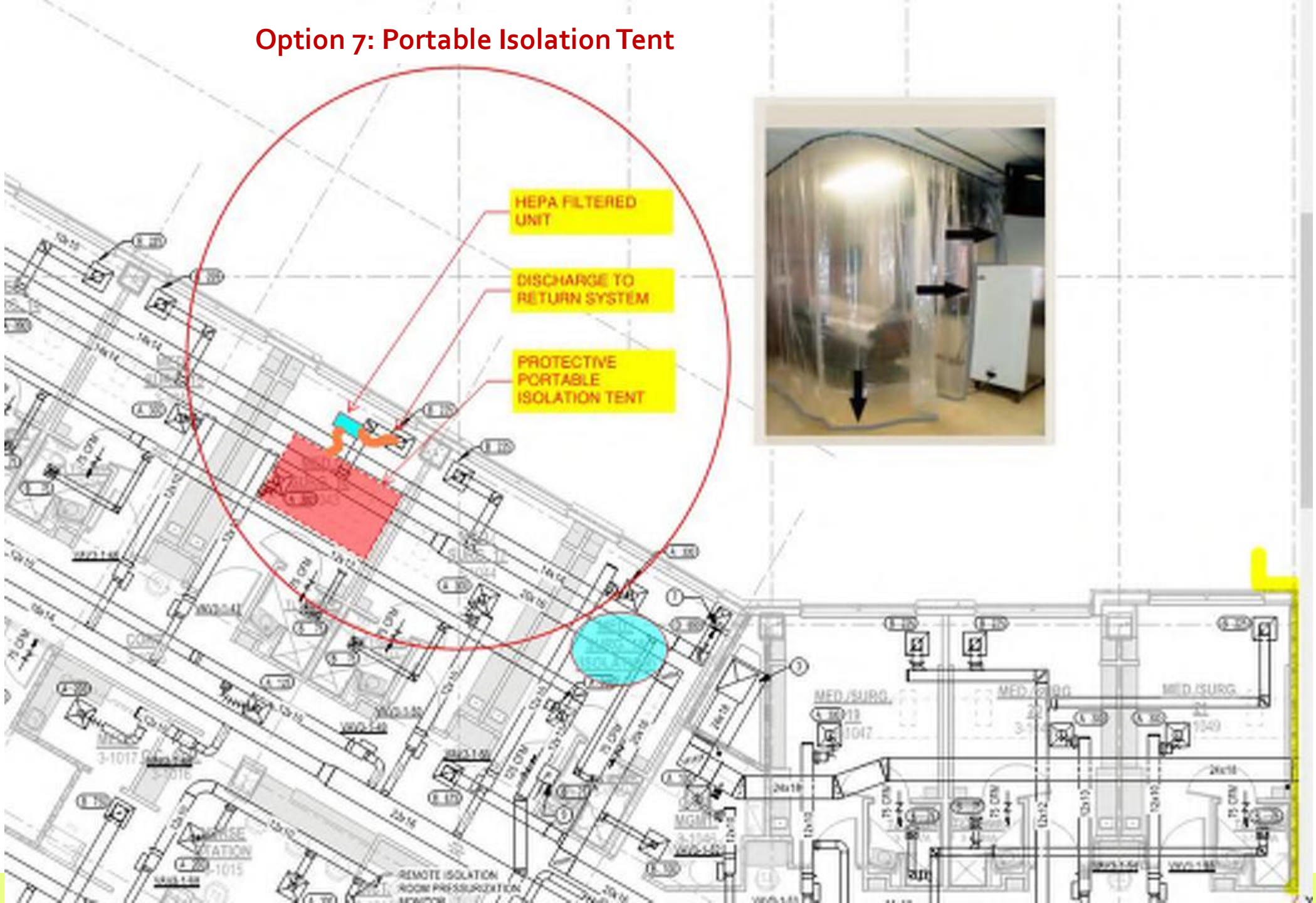
Small-Scale Surge

HEPA to corridor:

- Single patient room with dedicated bathroom
- Create "airtight" vestibule to patient room
  - Need minimum 5-foot egress clearance in the corridor
- Seal off return air grill in patient room
- Place HEPA-filtered negative air machine in vestibule
- Duct through vestibule to corridor
- Keep door to vestibule closed but door to patient room open
  - Verify that patient room door is not a fire-rated door!
- Verify negative pressure before placing room in service, and monitor negative pressure while in service
- Limit patient transport and patient transfers
- Terminal cleaning after ACH removes potentially infectious particles



Option 7: Portable Isolation Tent



Converting "Whole Patient Room Wings" To Negative-Pressure Exhausted Areas

- Convert air-handling units to 100% outdoor air by adjusting controls to close off return airflow paths
- Adjust terminal air controls to each room to create a negative pressure in each room
- Increase return airflow (now converted to exhaust) at central fans
- Reduce terminal controls at each room to reduce supply air volume if exhaust cannot be increased

** All of these ventilation changes are intended to **PROTECT the HEALTHCARE PROVIDERS**. This is the PRIMARY objective.

Warning: Intensive Care Unit (ICU)

Existing conditions of ICU rooms may be positive pressure* - verify and address!

- Designate specific room(s) or area(s)
- Proactively review and modify test and balance as needed
- Consider system-level, once-through air approach
  Recognize that changing the outdoor air amount might impact building pressure balance and also create humidity issues if unmanaged

*Was code-defined and common practice for many years

Warning: Room Recirculating Units

Avoid use for COVID patients if you can

IF YOU MUST:

- Consider Option 7 (previous slide, with isolation tent) as best approach
- If there's no other option than using a room recirculating unit, then increase room exhaust
  - Create negative relative pressure to corridor
  - May be accomplished by adding supplemental local exhaust fan per room
  - Consider system-level approach by increasing general toilet exhaust airflow
  - Consider means of sanitizing the RR unit between patients (peroxide fog, other?)
  - Deep decontamination of RR unit's coil after event is over

What Are Room Recirculating Units?

- Variety of in-room cooling/heating units
  - Fan coil units
  - Heat pump units
  - Packaged terminal air conditioner (PTAC)
  - DX and mini-split DX units
  - Special case: Induction units (seek expert guidance)
  - Special case: Active chilled beam (seek expert guidance)
- RR unit typically has ≤6 ACH air changes, and minimal filtration





Alternate Strategy: Source Control

- Consider local exhaust source control at patient head for patients on CPAP, nebulizer, or other AGP
- Patient tent with HEPA (i.e. Demistifier) https://www.peacemedical.com/2000A%202014.pdf
- Portable snorkel exhaust (i.e. SentryAir used for soldering) https://www.sentryair.com/portable-floor-sentry.htm

Alternate Strategy: Source Control

- Consider local exhaust source control at patient head for patients on CPAP, nebulizer, or other aerosol generating procedures (AGP)
- Ventilated headboard https://www.cdc.gov/niosh/surveyreports/pdfs/301-05f.pdf
  - Can be custom-built on site

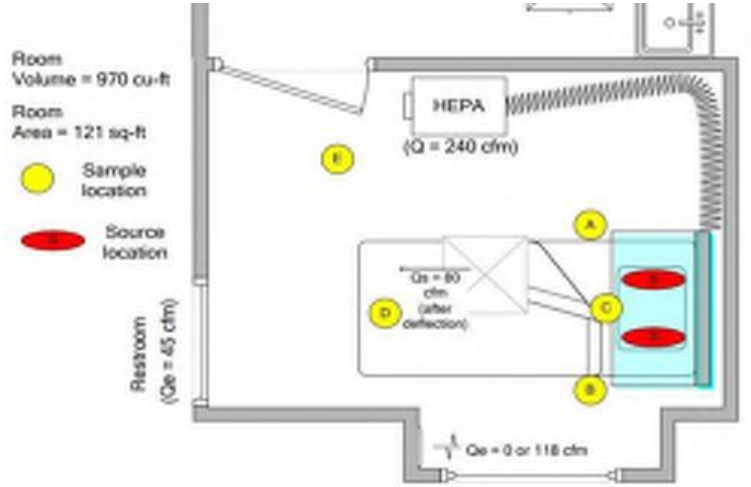


Figure 18. Schematic of ventilated headboard single-patient configuration evaluate at the VA Medical Center in Oklahoma City.

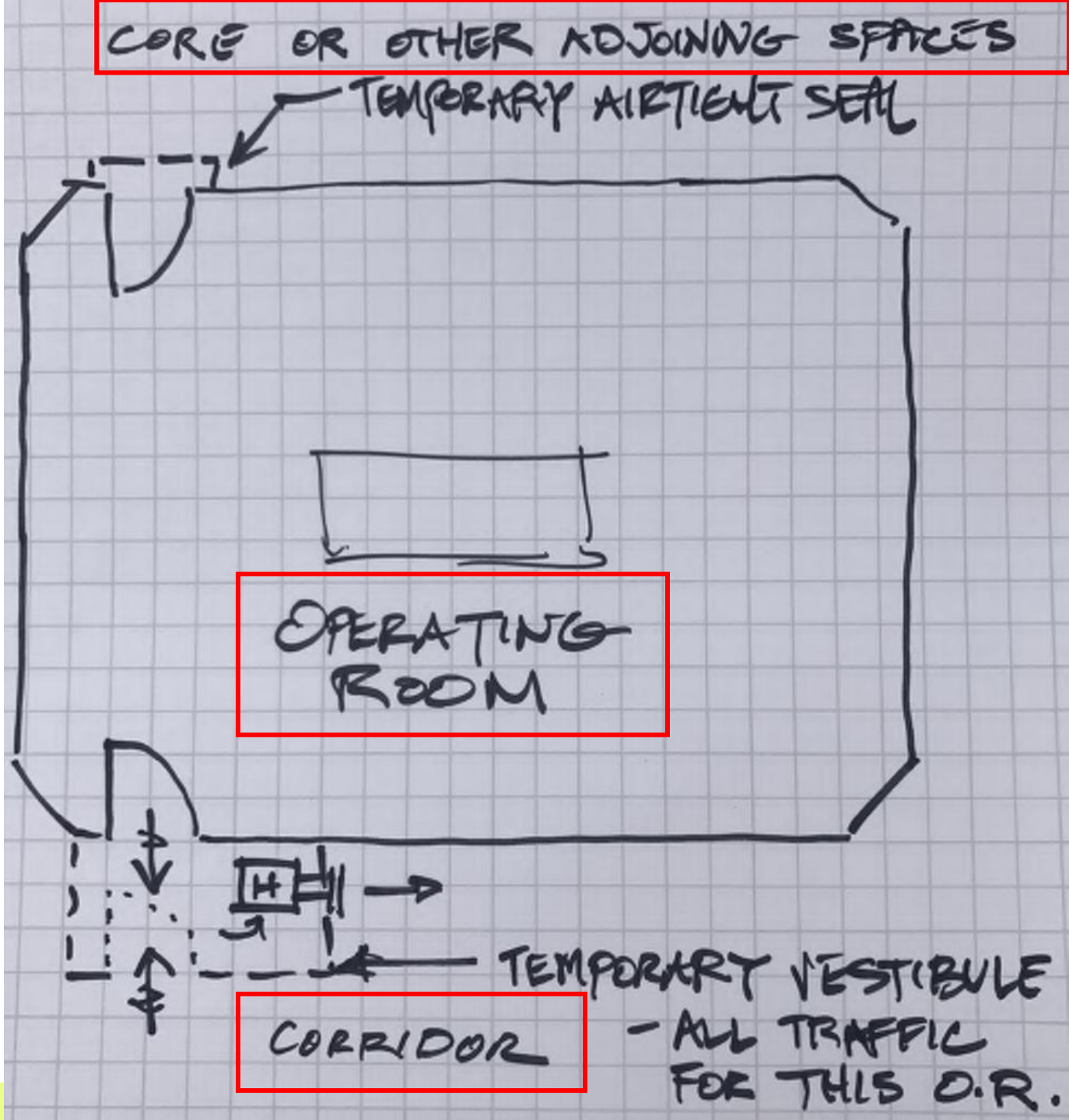
Figure 19. Photograph of ventilated headboard and hood frame as constructed for research at the Oklahoma City VA Medical Center.

Operating Room: COVID Patient

- Avoid use for COVID patients if you can
- See resources link for additional information
- IF YOU MUST:
  - Recommend intubation in operating room
  - Use negative-pressure operating room IF YOU HAVE IT (UNLIKELY)
  - Recommend creating a temporary vestibule in lieu of creating a negative-pressure OR
  - Creates buffer zone of negative pressure, but maintains OR cleanliness
  - Recommend considering dedicating an operating room for COVID

Operating Room: COVID Patient

- Temporary vestibule
- HEPA unit in vestibule to create negative zone
- Seal other entries



Difficulty With ICU Capacity

- COVID patients may cause the hospital to exceed ICU capacity
- ICU rooms are generally larger, have more air/O2, telemetry
- Hospitals may look to other areas to convert to ICU space

Operating Room: Alternate Use as an ICU

- Why? Large space that can serve multiple patients
- Why? Access to O2 outlets; anesthesia machine as ventilator
- IF YOU MUST:
  - Segregate this space from remainder of operating suite
  - Create a controlled-air vestibule
  - Reduce air changes to 6 to 12 total air changes; modify outside air balance to match total/exhaust air and capacity for cooling/dehumidification
  - All air must be exhausted from this space (alternate: HEPA filtered and returned)
  - Establish negative relative pressure

Recommended: Variable Air Volume

- Recognize that VAV systems will vary airflow quantity, impacting pressurization.
- IF HOUSING COVID PATIENTS in area served by VAV:
  - Recommend resetting minimum airflow setting to match maximum
  - Why? Varying airflow will hamper air balance goals of COVID area
  - Fixed air changes will permit stable air balance of COVID area
  - This will result in increased cooling, reheat consumption

Warning: HVAC System Consideration

- If you have a heat wheel energy recovery (ERV)
  - Must address how exhaust from COVID patient rooms is handled
  - Could contaminate these components
  - May have cross-contamination concerns
  - Either incorporate HEPA or discharge directly, not to heat wheel/ERV
  - Evaluate how airflow reduction may result in cool/heat capacity issue
- If you have a once-through system already
  - Verify if you have a heat wheel/energy recovery
  - See above notes

Further Considerations

- Emergency Department
  - Many hospitals are implementing access management plans that limit occupancy of patient waiting, including off-site triage protocols.
  - Evaluate air system operation and alternative measures
    - ✓ Example: Convert open bay or trauma room with use of HEPA recirculation unit to multiple patient station
    - ✓ Example: Convert AHU temporarily to once-through air system; supplement make-up air needs with temporary A/C as needed
    - ✓ Have a contingency/fallback plan
- Temporary spaces
  - Evaluate HVAC needs and arrangements

Frequently Asked Questions (FAQs)

- General HVAC
- Medical compressed air and oxygen
- Ventilators

FAQ: General HVAC Issues

- What temperature, RH, to run space at?
- Where might it be necessary to increase filtration levels in healthcare settings?
- What is the proper amount of outside air to spaces where infections exist or are known to have occurred?
- Air from areas with COVID patients must not be recirc'd unless HEPA filtered

FAQ: General HVAC Issues

- What is the proper level of negative pressure for isolation areas?
- How can this be measured un-scientifically?

FAQ: Medical Compressed Air (MCA) and Oxygen (O2)

- MCA and O2 piping and supply systems may not be sized to accommodate the increased deployment of ventilators

- Short-term interventions for central source equipment:
  - Portable fans on bulk O2 storage evaporators to prevent over-icing
  - Regulator changes (swap undersized for larger)
  - Pressure adjustments (increase in the O2 system)
  - Pressure alarm adjustments (avoid nuisance alarms)
  - Trailer-mounted oxygen systems (if supply is very inadequate)

FAQ: Medical Compressed Air (MAC) and Oxygen

- MAC and O2 piping and supply systems may not be sized to accommodate the increased deployment of ventilators
- Long-term interventions:
  - Resize source equipment
  - Resize some piping system sections

FAQ: Sharing Ventilators

Society of Critical Care Medicine (SCCM), American Association for Respiratory Care (AARC), American Society of Anesthesiologists (ASA), Anesthesia Patient Safety Foundation (APSF), American Association of Critical-Care Nurses (AACN), and American College of Chest Physicians (CHEST) issued a statement on extending ventilator use by splitting capacity:

- "Advise clinicians that sharing mechanical ventilators should not be attempted because it cannot be done safely with current equipment."
- https://www.asahq.org/about-asa/newsroom/news-releases/2020/03/joint-statement-on-multiple-patients-per-ventilator
- Note that ventilator advice for COVID treatment continues to evolve

UPDATE: Recent US-Based Guidance for Healthcare Facilities to Prepare for COVID-19 Patients

Prepared for the China Chapter of I²SL

Daniel L. Doyle, PE, LEED AP
ddoyle@grummanbutkus.com
Chairman, Grumman/Butkus Associates
Board Member, International Institute for Sustainable Laboratories

April 28, 2020