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CIBSE Healthcare Group seminar

October 18th, 2023

UNDERSTANDING AIRBORNE INFECTION REDUCTION IN BUILDINGS

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My technical airborne infectious diseases journey

TODAY

SARS 2003:
- Low-level extracts in hospital wards
- UV tube air kill rates
- Air movement through dry traps (HK high-rise)

C. diff 2007:
- DTM & CFD support for 2 Phds with focus on hospital wards

May 2021

March 2023 (started March 2021)

April 2023

CIBSE Building Simulation Group / IBPSA-England: Estimating airborne infection through simulation and analysis

[**BSG/IBPSA Event video & presentations**]

Airborne Infection Reduction through Building Operation and Design (AIRBODS) research programme

[**AIRBODS Guide**]


Building and Environment
Volume 233, 1 April 2023, 110099
ELSEVIER
A CFD-based framework to assess airborne infection risk in buildings
Giulio Vita [a b], Darren Woolf [a 1], Thomas Avery-Hickmott [a], Rob Rowsell [a]

Wirth Research's airborne infection R&D (openAIR) culminating in Building and Environment paper

[**B&E Paper**]

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AIRBODS programme

Loughborough University

UCL

The University of Nottingham

University of Cambridge

The University Of Sheffield.

EST 1892 LSBU

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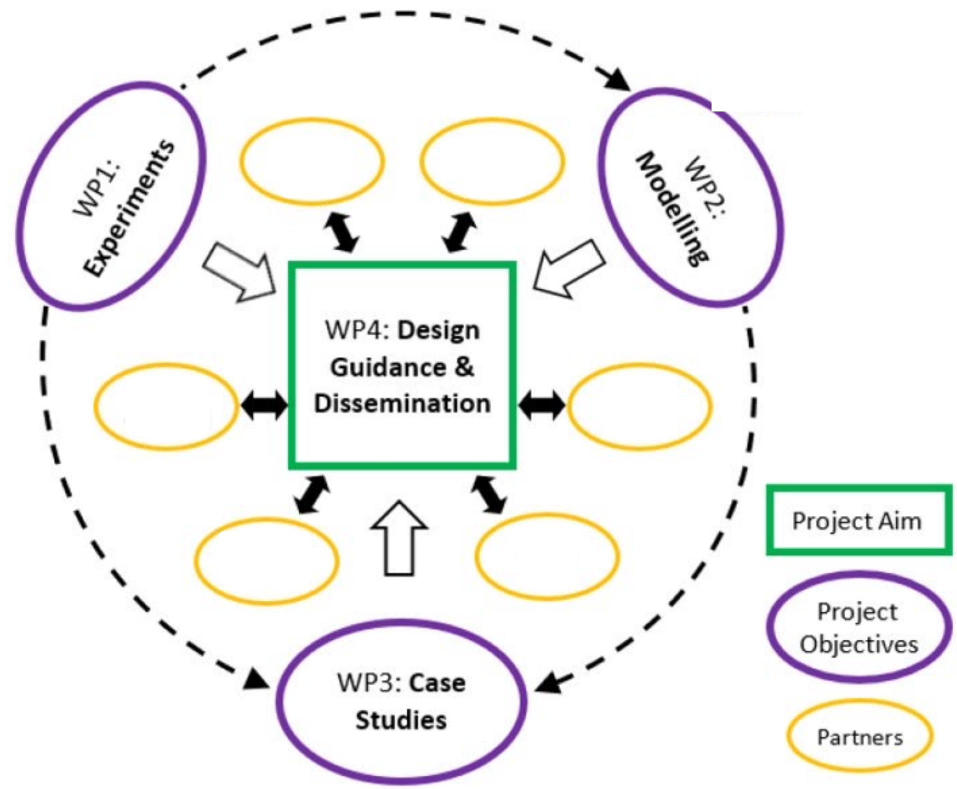
COMPLETE PERFORMANCE ENGINEERING

Research Team Organisations



Measurements: Monitoring and test chamber
Calculations: Analytical, computational fluid dynamics (CFD) and dynamic thermal models (DTM)

AIRBODS Guide and some additional material

Theme | One subject per page | Mostly bullet points for easy readability

AEROSOLS AND SARS-COV-2

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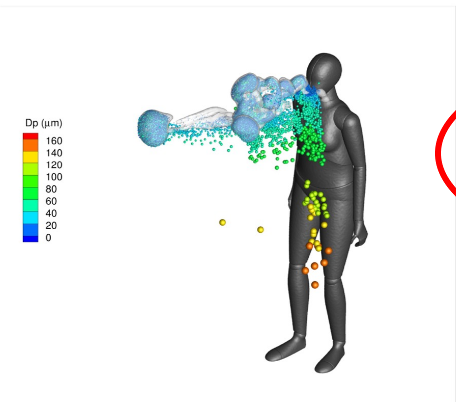

AIRBODS CFD model of exhaled breath or 'aerosol cloud' containing droplets and various gases – the larger droplets fall more quickly due to gravity.

AEROSOLS

DEFINITION

- Aerosols are small droplets emitted during different activities such as breathing, talking and coughing.
- Contained in jet of air from lungs exhaled through mouth or nose within cloud of gas and droplets
- Formation via picking up respiratory fluid from lungs, throat and mouth.
- Big debate on threshold diameter definition during COVID-19 pandemic:
  - World Health Organisation (WHO) 'historic' position less than 5μm.
  - More recent definition favoured by many aerosol scientists based on their ability to remain airborne for minutes or hours travelling long distances due to their small size and mass before they evaporate or disperse – *less than 100μm.*

IMPORTANCE

- Scientific community has demonstrated through accumulated evidence and analysis of reported super-spreading outbreaks that one of the modes of transmission of SARS-CoV-2 is the airborne route.
- It is considered that airborne transmission occurs through the inhalation of aerosols that contain viruses which can deposit in the lungs due to their smaller size.

(Shen 2021) (Escandón, 2021) (Malki-Epshtein, 2022) (Jones and Iddon, 2021a)

Some additional material:

- Other research programmes - CO-TRACE, PROTECT etc
- Recent guidance – ASHRAE Standard 241: Control of infectious aerosols + YouTube PODCAST
- Recent research – PhD on spaciotemporal uncertainty
- CIBSE Journal (Sept 2023): Hospital IAQ
- Royal Society: Winter ventilation paper

\+ many, many more

www.sciencedirect.com ?

AIRBODS material available on website https://airbods.org.uk/publications/

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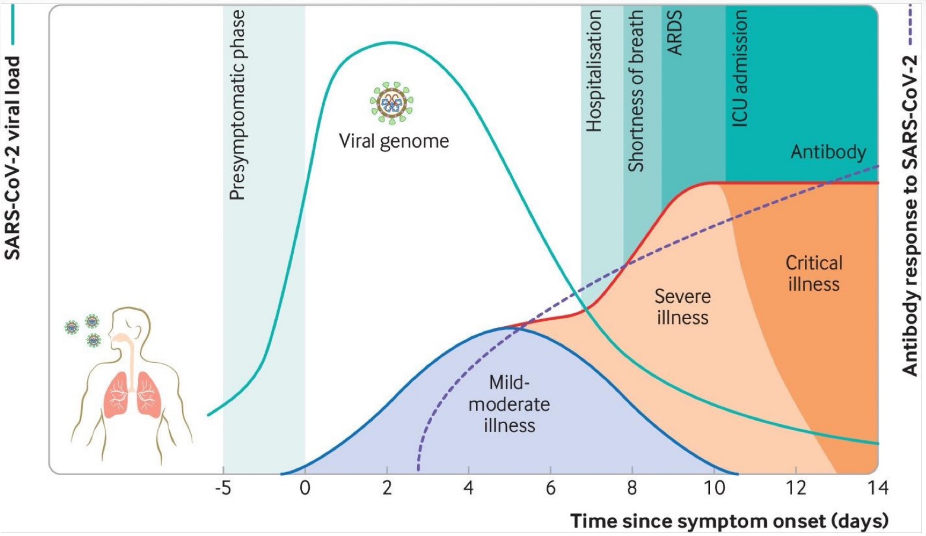
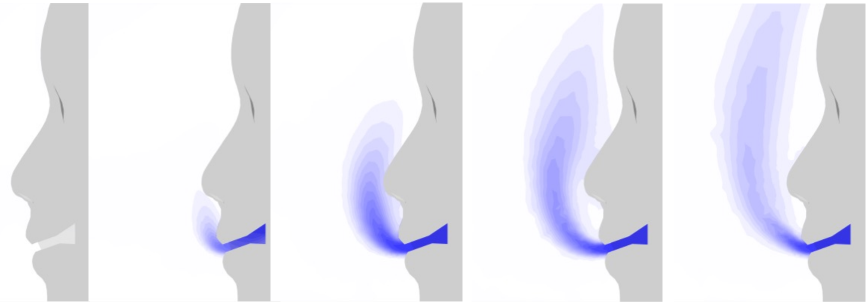
Airborne infection risk: Quantification, prevention or reduction?





<u>Quantifying</u> risk:

- Viral load uncertainty (breathed out)
- Infectious dose uncertainty (breathed in)
- Complexity of droplets within ambient environment

<u>Preventing</u> risk:

- No 100% kill solution
- <u>Absolute</u> term gives sense of safety where it may not exist

<u>Reducing</u> risk:

- <u>Relative</u> term recognises uncertainties and complexities - human, ventilation and other building-related factors
- *Comparative qualitative assessments* over quantitative - high levels of confidence
- Reflected in many calculation methods

[AIRBODS Guide: pp.17-24, p.123]

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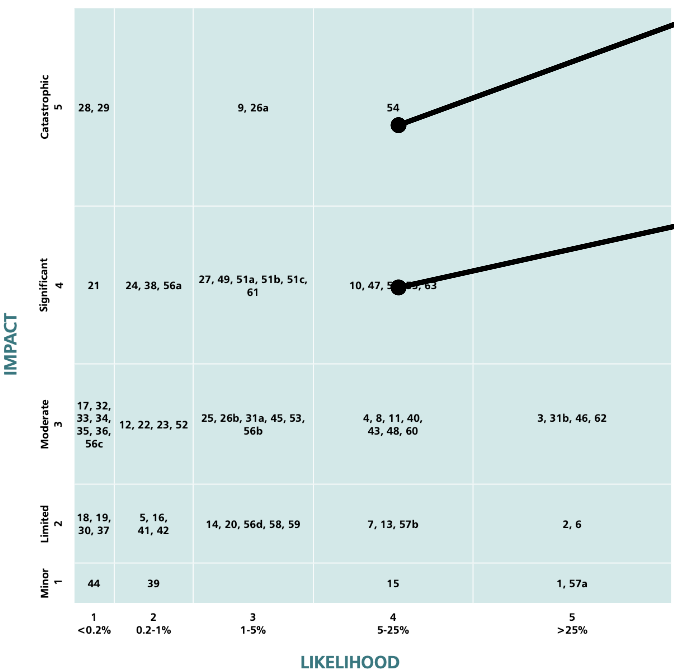
Air kills (or can seriously damage your health)



Pandemic - top risk out of 63 listed

Emerging infectious disease

Some of the many (often related) areas to consider:

- Aerosols
- Gaseous and particulate matter
- Mould
- Other IAQ (e.g. VOCs)

Some of the related headlines:

- Climate and air quality crisis
- Net zero
- ULEZ extension in London
- Ella & Awaab

https://www.ellaroberta.org

Awaab Ishak

A *quality* ventilation mindset is needed (effective and efficient delivery)

[National Risk Register]

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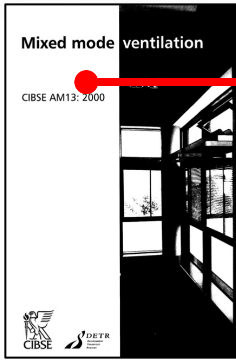
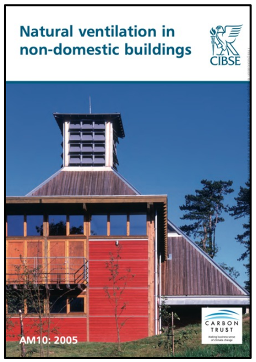
The ventilation juggling act

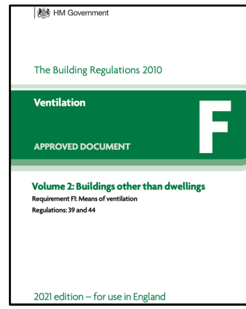


Healthcare buildings: non-surgical	CIBSE Guide B2 *Ventilation and Ductwork* (2016) NHS Activity DataBase Health Technical Memorandum (HTM) 03-01 (Department of Health) Health Building Notes (HBN) – various (Department of Health)
Hospitals	CIBSE Guide B2 *Ventilation and Ductwork* (2016) NHS Activity DataBase Health Technical Memorandum (HTM) 03-01 (Department of Health) Health Building Notes (HBN) – various (Department of Health)

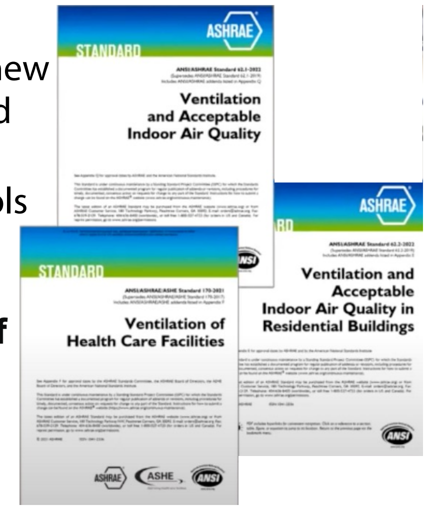
Table B1 Indoor air pollutants guidance values

Link to Parts B, J, L, M & O





Prerequisites to new ASHRAE Standard 241: Control of Infectious Aerosols



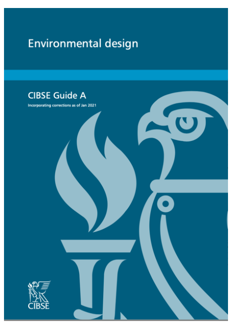
GOV.UK

Guidance

Ventilation to reduce the spread of respiratory infections, including COVID-19

Heating, ventilating, air conditioning and refrigeration

CIBSE Guide B



Building Safety Act (October 1st, 2023):

- BSR - safety and performance for all building works
- Special HRB fire and structural safety focus – height basis
- Next iteration - care homes on ventilation basis?

Risks: Multiple sources, priorities, conflicts, omissions, over-complexity - *reasonable* competency?

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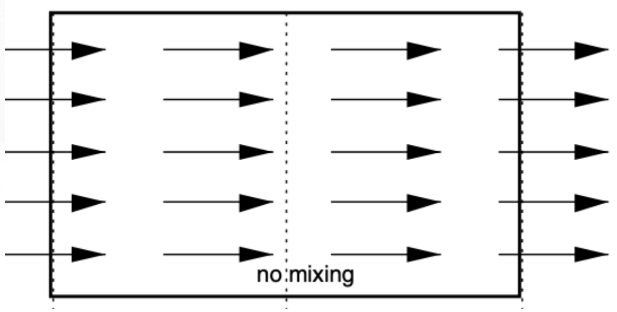
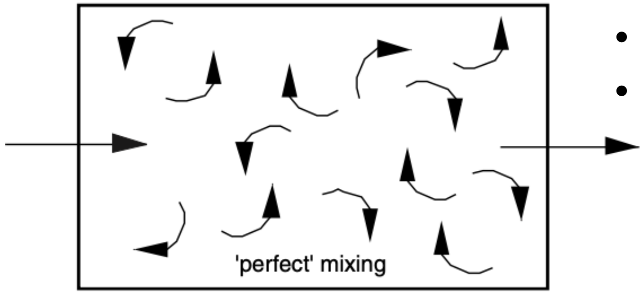
Air mixing



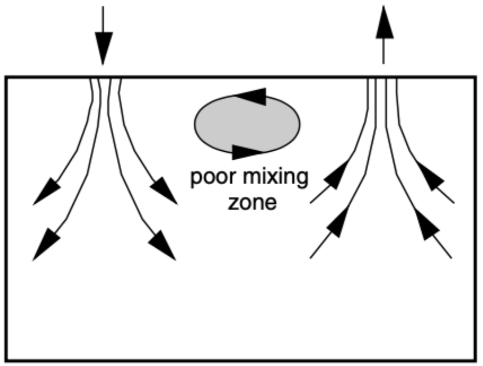
- Least common



- Often assumed within airborne infection metrics

Main mixing drivers:

- *Turbulence – How much? Where?*
- Room configuration and partitions
- Distribution and size of infiltration paths
- Supply and extract grille configuration
- Supply air characteristics
- Location and size of heat sources



- Most common
- Infrequently considered
- Standard CFD output

A Guide to Energy Efficient Ventilation, Ch.9 Ventilation Efficiency: AIVC/Martin Liddament, 1996

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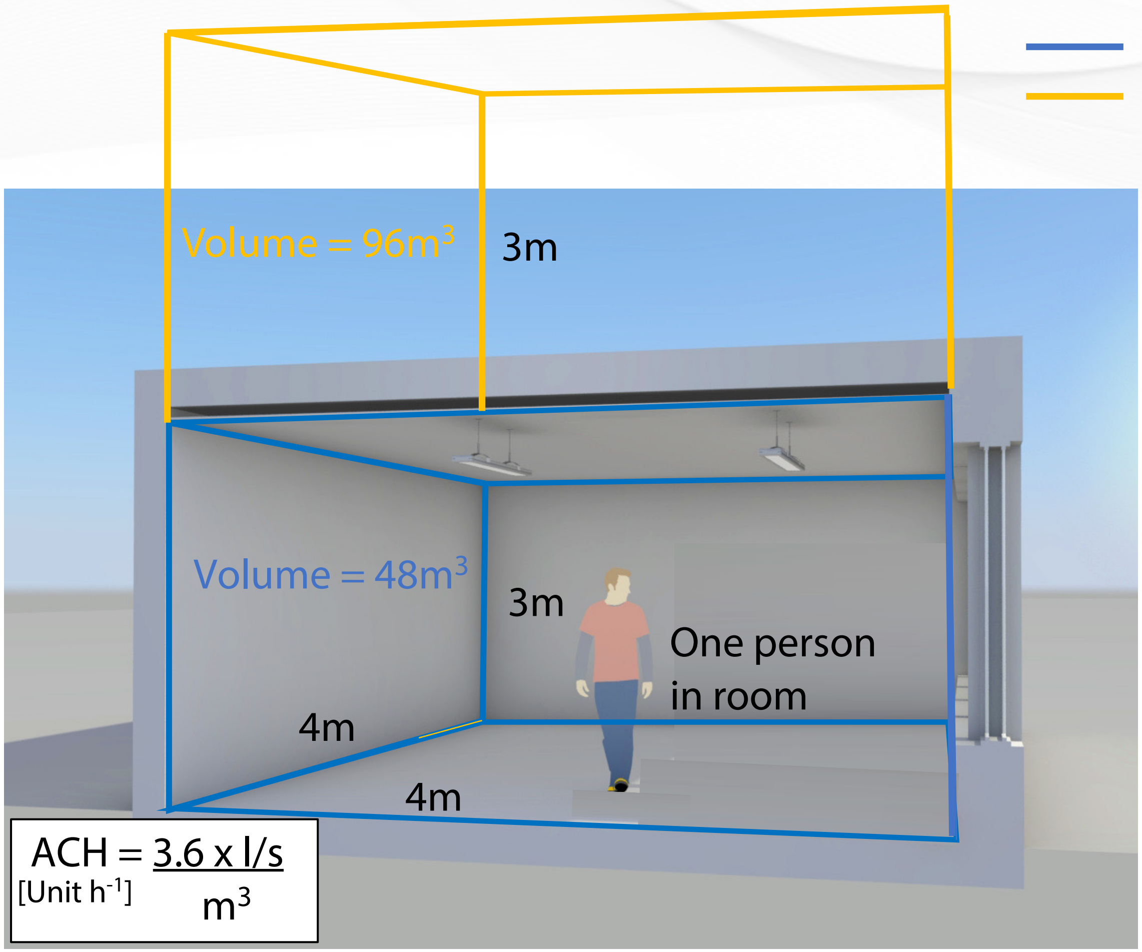
The air changes per hour (ACH) conundrum



Single height room (blue line)
Double height room (yellow line)

Ventilation rate 1:

- 10 l/s per person
- 0.625 $l/s.m^2$
- 0.750 ACH (single)
- 0.375 ACH (double)

Ventilation rate 2:

- 10 ACH
- 133 l/s (single)
- 266 l/s(double)

Double height:
= half ACH
= no change in rate per unit area or per person

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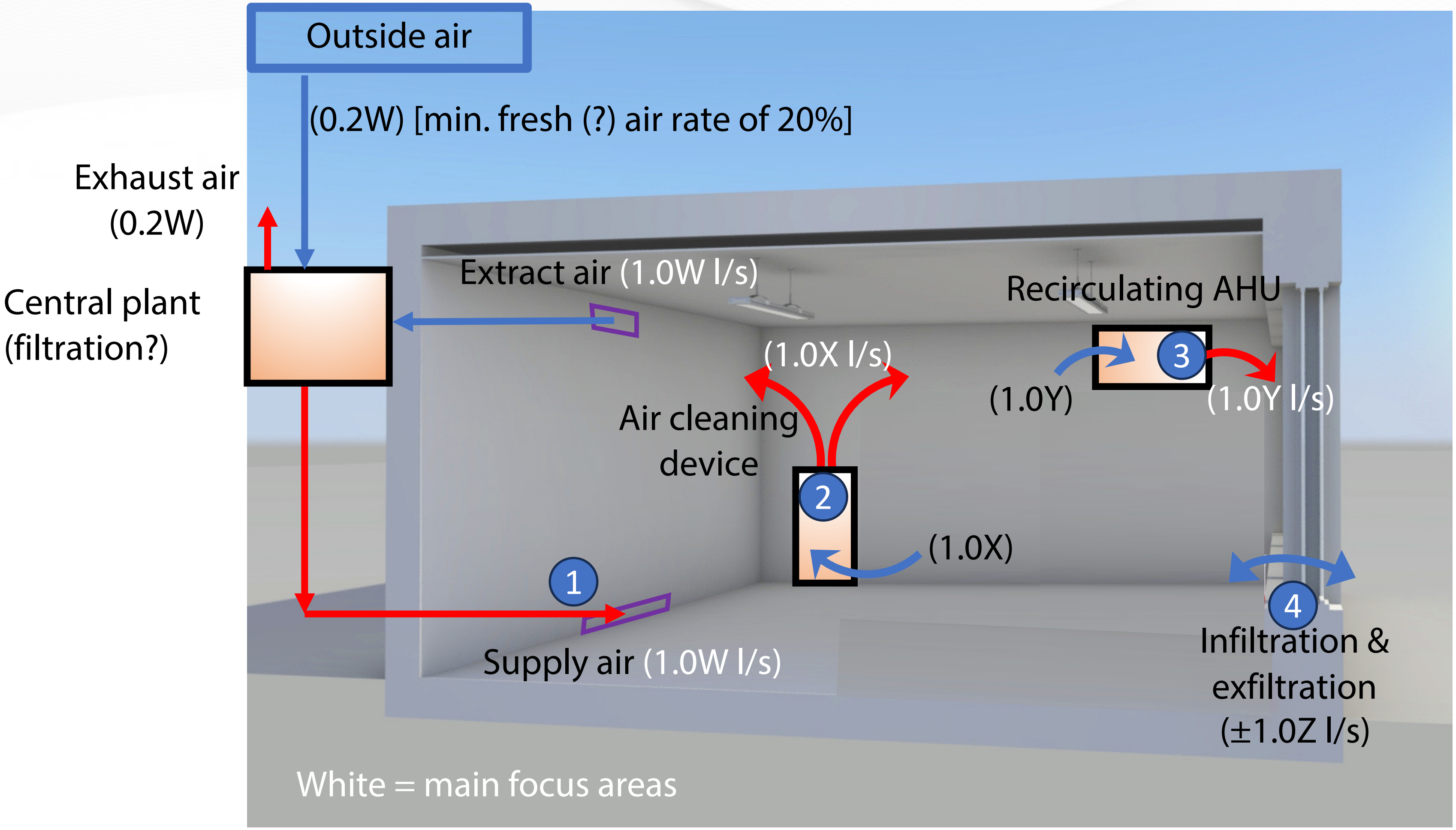
Combining ventilation rates



Effective ventilation rate = ① adjusted by ② & ③ including removal efficiencies

The ventilation rate challenge: Defined rates and units

Defined rates

Directly calculated or measured values:

- Supply air flow rate
- Natural ventilation rate
- Outdoor (fresh) air flow rate
- Volume per unit time

Indirect or derived values:

- Effective or equivalent
  - Effective ventilation rate
  - Equivalent outdoor air
  - Equivalent clean airflow
  - Equivalent volume flow rate

Need to understand detail within the definitions – equation level

Units

CIBSE Guide A: Supply air flow rates for many spaces **10 l/s per person**. Operating theatre 650-1000 **l/s**. CIBSE Guide B: Uncontrolled vent. - infiltration **5 m^3/h per m^2 of façade**.

Part F (not dwellings):

- Additional to 10 l/s per person provide at least **1 l/s per m^2 of floor area** whichever is higher
- Nat vent openings based on **min % of floor area** (not a flow rate).

HTM 03-01: Specialised Ventilation for Healthcare Premises:

- Neonates **10 ACH**

Flow rate into a space - Six different ways to do the same thing?

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The ventilation rate challenge: Space types and sector rules

Space types

Examples of critical ventilation systems:

- Operating suites / airborne isolation facilities
- Critical care areas / invasive treatment
- Containment level 3 laboratory
- Pharmacy aseptic preparation facility
- IAP room in a sterile services department
- MRI / CAT / emerging imaging technologies

- Toilets, corridors, atria, cafes etc

Use ventilation typology and space grouping techniques

Sector –specific rules (HTM 03-01)

Air supply volumes

4.63 The minimum air supply volume for a room is determined by the greatest of:

- the minimum fresh air requirement;
- (?) the air required to achieve the room differential pressure and provide open door protection at the key door;
- the minimum supply volume for the room load as determined by the maximum heating or cooling supply temperature differential;
- the desired air-change rate;
- (?) the make-up air for a local extract (for example, cooker hood or LEV system).

3-5 outputs for each room covering wide range of 'optimum' ventilation strategies

Ventilation juggling act and ventilation rate challenge: Time to go digital?

[AIRBODS Guide: p.31]

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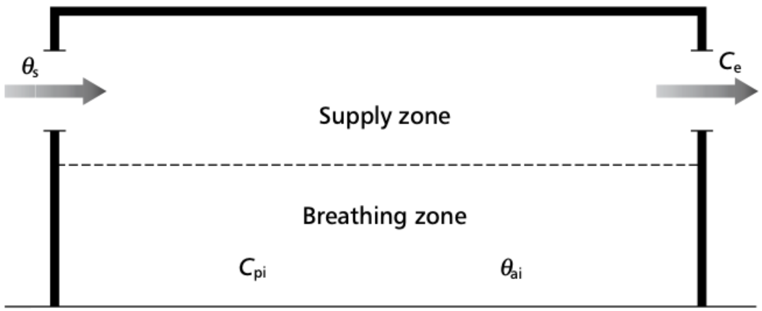
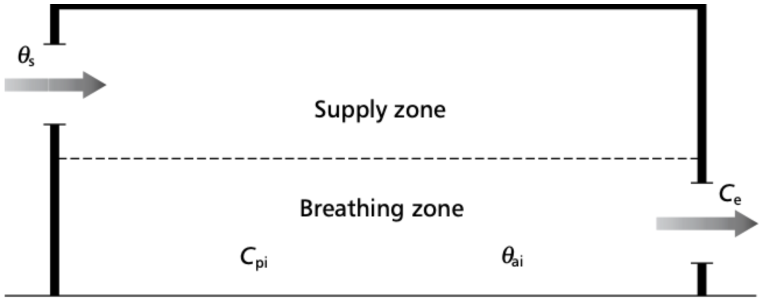
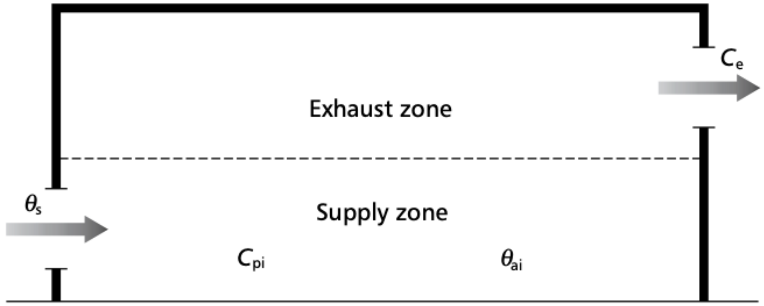
Ventilation performance metrics: Ventilation effectiveness (zonal)



Mixing: Supply & exhaust at high level



Mixing: Supply at high level & exhaust at low level



Displacement

Ventilation arrangement	Temp. difference (/ K) between supply air and room air, ($\theta_s - \theta_{ai}$)	Ventilation effectiveness, E_v
Mixing; high-level supply and exhaust	< 0	0.9–1.0
	0–2	0.9
	2–5	0.8
	> 5	0.4–0.7
Mixing; high-level supply, low-level exhaust	< –5	0.9
	(–5)–0	0.9–1.0
	> 0	1.0
Displacement	< 0	1.2–1.4
	0–2	0.7–0.9
	> 2	0.2–0.7

- Ventilation effectiveness estimates efficiency that pollutant is diluted or removed
- Assumes each zone is perfectly mixed
- Air change efficiency metrics: 'age of air' - mean time taken for air molecules arriving within the domain to travel to the point of interest

- Re-examine zonal metrics most suitable for airborne infection estimations, e.g. local air quality index or use of multiple metrics?

[CIBSE Guide A, 2021: Sect. 1.8.4]

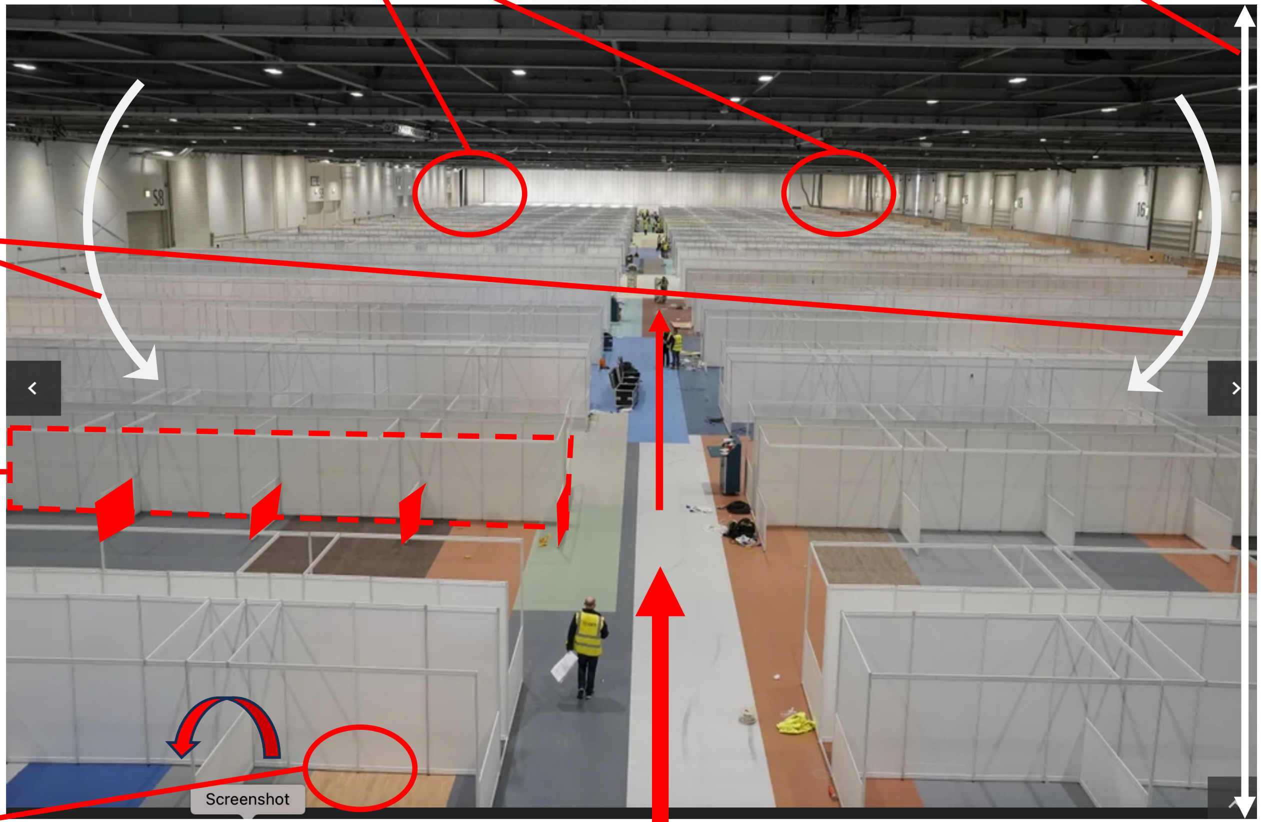
Ventilation in healthcare premises – what I see... what do you see?

Are cold wall surfaces drawing contaminated air at high level towards low level in the corners (surface buoyancy effect)?

High ceiling = increased reservoir. Is this good or bad for the limited ventilation rate within given ventilation performance?

Does background room air flow patterns support delivery of outside air to individual breathing zones?

Are screens making cross-contamination and/or local conditions better or worse?



Use bed positioning strategy to minimise cross-contamination

Use breathing channels to improve ventilation performance.

Challenge to combine different viewpoints / priorities into all-encompassing strategic plan

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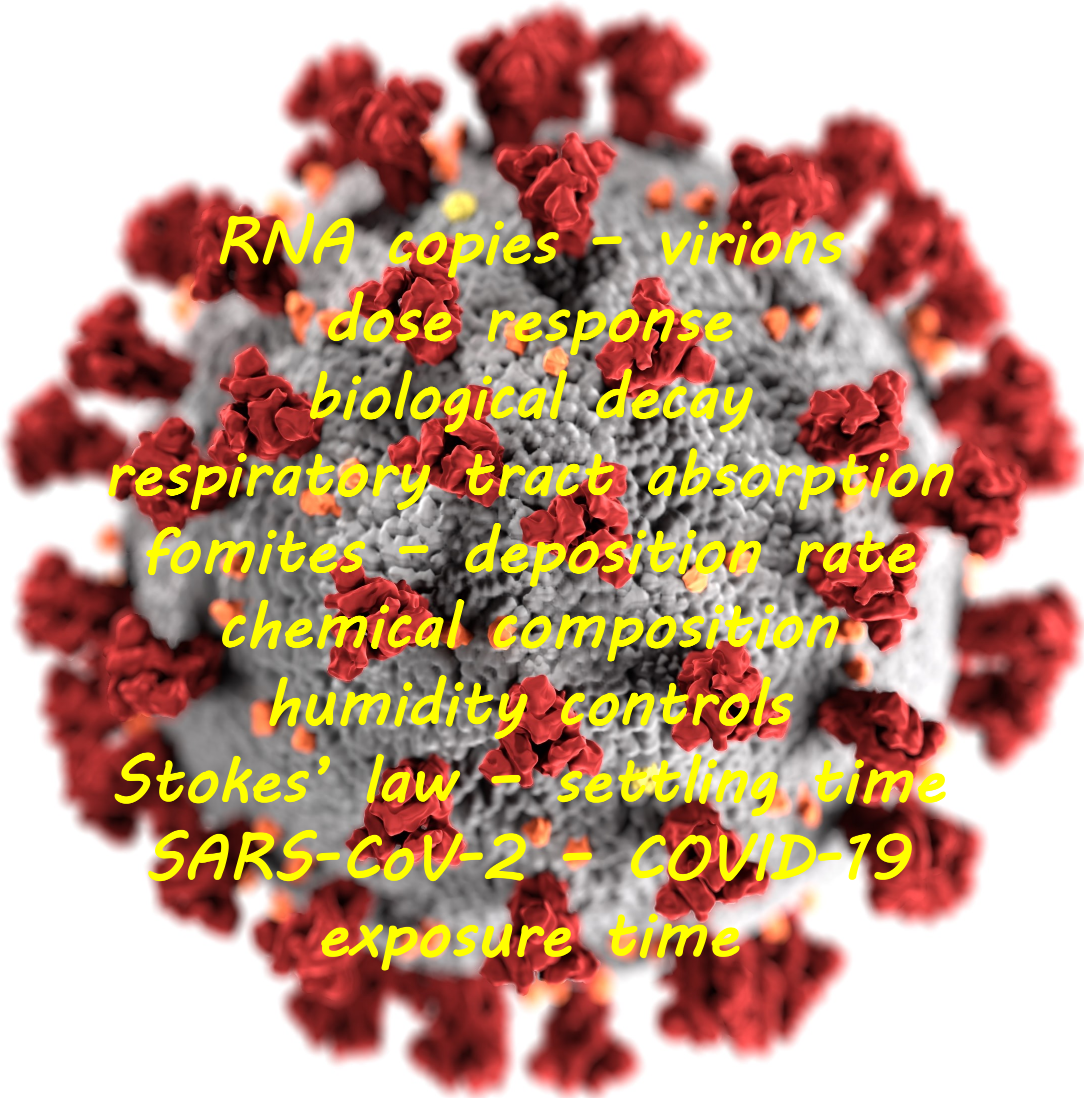
Beyond ventilation performance



Basics including environmental factors:

- AIRBODS Guide – Chapter 2

In-house expertise:

- Deeper understanding
- Wider context
- Time and bandwidth
- Better solutions?

3rd party support:

- Relative cost to in-house
- Maintenance and development costs
- Expert sign off or just increased confidence?

- Future guidance should be simplified to ventilation performance on a 'need to know' basis.
- Many defaults & scenario-driven.

[Aerosols and Transmission of Respiratory Viruses 101 by Linsey Marr]

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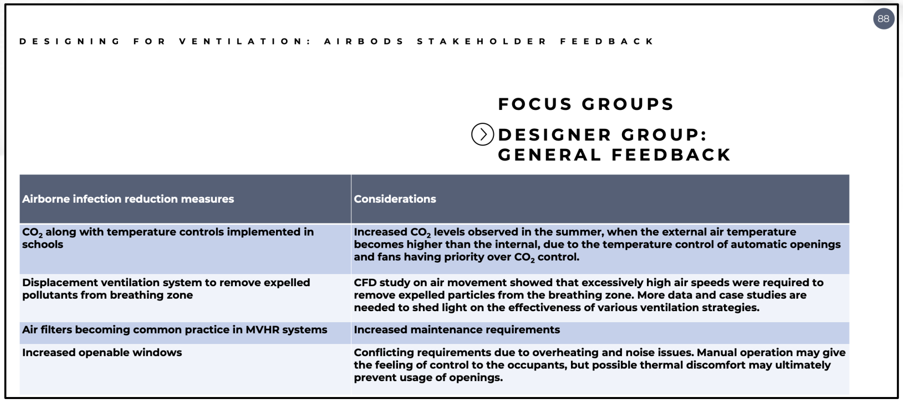
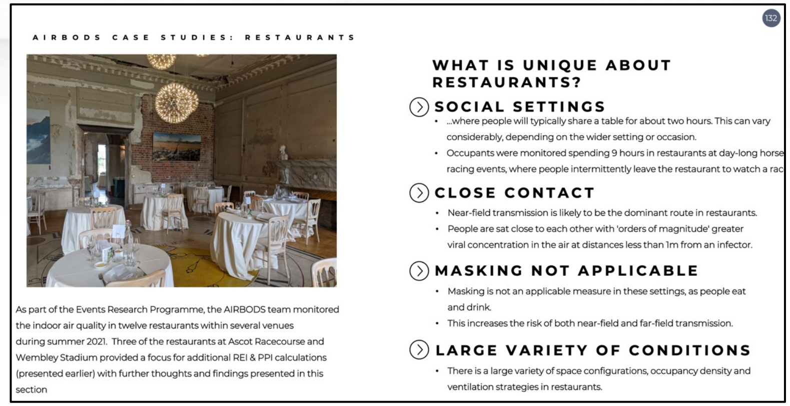
Be prepared

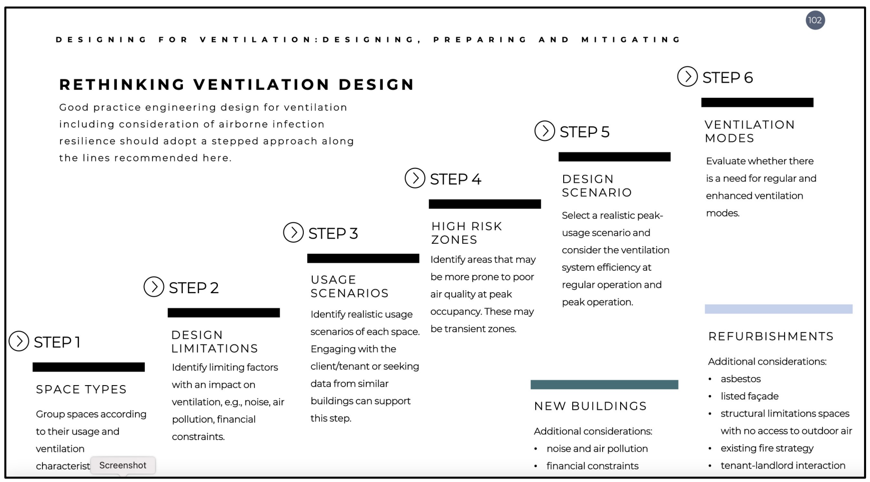


Airborne infection reduction measures	Considerations
CO_2 along with temperature controls implemented in schools	Increased CO_2 levels observed in the summer, when the external air temperature becomes higher than the internal, due to the temperature control of automatic openings and fans having priority over CO_2 control.
Displacement ventilation system to remove expelled pollutants from breathing zone	CFD study on air movement showed that excessively high air speeds were required to remove expelled particles from the breathing zone. More data and case studies are needed to shed light on the effectiveness of various ventilation strategies.
Air filters becoming common practice in MVHR systems	Increased maintenance requirements
Increased openable windows	Conflicting requirements due to overheating and noise issues. Manual operation may give the feeling of control to the occupants, but possible thermal discomfort may ultimately prevent usage of openings.

1. Feedback from focus groups (designers, operators and non-technical)



2. Case studies – Theatres and restaurants guidance transposed to your similar space types?



3. Start thinking about your plan (new build or refurbishment or just change in operation)

4. Organise **budget and time resource**:

- Learning and training elements
- Select operating and design scenarios
- Clarify and sign-off expectations
- Starter surveys – not new build!
- Calculations and measurements (as appropriate)
- Pandemic preparedness and operating plans
- Implementation, monitoring, updates etc

Cost of not doing it? Reputation? Critical business risk?

[AIRBODS Guide: Sect.6.4, Sect.6.5, Ch.9]

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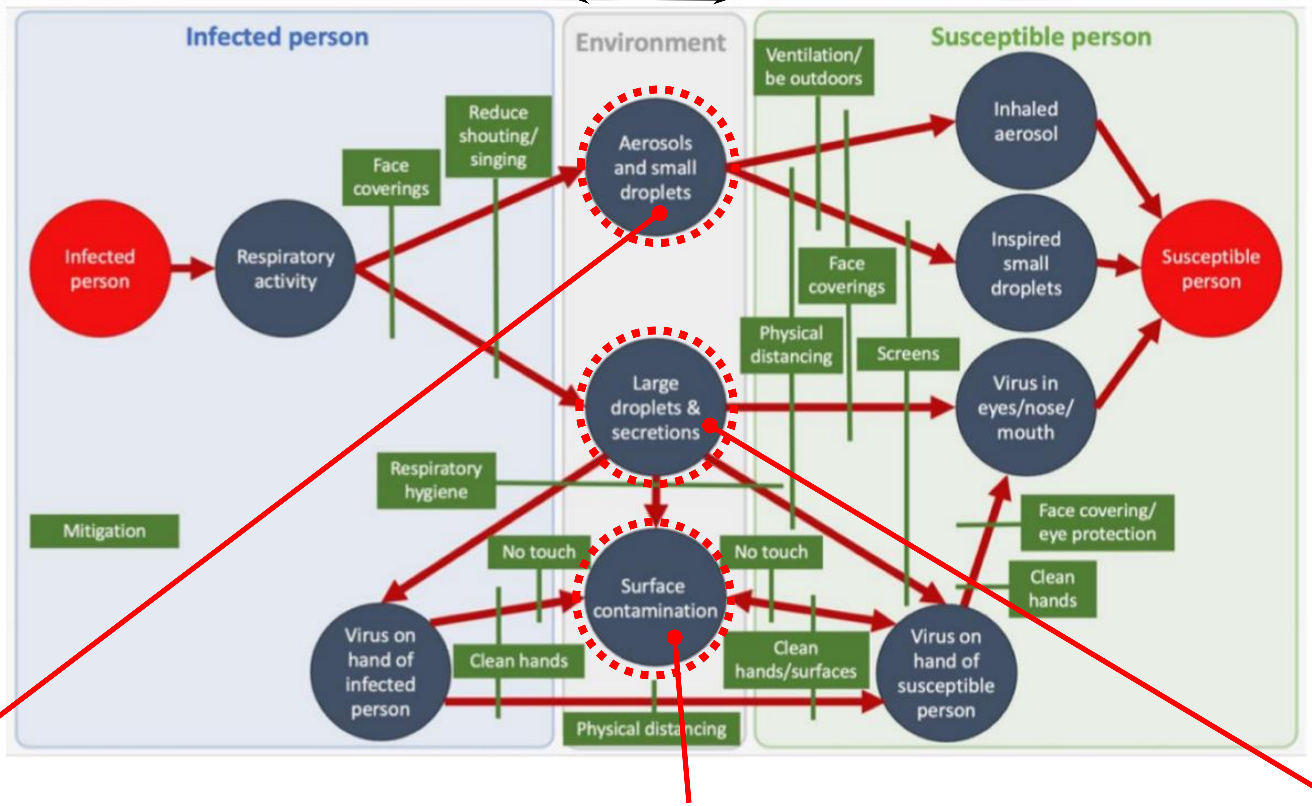
Transmission paths guide mitigation solutions

Transmission medium



Long- and short-range airborne transmission:

- Medium and high transmission risk
- Highest superspreading event risk

Surface transmission:

- Lowest transmission risk
- Reduced by cleaning

Short-range airborne transmission:

- High transmission risk
- Reduced by physical distancing

[CIBSE Air Cleaning Technologies Guide]

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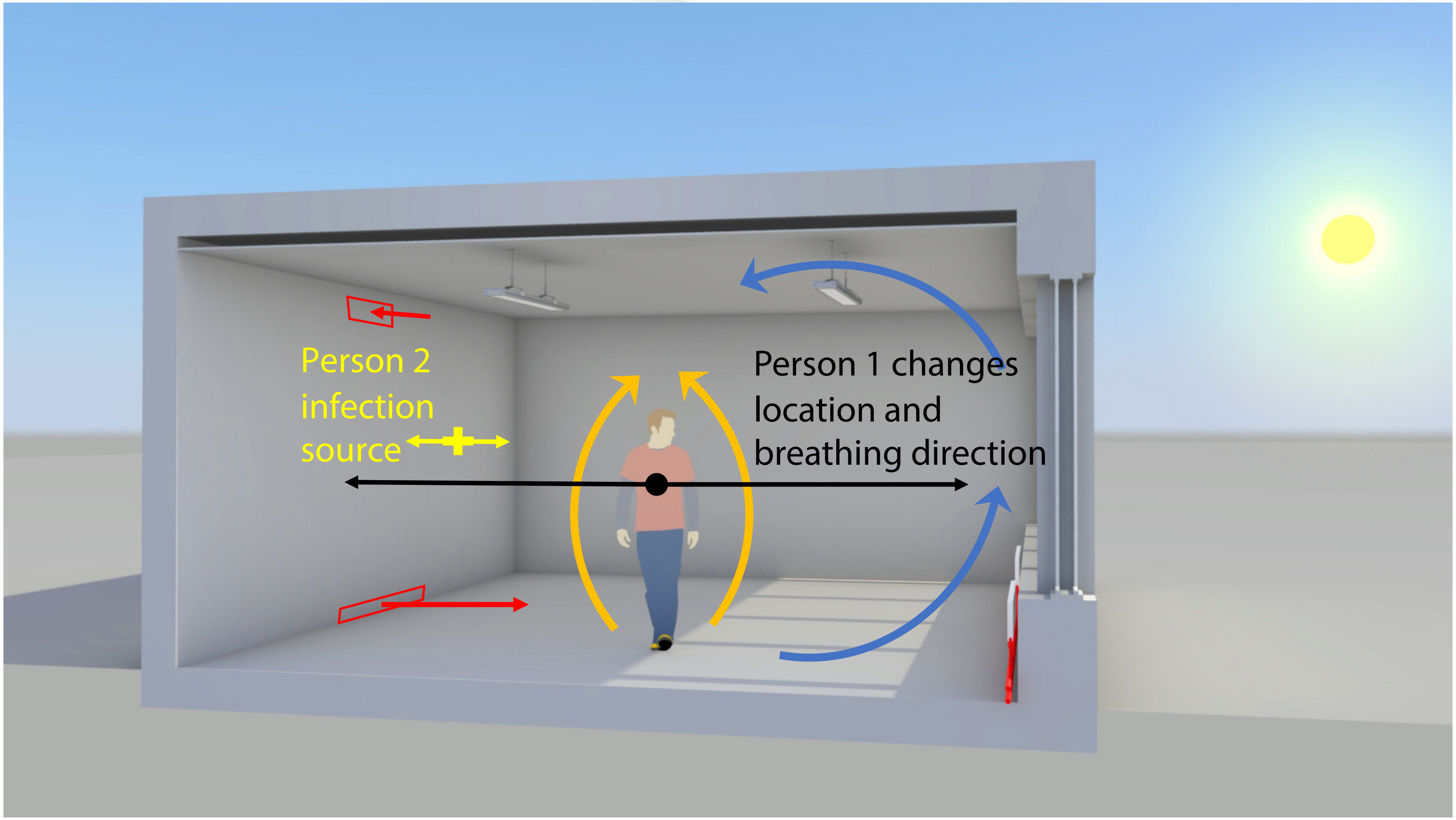
Relative positioning of a person/s to room air movement



Background air flow pattern from ventilation air flows + surface temperature flows + internal heat gains flows (people, equipment & lights):

- Surface-to-air and air-to-air buoyancy effects
- Changes by hour, day & season

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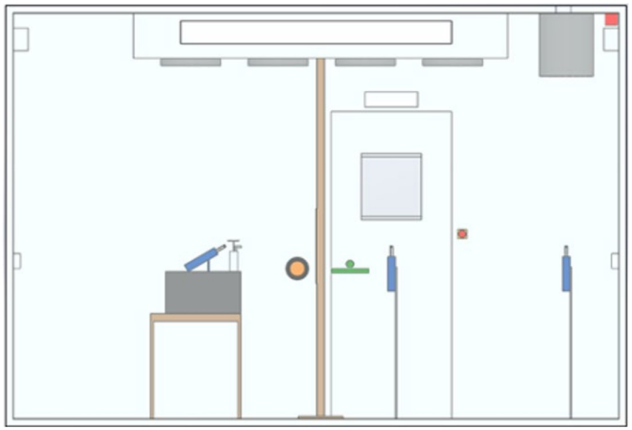
Not is all that it seems... 'dividing screens reduce airborne infection risk'



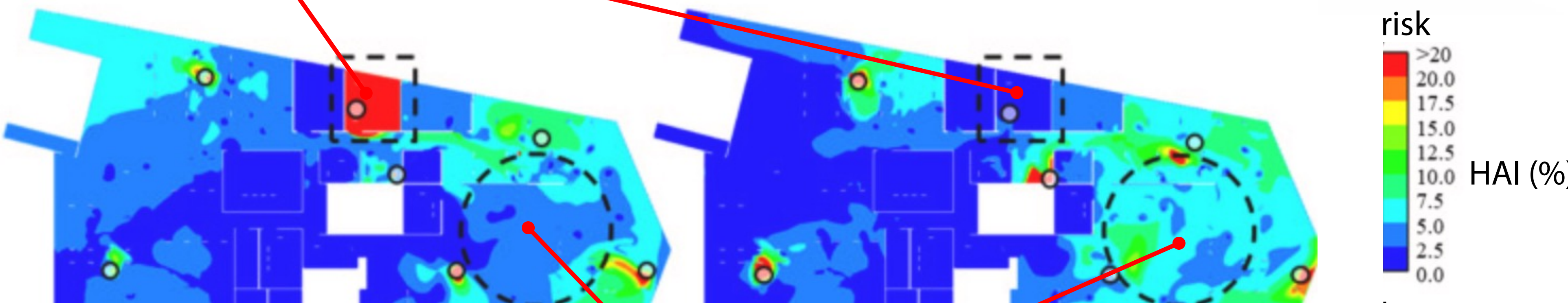
- Ventilation rate and then mixing is far more effective than screens
- Screens can reduce mixing
- *More* effective reducing larger droplets
- *Less* effective reducing aerosols
- Consider *in situ*
- **Screens can *increase* number of aerosols** reaching a susceptible person

- Practical implications - when not to use.
- Protect staff or public more? Both?
- Screen calculations or measurements can support designs.
- Challenging to cover all scenarios – create case study library?

[AIRBODS Guide: Sect.6.1, p.80]

Not is all that it seems… ‘opening a window reduces airborne infection risk’

Opening window *reduces* airborne infection risk in small, perimeter room



Closed windows

Open windows

Opening window *could increase* airborne infection risk in large, densely-occupied open plan room when the impact on air movement and mixing is estimated *locally*

- How important is *local* airborne infection reduction within a specific room?
- What are the ‘easy wins’ to increase airborne infection resilience such as moving furniture to generate breathing channels?

[B&E Paper: Fig.15]

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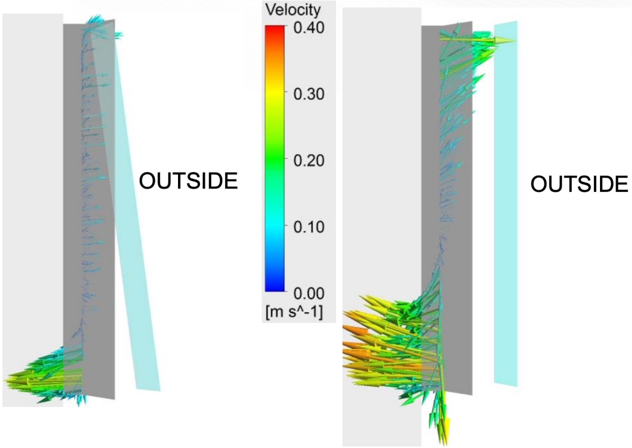
Compliance vs Performance: Natural ventilation

Guidance: Nat vent (priority No.1) then mixed-mode (No.2) then mechanical (No.3)

Top-hung window with 100mm gap

- Estimate flow rate of 290l/s



Parallel window with 100mm gap

- Estimated flow rate of 560l/s (approx. twice top-hung)

Flow of air through two different window types on a hot day
(same internal heat gains, internal configuration & external conditions)

- Effective area of opening includes a pressure loss coefficient
- Zero air temperature difference + zero wind pressure = zero flow rate

- Full annual *compliance?*
- Policing?
- Exceedance-based time targeting?

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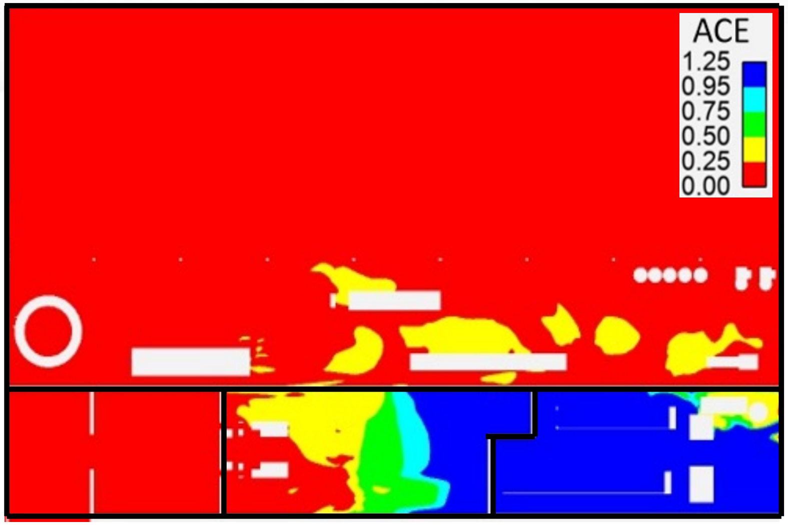
Compliance vs Performance: Mechanical ventilation

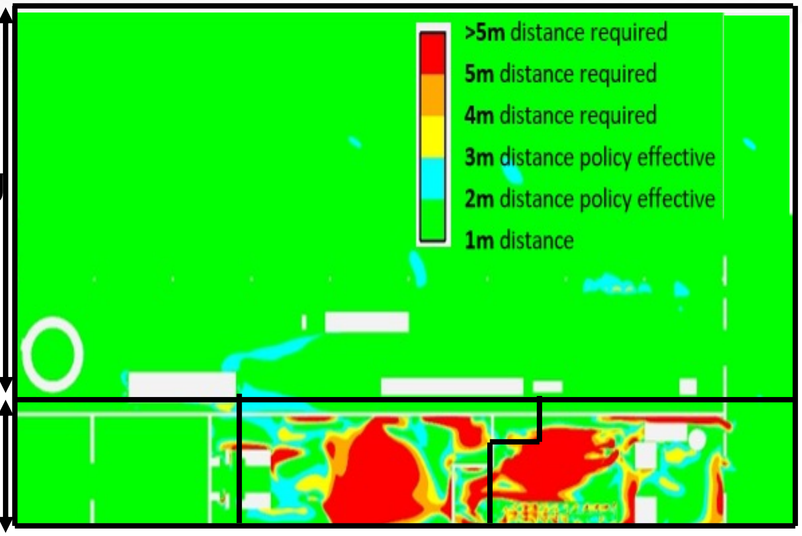
Guidance: Minimum ventilation rate



Air change effectiveness

Novel ventilation design promoting **vertical** air movement

High ACH (not in design)



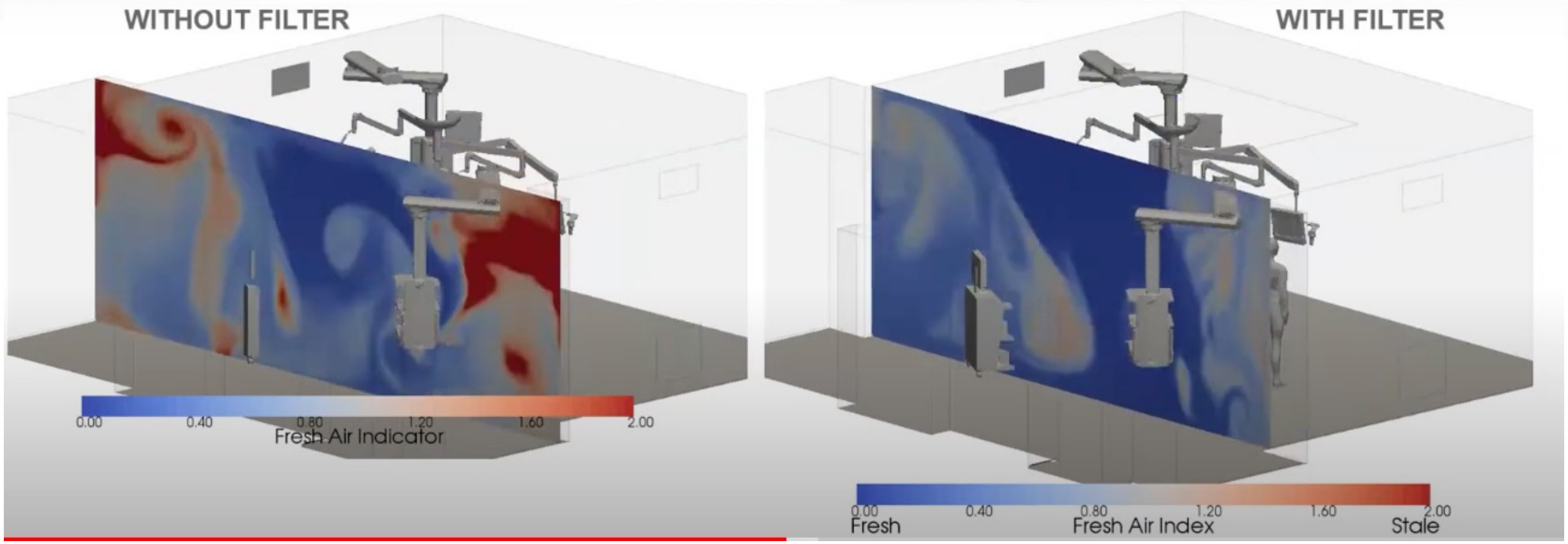
Minimum horizontal distance

Case study for an occupied food production facility

- Design function: Raw dough skin needing close local controls to ensure good crust formation
- Design strategy: Less horizontal air movement reduces carry distance before adequate dilution

- Optimising performance including air quality and energy usage – 4.7ACH
- EHEDG guidelines - 5ACH minimum
- If compliance trumps performance, the only acceptable design is sub-optimal!

Best time and place for airborne infection reduction



CFD model of operating theatre with and without an air cleaning device

Logical thought process:

1) Operational scenarios - wait between patients?
2) 'Surface-mounted' ventilation system
3) People and equipment obstructing / reducing ventilation performance
4) Best practice / practical air cleaning device location
5) Performance specifications

[BSG/IBPSA Event @ 54min]

Kills 99.9999999999% of *all known* germs

‘removes 99.9% of viruses in two hours’

- Understanding tolerances, accuracies and sensitivities on surfaces *and* in the air
- Combined surface-air treatment strategy
- Combined capture, removal and/or inactivation strategy
- Natural biological decay in large spaces?
- Kill rates (next slide)

- To what extent can a surface cleaning strategy be reduced by installing a highly-performing ventilation system?
- Reanimation of virus-laden particles off the floor into the air?

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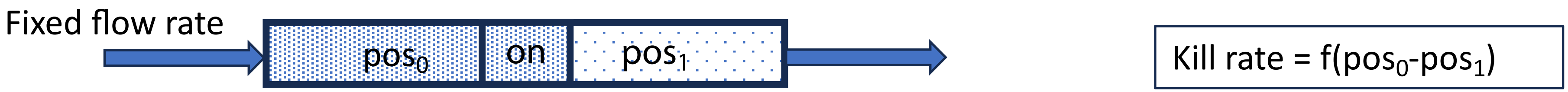
[CIBSE Air Cleaning Technologies Guide]

Testing kill rates

Test 1: Concentration over time in fixed volume (aerosolized pathogen at start)



Test 2: Concentration at one time at a specified flow rate (flow-performance rating curves?)

- Challenge to align test methods with reality and provide modelling performance data.
- 'Actual specific risk' may be unknown – surrogates used.
- Challenging to choose appropriate kill rate - targets undeveloped.

Single pass Standards and testing facilities to be developed?

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Using proxies and banding

Air Quality Bands	Classif-ication	Range of CO_2 concentrat-ions: Absolute values (ppm)	Range of excess CO_2 concentrat-ions: Above outdoor (ppm)
At or marginally above outdoor levels	A	400 - 600	0 - 200
Target for enhanced aerosol generation (singing, aerobic activity)	B	600 - 800	200 - 400
High air quality design standards for offices	C	800 - 1000	400 - 600
Medium air quality	D	1000 - 1200	600 - 800
Design standards for most schools pre-Covid	E	1200 - 1500	800 - 1100
Priority for improvement (SAGE EMG)	F	1500 - 2000	1100 - 1600
Low ventilation/dense occupancy. Must be improved	G	>2000	>1600

Be aware of 801ppm when people are exercising or singing !!!???!!!

Always be aware of 2001ppm !!!???!!!

- CO_2 sensing accuracy ±30ppm (best case)
- Limits should trigger discussions on severity

Banding has role to play but appropriate responses to limits should be clear based upon wider risks

[AIRBODS Guide: p.32]

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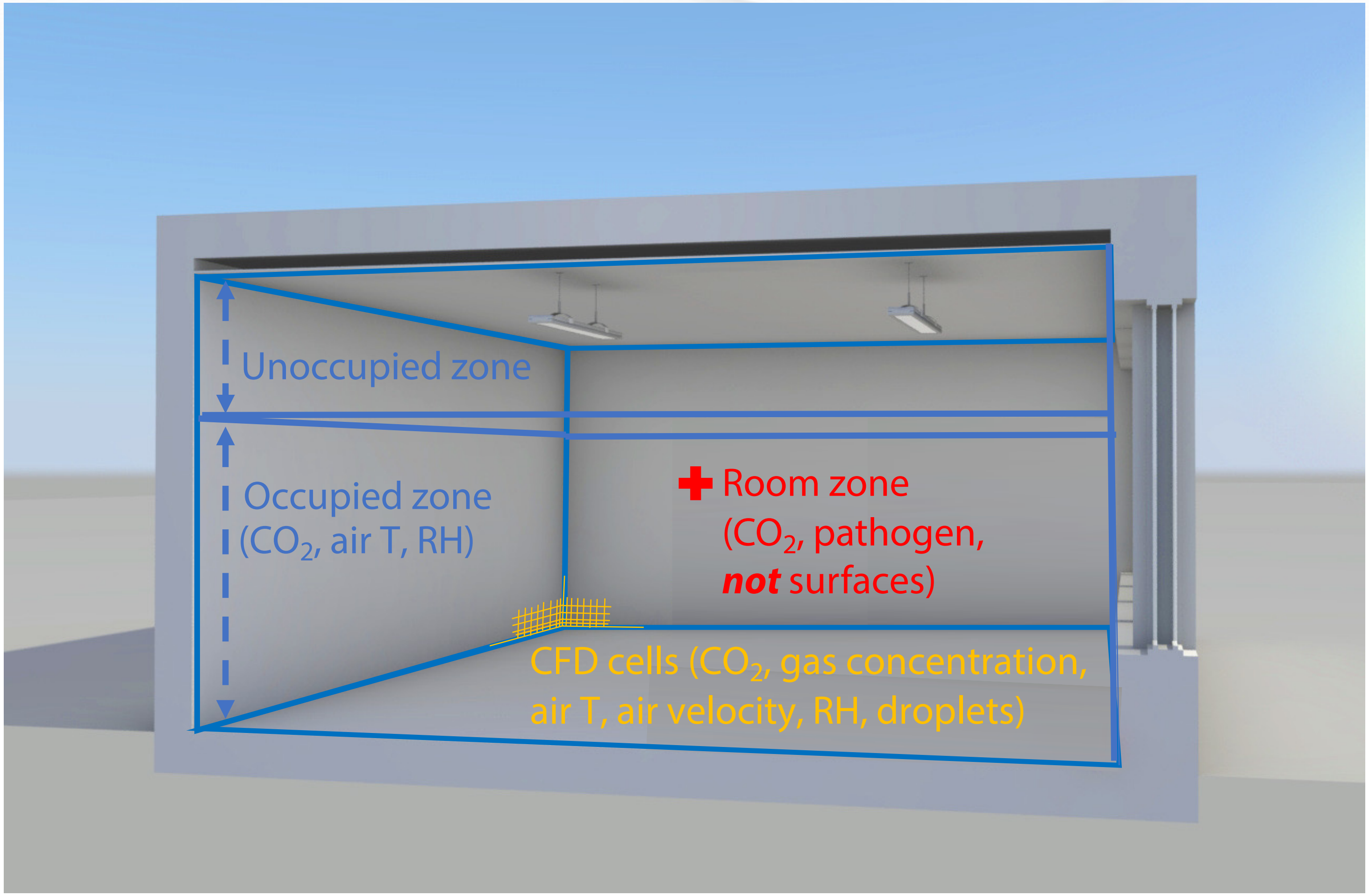
Our toolkit: Calculation data points and variables



- Analytical model – single data point
- DTM - 10's of zones (one data point per zone)
- CFD model - 10^4 to 10^7+ data points

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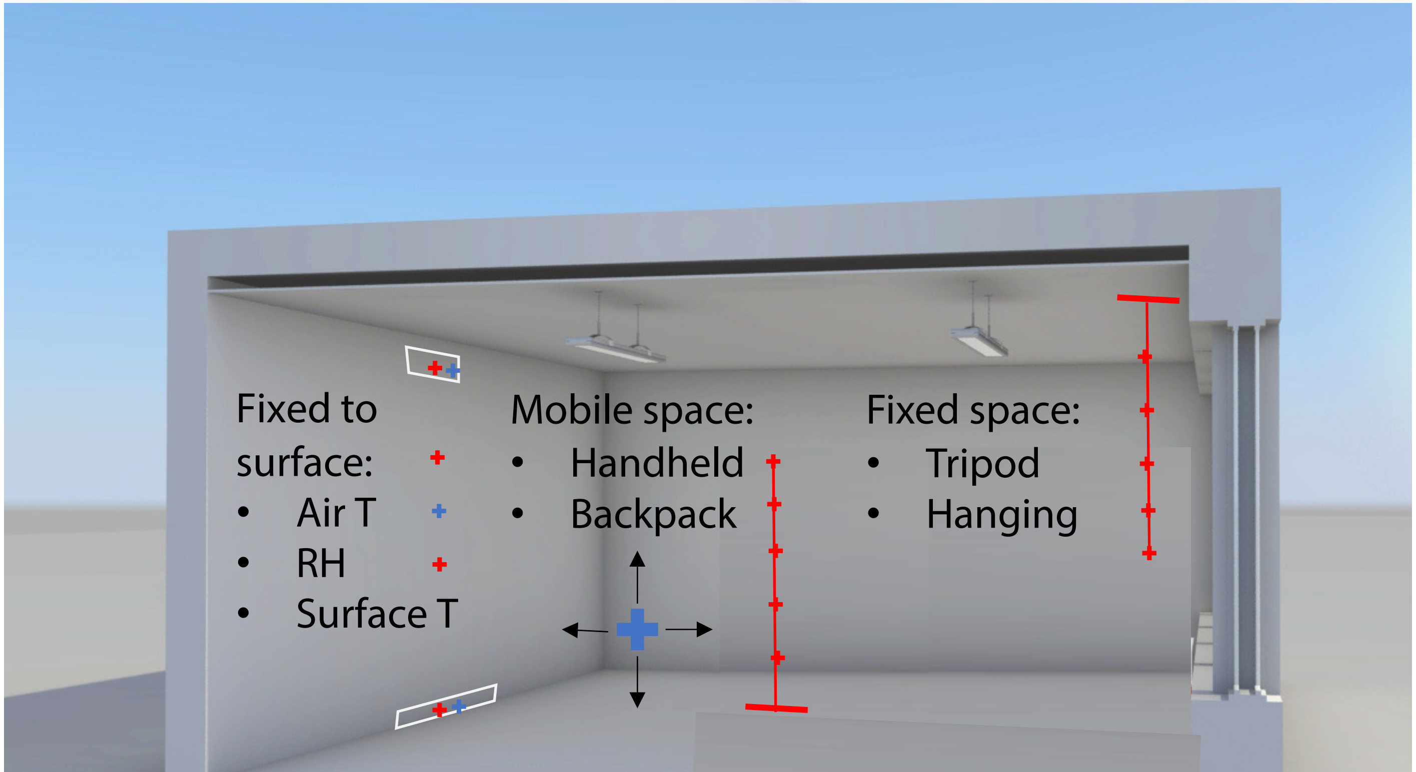
Our toolkit: Measurement data points and variables



- Air *speed* or velocity? – Smoke? Other, e.g. LIDAR (infrequent)?
- Gas concentration.
- Pathogen / bioaerosols - Surrogate? Agar dish period.

- Test chamber - higher spatial resolution of data points
- Monitoring - lower spatial resolution of data points needing 'time plus location' recording if mobile

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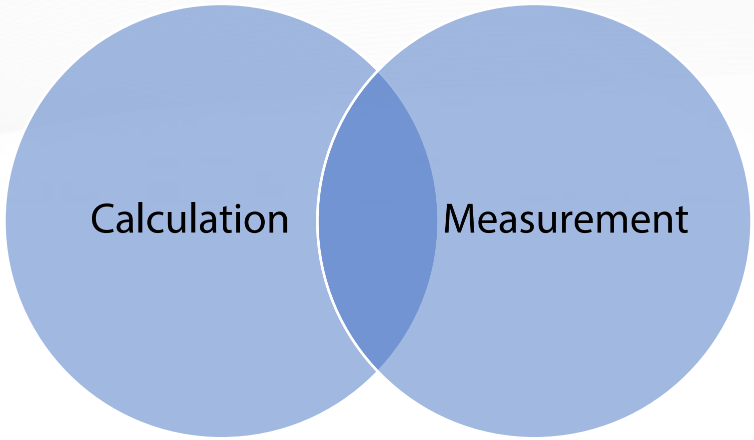
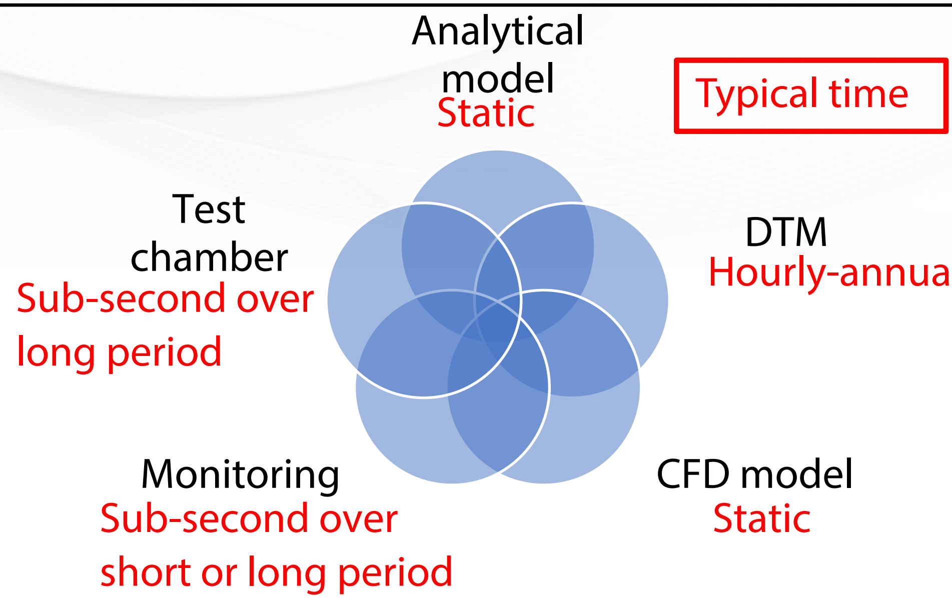
Our toolkit: Calculations and measurements - summary





- Data type (direct or derived values):
  - Physics / biology / chemistry
  - Gas / particulate / droplet / aerosol
- Spatial resolution, scale (metres to micrometres) and distribution
- Behaviour and space dynamics:
  - People moving
  - Opening window
  - Surface temperature (hour-DTM) versus air movement (second-CFD)
- Accuracy, tolerances, simplifications and space-time averaging
- Validation – comparative evaluation at common points - plus verification

No single calculation or measurement method covers all of space and time – correlation?

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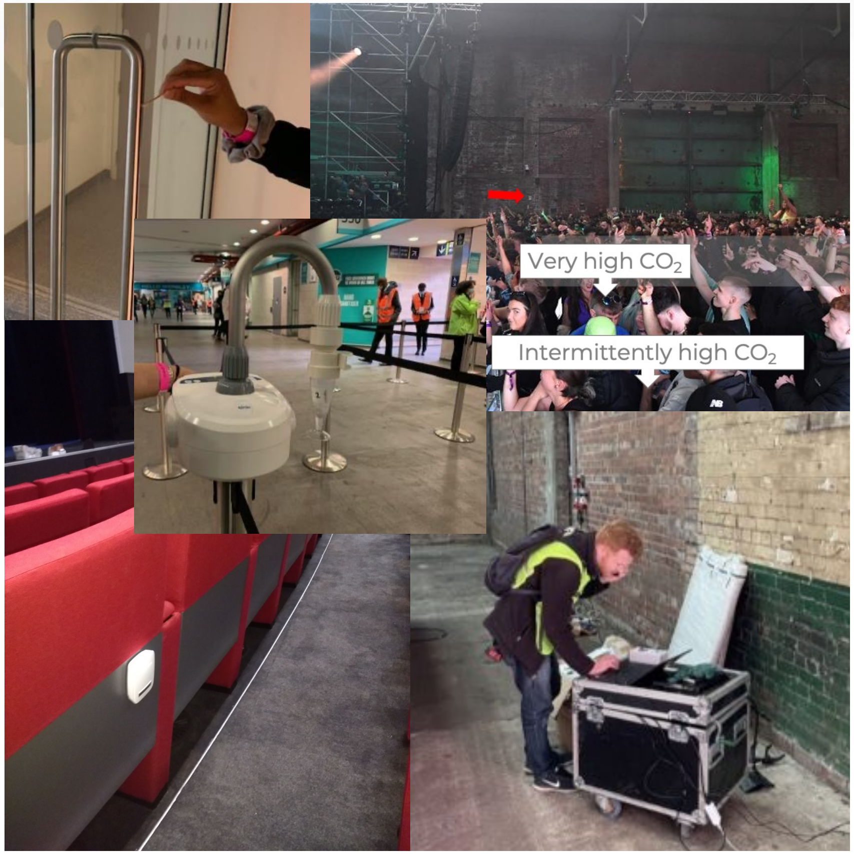
Measurements



Environmental surveys

CO_2 monitoring:

- Strong relationship between outdoor air, occupancy (numbers and activities) & airborne infection
- CO_2 proxy - poorly ventilation and/or overcrowding
- Inexpensive sensors - whole building at high resolution - air mixing and occupant dynamics

Microbiological sampling:

- Detects specific pathogens in air and on surfaces
- Specialist expertise required
- Data helps identify transmission routes and risks

- Needs existing building and to monitor 'in use'
- Challenging to change operation
- Calibration of fixed sensors over very long periods

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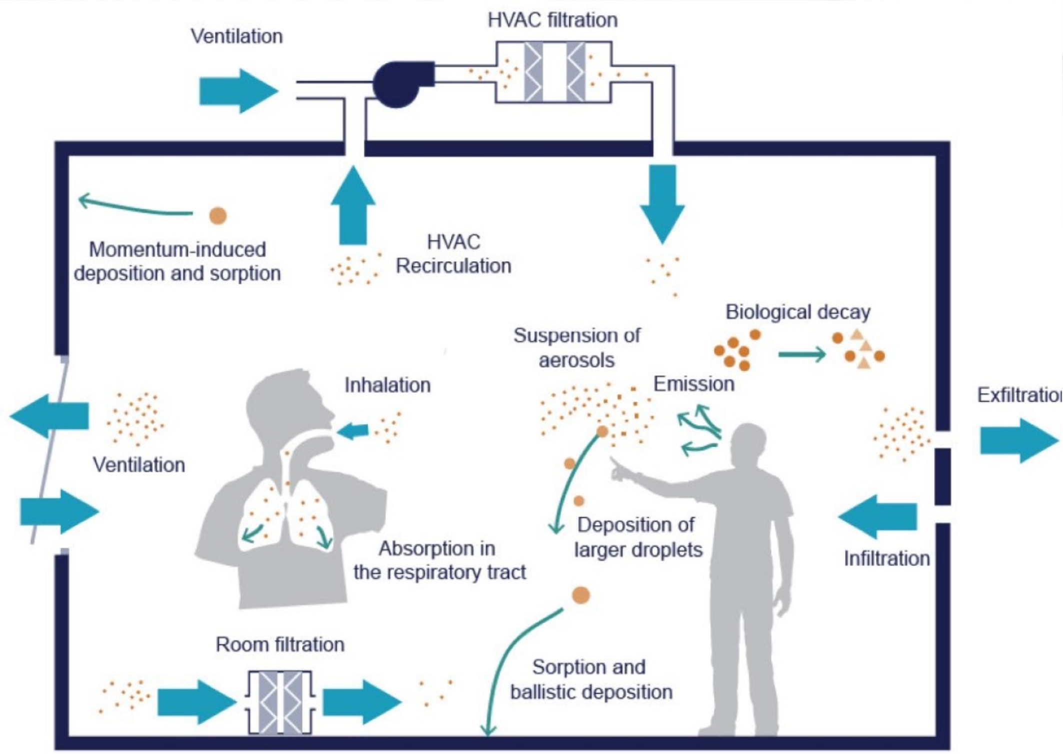
[AIRBODS Guide: Ch.5]

Analytical model: Estimating relative risk



- Analytical model of Relative Exposure Index (REI) – long-range only
- Mass balance approach - concentration of virus in the air to estimate inhaled dose
- Single infector with same viral load for comparative risk

Gains:
- Emission from a person (occupancy)
- Entry from outside via ventilation
- Entry from outside via infiltration
- Virus already present in the space

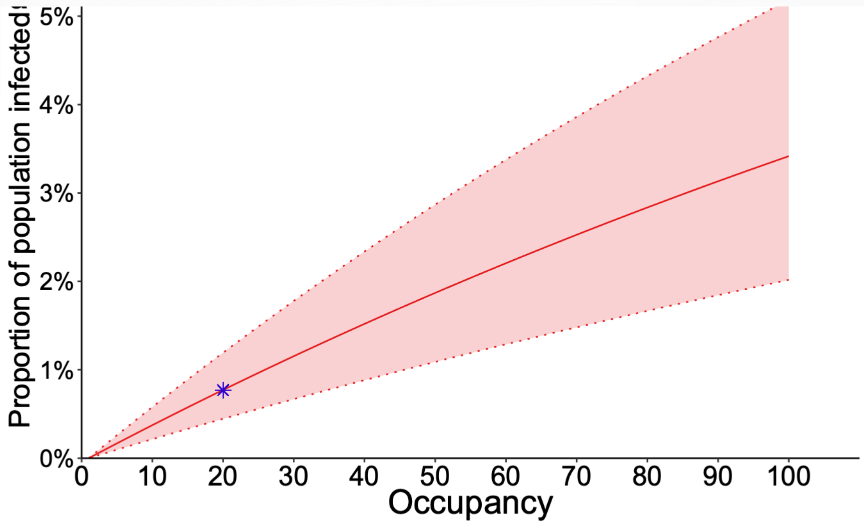
Losses:
- Dilution via ventilation (nat vent & mech systems)
- Surface deposition
- Biological decay and UVC denaturing
- Respiratory tract absorption
- Filtration (inc. air cleaning device)

—— Primary engineering solutions and controls

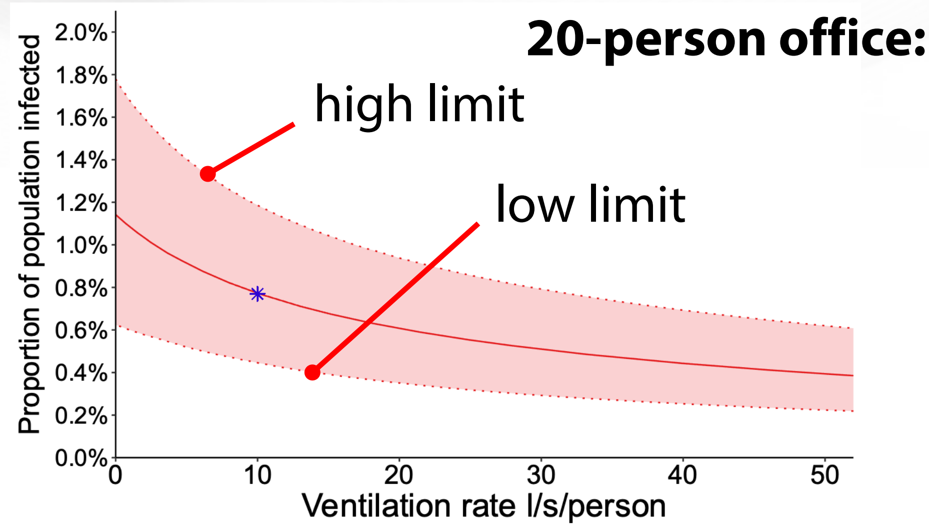
[AIRBODS Guide: p.24, BSG/IBPSA Event @ 10min, CIBSE Air Cleaning Technologies Guide inc. REI calculator]

Analytical model: Sensitivity tests

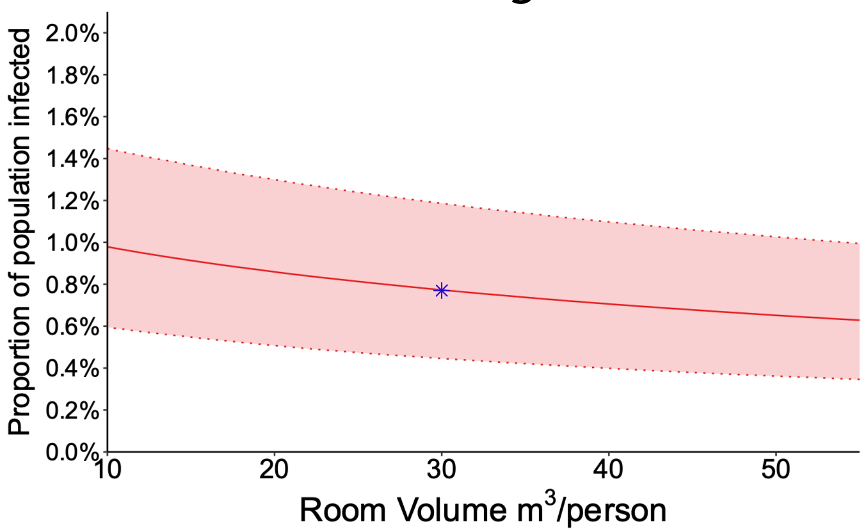
Occupancy (+ activity + exposure time)



Ventilation rate



Architectural design (+ behaviour)



Analytical model:

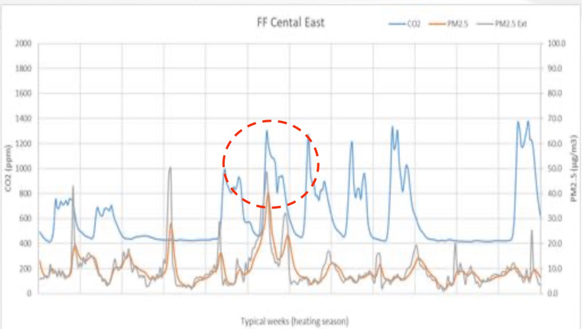
- Indicates resilience specific to room/s with *different* ventilation rates, occupancies and activities
- Long-range airborne exposure focus subject to limitations

[AIRBODS Guide: pp.34-36, pp.70-71, Ch.7]

Multi-physics & multi-objective DTMs

DTM with advanced controls

DesignBuilder SOFTWARE



Holistic IAQ control strategy requiring extra coding

Revised control strategy:

- Relax CO_2 setpoint (1500ppm)
- Close vents if outdoor $PM_{2.5}$ above threshold

Highlights:

- Outdoor $PM_{2.5}$ above indoor $PM_{2.5}$ (peak below 40 µg/m³)
- Energy use (heating) 105 Wh/m²/day (28% less due to relaxation of CO_2 limit)

What would an airborne infection control strategy look like?
Use of IAQ proxies for airborne infection?
Calculating UV & filtration system value?

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CIBSE BSG Event 'Hacking Simulation', March 2018 https://www.cibse.org/networks/groups/building-simulation/bsg-past-presentations 11

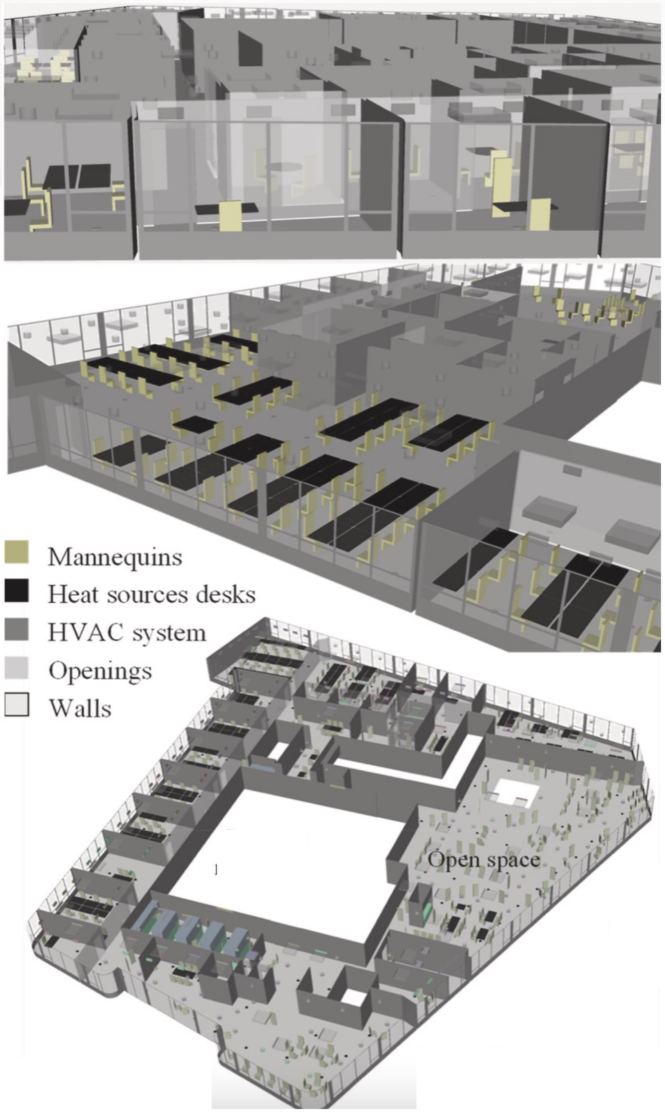
Single DTM can include:

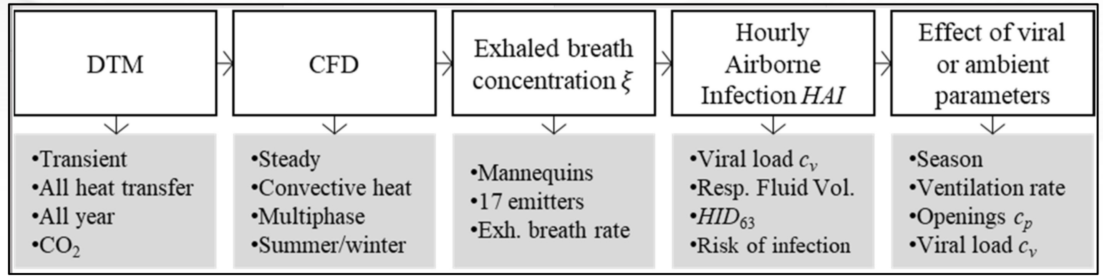
- Thermal comfort
- Occupant behaviour (6min minimum)
- Air quality
- Mechanical & natural ventilation systems
- Energy usage
- Controls strategies

- More models available from new overheating guidance (Approved Doc O for residential)
- Opportunity to develop digital twin supporting 'live' health and safety controls

[BSG/IBPSA Event @ 64min & 80min]

Detailed CFD models guided by DTMs





- Calculation framework with CFD focus
- DTM support - design scenarios & surface temperatures
- Hourly Airborne Infection (HAI) rate metric - sensitivity of different areas to different viral loads
- High spatial resolution - moving of a supply air grille or desk
- Possibly different mitigations from 'mixed zone' methods
- Potential future developments - less dependence on infector and susceptible person locations / disease switching

[B&E Paper]

Our toolkit: Calculations and measurements - significant challenges

Emission rate / droplet distribution / gradients
Capturing air movement with time-location recording
Equipment costs and availability beyond CO_2 sensing

CO_2 verification and validation (space & time)
Integration of analytical models

Some spatial, temporal and building science disparities

Experimental / fieldwork
- Limited measurements sometimes single point by zone
- Sometimes high frequency sampling (not if identification needed)
- Sample resilience from capture to testing
- * Proxies versus limited biology & epidemiology at microscale

Dynamic thermal modelling (DTM)
- Multi-mixed-zone DTM (often coarse zones)
- Typically one hour time steps – limited to 6min intervals?
- * Detailed systems models and controls possible
- Good capture of surface temperatures important for buoyancy-driven flows

Analytical / simple (?) tools
- * Single point / mixed-zone outputs
- Steady state or transient defined by calculation type
- Simple or complex physics

Computational fluid dynamics (CFD) modelling
- * Detailed air movement – advanced aerosol turbulence / mixing / transport capture
- Mainly steady-state but could be minutes (not practically hours)
- Some detailed source or receptor models possible

Limited biology & epidemiology in tools / models but still useful for design purposes!

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Debate around validity of mixed-zone models
Over-interpretation on spatial aspects

Surface temperature and thermodynamic effects (running CFD only)
Simplifying the advanced biophysics

[BSG/IBPSA Event @ 80min]

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Make hay while the sun shines

Expert calls for future pandemic planning amid 'signals' from bird flu

Professor Devi Sridhar said preparations were needed in case of future disease outbreaks.

Lull between pandemics? Aug 2023

How likely is it for respiratory virus transmission to occur via surfaces?

How important is ventilation?

Possibly reduce infection rates by up to 50% against poorly ventilated spaces Oct 2022

National Engineering Policy Centre

Buildings & health | Benefits of ventilation | Types of ventilation | Managing ventilation

Ventilation matters - why clean air is vital to health

- Balance outside air demand with reduced energy
- Illness, allergy, mould, airborne disease, mental health, sleep, productivity, smells etc RAEng website

Better understanding of holistic value off the back of accelerated R&D is likely to lead to:

- Increased gearing of investments
- Improved decision making

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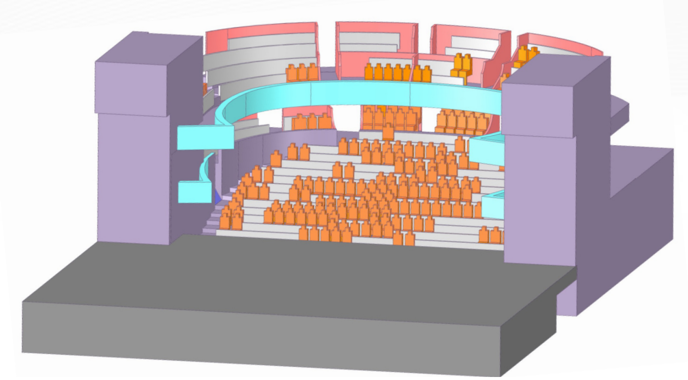
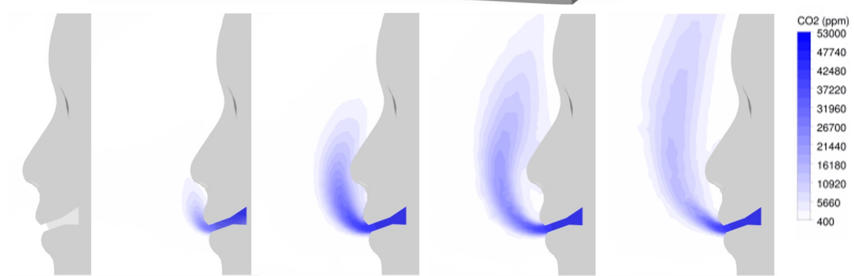
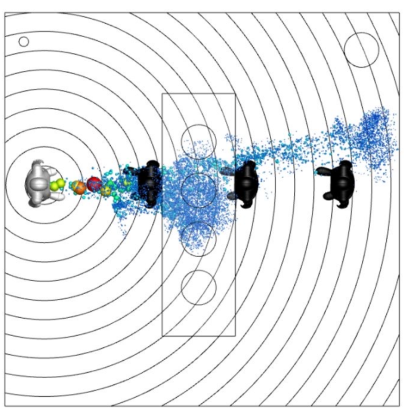
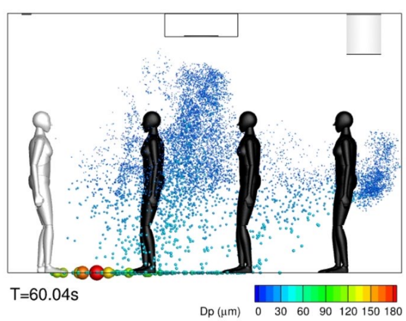
Airborne infection reduction assessments in the future?









- Standardization within well-defined best practice
- Fully integrated into IAQ assessments
- RIBA Stage integration
- Increased confidence in 'killer products' integration
- Mix of male, female and child
- Improved space-time-occupancy-targeting
- Better validated models simplified for industrial usage
- Clarity on accuracies, tolerances and sensitivities
- Sector-specific guidance - common libraries?
- Crowd simulation - breathing & people dynamics
- Better-educated & highly-skilled designers and operators

[AIRBODS Guide: Ch.8 & Ch.11]

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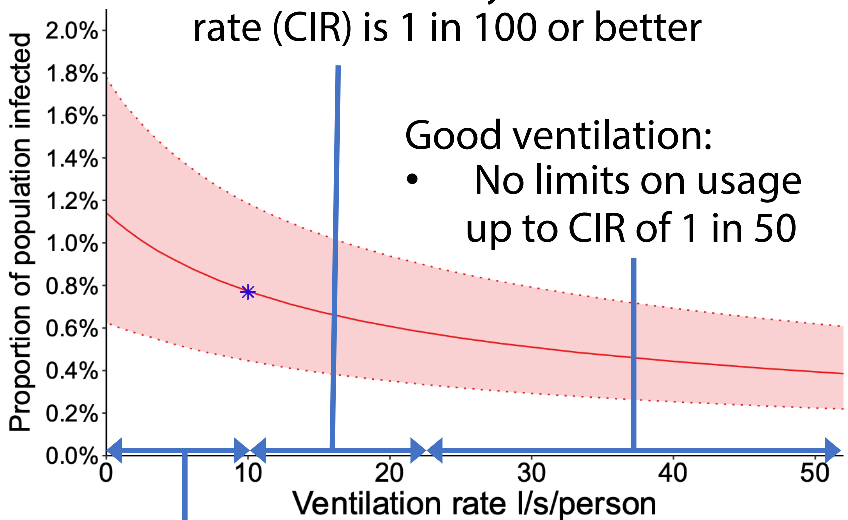
Airborne infection *compliance* assessments in the future?

Submitted design for 20-person office:

Adequate ventilation:

- Operate up to 20 persons when community infection rate (CIR) is 1 in 100 or better

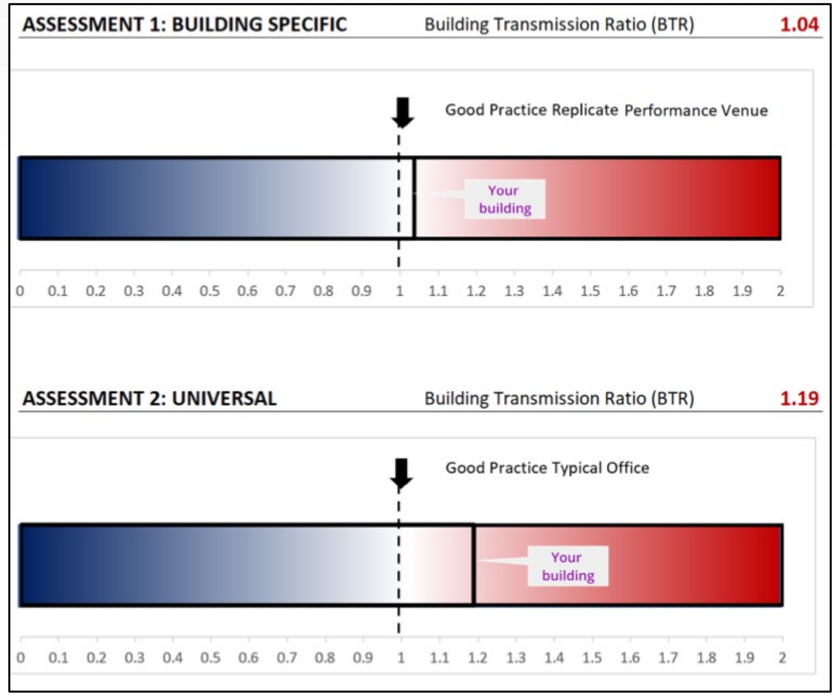


Good ventilation:

- No limits on usage up to CIR of 1 in 50

Unsafe ventilation:

- Not enough outside air entering breathing zone
- Multi-metrics indicate unsafe operation for intended use
- Change use or improve ventilation performance



BODS (Building Operation and Design Support) Tool - Lessons from energy rating systems?

[AIRBODS Guide: p.149]

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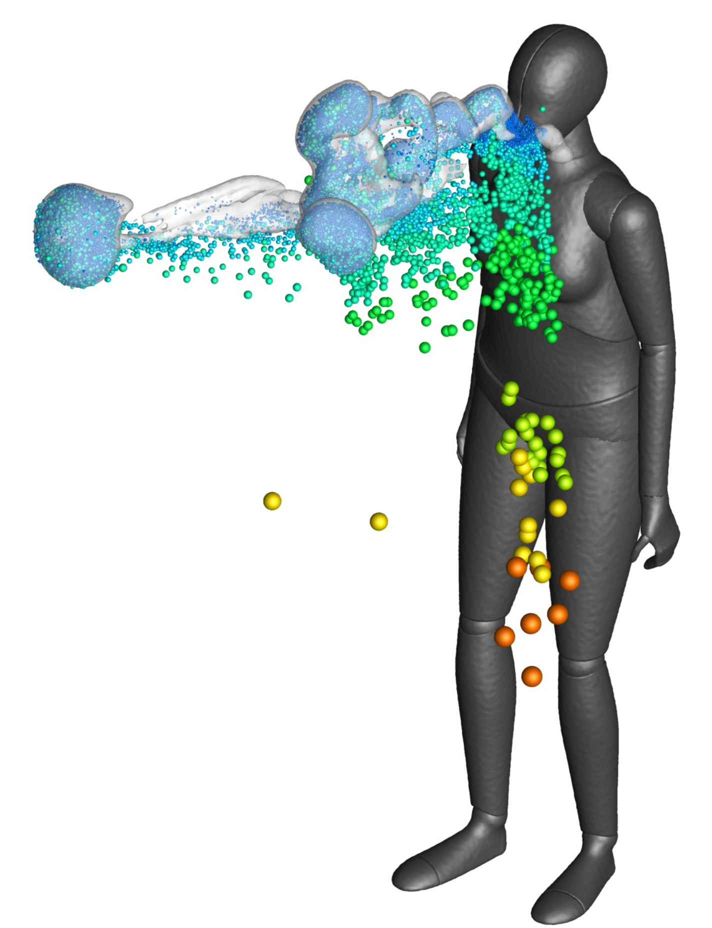
Some additional thoughts



- AIRBODS - experts with different skills sets integrated into one team - significant challenge for industry
- Siloed engineering and procurement of services
- How can we ensure that the lessons *not* learnt from SARS 2003 aren't repeated?
- Competency and health & safety requirements
- Value of research in pandemic is lower than if completed beforehand – make hay!

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Any Questions?