The Controlled Active Ventilation Environment Laboratory (CAVE) – Resilient Buildings and Indoor Environments

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TAPAS

Tackling air pollution at school

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Change the world

The built environment we live in - challenges

- Some of the biggest challenges facing the world today are population growth, rapid urbanisation, and climate change.
- These trends result in urban overcrowding, traffic, air pollution, increased transmission of infectious diseases, and high energy consumption and carbon emissions.
- Building design guidelines are appropriate and many improvements are possible.
- But -> the actual quality of ventilation across the UK building stock is unknown
- This makes it impossible to assess the overall indoor air quality of schools, hospitals, offices, restaurants, performance venues, museums and galleries, buses and trains around the UK
- Our ignorance of the scale of the problem means we cannot estimate the health impacts of “ordinary” poor indoor air quality and disease transmission

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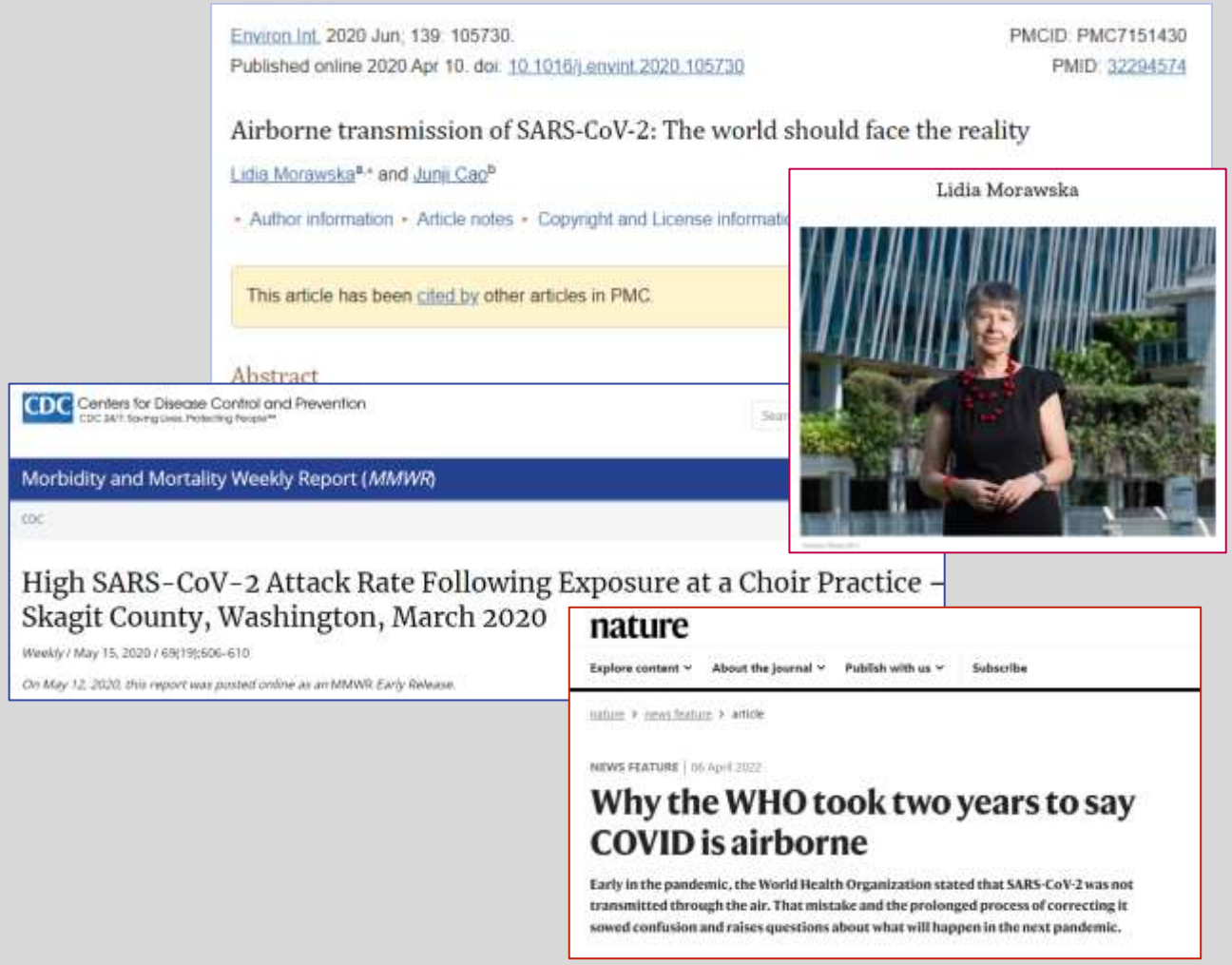
Context: COVID-19, Airborne transmission is established

- Super-spreading events were seen as evidence of airborne transmission of SARS-CoV-2, especially in very poorly ventilated spaces

Risk factors for airborne transmission include:

- Duration of time spent in a space
- Activities that may generate more viral aerosols (singing, loud talking, aerobic exercise)
- Low ventilation rates
- Large number of people present



Research on COVID-19 transmission – IAQ/Ventilation monitoring buses

COVID response research questions:

- How to protect bus drivers from prolonged exposure to COVID-19
- How long do episodes of poor air quality last?
- What time of day is worst?
- How many people are on board when air quality deteriorates?
- How many windows need to be kept open?
- Can the impact of national restrictions be understood from IAQ on buses?

Current Research:

- What should ventilation targets be?
- What are the measured temperatures on buses throughout the year
- What is the energy cost?

Project team:
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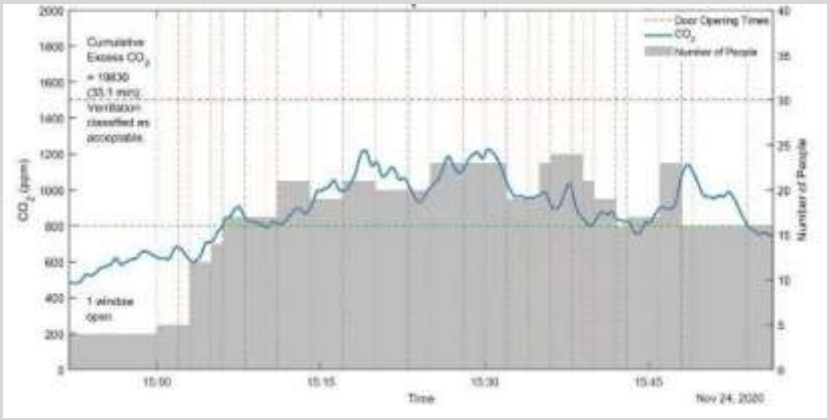

CO_2, Door Opening Times and Number of Passengers

Project VIRAL: bit.ly/uclviral

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TRANSPORT FOR LONDON
EVERY JOURNEY MATTERS

UK Research and Innovation

The Events Research Programme: Large scale Monitoring of IAQ

The AIRBODS project – to deliver guidance on the ventilation operation and future design of non-domestic buildings and to quantify the risk of, and reduce the transmission of SARS-CoV-2 in buildings, led by Prof Malcolm Cook, was funded by the EPSRC grant EP/W002779/1

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The Environmental Study, of the Events Research Programme, led by Dr Liora Malki-Epshtein, was funded by the Department for Digital, Culture, Media & Sport

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COMPLETE PERFORMANCE ENGINEERING

UKRI Engineering and Physical Sciences Research Council

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Department for Digital, Culture, Media & Sport

Events Research Programme

Department for Business, Energy & Industrial Strategy

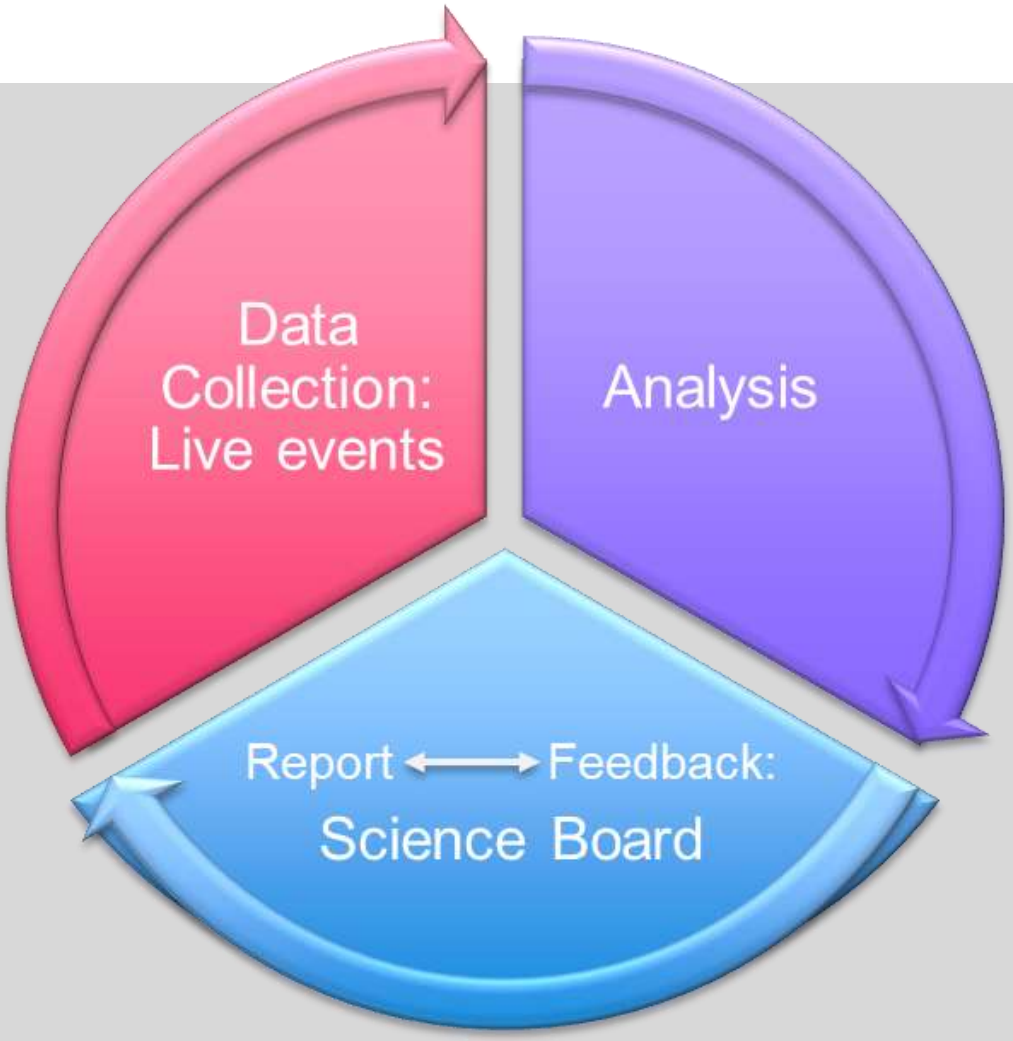
Department of Health & Social Care

AIRBODS

The Process

The research programme was updated every week between April and August 2021

1. The research team attended live events to supervise the monitoring and understand how the events were run
2. Phase I: Data was quickly analysed for lessons learned
3. First reporting cycle to DCMS by May -> for ministerial review -> overall picture of AQ and analysis of exposure compared with “a day at the office”
4. Phases II-III of ERP planned and executed in rapid succession between April and May 2020
5. Weekly presentations and reports to Science Board
6. Phase III: Risks and mitigations communicated to Science board and venues – June-July 2020



Analysis: Space Classification

Ventilation Classification

- Outdoors
- Outdoors, sheltered
- Indoors, naturally ventilated, high ventilation
- Indoors, naturally ventilated, low ventilation
- Indoors, mechanically ventilated

Usage Classification

- Arrival and Departure Areas
- Dwelling Areas
- Concessions / Bars-Standing
- Bars / Restaurant-Seated
- Main Activity Areas (Structured)
- Main Activity Areas (Unstructured)
- Private Boxes / Meeting Rooms
- Toilets, Corridors, Lifts, Stairwells (small, enclosed, short occupancy)

Analysis: Air Quality Classification

- For the ERP, we proposed a nuanced classification for IAQ based on seven bands of CO_2 concentrations
- All spaces were classified according to their air quality at every event using bands of A to G to enable a detailed assessment of large venues
- Air quality bands were calculated during events for the duration of an event
- We presented finally only bands of average and maximum CO_2 values

Air Quality Bands	Classification	Range of CO_2 concentrations - Absolute Values (ppm)	Range of excess CO_2 concentrations - 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

Field Studies

Field studies make for challenging projects due to:

- Local risk assessments,
- Bringing equipment on site
- Disturbance to the usual activities occurring on site
- Monitoring and data sharing from existing buildings partners can be at odds with commercial and reputational interests

A Dedicated Laboratory

- Controlled conditions can be created and maintained
- Validation of realistic and complex models; these models can then be applied to a wider range of situations.
- Results are more generalisable to other settings.
- Stronger and wider collaborations between academia, industry and other research agencies made possible
- Data sharing and dissemination
- Different technical solutions can be tested in the laboratory at a fraction of the cost of implementation on a real site

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CAVE is designed to enable people to participate in experiments to allow us to measure the user's response to their indoor environment

With a plan area 206m^2 and height of 9m, CAVE's large size allows indoor environments to be built at full-scale inside the laboratory space.

Our laboratory HVAC systems enable the creation of completely independent "interior" and "exterior" environments

CAVE - the first laboratory in the world explicitly designed to tackle Air Quality challenges and ventilation at full scale

We can, for example:

- Measure the links between indoor overcrowding and disease in the air
- Test solutions to reduce the risk of poor air quality and disease transmission
- Test low energy ventilation technologies under realistic operations
- Quantify the trade-offs between conflicting targets for energy, sustainability and health
- Learn how to improve people's experience of indoor air in terms of health, comfort, and wellbeing

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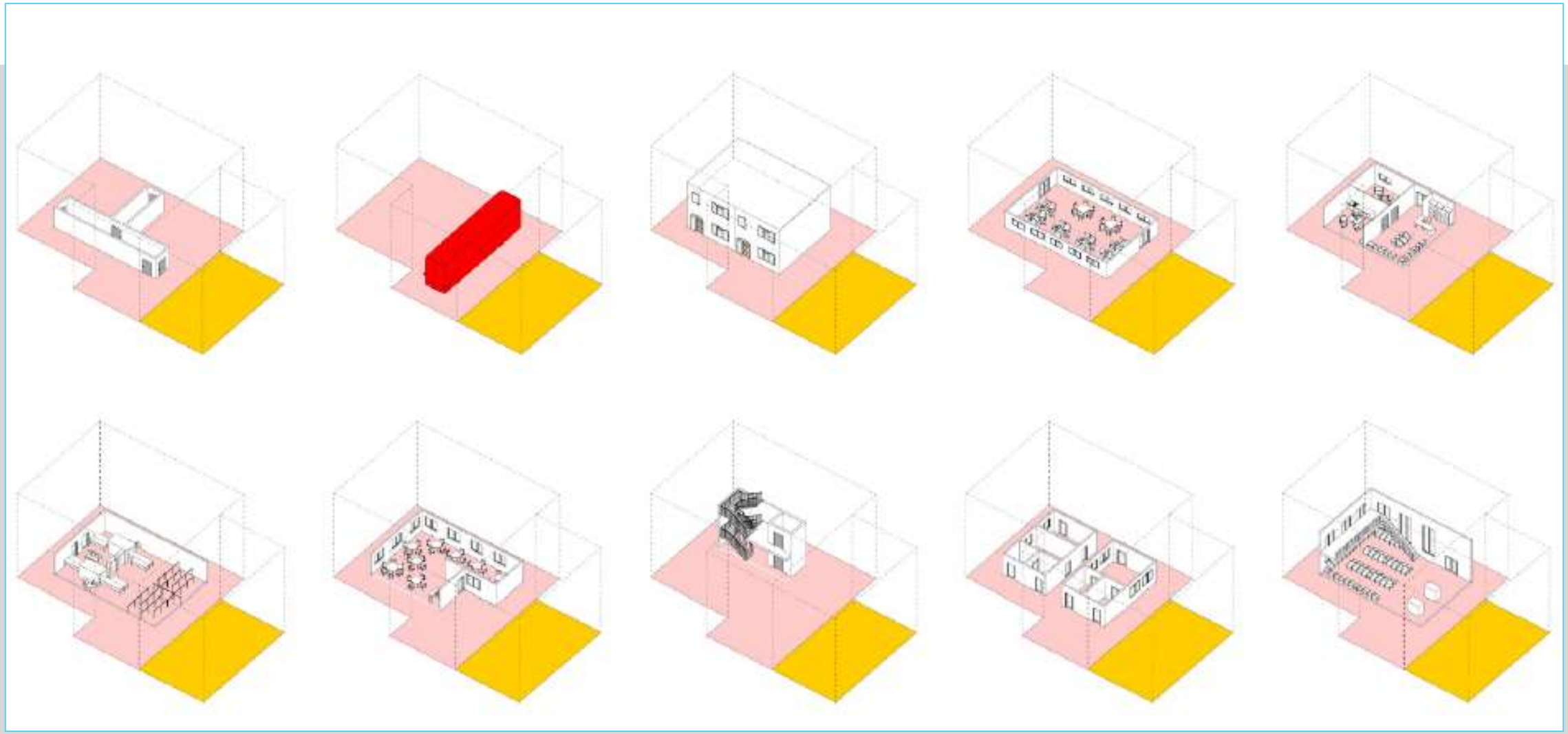
Different scenarios can be built and tested in CAVE



Problem Statement

- Desk study
- Field studies

Modelling

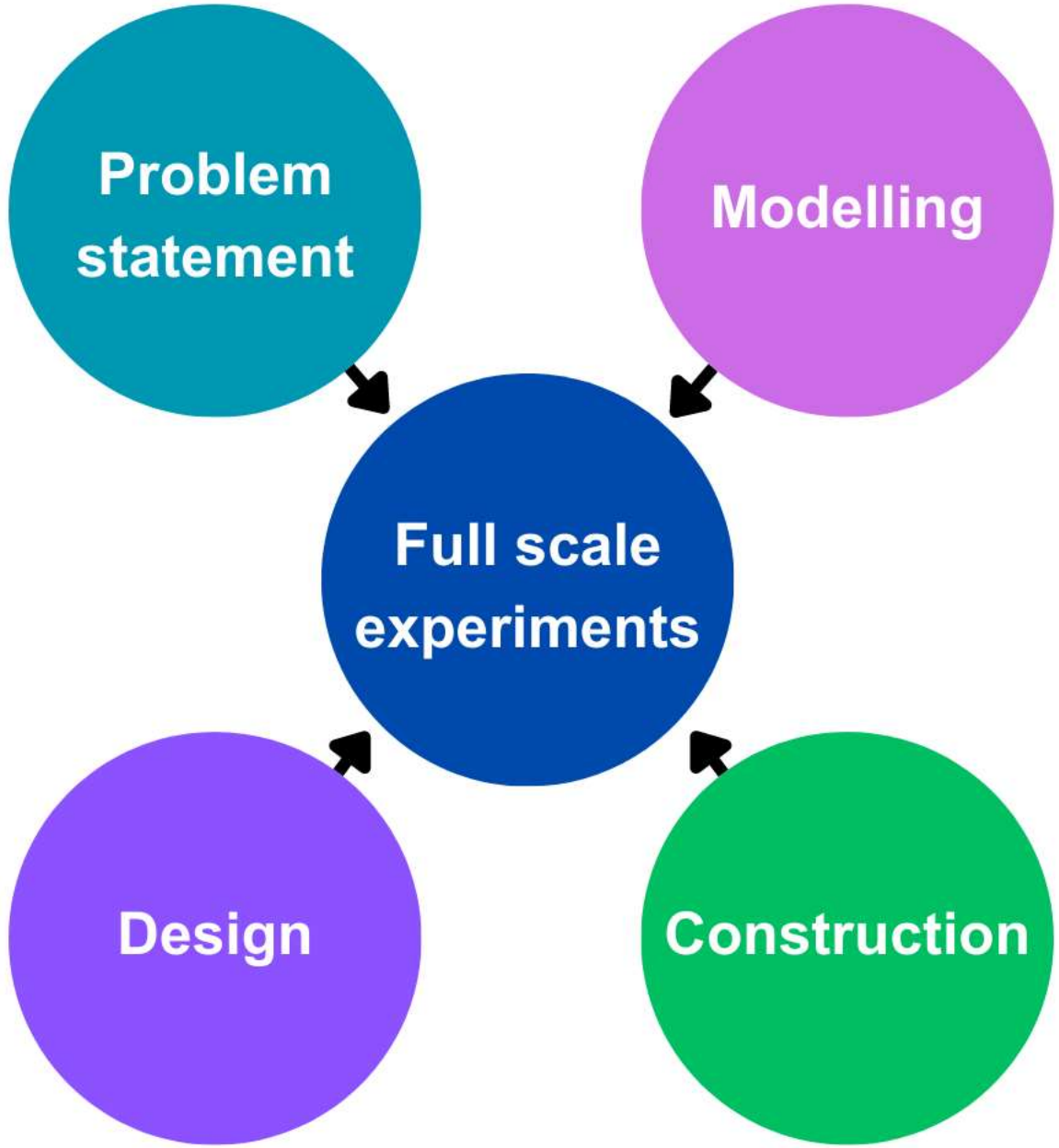
- Energy, heat exchange (IES)
- Airflows, buoyancy effects (CFD)
- Contaminants, dispersion (CONTAM – building scale/ ADMS – street scale / CFD – both)

Design

- Building envelope
- Ventilation systems
- Building components
- Occupant scenarios

Construction

- Building envelope
- Building interiors
- HVAC systems
- Building components



CAVE – Constructed Jan 2022 - April 2023

Contact Details

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