RATIONALISATION OF CFD GEOMETRY FOR MECHANICAL SMOKE CONTROL SYSTEMS IN RESIDENTIAL CORRIDORS

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Speaker Profile

- **Joe Hart** BSc (Hons) MSc MIET MIFireE MSFPE AMEI

- Founder and CEO of the Delta Innovation Group

- Director and Head of Fire Engineering at Delta Fire Engineering
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- Course Director and Chief Instructor at Delta Fire Training
- Vice President of the Institution of Fire Engineers Southern Branch

- BSc (Hons) Fire Engineering
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Overview, Aims and Goals

- This project investigates a proposal to rationalize meshing requirements where a mechanical smoke control system is provided in residential corridors.

- The study is based on the peer review of a report submitted as part of the Building Control submission for a project in London

- Following the Peer Review study a methodology is proposed for rationalising CFD geometry when designing mechanical smoke control systems

- A reduction in meshing requirements for shaft overruns is investigated in order to reduce computation time and cost

Grenfell Tower Fire

- 14th June 2017
- Fridge fire that started in Flat 16 on the fourth floor
- The fire spread to the external wall system and spread rapidly around the building, quickly involving all floors
- 72 fatalities and circa 100 injuries
- Fire and smoke spread into the central corridor and stair resulting in significant density of fatalities in the common areas
- Firefighting operation lasted three days
- Estimated costs to economy of up to £50 billion

Building Regulations 2010 (as amended)

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PART B FIRE SAFETY

Means of warning and escape

B1. The building shall be designed and constructed so that there are appropriate provisions for the early warning of fire, and appropriate means of escape in case of fire from the building to a place of safety outside the building capable of being safely and effectively used at all material times.

- The Building Regulations 2010 are *functional* and provide a series of *functional requirements* (i.e. the Regs tell us what we have to achieve, but not how to do it)
- The five Requirements for fire safety (Part B) are:
  - B1 – Means of Warning and Escape
  - B2 – Internal Fire Spread (Linings)
  - B3 – Internal Fire Spread (Structure)
  - B4 – External Fire Spread
  - B5 – Access and Facilities for the Fire Service

Three Approaches to Fire Strategy Design

Code Compliant – following a prescriptive code e.g. the guidance of Approved Document B

Full Performance-Based Design (PBD) – design based on first principles fire engineering

Comparative Analysis – benchmarking against the prescriptive guidance

Approved Document B - (ADB)

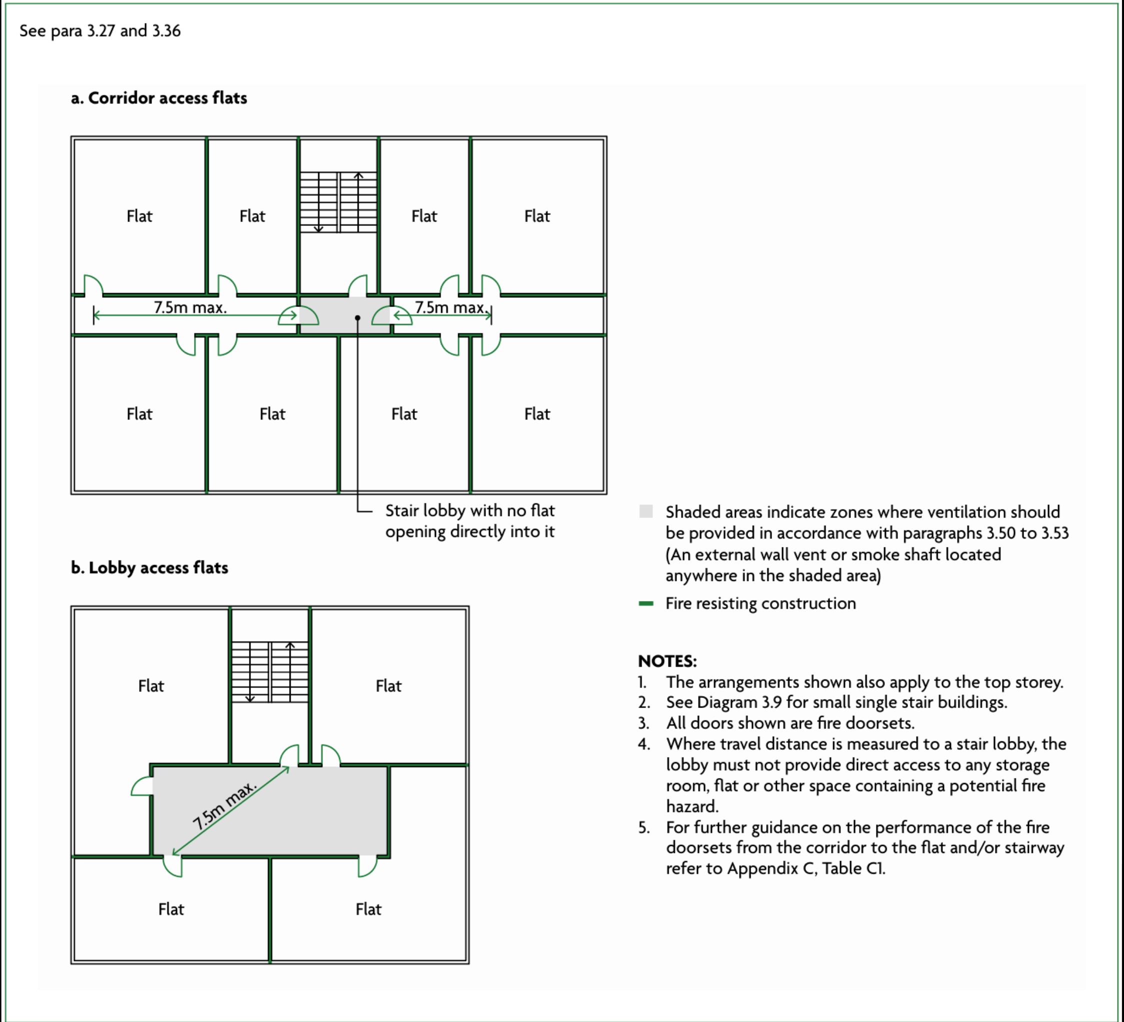
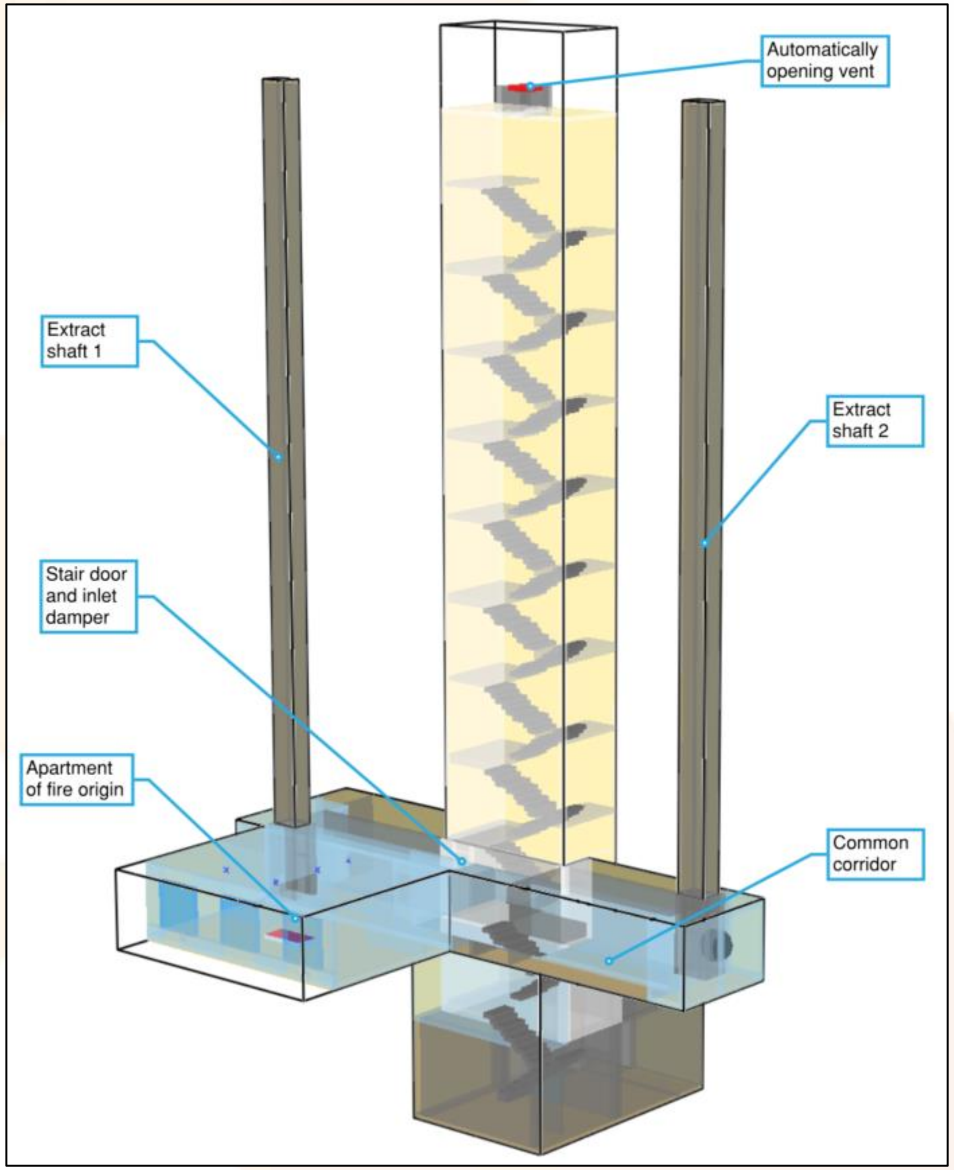


Diagram 3.7 Flats served by one common stair

- Approved Document B provides prescriptive guidance on design of residential buildings in England and Wales
- Residential corridor design relies on smoke exhaust/extract in common corridors, generally in the corridor or lobby directly adjacent the stair
- Corridors are typically ventilated by 1.5m2 natural shaft interfaced with smoke detectors in the common corridor or lobby

Mechanical Smoke Control Shafts



More favourable as they allow a reduction in size

Also have greater efficiency and improve safety in buildings (both for Means of Escape and Firefighting)

A common use of CFD is in benchmarking a proposed mech shaft against a *code-compliant* natural shaft (i.e. a comparative assessment)

A recent report proposed extracting directly from the corridor to reduce simulation time

CFD Modelling Example – Admiralty Arch

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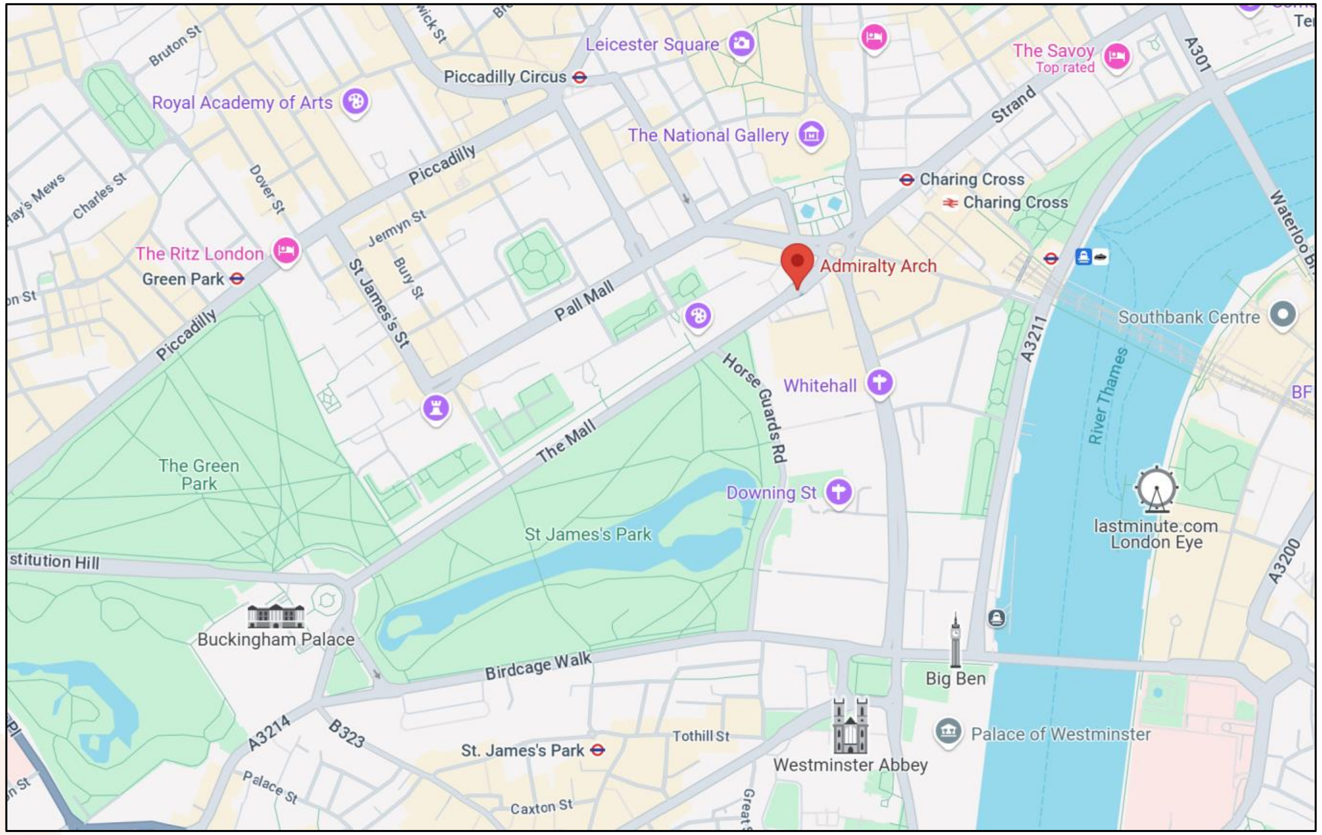
Historic former government office on The Mall in central London

Currently undergoing refurbishment into high-end hotel and flexible residential



Ardmiralty Arch CFD Modelling Study

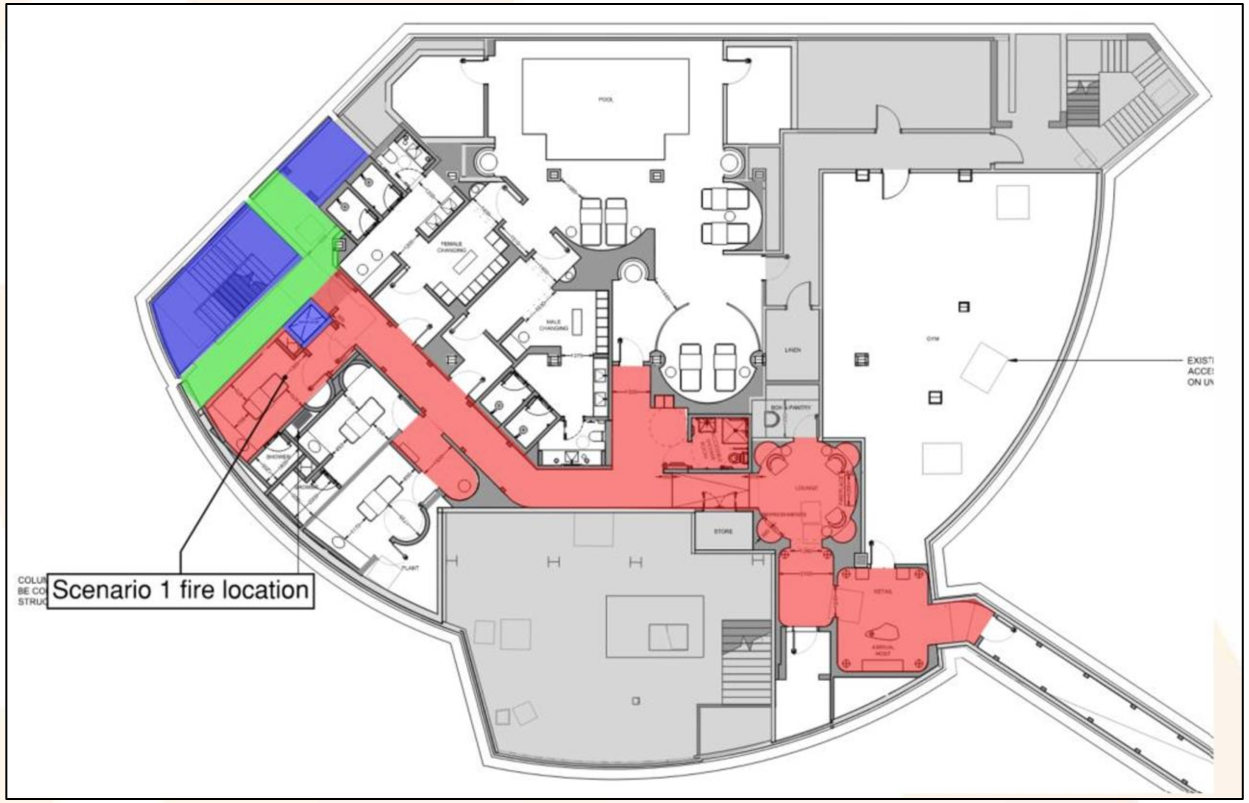
Firefighting shafts provided throughout all floors including extensive basement levels

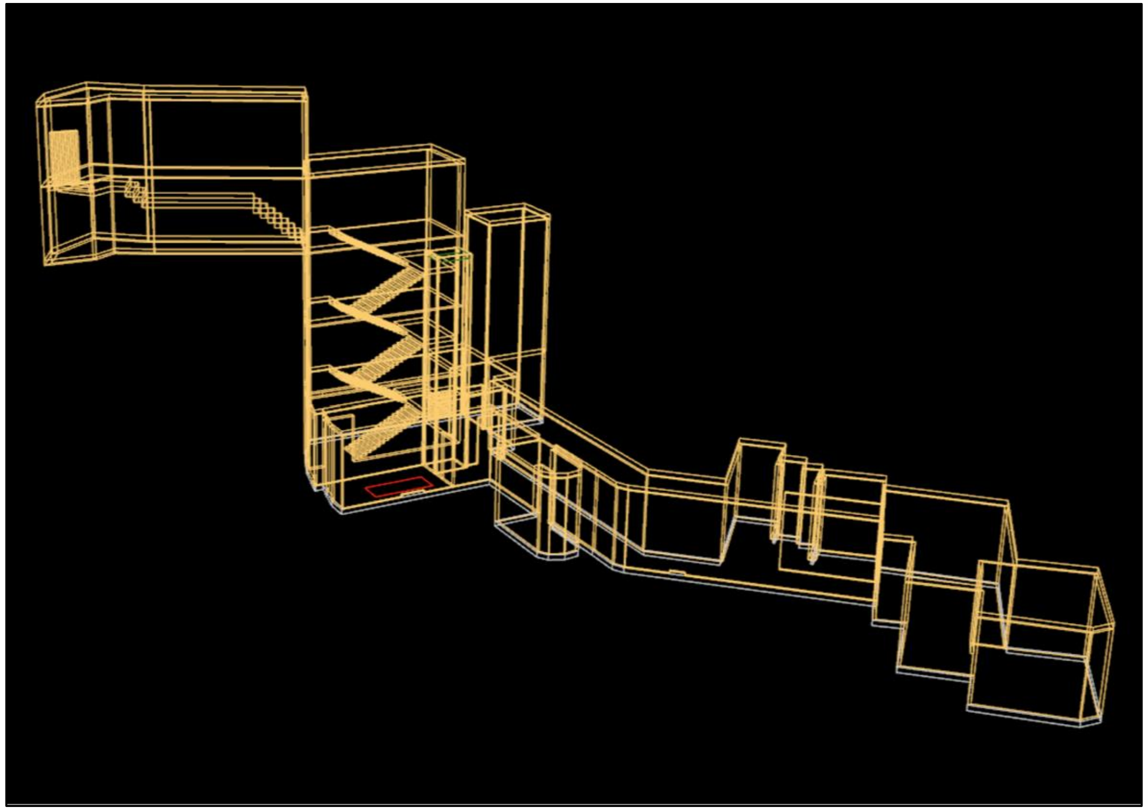
LFB required CFD modelling to specify mechanical extract shafts serving FF stairs and lifts

A total of 20 models were required (10 different scenarios, each with two fire scenarios)

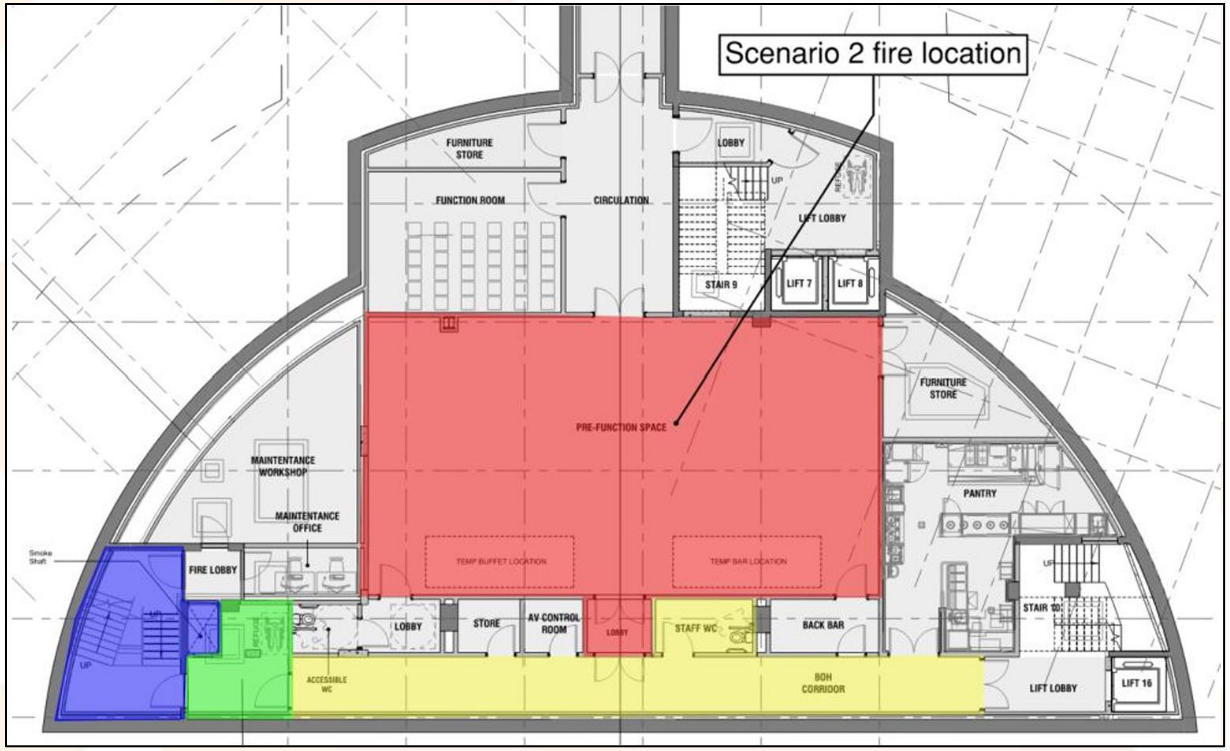
Heritage construction and complex geometry

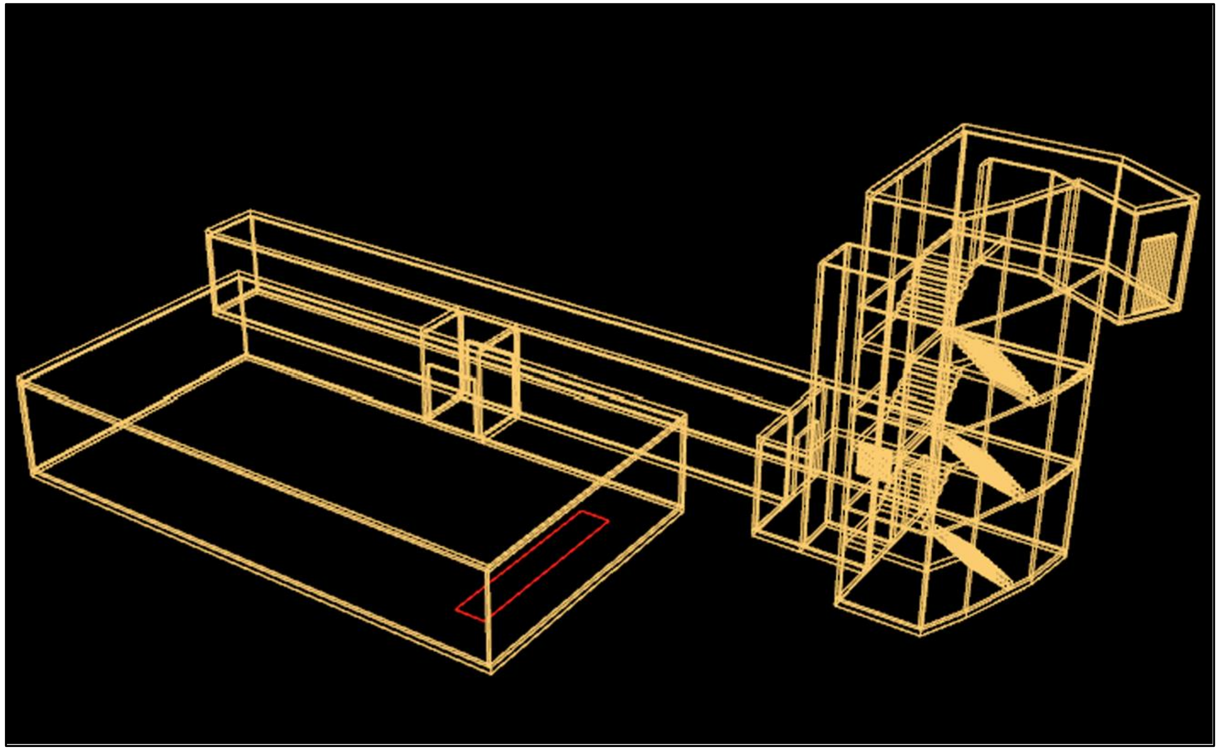
Basement Level 04



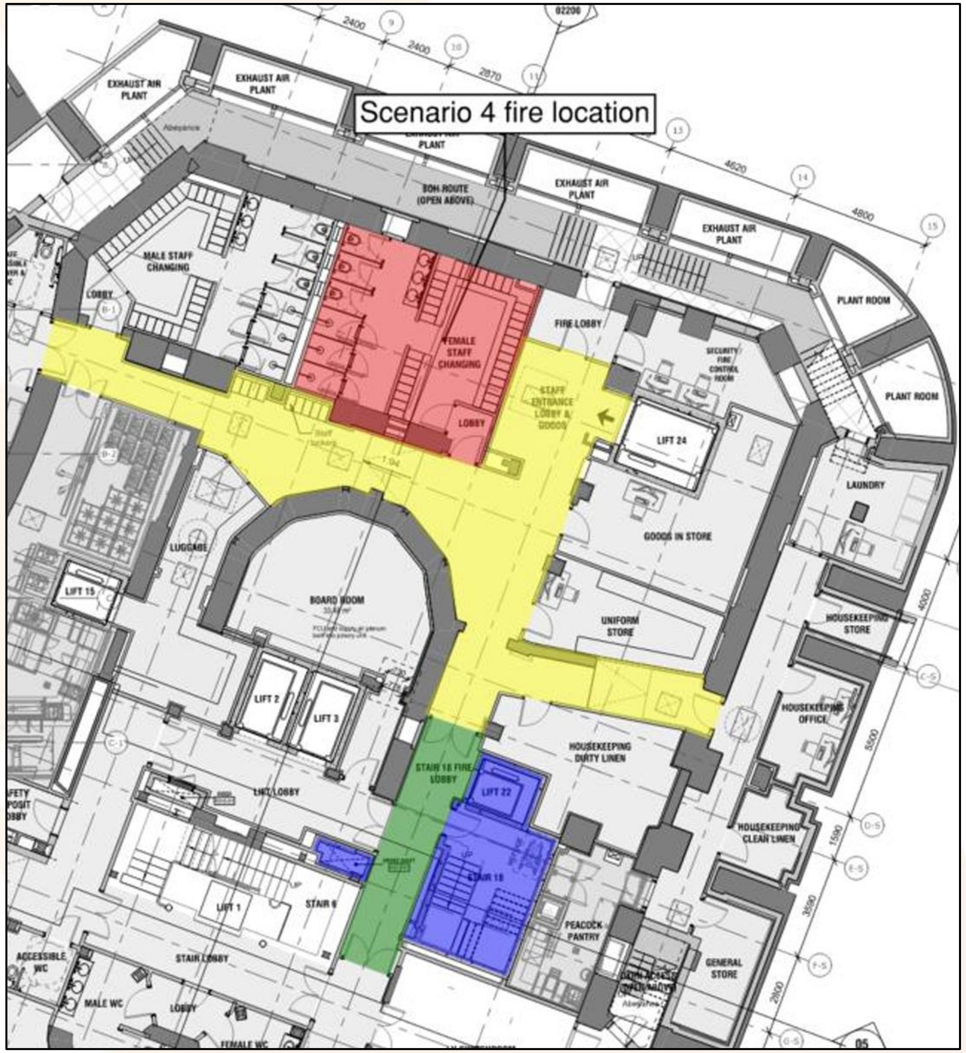


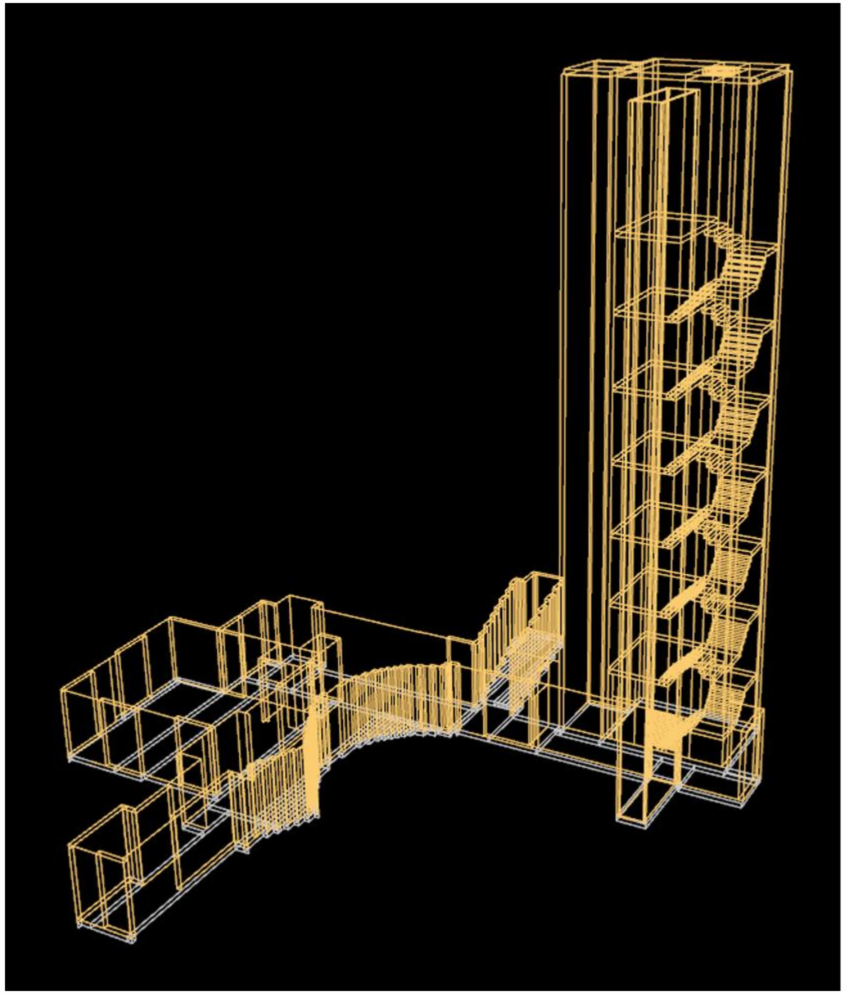
Basement Level 03





Basement Level 01





Level 04 (Penthouse)

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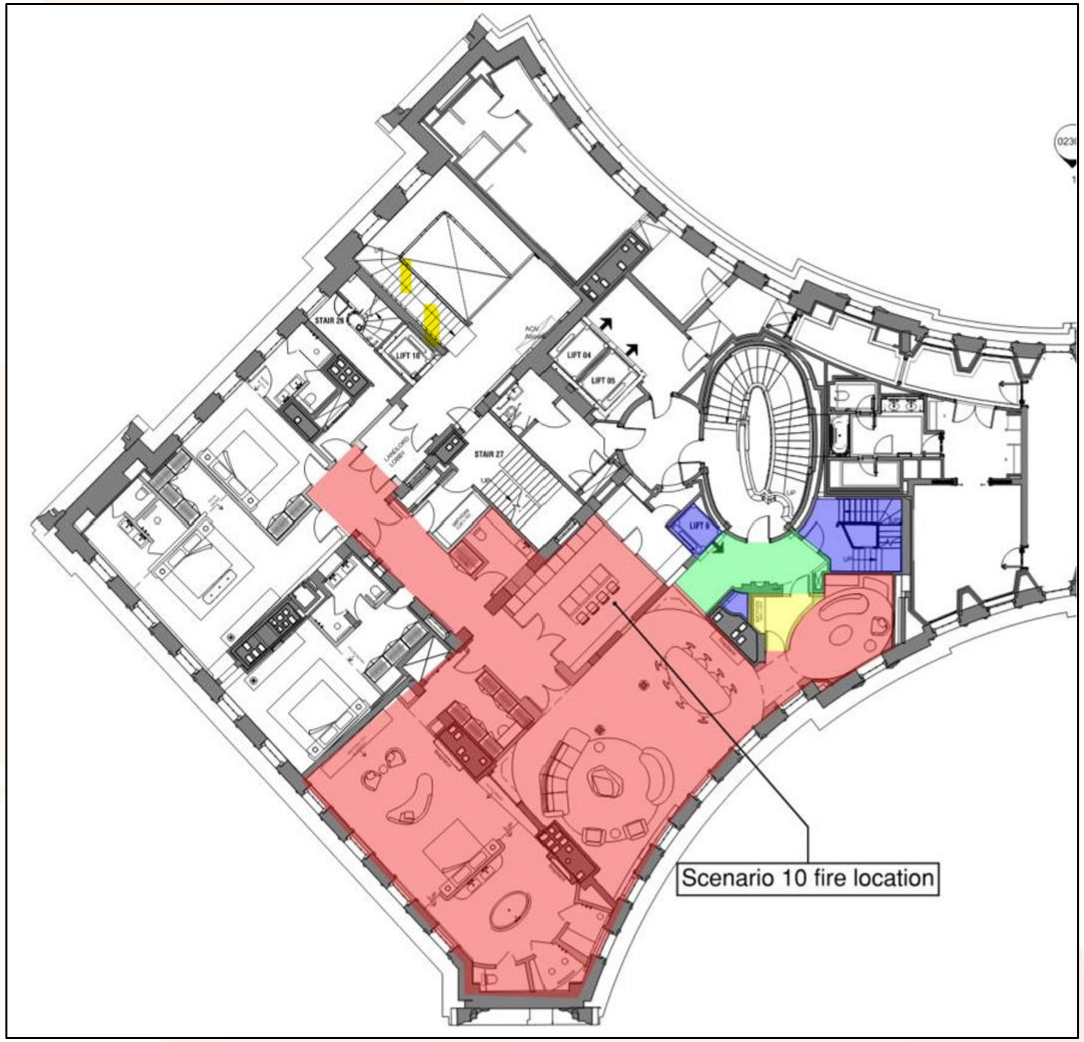
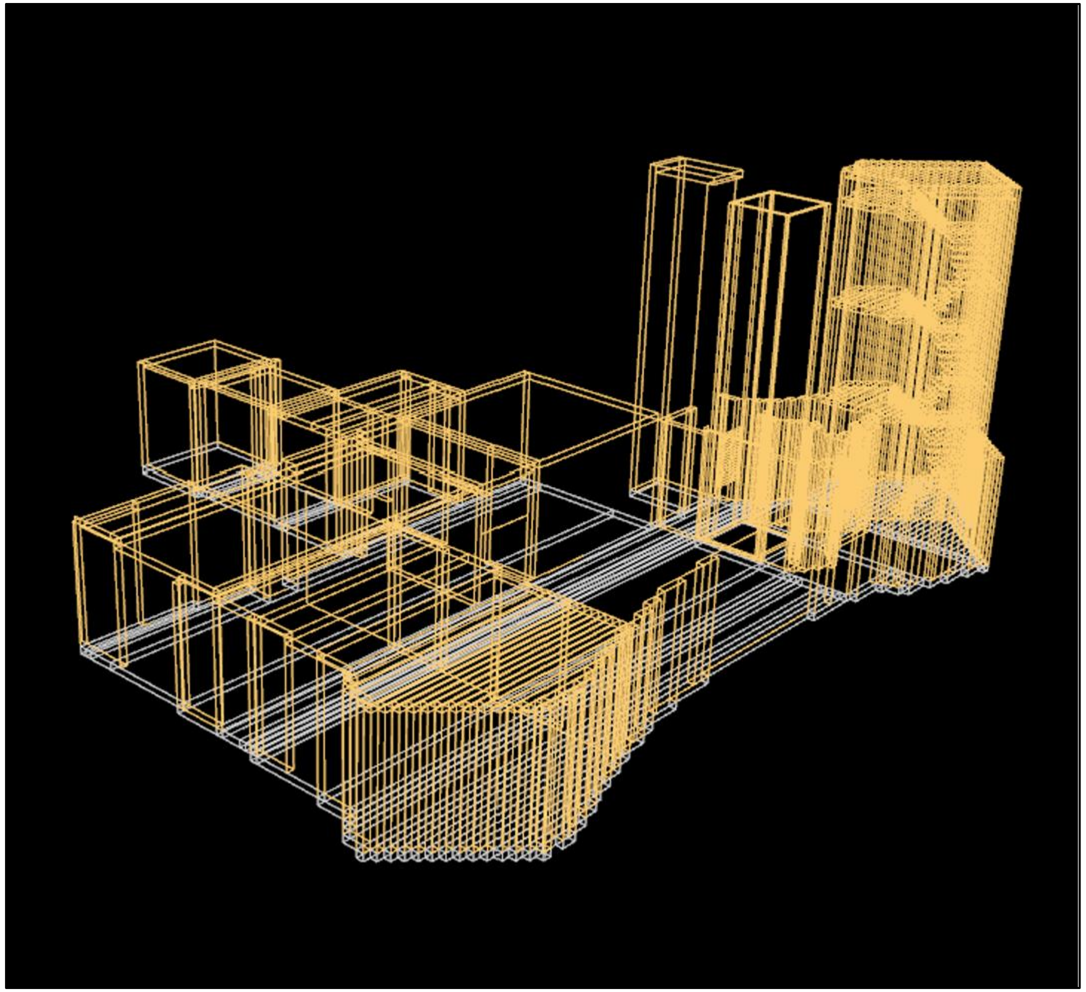
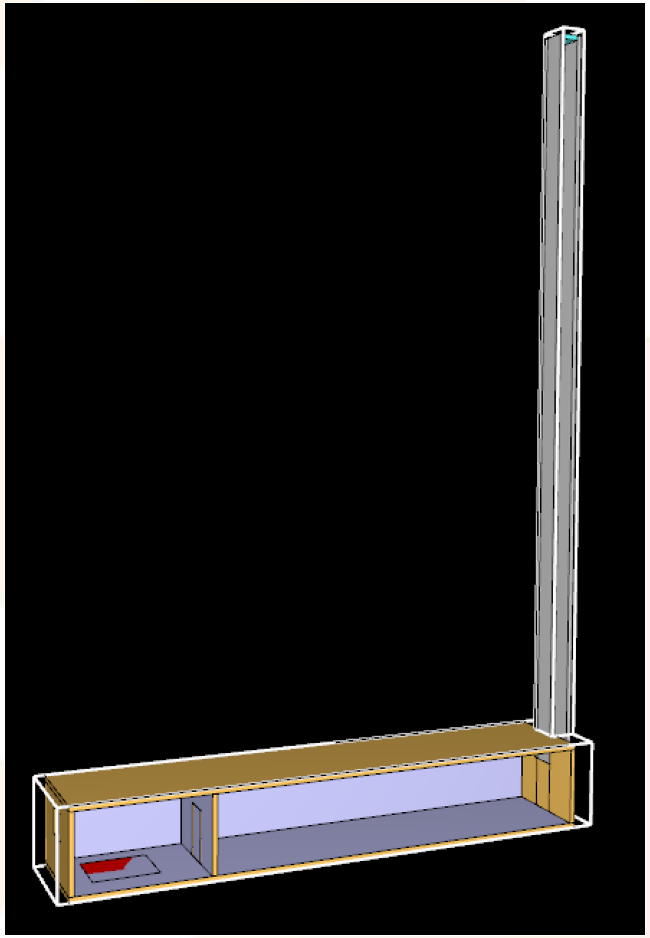


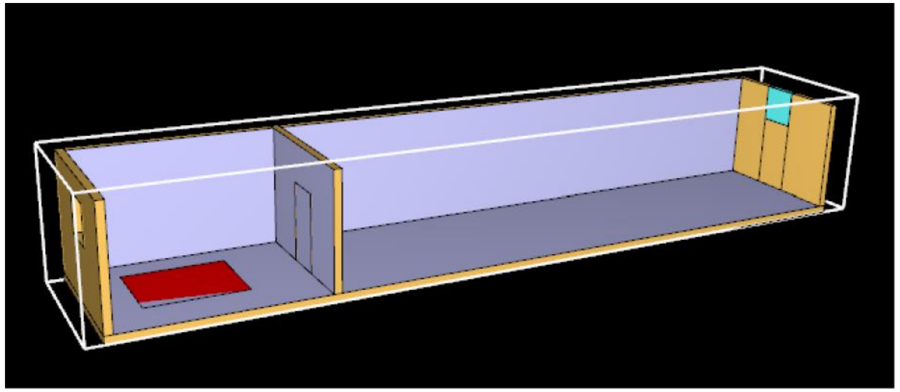


Rationalising CFD Geometry

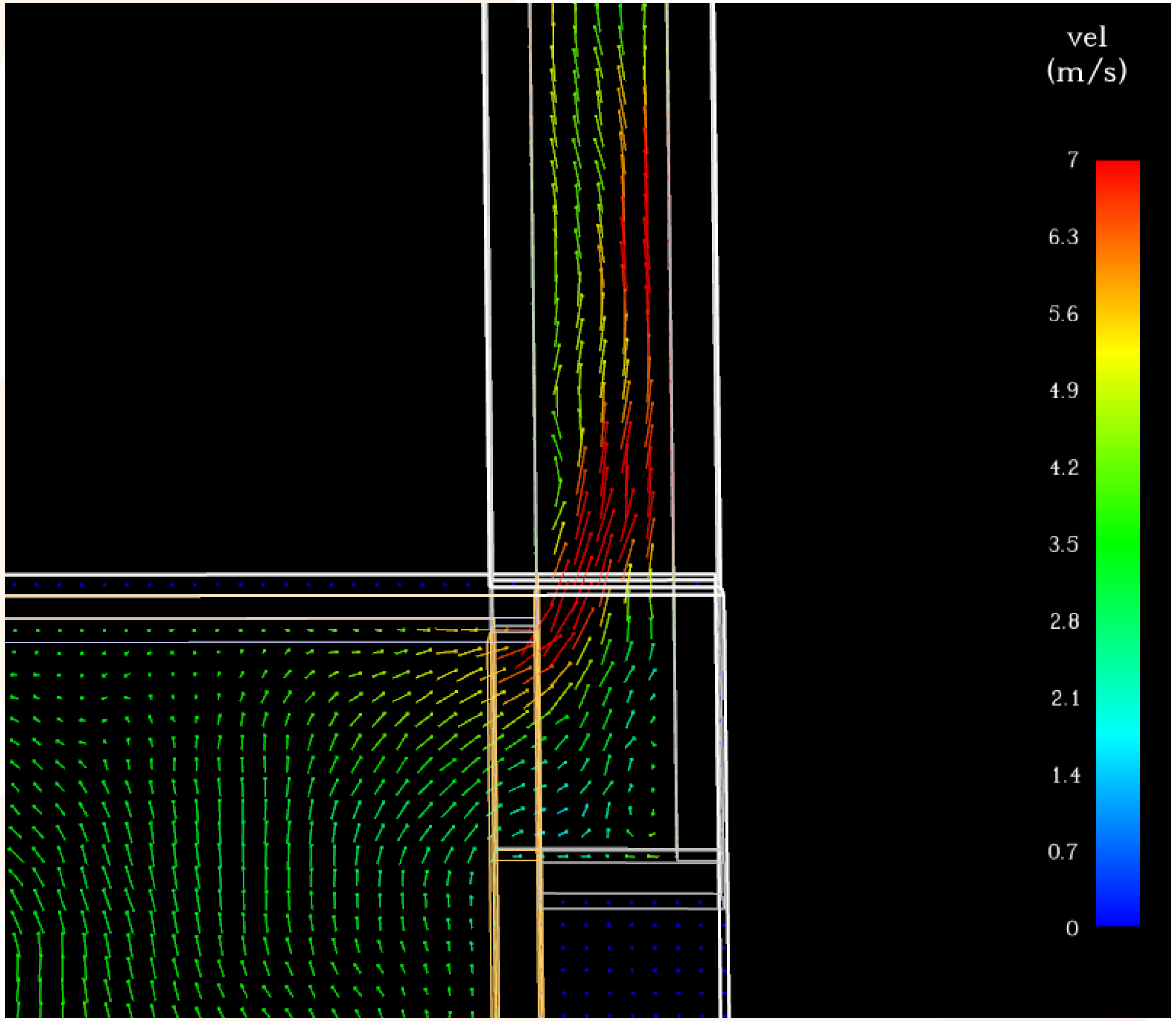


It was proposed to provide an extract vent directly from the corridor mesh instead of constructing the shaft with a vent at the head

If the extract velocity is drawn from the head of the shaft, does this match that which is drawn from the corridor? i.e. do we achieve a mass balance and can rationalise the mesh by not modelling the shafts?

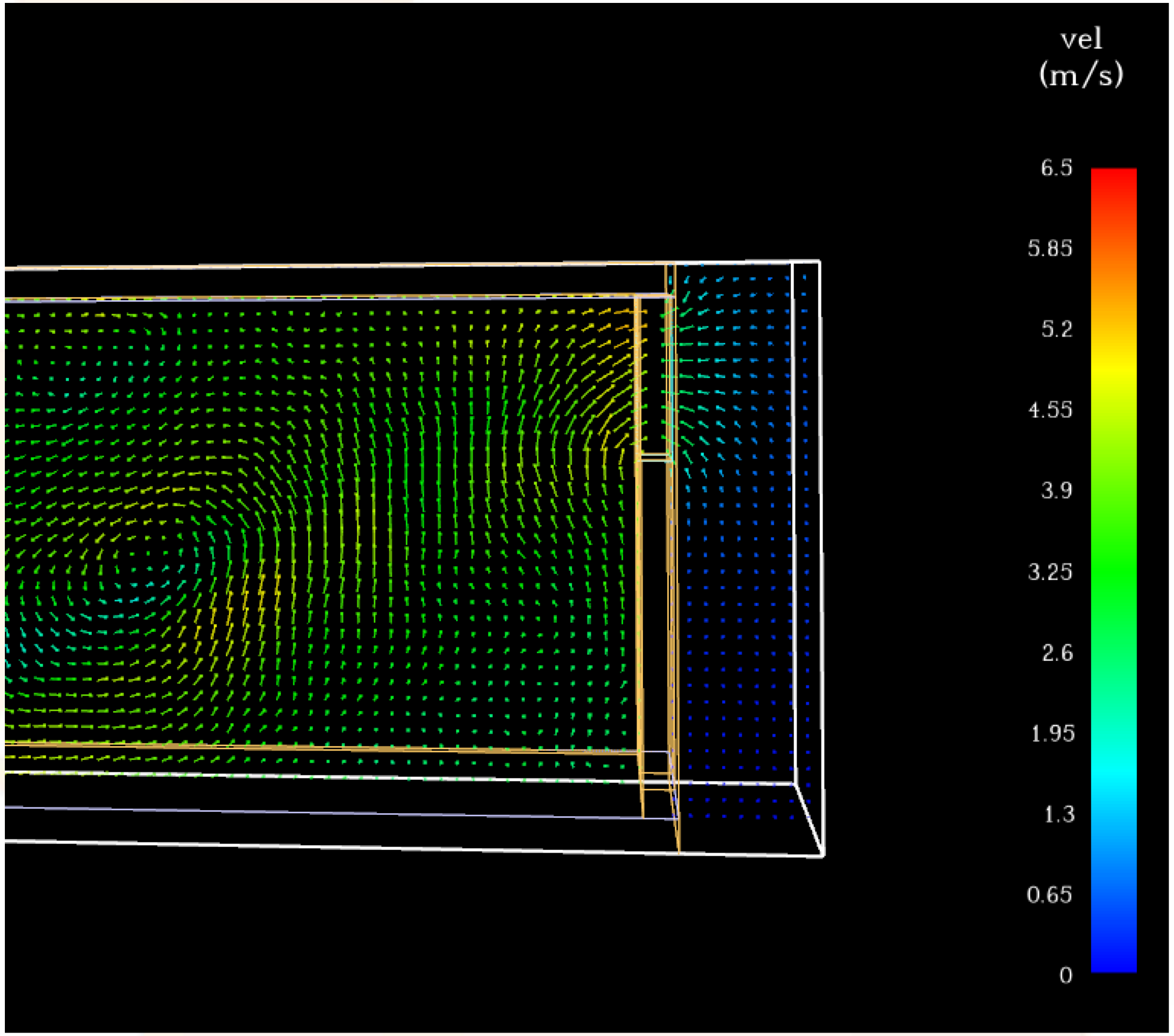


Case 1 – Full Shaft Overrun



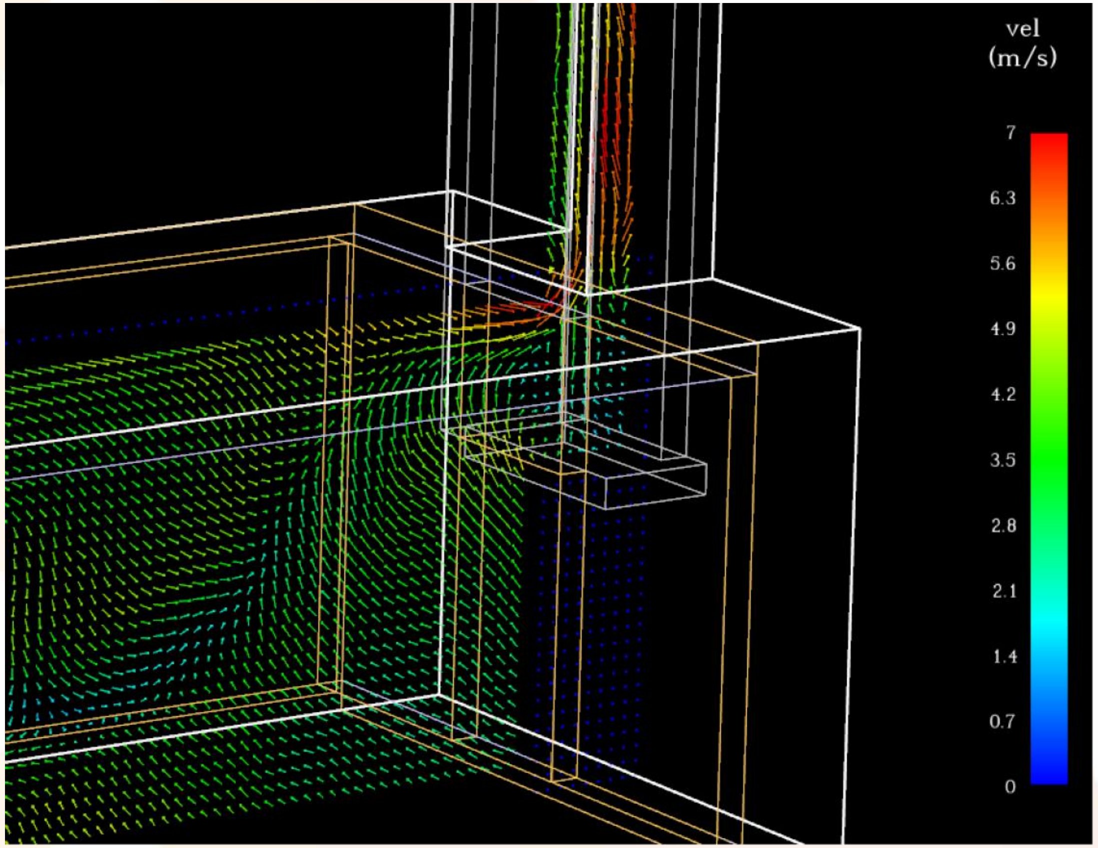
- With extract velocity set to $7m^3/s$, a clear velocity distribution is visible in the z-direction
- Higher velocities are observed at the top of the aperture, with negligible (even *negative*) pressures shown at the base of the opening

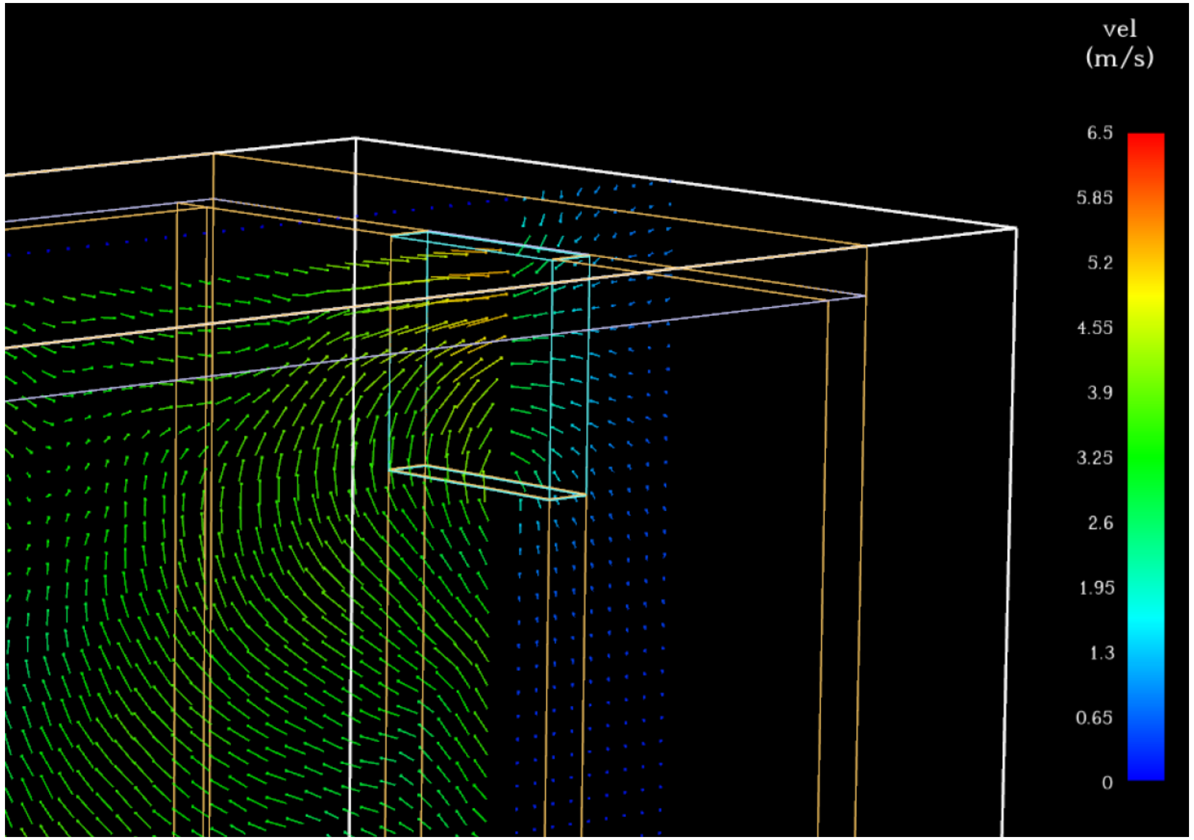
Case 2 – Direct Extract



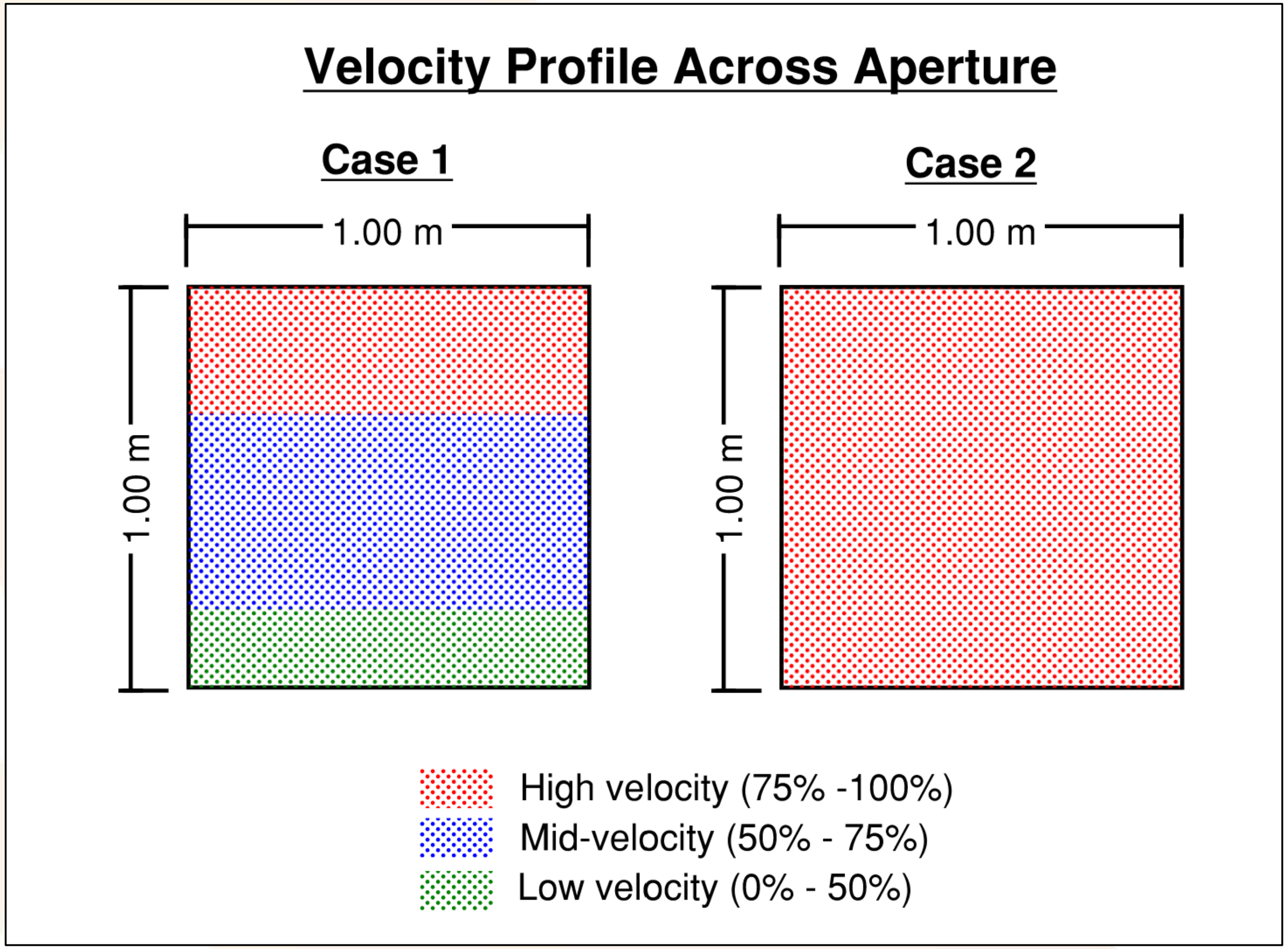
- When extracting directly from the corridor, the velocity profile is evenly distributed in the z-direction
- This has the effect of disproportionately extracting smoke from lower levels as well as creating turbulence in the corridor volume

Case 1 vs Case 2



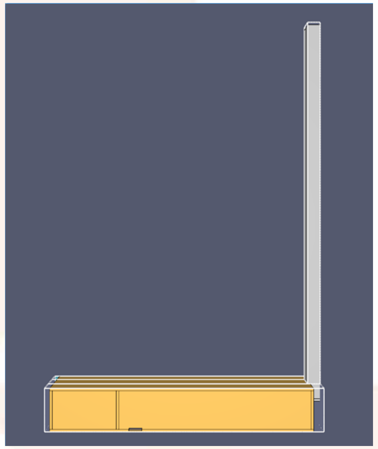


Velocity through Aperture

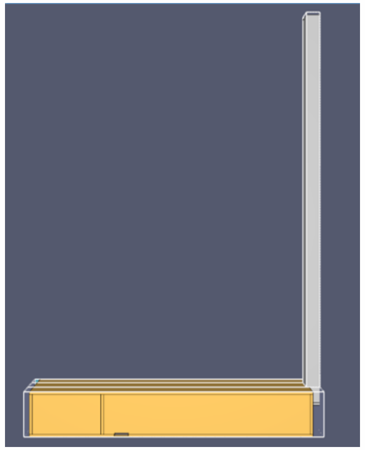


- It was found that the *velocity through aperture* was a critical factor
- In Case 1 the extract velocity was unevenly distributed along the z-plane of the opening
- Whereas in Case 2 (extracting directly from the corridor) the extract velocity was evenly distributed

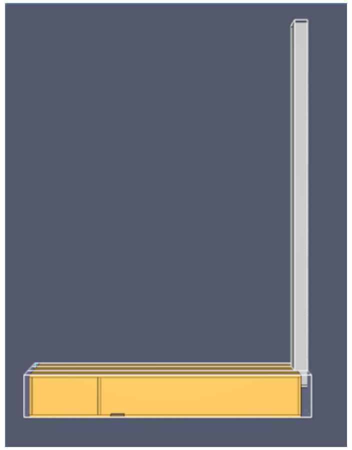
Sensitivity Studies on a Project Basis



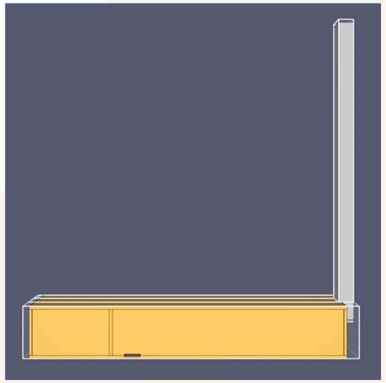
Model 1 – 30m



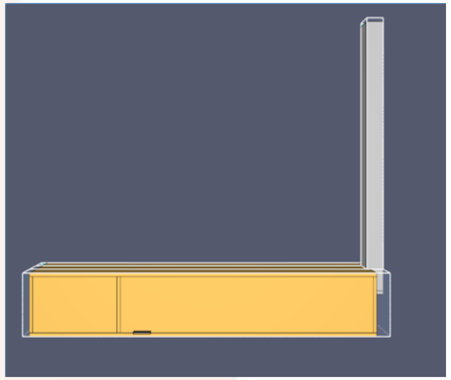
Model 2 – 25m



Model 3 – 20m



Model 4 – 15m



Model 5 – 10m

Model 6 – 5m

Conclusion and Further Research

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It is possible to rationalise CFD geometries when designing mechanical corridor extract

However, extracting directly from the corridor itself is **not** a suitable approach due to the velocity profile across the opening aperture

By first undertaking a sensitivity study, a limited shaft overrun can be modelled with a little-to-no impact on model accuracy

Rationalisation of circa **5% - 7%** have been observed for typical corridor layouts

Next Steps/Further Research

(Partial) adoption of rationalised geometries for residential CFD modelling on projects

Development of exemplar design solutions for meshing of mechanical corridor vents

Development of formula based on corridor volume, extract velocity and aperture size/location

~~Hart - Goosen Formula~~
~~Goosen – Hart Formula~~
Hart – Goosen Formula