

A study of the ventilation on an inter-city train carriage

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Railway carriages: a complex environment

Different train types

- Windows, mechanical or both?
- Seating?
- Tables?

Different journey types

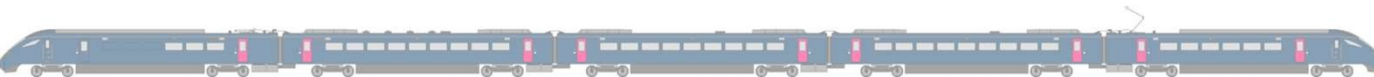
- Purpose?
- Duration?
- Frequency of stops?
- Doors automatic or push-button?
- Load level?
- Standing?

External factors

- Station environment? Wind?
- Tunnels?

Passenger behaviours/choices

- Windows?
- Standing?



Intercity Express

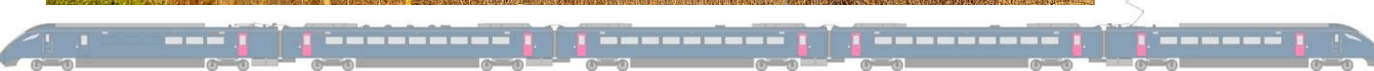
Class 802 – bi-modal

- Hitachi
- Japan/Italy
- 2017–2020
- 60 built
- 5 or 9 carriages
- First Group
 - GWR
 - Hull Trains
 - Trans-Pennine Express

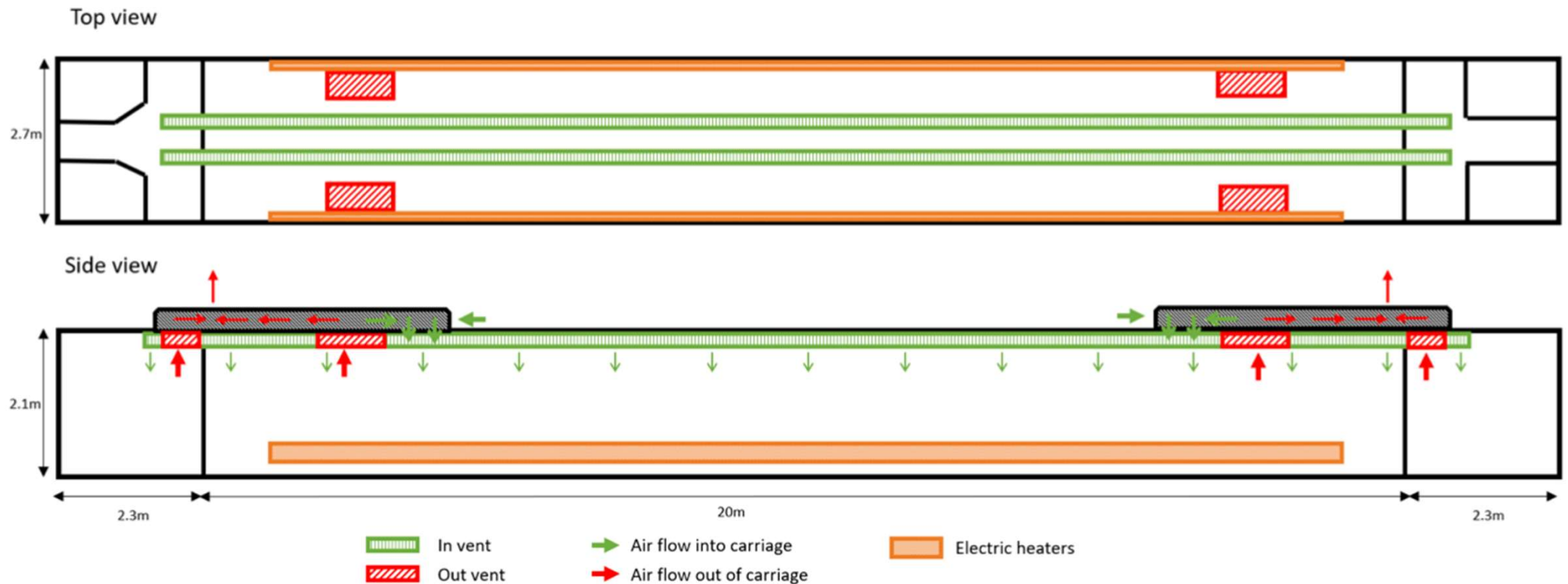
AT300 series (electric and bi-modal)

- 229 trains
 - Class 395: 29 (electric)
 - Class 800: 80 (bi-modal)
 - Class 801: 42 (electric)
 - Class 802: 60 (bi-modal)
 - Class 803: 5 (electric)
 - Class 805: 13* (bi-modal)
- *In service from 2023
- Various train operators

Hull Trains 802302



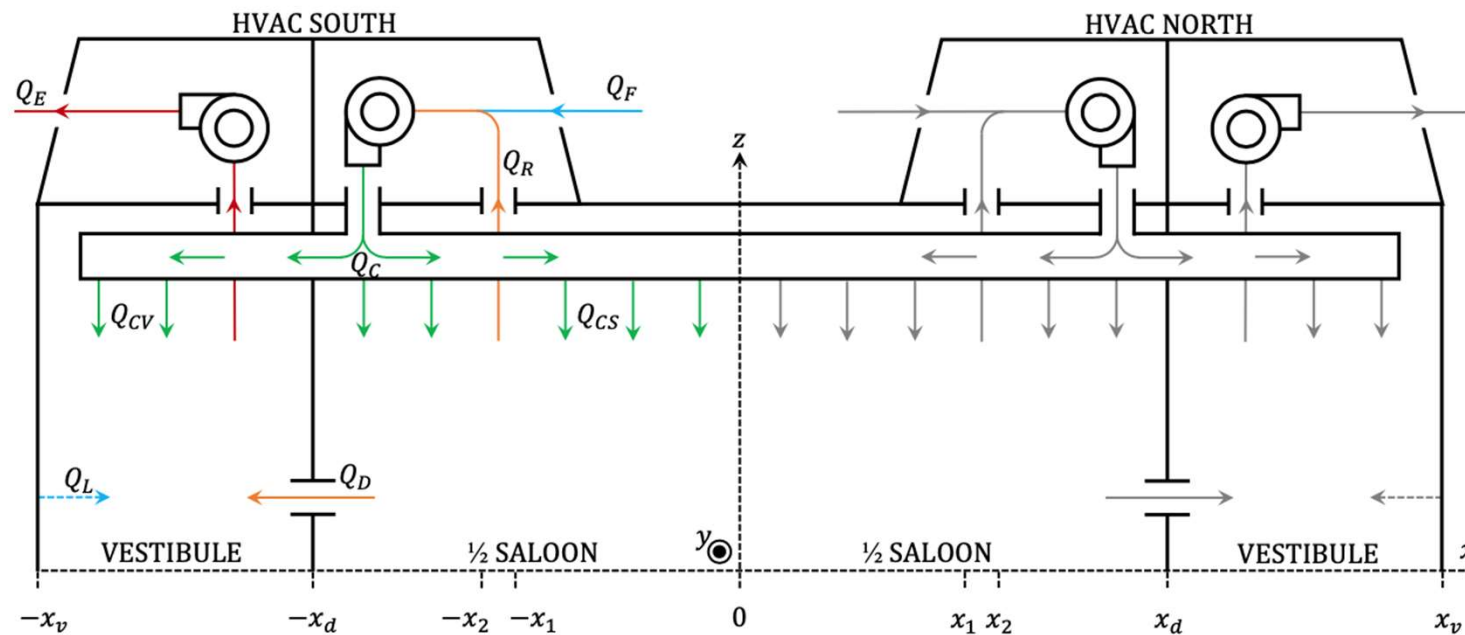
Hitachi 802 Train Carriage – Ventilation Systems



1. W.H. Woodward *et al.* 2021. Air flow experiments on a train carriage – towards understanding the risk of airborne transmission. *Atmosphere*, 12(10):1267.



Hitachi 802 Train Carriage – Ventilation Systems

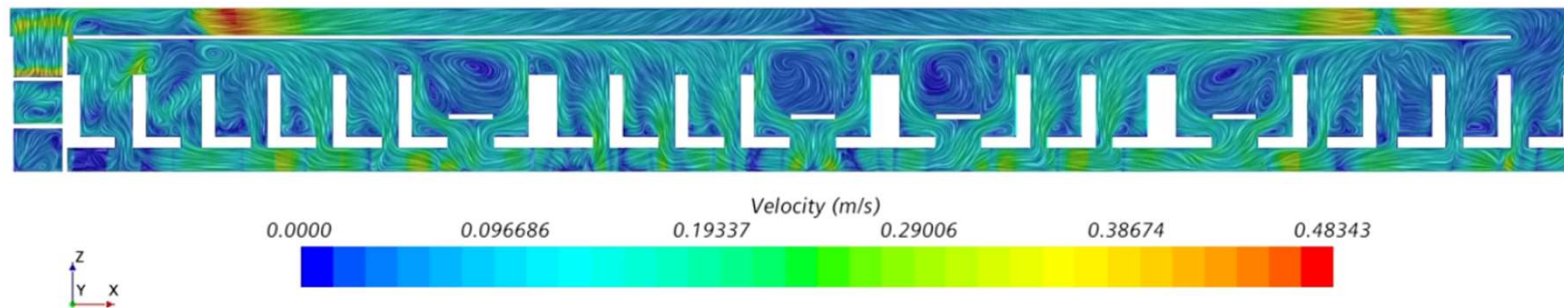


$Q_F \approx 20 - 26.7 \text{ m}^3/\text{min}$
 $\approx 11.1 - 14.8 \text{ ACH}$
 $\approx 3.79 - 5.05 \text{ l/s/person}$ (based on all the seats occupied)

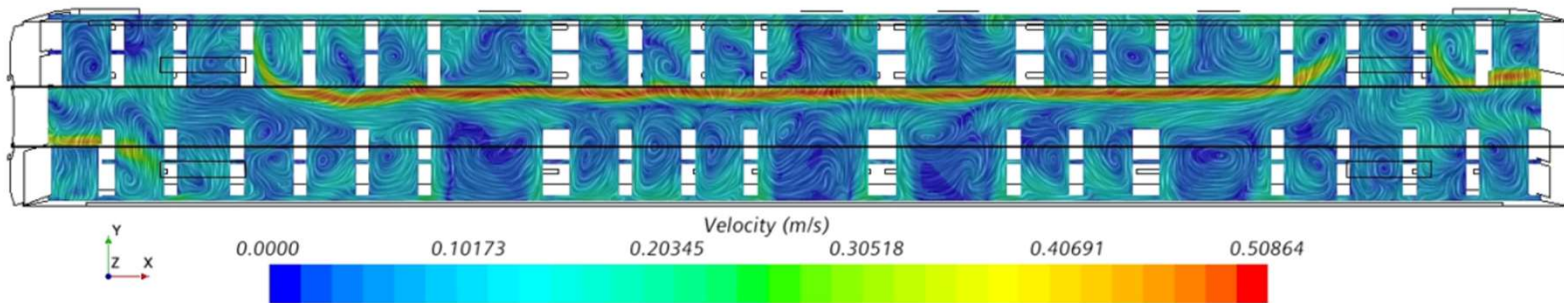
1. W.H. Woodward *et al.* 2021. Air flow experiments on a train carriage – towards understanding the risk of airborne transmission. *Atmosphere*, 12(10):1267.



802 Train Carriage – Ventilation Systems



(a)

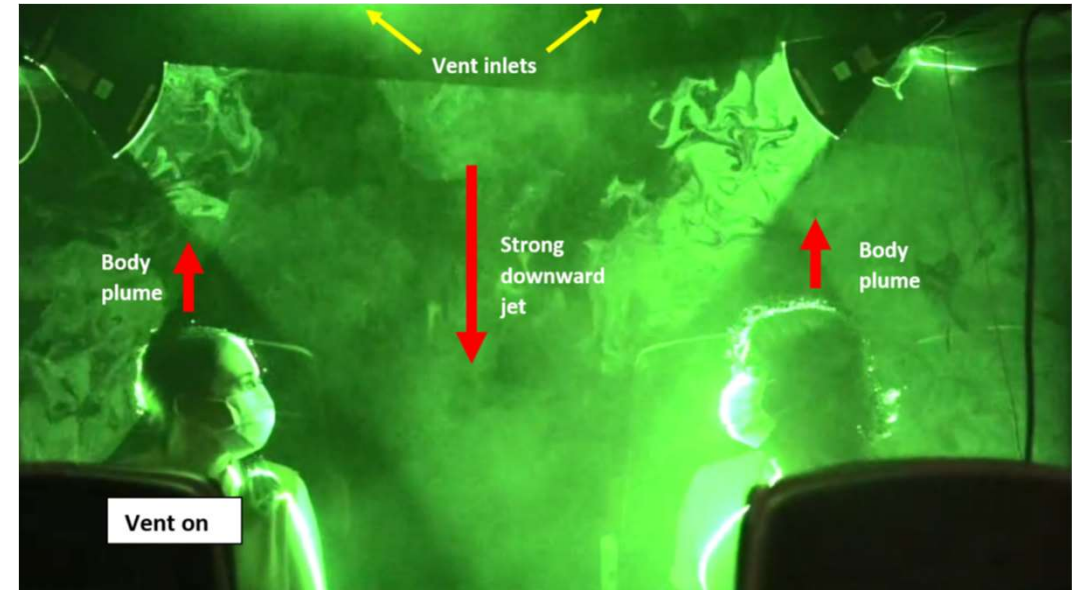


(b)

1. W.H. Woodward *et al.* 2021. Air flow experiments on a train carriage – towards understanding the risk of airborne transmission. *Atmosphere*, 12(10):1267.



Preliminary view – middle of carriage

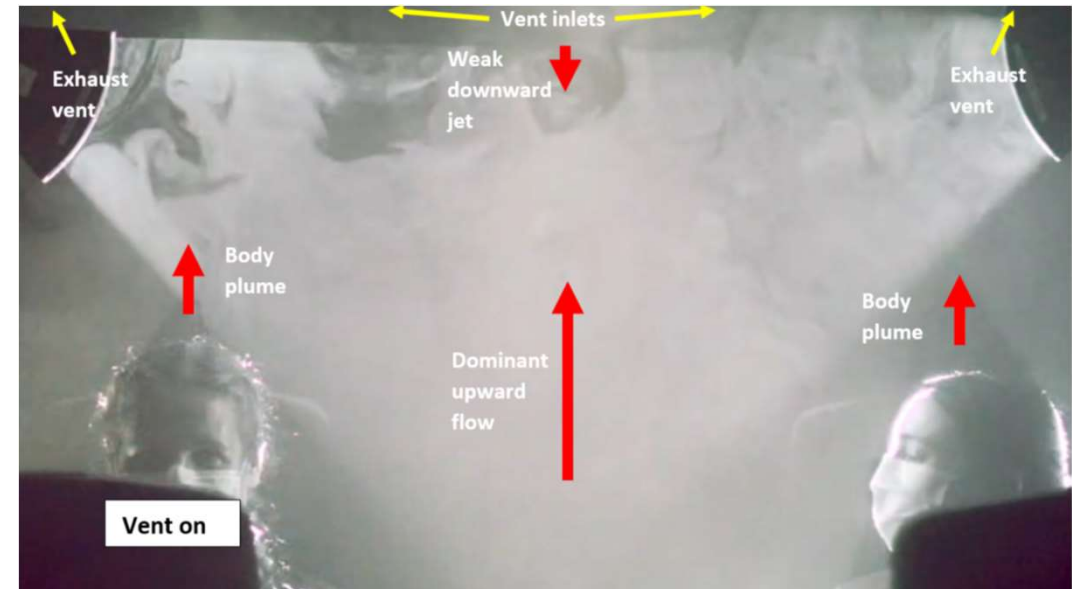


Hitachi, Class 802, August 2020

1. W.H. Woodward *et al.* 2021. Air flow experiments on a train carriage – towards understanding the risk of airborne transmission. *Atmosphere*, 12(10):1267.



Preliminary view – end of carriage

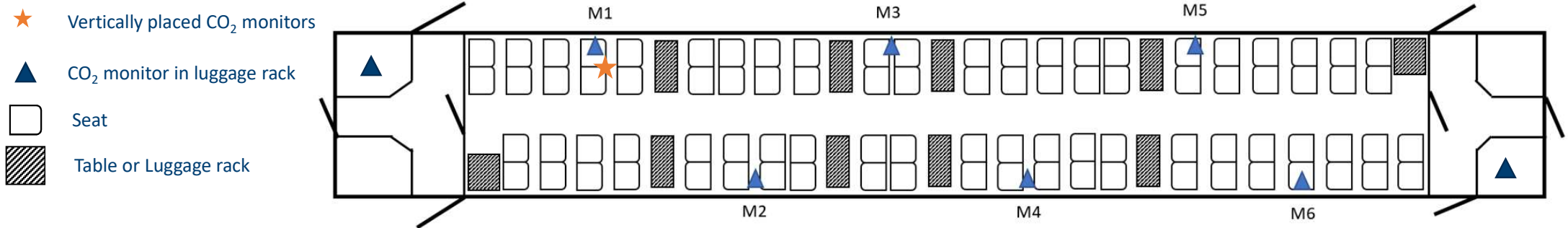


Hitachi, Class 802, August 2020

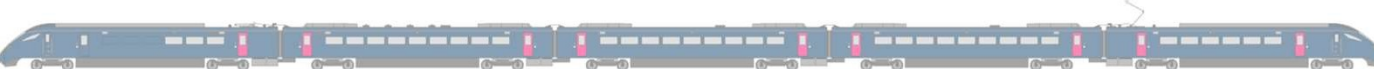
1. W.H. Woodward *et al.* 2021. Air flow experiments on a train carriage – towards understanding the risk of airborne transmission. *Atmosphere*, 12(10):1267.



Full scale experiments with First Group Rail– 802 carriage (November 2020/21)

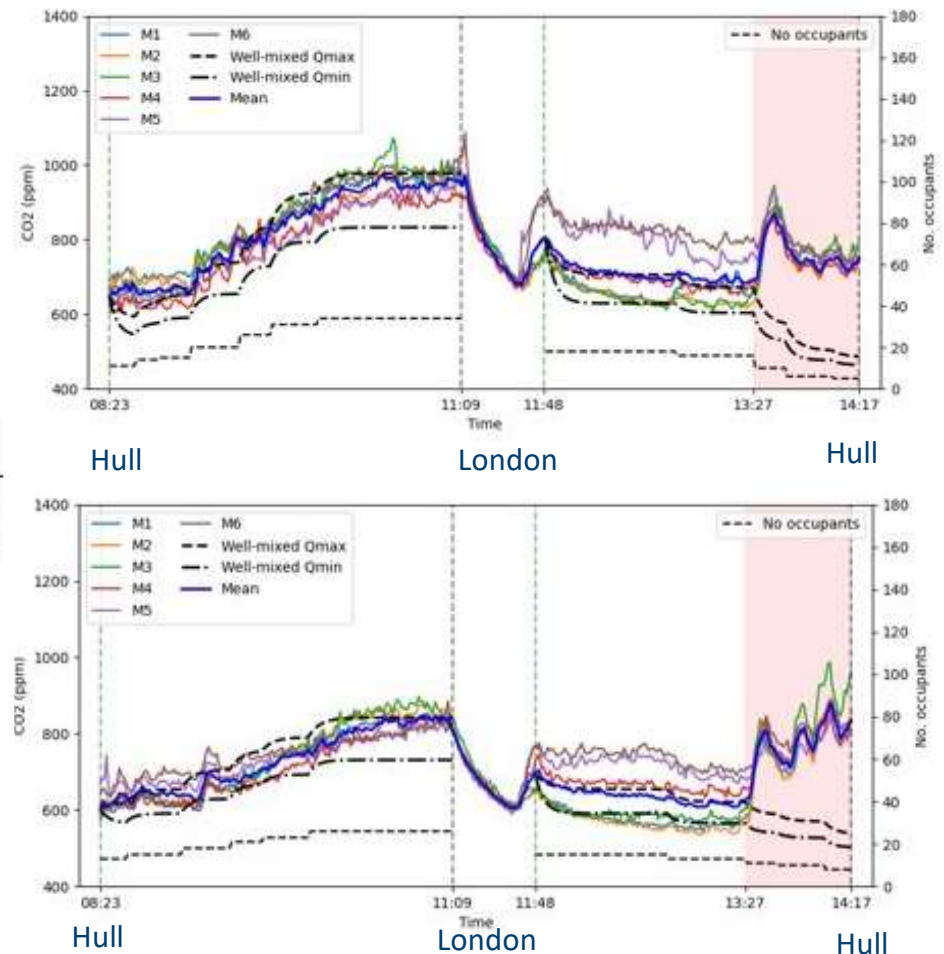
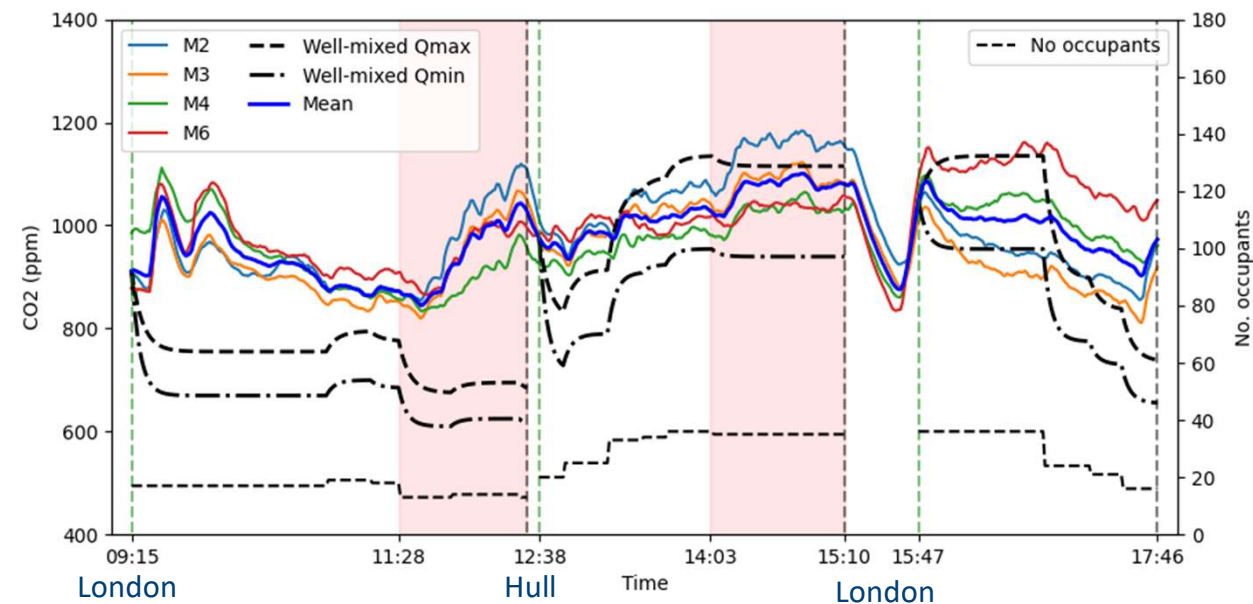


2. W.H. Woodward *et al.* 2022. An evaluation of the risk of airborne transmission of COVID-19 on an inter-city train carriage. *Indoor Air*, Accepted.



CO₂ Data – Main Carriage Luggage Racks (November 2020/21)

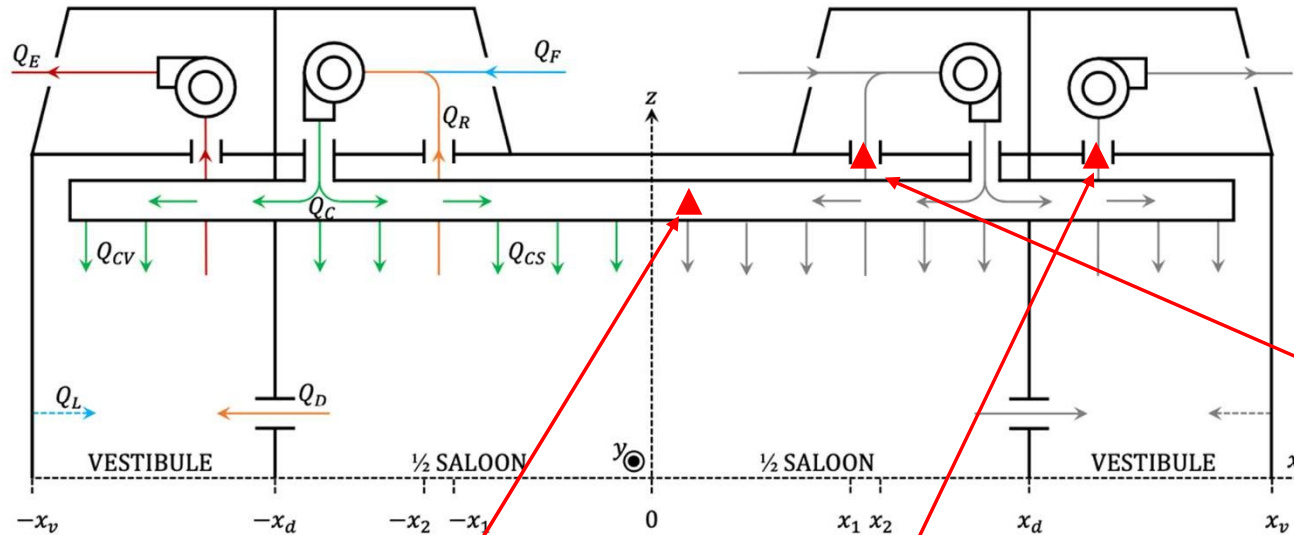
$$V \frac{dC(t)}{dt} = G + Q_f C_a - Q_f C(t)$$



2. W.H. Woodward *et al.* 2022. An evaluation of the risk of airborne transmission of COVID-19 on an inter-city train carriage. *Indoor Air*, Accepted.



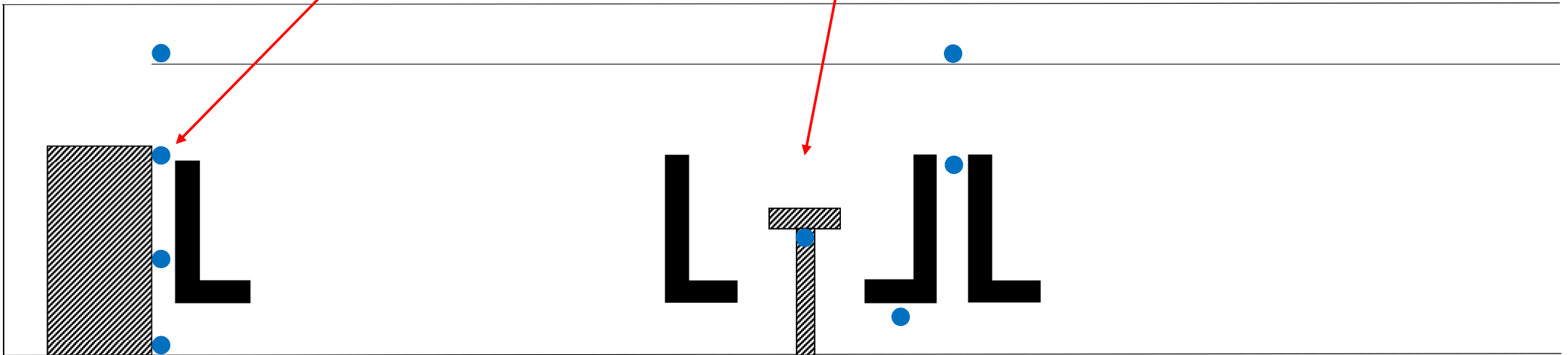
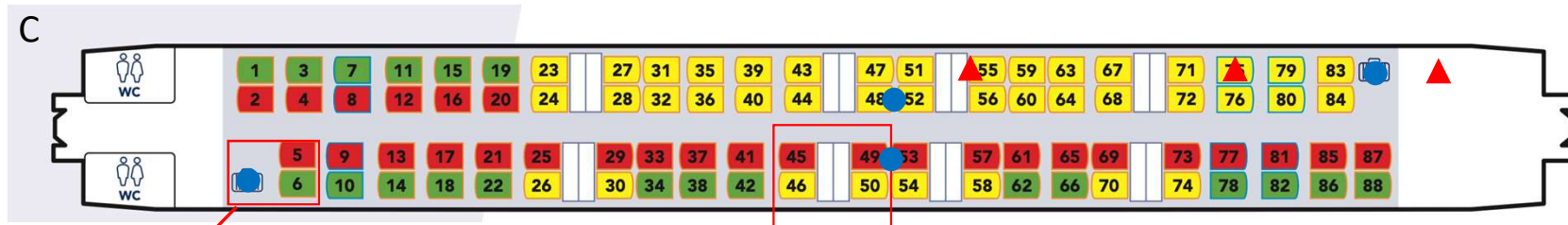
Long Term Monitoring with First Group Rail – CO₂ Sensors



▲ Aranet CO₂ Sensor



Long Term Monitoring with First Group Rail – Temperature Sensors



▲ Aranet CO₂ Sensor

- Elitech Temperature Sensor



Conclusions and Future Work

- Despite being a complex system designed for thermal comfort the 802 carriage maintains **800 - 1200ppm for intermediate occupancies**.
- Rises in **ambient CO₂ levels** and **recirculation** rates need to be considered in any **model used to predict CO₂ levels**.
- We now have **CO₂ and temperature sensors placed in an 802 carriage for the winter** to capture the effects of higher occupancy levels and changing seasons.
- **Further in-service testing** to ensure sensors left in the train are indicative of what is happening in the main carriage.
- **Controlled CO₂ releases** to investigate the effects of **doors opening in stations**.
- **Controlled CO₂ releases** to investigate the **effects of strong temperature stratifications on the decay rates of CO₂** various heights.

1. W.H. Woodward *et al.* 2021. Air flow experiments on a train carriage – towards understanding the risk of airborne transmission. *Atmosphere*, 12(10):1267.
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