Airborne Transmission of COVID-19 in buses and coaches

In collaboration with :

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Airborne Transmission of Viruses

- Respiratory activities (breathing, speaking, coughing, sneezing …) cause emission of micro-droplets.
- Microdroplets (0.1µm to 100µm) contain viral copies if individual is infected
- Large droplets fall down, small droplets can stay airborne (aerosols)
- Inhalation of infected microdroplets can cause cross-infection
- Infection risk decreased via effective ventilation ??

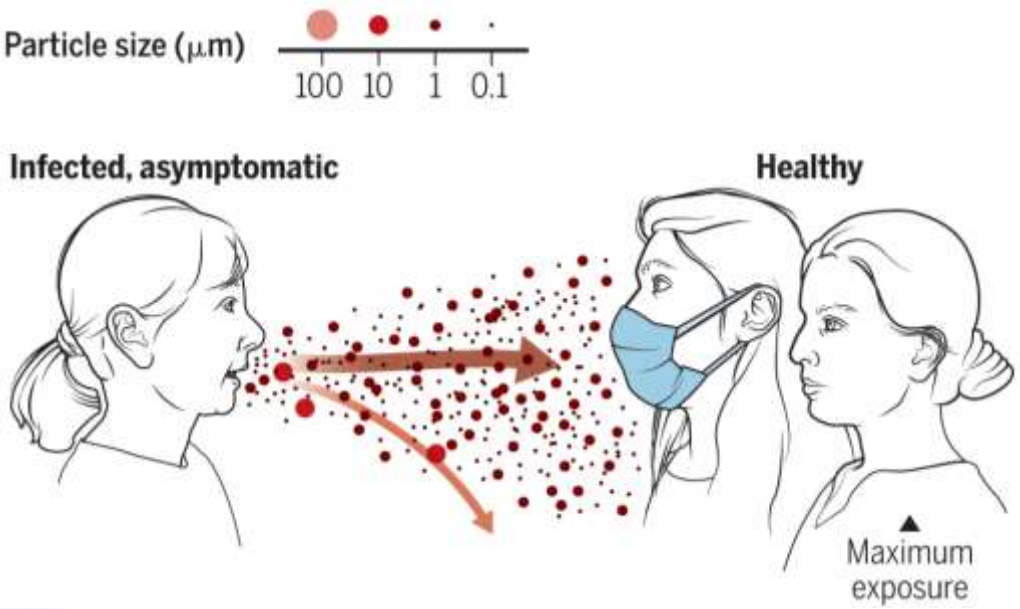


Fig. 1: Release of infectious microdroplet particles [1]

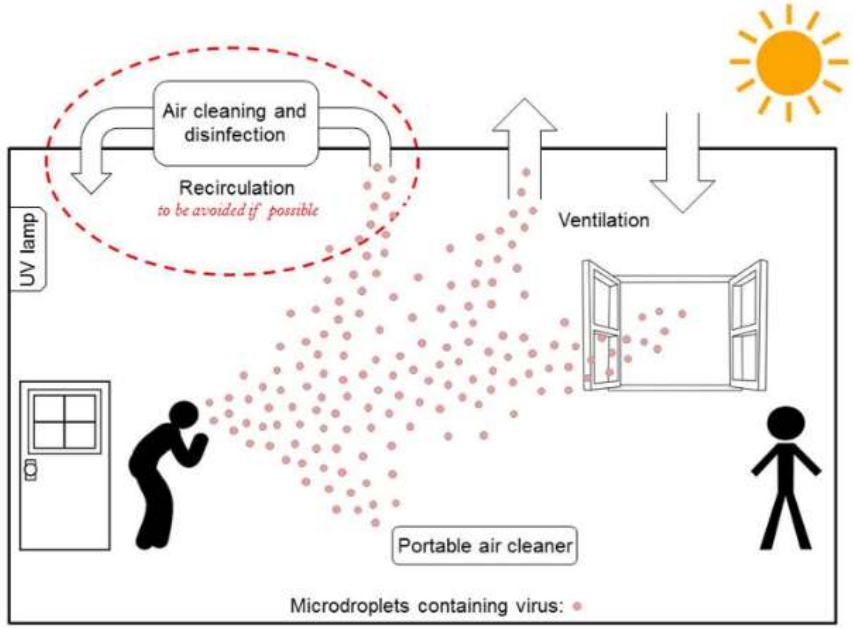
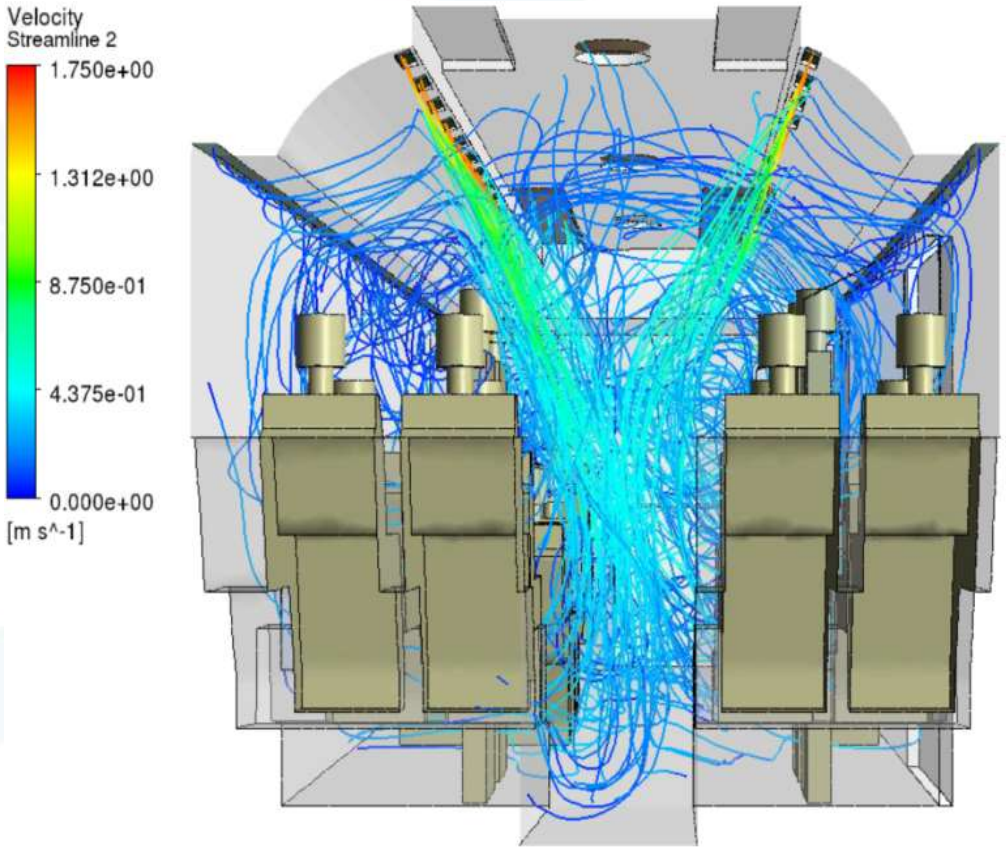


Fig. 2: Engineering level control to reduce environmental risks for airborne transmission of COVID-19 [2]

[1] Prather K., Wang C., Schooley R., Reducing transmission of SARS-COV-2, American Association for the Advancement of Science, 2020, ISSN 1095-9203
[2] Lidia Morawska *et al.*, How can airborne transmission of COVID-19 indoors be minimised?, Environment International, Volume 142, 2020, 105832, ISSN 0160-4120

Approach

- Simulate ventilation flow field in Computational Fluid Dynamics
- Calculate and visualize spread of micro-droplets with Discrete Phase Modelling
- Estimation of cross-infection risk and evaluation of ventilation effectiveness



Case Description: Long Distance Coach

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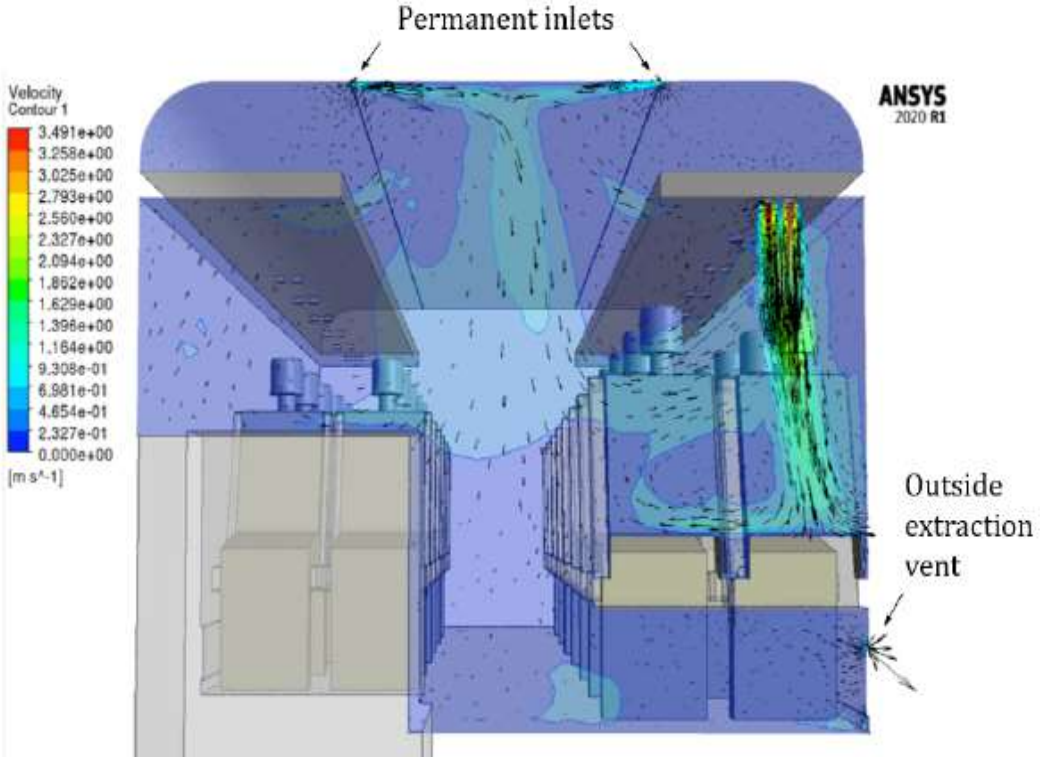
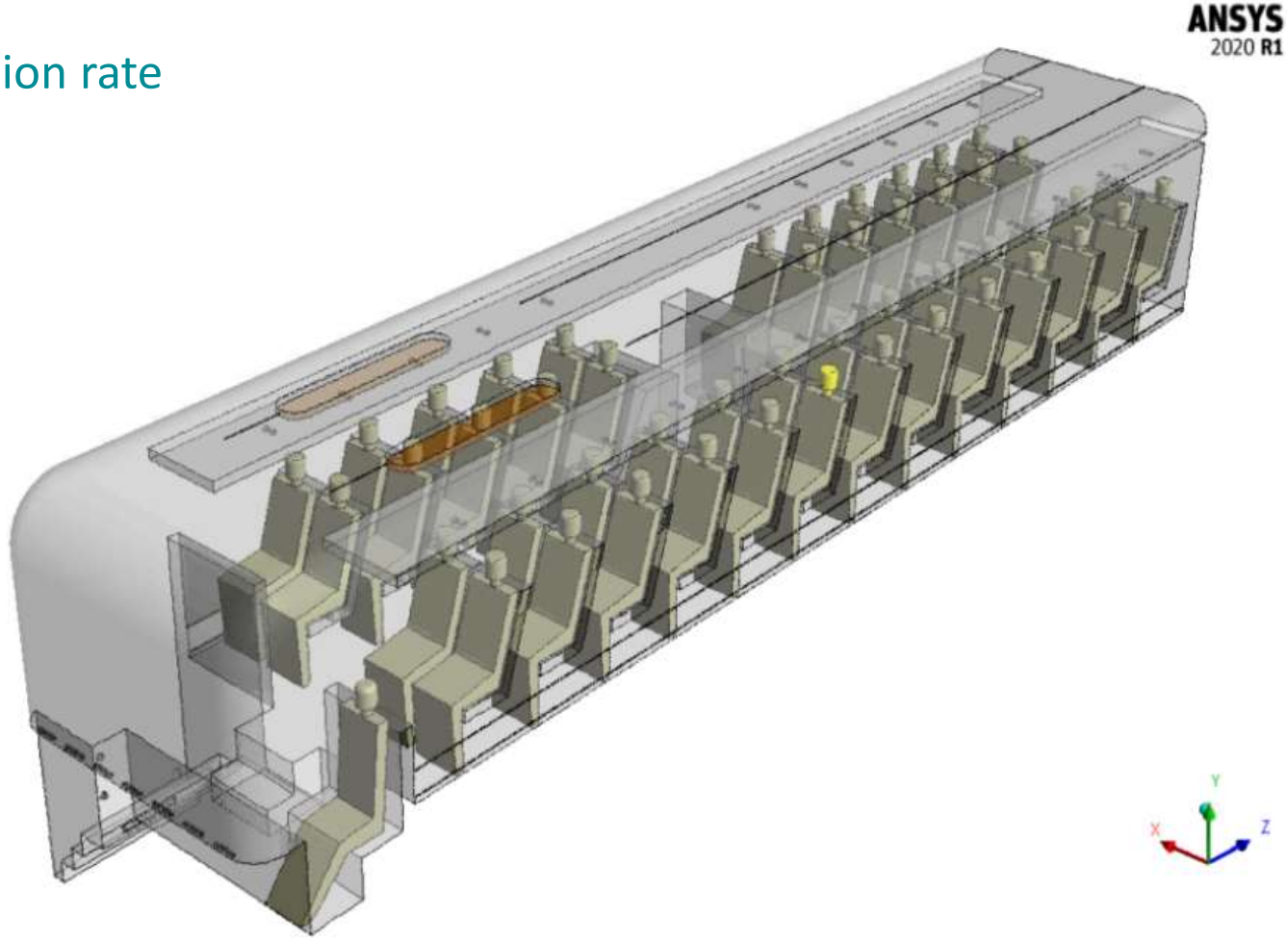
- 12m coach at full capacity
- Various ventilation regimes
- Single infected source with constant aerosol emission rate
- Steady state simulations





Results: Long Distance Coach

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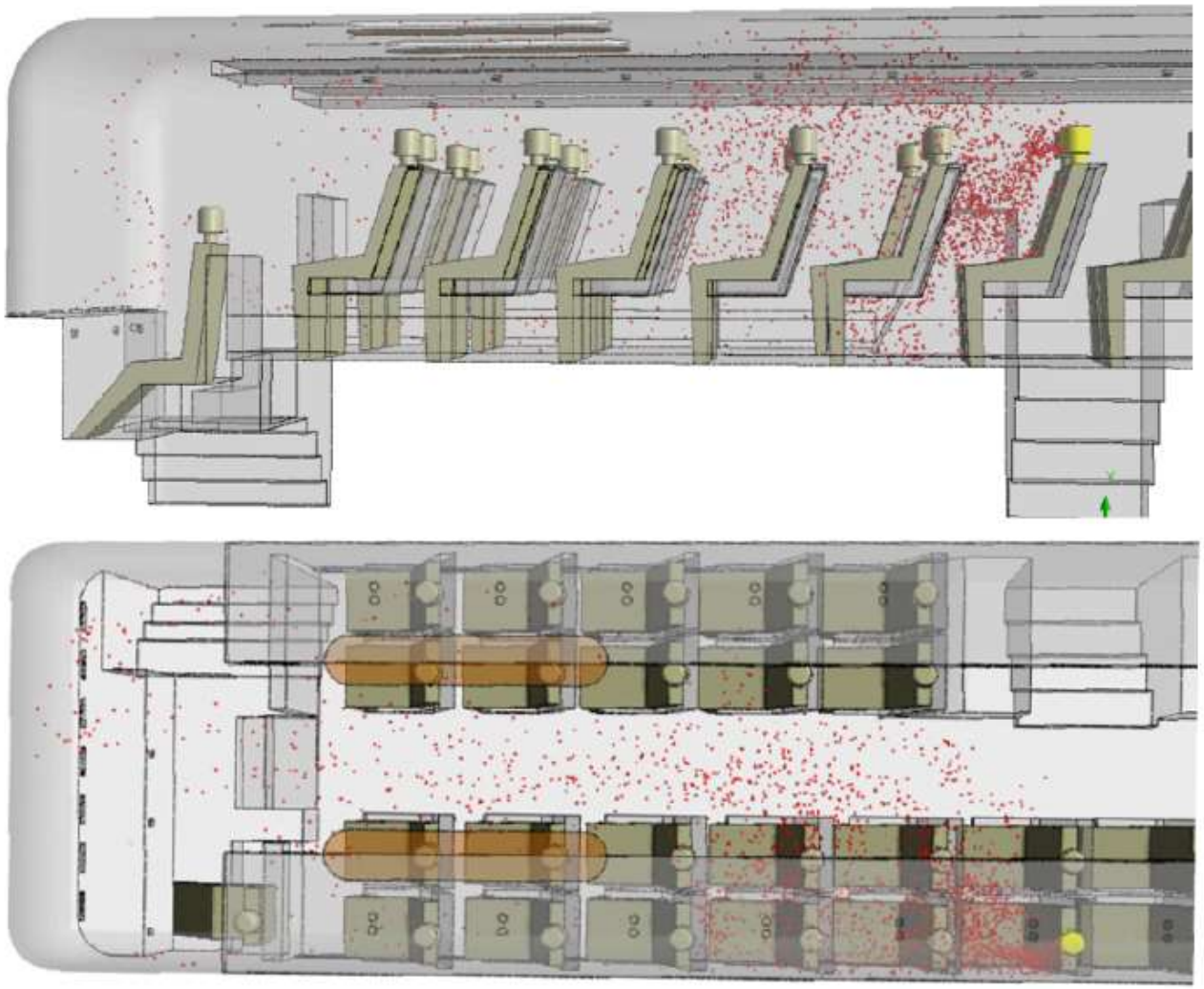
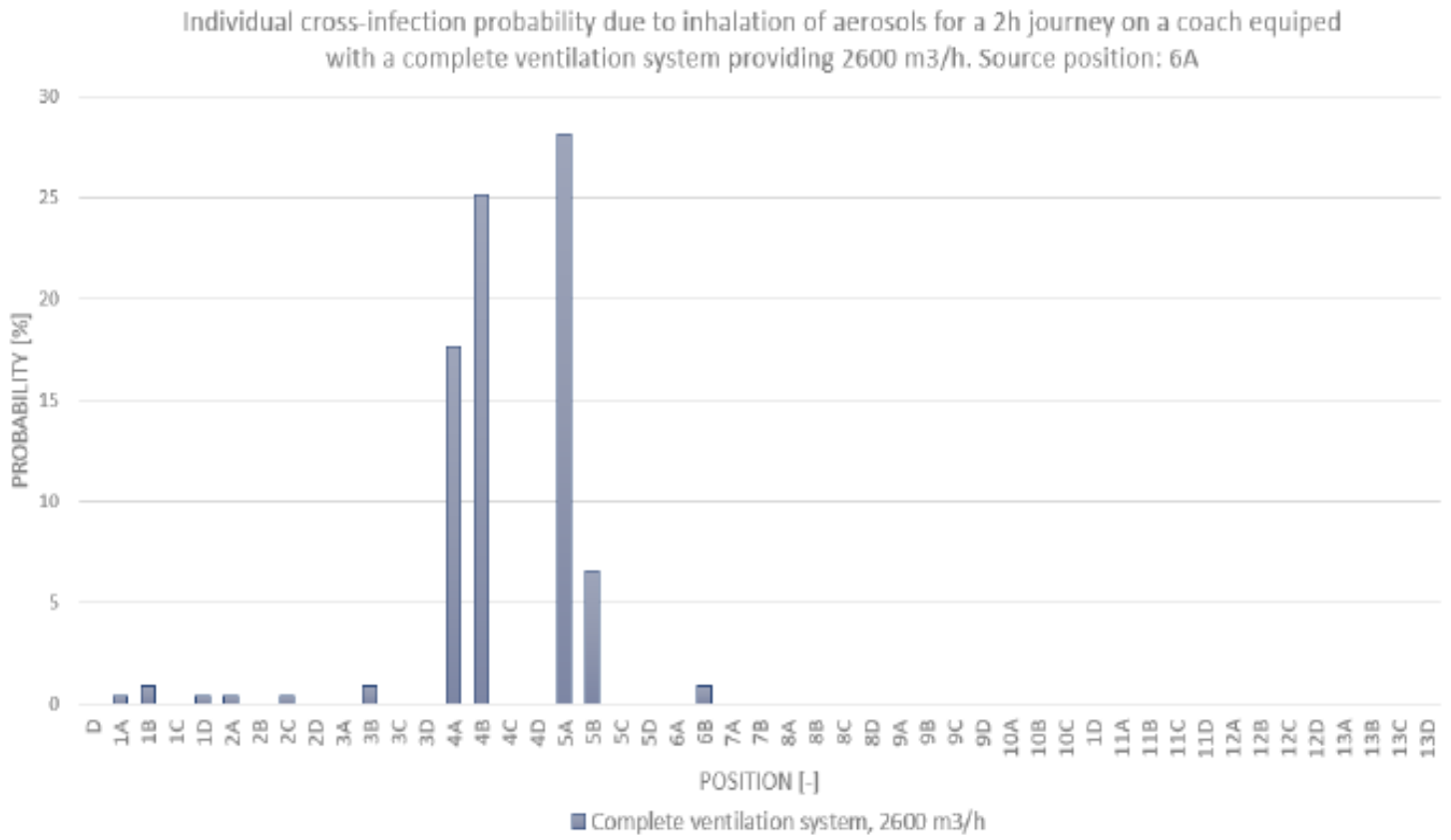
- Aerosols follow the streamlines of the flow field
- Highest concentration near source
- Only about 15% of the aerosols is extracted, the remainder is deposited onto surfaces
- Higher ventilation rate does not lead to increase in extraction rate

Particle Faith	Fraction [%]
Deposited	84.6
Extracted	15.4
Incomplete	0



Results: Long Distance Coach

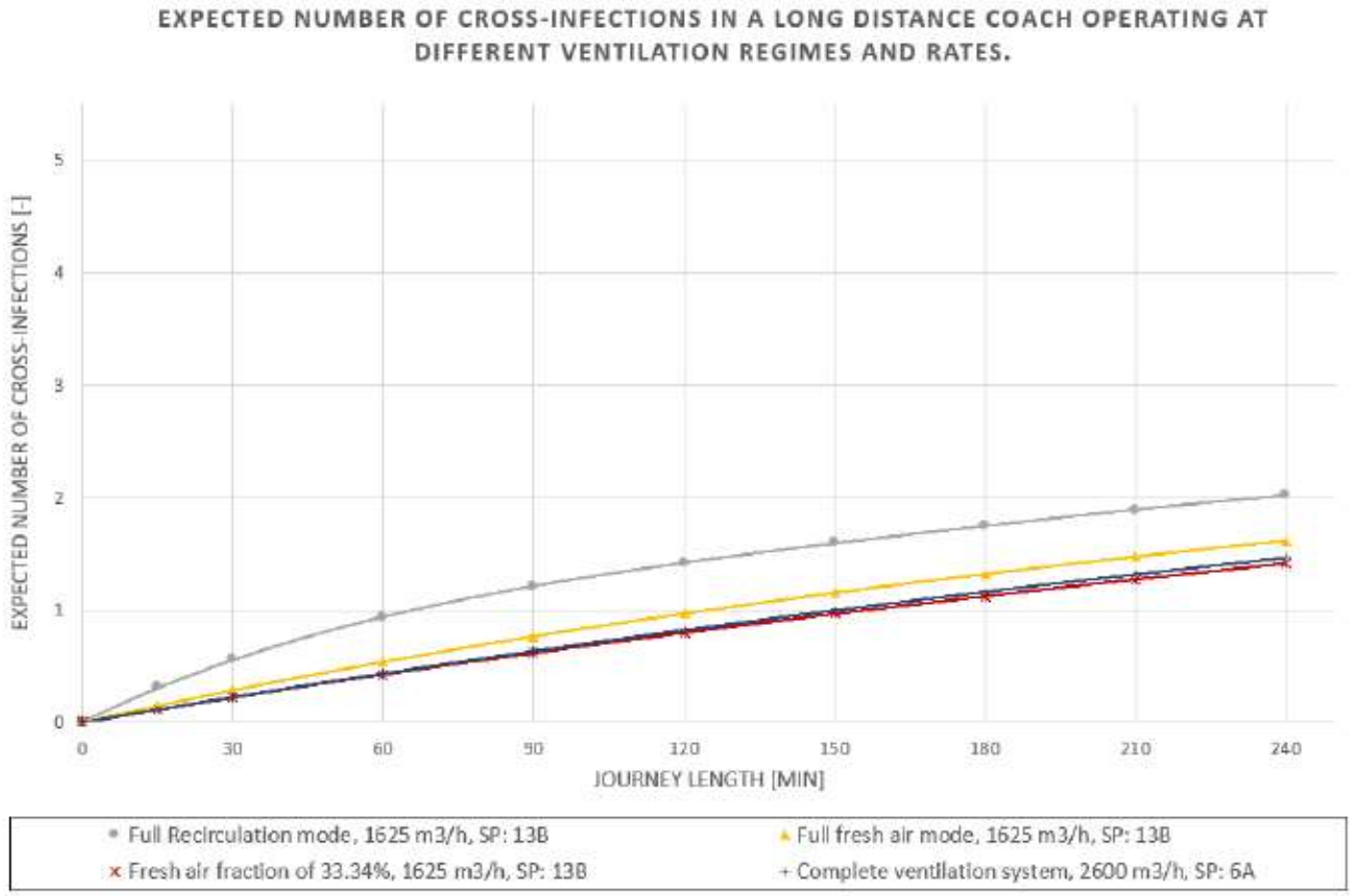
- Individual cross-infection probability depends on ventilation regime and relative passenger position.
- Infection probability for a 2 hour journey between 0 and 30%
(2600 m^3/h, 50% fresh air)



Results: Long Distance Coach

BUSWORLD foundation

- Individual cross-infection probability depends on ventilation regime and relative passenger position.
- Infection probability for a 2 hour journey between 0 and 30%
- Expected number of cross-infections between 0.5 and 1.5 for a 2h journey
- Cross-infection risk is greatly reduced by wearing face masks (-90%+)



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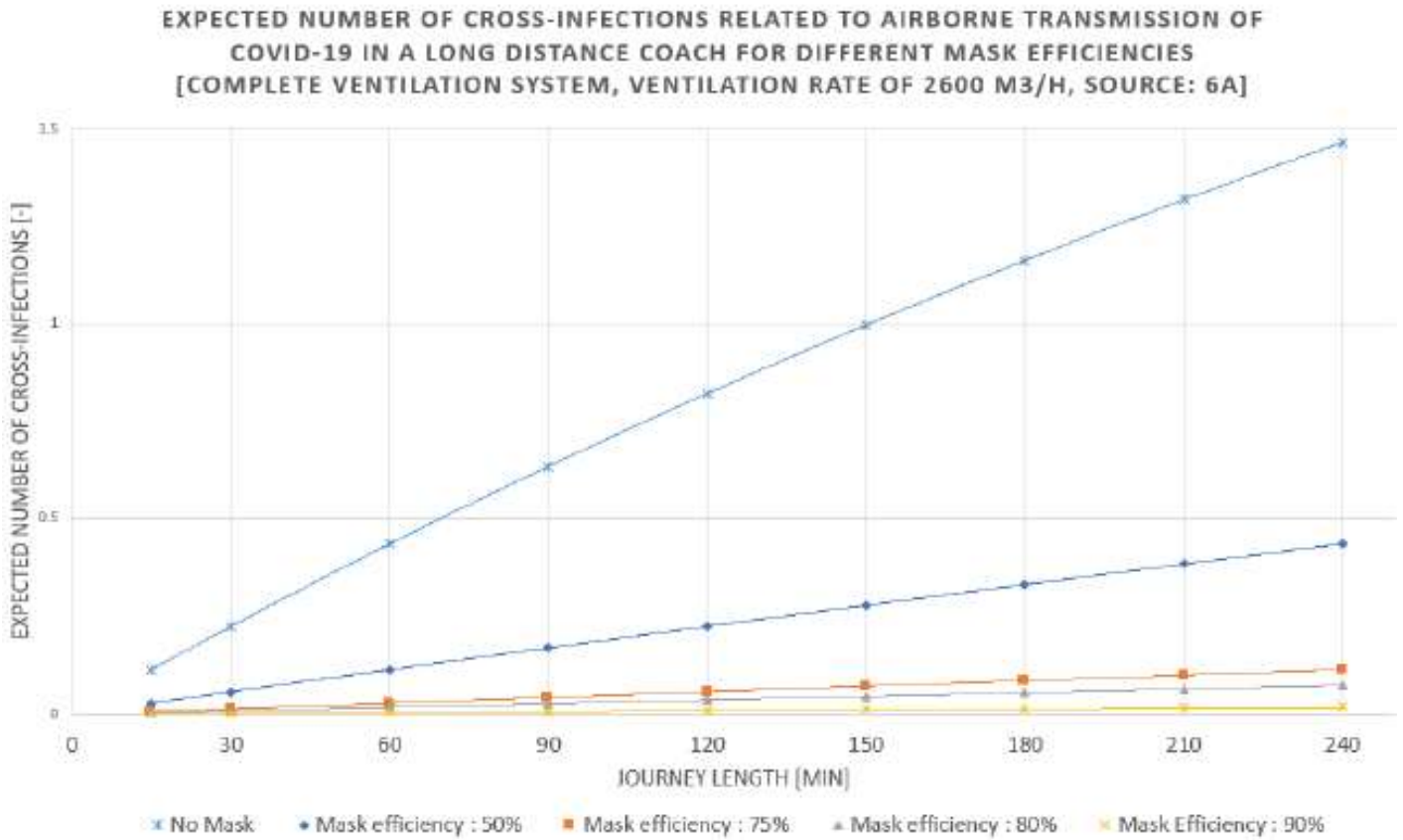
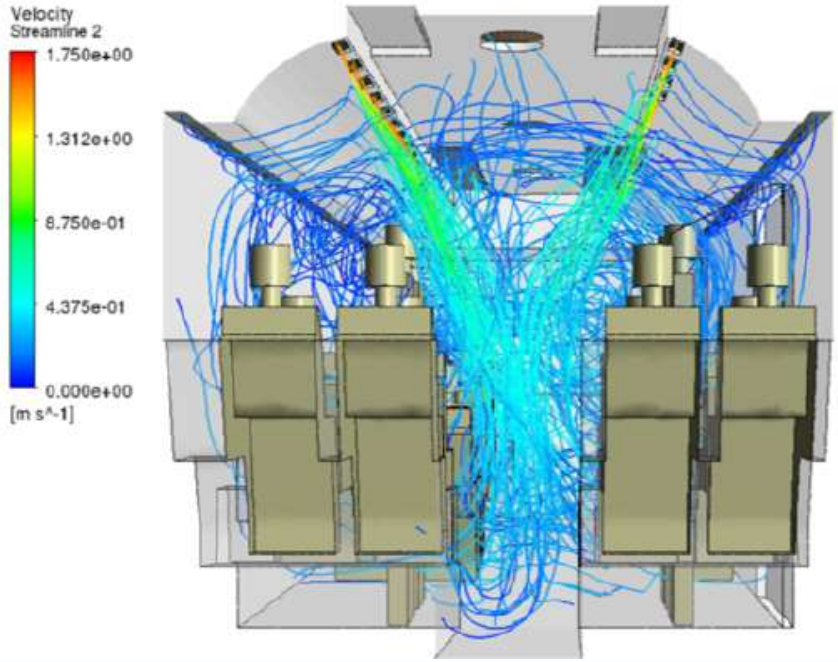
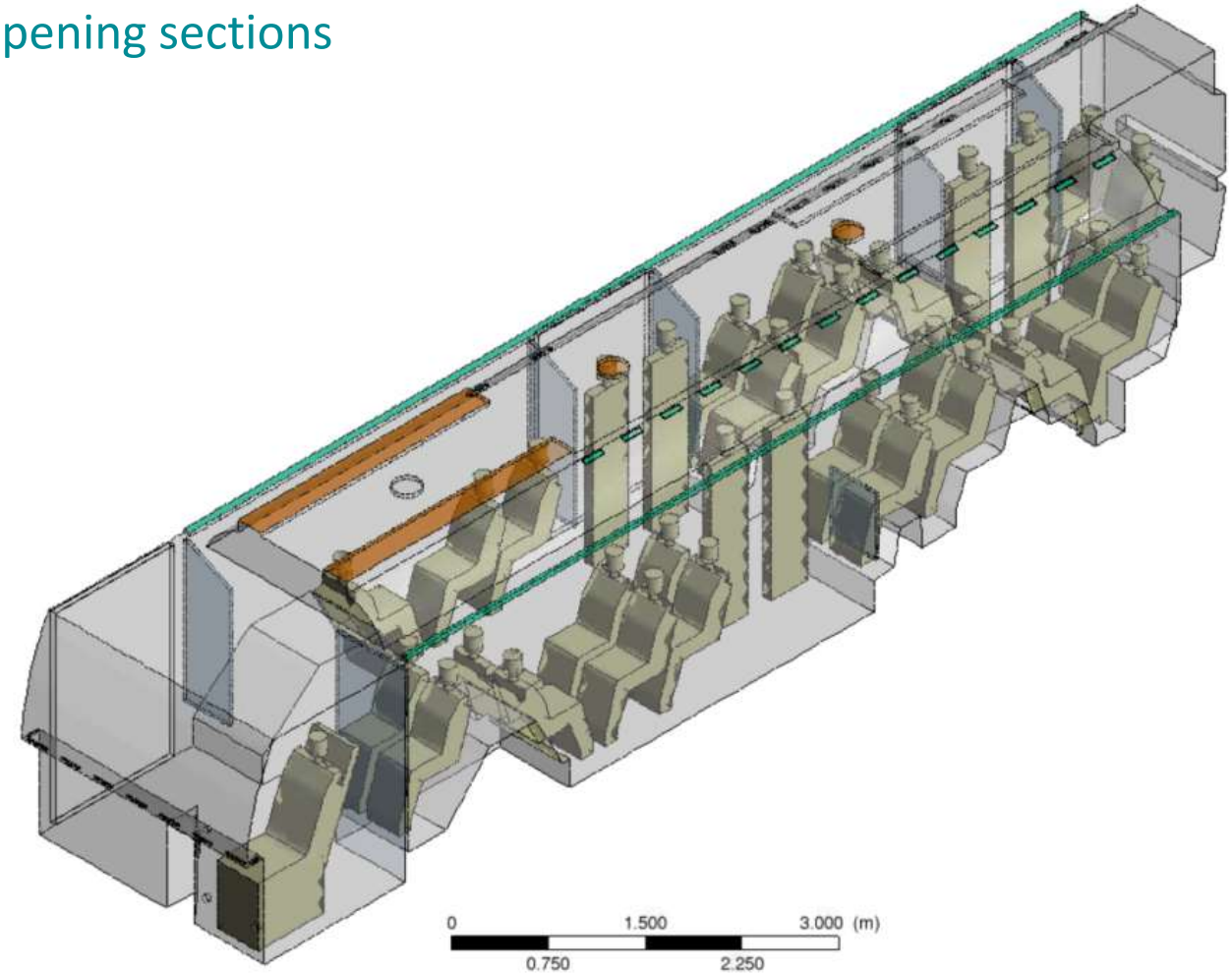


Case Description : Urban Bus

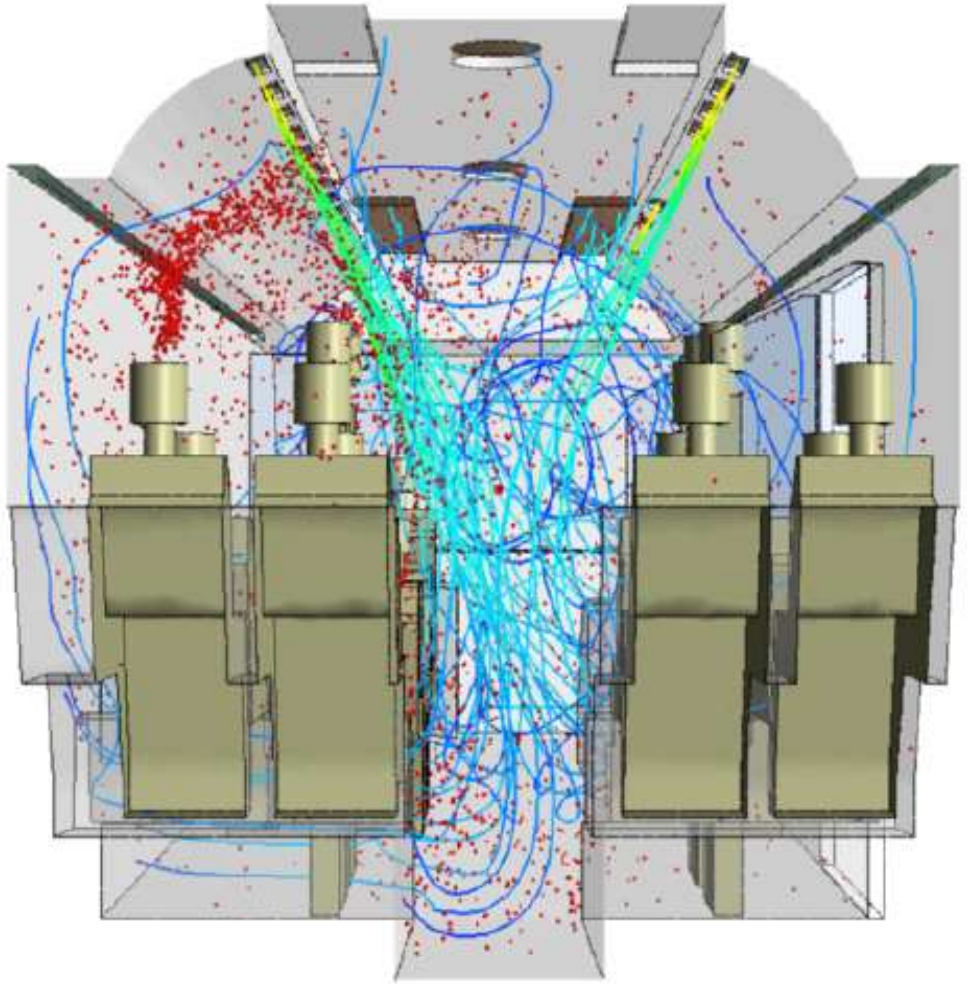
- 12m city bus at near full capacity
- Transient simulations with driving sections and door opening sections
- Various ventilation regimes
- Source position varied between 4 positions





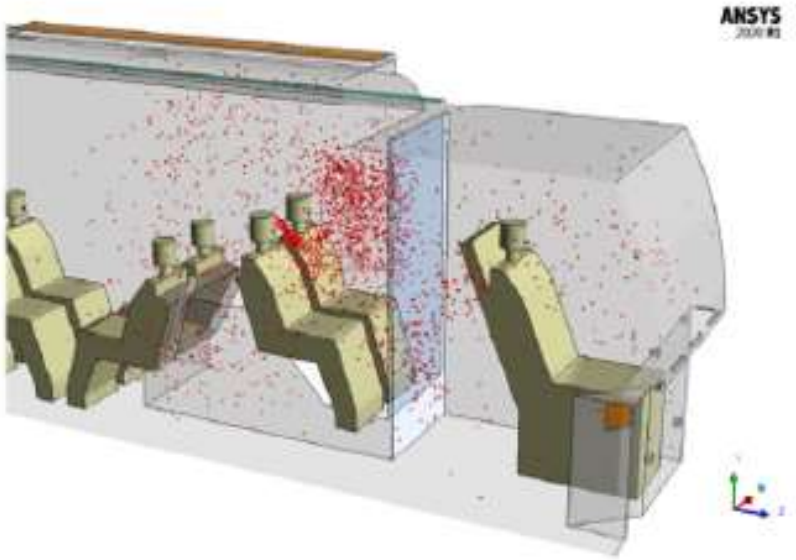
Results: Urban Bus

- Aerosols follow the streamlines of the flow field
- Highest concentration near source

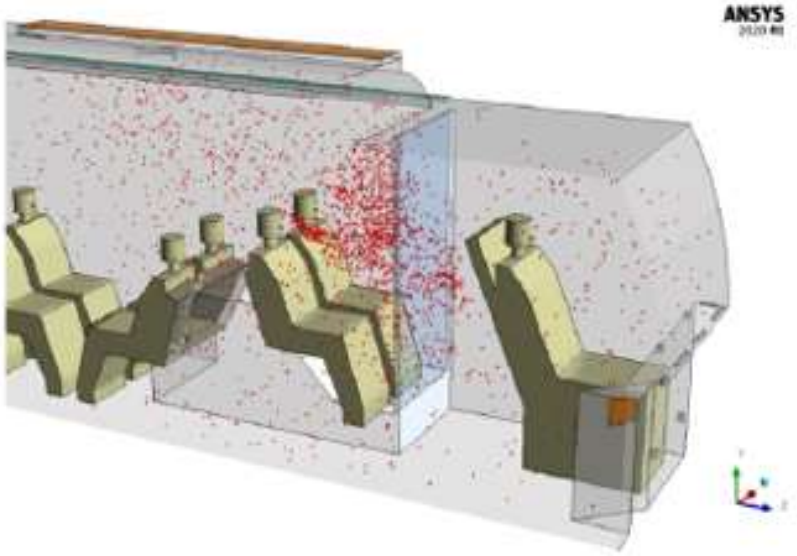


Results: Urban Bus

- Aerosols follow the streamlines of the flow field
- Highest concentration near source
- No clear effect of door openings on aerosol concentration level



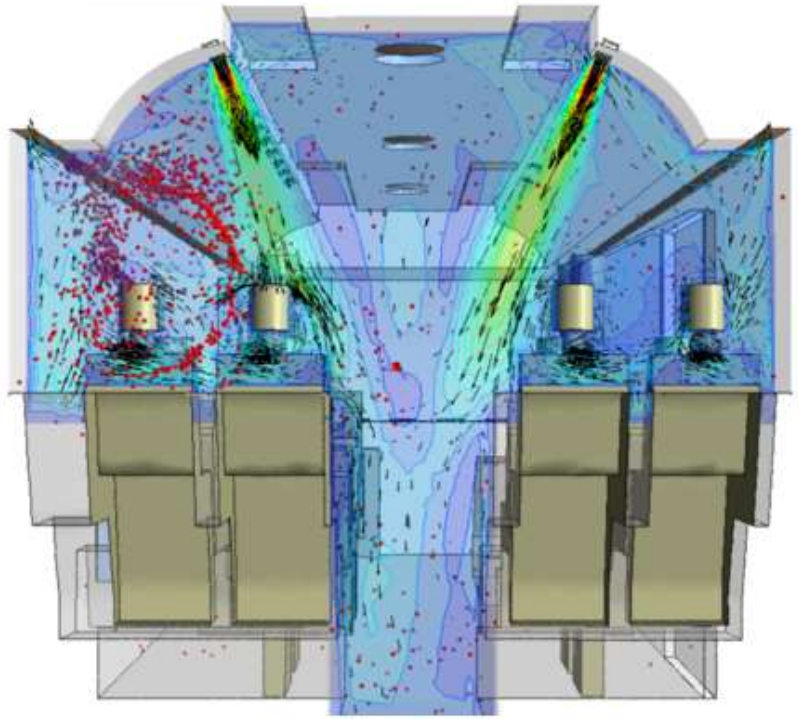
a) Before door opening (t=90s)



b) After door opening (t=105s)

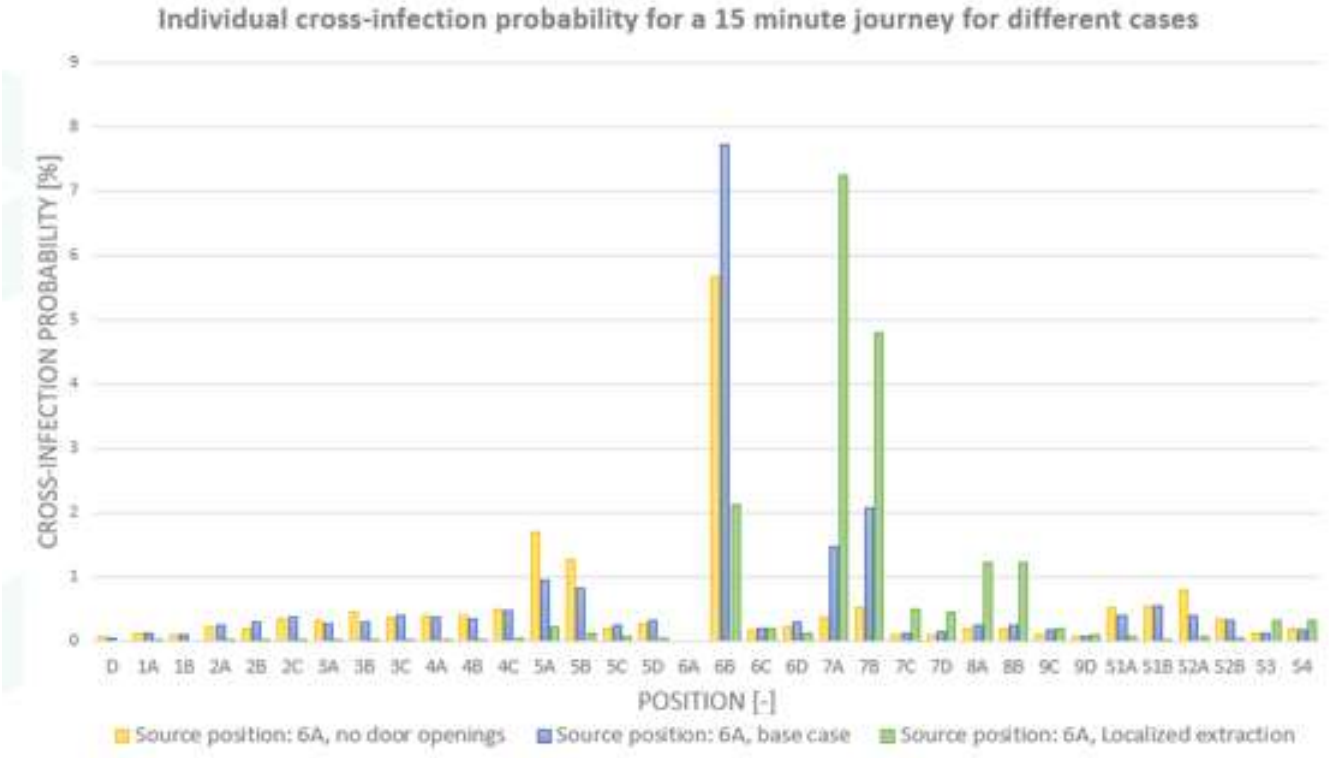
Results: Urban Bus

- Aerosols follow the streamlines of the flow field
- Highest concentration near source
- No clear effect of door openings on aerosol concentration level even when all air leaves the bus via the doors
- For the default ventilation system, only about 15% of the aerosols is extracted, the remainder is deposited onto surfaces
- Extraction rate increased to about 35% with the use of localized air extraction



Results: Urban Bus

- Cross infection risk for 15min journey <10% in all cases
- Very low risk for the driver, even when source is nearest to the driver
- Cross-infection risk not decreased due to door openings
- Shift in distribution of cross-infection risk rather than decrease due to localized air extraction



Conclusions and lessons learned

- Aerosols follow the ventilation streamlines
- Higher ventilation rates do not necessarily lead to lower transmission risks
- Only a small fraction of droplets is effectively extracted. This can be increased with the use of a localized extraction system, but most particles are still deposited
  → regular cleaning
- Wearing face masks greatly reduces the airborne transmission of COVID-19
- In order to minimize cross-infection risk, a combination of localized extraction and air purification/sanitization is likely advisable