RAIL SAFETY AND STANDARDS BOARD

Air quality for rail – measurements and mitigation challenges

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Structure of presentation

- Who is RSSB and what do we do?
- The Stations Air Quality Monitoring Network (AQMN)
  - Engagement, logistical and technical challenges
  - Latest status and key findings
  - Next steps and mitigation challenges
- Onboard trains air quality measurements
  - Key findings and mitigation challenges

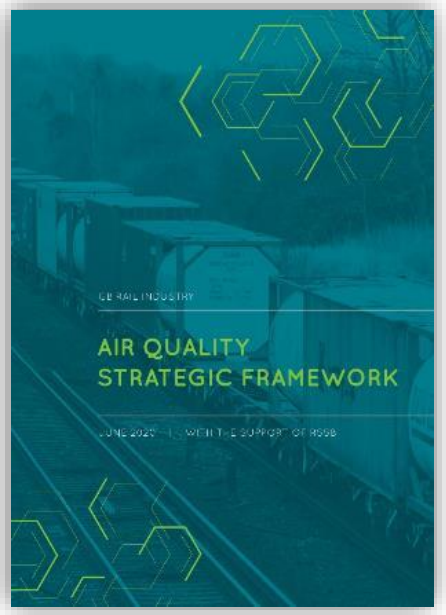
The Rail Safety and Standards Board (RSSB)

The independent safety, standards and research body for Great Britain's rail network

- Not-for-profit company owned by major industry stakeholders
- **The Sustainable Rail Blueprint**: a comprehensive sustainability strategy for the rail industry across both environmental and social topics
- 11 sustainability topics, including **Clean Air**

Flagship goal: A railway that supports a positive impact on local air quality

- **Air Quality Strategic Framework**
  - Setting the future path for rail to achieve the flagship goal
  - Underpinned by a **collaborative research programme (CLEAR)**
  - Three key themes: Monitoring, Modelling and Mitigation



Stations Air Quality Monitoring Network (AQMN)

The first systematic and coordinated air quality monitoring programme for GB rail

Stations AQMN

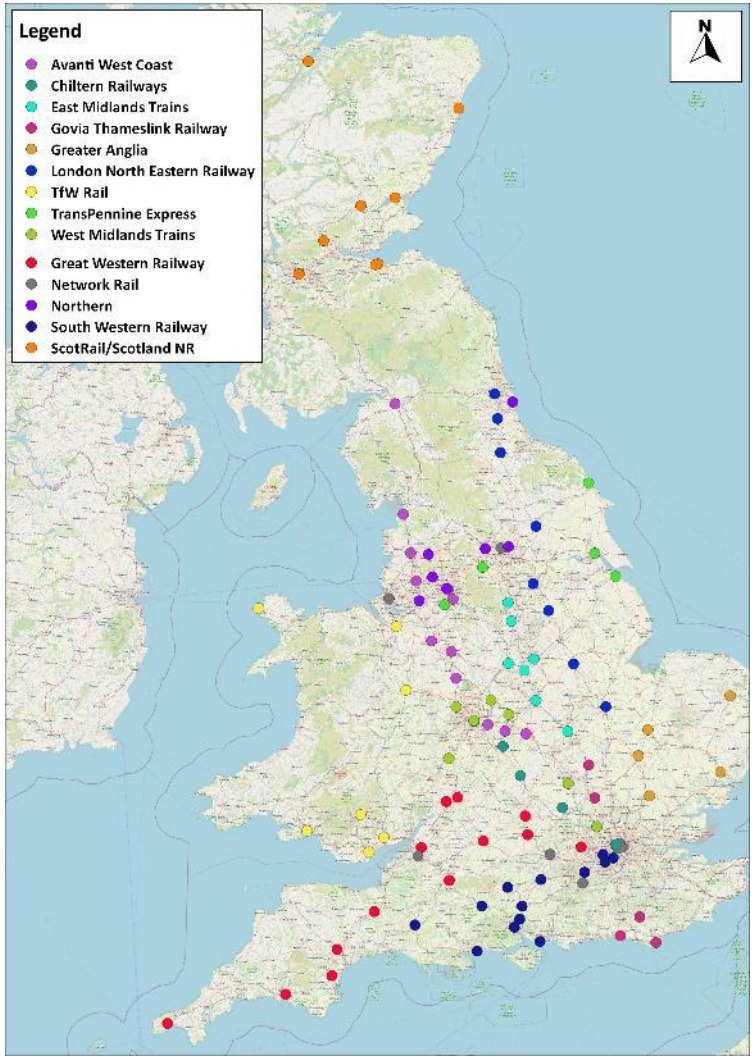
Objectives

- Provide information on the current state of air quality (**i.e. baseline**) across the rail network focussing on train stations;
- Provide location specific air quality information to **prioritise improvement** measures in the highest risk locations;
- Capture the future changes in air quality due to policy changes and application of mitigation measure, so as to **assess their effectiveness** in improving air quality at stations;
- **Inform the public** about air quality at train stations; and
- Establish the most accurate and cost-effective air quality monitoring solutions for rail

Stations AQMN

Scope and coverage

- Funding received from the DfT
- Focussing on pollutants from diesel exhaust: **NO_2, PM_{10} and $PM_{2.5}$**
- Scale
  - **116 stations** in England, Scotland and Wales
  - **13 Train Operating Companies (TOCs)** involved
  - **16 Network Rail (NR) managed stations**
- Timeline
  - Preparation started back in 2020
  - The monitoring network commenced its operation in January 2022 and will run until December 2023 and possibly beyond



Credit: Produced by Air Quality Consultants Ltd. (AQC)

Monitoring equipment

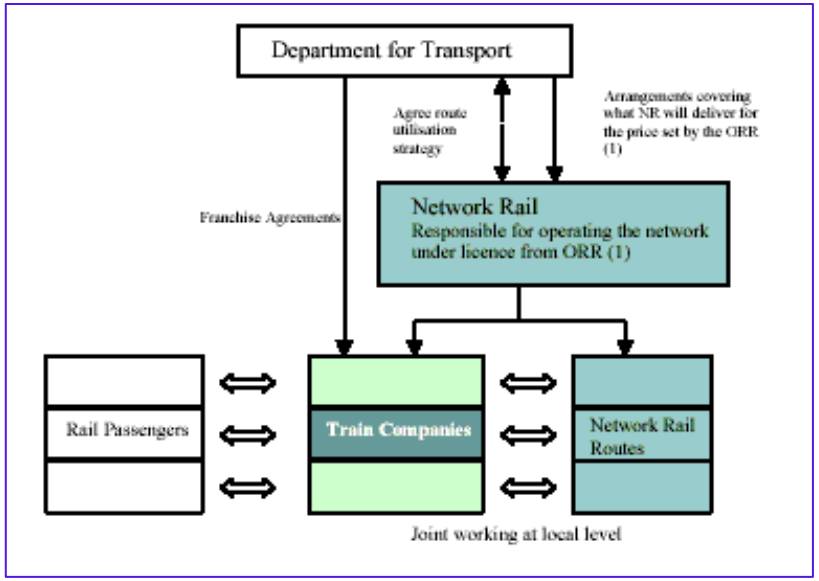
Passive and active

	Meshed diffusion tubes (DTs)	Reference monitors	Low-cost sensors (LCSs)
Stations	116	5	~40
Average # per station	5	1	3
Locations	Platform(s) Concourse Waiting room Station background	Platform	Platform Concourse Station background
Key purpose(s)	To capture long-term changes in NO_2 concentration in stations	To capture accurate and reliable data at key locations To provide reference point for monitoring approaches (bias adjustment for DTs, calibration for LCSs)	To capture transient changes in pollutant concentrations, which has the potential to enable correlation with train activities data

Challenges in early engagement

Navigate through a complex industry

- **Buy-in from the industry is a key factor in ensuring the successful delivery of the AQMN!**
- Need to engage with multiple bodies
- Staff often has very specific and distinct roles
  - Need to navigate and identify the key contact(s) – most time consuming!

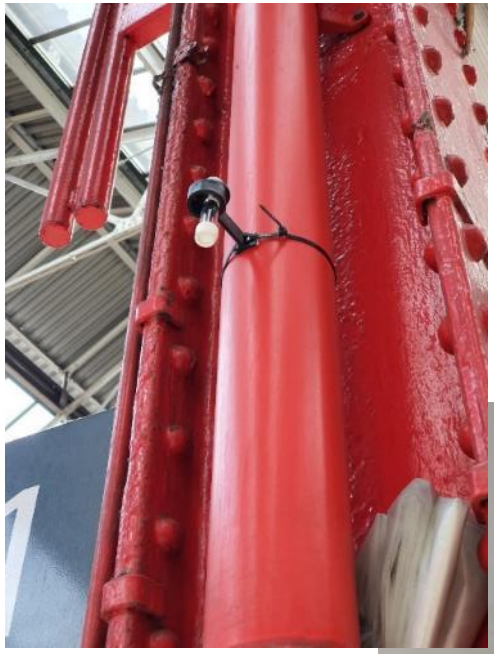


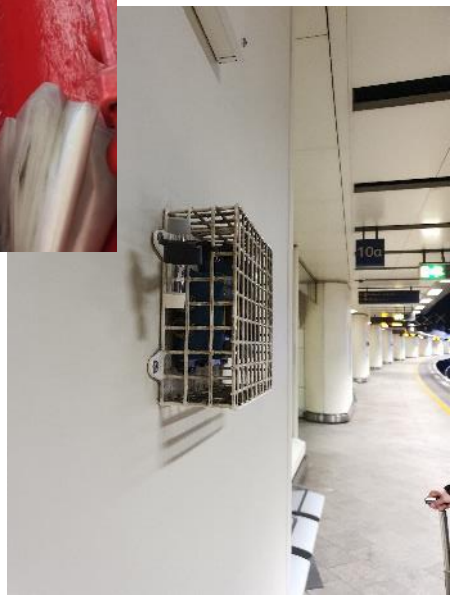
Source: House of Commons - Public Accounts - Twenty-Eighth Report (parliament.uk)

Logistical challenges

Diffusion tubes

- Over 500 diffusion tubes that need to be changed on a monthly basis (adhering to Defra's DT calendar)
- Task delegated to local station staff, or maintenance contractor
  - Provision of training
  - DTs sorted in packs and posted to individual station (or key contact) each month
  - Pre-paid envelope with address label to lab provided
- Key challenges so far:
  - Communication difficulty
  - Strike actions (rail and Royal Mail)
  - Staff changes and sickness

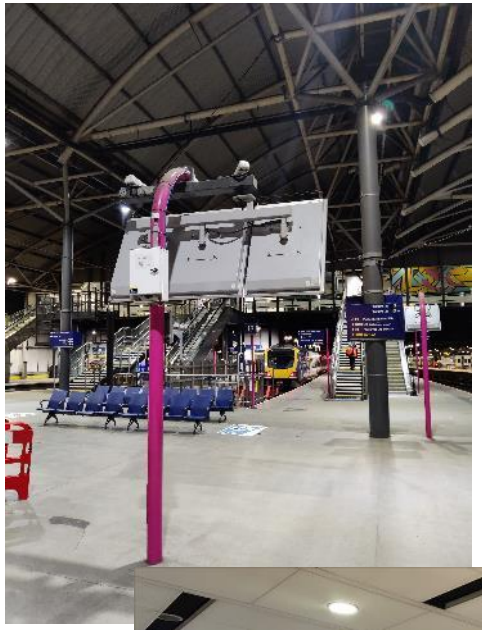




Logistical challenges

Reference monitors and low-cost sensors

- Location of equipment
  - AQ considerations (worst case location? exposure?)
  - H&S considerations (risk adverse)
  - Availability of secure, continuous mains power supply
  - Structural considerations
- Consents
  - Listed Building Consent
  - Landlord Consent
- Installation
  - Coordination with electrician and operation of the station
  - Careful logistical planning required (e.g. loading and size of lift)

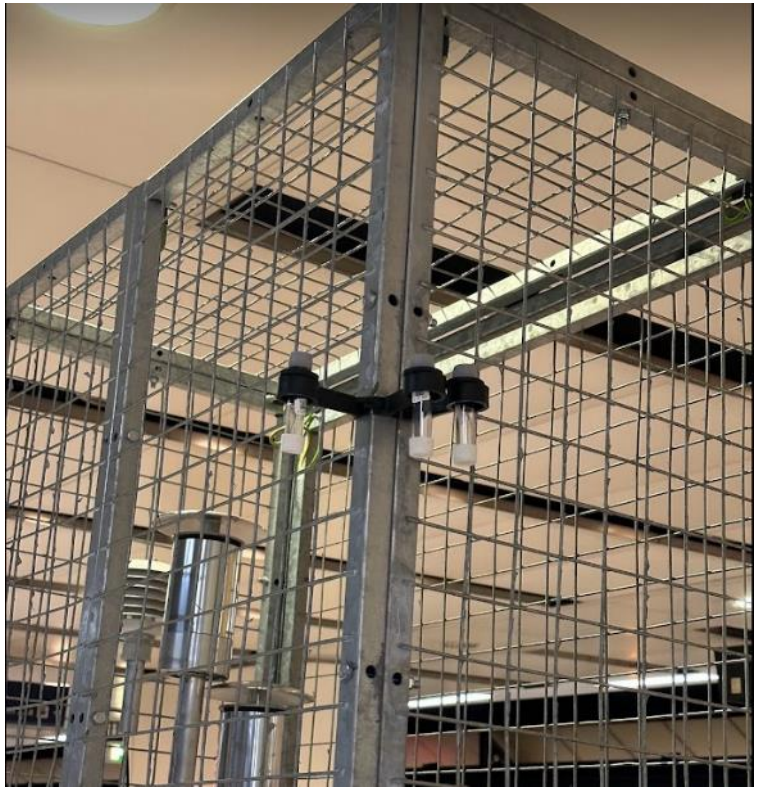


Credit: Photo taken by Aecom

Technical challenges

Diffusion tubes

- Latest meshed DTs chosen for network (same as those used in the UUNN)
  - Remove the effect of wind turbulence at the end of the tube, which effectively reduces the tube length
  - Able to meet the uncertainty requirement for fixed (chemiluminescent) measurements (in ambient environment), and much better precision from triplicate tubes
- Challenges in data processing:
  - Bias-adjustment(s) specific to station environment?
  - Annualisation process?
  - TBC, co-location study is ongoing



Technical challenges

Reference monitors and low-cost sensors

- Optical vs BAM: possible influence from particles with high iron content?
- Low-cost sensors: A four-month co-location study (using 3 sensors) with a reference monitor in an enclosed train station has been carried out
- Outcome:
  - NO_2 data shows generally good agreement ($R^2 \geq 0.96$)
  - **PM data** (PM_{10} and $PM_{2.5}$) shows **considerable under-reading**
- Possible reasons for PM under-reading (current hypothesis):
  - Difference in particle size distribution in enclosed station environment vs. ambient environment (the default setting)?
  - Potential contamination of sensors due to the presence of unburnt diesel in the air?
  - **Any other thoughts?**

Latest status of AQMN

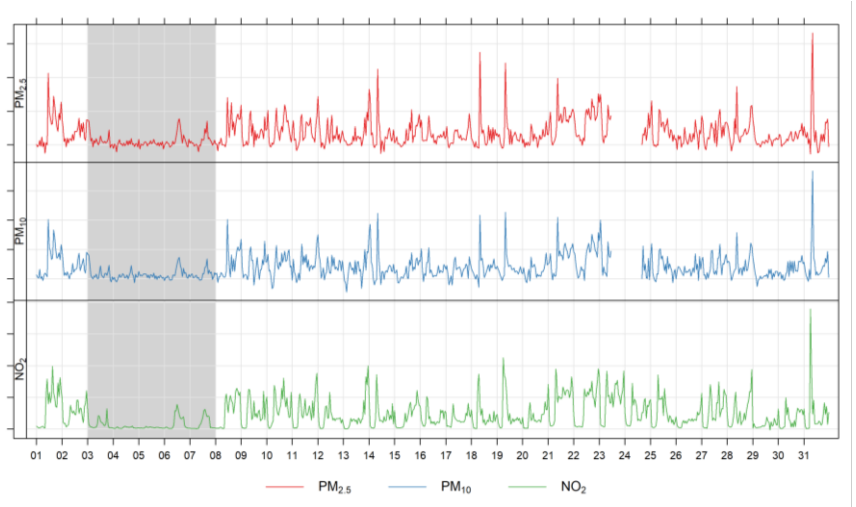
What have been achieved so far?

- Diffusion tubes
  - **Up to 12 months of data** collected so far
  - Overall data capture rate for the first year of operation **nearly 90%**
- Reference monitor
  - First unit installed at **Birmingham New Street** and has been in operation since July 2022
  - Four more units to go (Hull, London Marylebone, Sheffield, Sunderland)
- Low-cost sensors
  - Further evaluation work is ongoing

Key findings

What have we learnt so far?

- **Data is restricted** to the project stakeholders at present
  - An annual report will be produced by RSSB and will be published later this year
- Some key high-level findings to share:
  - **Less than 50 stations** (at one location or more) where the period mean NO_2 concentration was above 40µg/m^3 (based on provisional raw data)
  - **Numerous transient peaks** of NO_2 exceeded 200µg/m^3 (hourly average)
  - PM data is to be confirmed; provisional PM data suggests $PM_{2.5}$ concentration and PM_{10} concentration were quite close to each other (at platform)



Next steps

What should the industry do?

- The Rail Environment Policy Statement (REPS) has stated that DfT will:
  - *"set targets for levels of **$PM_{2.5}$, PM_{10} and NO_2** for all parts of the network that the **public can access** in 2022, with the ambition of meeting these targets **by the end of 2030**, consistent with the Clean Air Strategy"*
- AQMN data will be used to compare against **Rail Air Quality Targets**
  - Any location unlikely to meet any of these targets by 2030 will be identified as **Priority Locations**
  - **Air Quality Improvement Plans (AQIPs)** will be required
- Development work is in progress

Mitigation challenges

Complex environment with multiple sources

- Biggest contributor – diesel trains
  - Choice of rolling stock by operators limited by many factors
  - Asset life (up to 40 years): not easily changed
  - Idling
- Complex environment
  - Stations not designed with AQ in mind
  - Listed building
- Apportion of responsibility
  - Multiple operators in one station
  - Various activities and emission rates from different trains
  - Role of the infrastructure itself
  - Ambient air quality

RAIL SAFETY AND STANDARDS BOARD

T1188 Onboard Trains Air Quality Measurements

Improving knowledge on the exposure of railway passengers and staff to air pollutants while onboard trains

Key findings

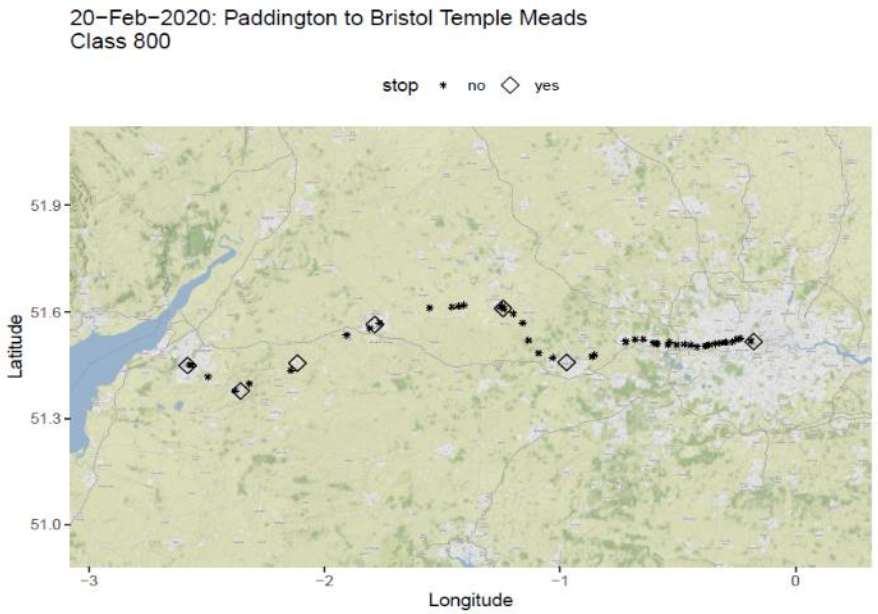
Air quality onboard trains was different along the different routes

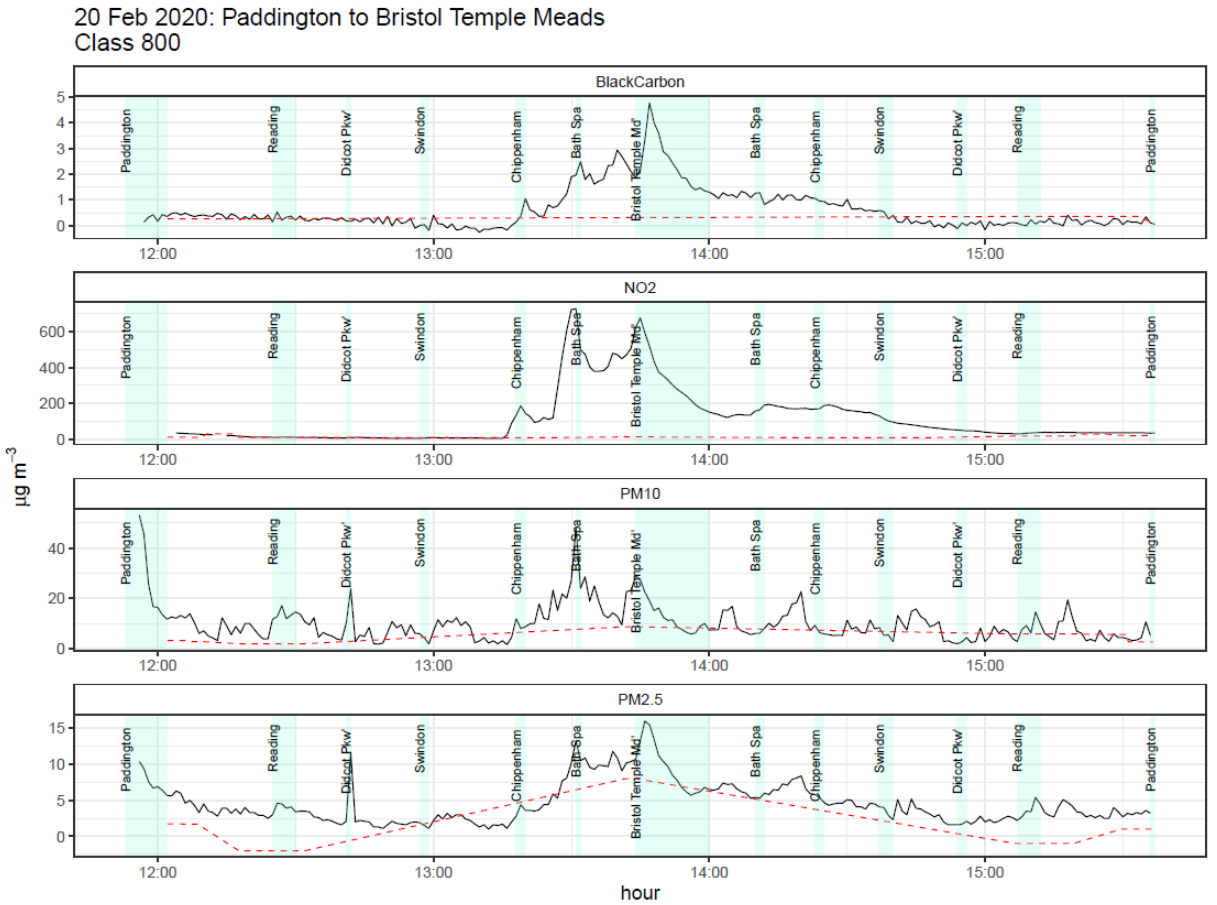
- Air quality measured on six different train types on five separate journeys, 30 journeys in all
- The highest levels of nitrogen dioxide were found between Paddington to Bristol Temple Meads, on board a Class 800 bi-mode (electric and diesel powered) train when in diesel mode.
- There was a large difference in measured nitrogen dioxide when comparing diesel mode to electric mode on the bi-mode trains.
- The levels of pollutants and the exposure of the passengers were found to vary depending on:
  - Train type
  - Location of the exhaust relative to HVAC inlet
  - Track gradient
  - Whether the train was in a tunnel/station.
- Newer train types do not necessarily have better on-board air quality compared to older trains.

Influence of exhaust and HVAC inlet locations

Entrainment of exhaust emissions into the cabin

Pollutant	Average	St. Dev	Urban	Rural
NO_2	208	214	16.7	2.8
PM_{10}	11.8	6.8	9.7	8.8
$PM_{2.5}$	7.5	3.2	5.1	5.2
Black Carbon	1.4	1.3	0.5	0.1

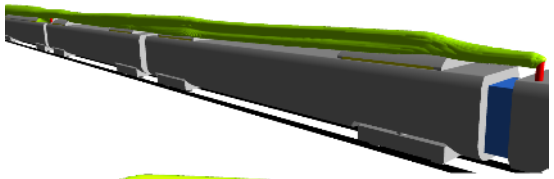


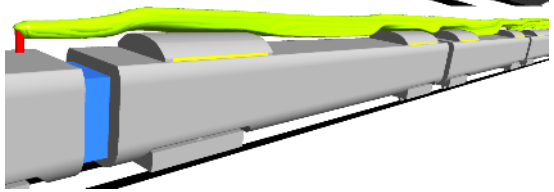


Mitigation challenges

No one-size-fits-all

- Developed a robust modelling methodology for the GB rail industry that allows the dispersion of exhaust pollutants around trains to be calculated (based on a generic train type)
  - Roof configuration is key: irregular roof could be beneficial
  - Highest pollutant concentration likely to occur around the trailing end car of a 4-car train
  - Specific design will need to be studied in detail separately
- Potential for better filtration in the HVAC system
  - G4 filter as rolling stock standard; potential for much better performing filter to tackle entrainment of external PM





Thank you!

Any questions?

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