THE LONDON AIRGRID

DELIVERING A NEW TYPE OF NETWORK TO MONITOR, DETECT AND FILTER PARTICULATE MATTER, GIVING YOU COMFORT ON THE GO

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Collaboration was essential to achieve all that is presented here.

THE CARDINAL VAUGHAN MEMORIAL SCHOOL

OUR REFERENCES

OUR GOAL

The London AirGrid's goal is to establish a comprehensive **particulate monitoring and filtering network** - starting in the London Underground - equipped with the tools to reduce harmful exposure to $PM_{2.5}$ and PM_{10} particles, protect vulnerable individuals and to clearly present actionable air quality data to our end-users with full transparency.

OUR FOCUS

By deploying a city-scale 'particulate network' across enclosed, **high-footfall environments**, TLA will have a system that detects and filters harmful particles in real time, all the while generating thorough datasets which will inform health-conscious decisions. We want to enable safer travel for those with respiratory conditions, and ultimately support long-term public health resilience.

WHAT IS COPD?

- Chronic Obstructive Pulmonary Disease (COPD) is a progressive lung disease that makes breathing increasingly difficult over time, with symptoms including chronic cough, phlegm production, and shortness of breath.
- While smoking is the primary cause of COPD, exposure to high concentrations of $PM_{2.5}$ and PM_{10} especially in poorly ventilated underground stations significantly contributes to lung damage and accelerates disease progression.
- For daily commuters in these environments, repeated exposure to particulate pollution poses serious health risks, worsening COPD symptoms and increasing the likelihood of hospitalisations and long-term lung impairment.

WHAT IS ASTHMA?

- Asthma is a chronic condition where the airways become inflamed and narrow, causing symptoms like wheezing, coughing, chest tightness, and difficulty breathing.
- Exposure to fine particulate matter such as $PM_{2.5}$ and PM_{10}-common pollutants found at dangerously high levels in underground stations-can trigger asthma attacks and worsen inflammation.
- Underground environments often have poor ventilation and concentrated particulate pollution, people with asthma who commute regularly through these spaces face increased risks of severe symptoms and respiratory distress.

OUR PROPOSAL

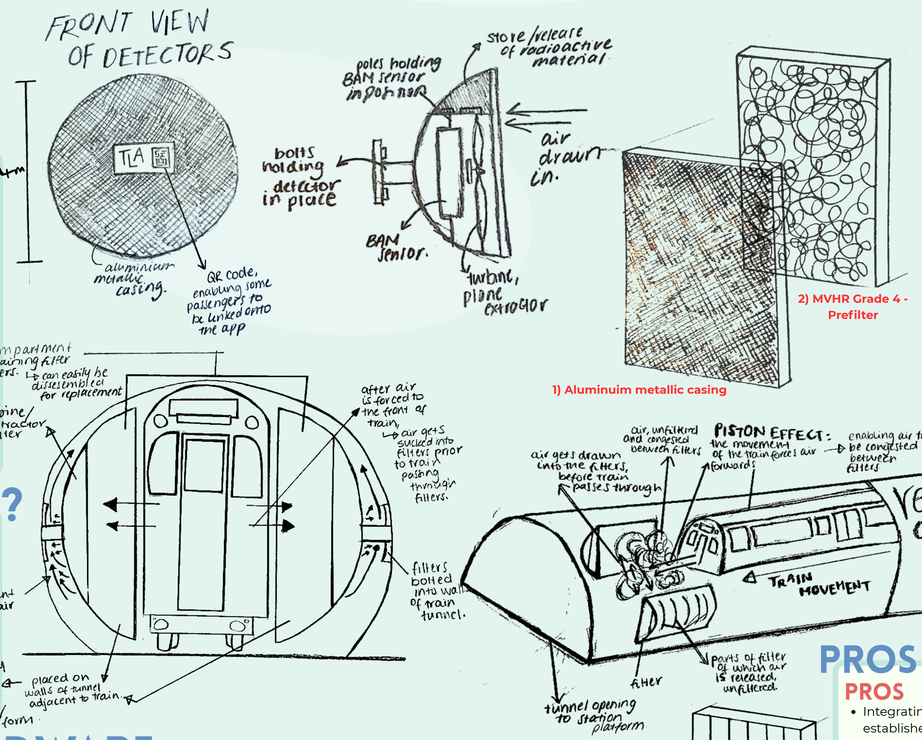
A smart, scalable solution for urban air quality—combining advanced monitoring, active filtration, real-time data, and a user-friendly app to reduce exposure and improve respiratory health.

1. TLA Monitoring & Filtering Unit
- High-precision Beta Attenuation Monitoring (BAM) sensors for real-time detection of fine particles.
- Integrated filtration actively removes particulates from the air.
- Modular, wall-mountable, and suitable for stations, platforms, and (in the future) homes.
- Fully automated and low-maintenance.

2. TLA City Network
- A distributed system of monitoring/filtering units, starting in the London Underground and expanding citywide.
- Devices continuously measure and filter air, uploading live data to a central hub.
- Provides real-time citywide particulate maps, highlights pollution hotspots, and enables quick interventions.

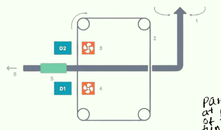
3. TLA Companion App
- Mobile app delivers live air quality data from all TLA network locations.
- Instant alerts for $PM_{2.5}$/PM_{10} spikes.
- 24-hour and historical air quality scores.
- Smart route planning to avoid high-pollution zones.
- Personalised notifications for at-risk users (asthma, COPD, etc.).
- Transparent access to raw data and AQI scores.

DESIGN AND HARDWARE



HOW DO WE MEASURE PARTICULATES?

- The **Beta Attenuation Monitor (BAM)** is an effective, modern method for measuring $PM_{2.5}$ & PM_{10} levels in the air.
- It works by drawing air through a filter that collects particulate matter, then passing beta radiation (from a source like Promethium-147) through the filter.
- As more particles accumulate, the radiation is increasingly weakened (attenuated), and sensors measure this reduction using the exponential attenuation formula $I=I0e-\mu xI=I0e-\mu x$, where the drop in radiation intensity reveals the particle mass per unit area.
- BAM offers real-time, continuous, and highly accurate data without the need for manual weighing or lab work, making it ideal for busy public spaces.
- It's automated, low-maintenance, and widely trusted by researchers and governments.



CHOICES

The Piston Effect
- Describes the movement of air and airborne particles inside these tunnels. When the train passes through the tunnel it forces air to be congested and built up in front of it.
- We have decided to place one filter on either side of the tunnel wall about 7 metres towards the opening of the tunnel as it leads to station platforms. This ensures we can maximise the collection of $PM_{2.5}$ at a period of which the movement of air is most predictable and consequently easiest to capture best.

Electrostatic Filters
- We have focussed on this type of filter as the majority of $PM_{2.5}$ particles found in the underground have metallic properties and are largely composed of iron in the form of maghemite.
- Most particles come from the wearing or degradation of train tracks and wheels over time as well as the braking of the train particularly in the form of friction braking.
- Particles present inside tunnels go on to be picked up by the air due to the Piston Effect of the train inside the tunnel.

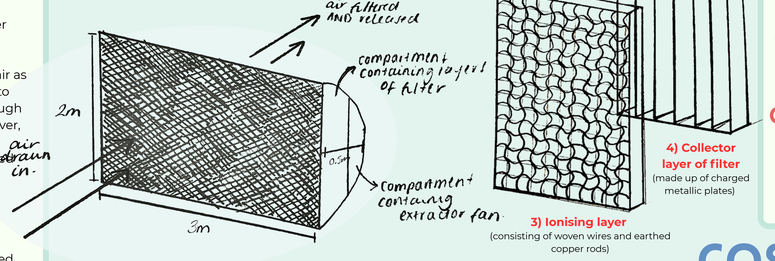
FILTERING AND HARDWARE

1) Metallic Casing
Filters first have an aluminium metallic casing which simply protects the outer layer of the filter.

2) MVHR Grade 4
Acting as a pre-filter, this layer will collect human waste like skin flakes and hair as well as dust particles that are greater than 10 micrometres in size. This refers to the dust particles that can be removed from healthy respiratory systems through sneezing for instance will mostly be eliminated by this layer of the filter, however, it's required as COPD patients and individuals suffering from asthma have weakened respiratory systems, which when exposed to less of these larger sized particles can potentially cause asthma attacks or COPD exacerbations.

3) Ionising layer
Consisting of fine woven wires charged to a voltage of 13kV and alternating earthed rods, this layer aims to induce the metallic dust particles that pass through this layer with a positive electrostatic charge. This is achieved by the Corona discharge that results across the hardware of the fine wires and earthed rods.

4) Collector layer
Placed in front of the turbines, this layer will be made up of a series of 20 parallel, vertical metal plates with a potential difference of 6–7 kV between adjacent plates. Ionised air dust particles will be drawn to metallic plates and be captured, before the filtered air leaves the system past the extractor fan and through the curved backside of its structure.



ROADMAP OF FUTURE ASPIRATIONS

NOW

Our current focus now is to deploy our particulate detection and filtering network across all London Underground stations and areas. This will allow us to integrate our product into an infrastructure that is already well-connected and established. We look to analyse the improvements across these contained areas, develop thorough datasets, and to mitigate or control as many issues as possible that arise as a result of the harmful particulates present in these stations. This foundational rollout will not only validate our system's effectiveness but also pave the way for broader applications in other urban environments.

EXPANDING TLA

We want the people of London to better understand the air they move through every day. TLA can expand beyond the Underground by deploying weather-proof detectors in densely populated areas across the city. Individuals vulnerable to conditions like COPD and asthma will benefit from richer, location-specific data through our companion app. TLA can alert them when certain routes or areas pose higher risks, and enabling smarter, safer journey planning.

SMALLER, SMARTER, CLOSER

Expansion and larger datasets are great, but TLA needs to keep its focus on the people. Our initial phases would have involved monitoring and reducing risks of COPD in public spaces; TLA strives to make its technology more compact, more cost-effective, more accessible, and more bespoke to its end-users.

Our future aspiration is to have an all-in-one filtering and monitoring unit which can be installed directly on the wall of a patient's home. Residential areas where PM2.5 and PM_{10} may be dense, this TLA unit will be able to learn and adapt to the home, generating reports and responding to the environment in a way tailored for the patient.

By doing this, TLA feels more secure in helping COPD or asthma vulnerable patients across all areas of their lives, ultimately hoping to promote comfort for in every space they encounter.

PROBLEMS WITH THE UNDERGROUND

- Worldwide Underground air pollution crisis poses severe public health threats. In London, levels of $PM_{2.5}$ on Victoria Line range up to 885 μg/m³ - 35 times higher than WHO's safety levels - with nearly half being iron oxide from brake and rail wear.
- Particles are thinner than in normal city pollution, reaching deep into lungs and bloodstreams. These ultra-fine, needle-like particles penetrate deep into lungs and the bloodstream, driving up risks of asthma, COPD, heart disease, and cancer.
- Network ventilation system, based on 19th-century "piston effect" ventilation, is of no use in deep tunnels where air stagnates.
- 79% of train heat is soaked up by clay walls, forcing the system to focus on cooling instead of pollution reduction. Even new mechanical fans (e.g., Victoria Line) cannot handle PM burdens above 300 μg/m³.

Daily exposure is a disaster:
- A daily return journey on the Victoria Line is equivalent to 1.5 cigarettes a day (300+ a year) in terms of particle exposure .
- Central/Piccadilly Line train drivers record 30% higher sick leave due to respiratory disease.
- Interchange station staff are exposed to 15× higher levels of $PM_{2.5}$ than street-level air.
- Communities in East London, disproportionately dependent on deep-tube lines, have asthma hospitalisation rates 42% higher than more affluent districts—unveiling systemic environmental injustice.

PROS AND CONS

PROS
- Integrating into an already well-established, well-connected network (Travel for London).
- Our three-part system establishes a robust ecosystem across the TLA network.
- Expands on public health datasets to better inform researchers and the NHS.
- Free, accessible and scalable TLA Companion platform.

CONS
- Large initial investment needed to deploy filtering units and detectors.
- Difficult to plan maintenance in busy underground stations.

COSTS

Hardware	Maintenance
Aluminium Casing (20m) - £65	MVHR Filter Replacement - Every 9–14 months - £40 per unit
Corona Discharge Wiring + Rods - £150	Collector Plate Cleaning - Every 2–3 months - V-Tuf HEPA Extractor + staff
MVHR Grade 4 Pre-Filters - £40	Oil Retreatment - After cleaning - £100 per litre
Oil-Coated Collector Plates - £140	Plate Charge Maintenance - Daily - £30/day
Axial Fans (Systemair AW 350EC ×2) - £762	Thermoelectric Fan Operation - Daily - £160/day
Thermoelectric Tiles (10m section) - £75	BAM Calibration & Data Upkeep - £300/year
BAM Monitor (MetOne BAM-1020) - £6,000	Operational Cost (per unit): ~£196/day
Total per Unit - £7,232	

ACCEPTABILITY

Integration process:
- Our filter system is designed to seamlessly blend into tunnels, positioned directly before and after platforms.
- Therefore they would not be visible from the platform, so no damage to aesthetics.

Cost:
- We plan to install filters in a phased rollout strategy, starting with the most polluted Central London platforms
- Installing a pair of filters per platform in all 190 Zone 1 platforms would have an initial cost of £2.746 million, and an upkeep cost of £53.8 million per year, only 0.6% of TFL's annual budget for comparison.

Acceptance:
- There has historically been high acceptance and high success rates for clean air schemes in London, with the ULEZ scheme, with 99% of monitoring sites reporting cleaner air compared to 2019.

TIMELINE

1. Concept Validation & Ethics Scoping
Define the product's aims: accurate $PM_{2.5}$/PM_{10} detection, commuter guidance, and filter longevity. Identify ethical, legal, and regulatory boundaries (e.g. GDPR, MHRA, REC), especially regarding user data and health claims. Begin drafting language for responsible communication in-app.

2. Early Technical Trials (Non-Clinical)
Conduct lab-based testing of the detector and filter system using known $PM_{2.5}$/PM_{10} concentrations. Evaluate detection accuracy, sensor responsiveness, and filter degradation rate to establish baseline performance.

3. Environmental Simulation Testing
Simulate London Underground conditions (e.g., temperature, humidity, dust concentration) to test device robustness, calibration drift, and how long filters remain effective under heavy use.

4. Controlled Usability Study
Test app interface with diverse user groups, especially individuals with respiratory conditions. Focus on clarity, interpretability, and user autonomy—can they understand and act on air quality data confidently?

5. Pilot Human Study with Questionnaires
Recruit a sample of commuters with COPD or other vulnerabilities. One group uses the app; another travels without access to PM data. Track self-reported symptoms after journeys via short post-commute questionnaires.

6. Behaviour Impact Analysis
Run statistical tests to compare symptom trends, route changes, and satisfaction across groups. Assess whether PM data influences real-world decisions and health outcomes significantly.

7. Feedback Integration and App Refinement
Use participant feedback to refine how information is displayed, e.g. route suggestions, alerts, visual cues, prioritising accessibility, minimal anxiety, and user preference.

8. Ethical and Regulatory Submission
Prepare final submission for ethical (REC) and regulatory (MHRA if applicable) review. Ensure clear consent procedures, anonymised data handling, and no misleading medical claims.

9. Public Launch Preparation
Final adjustments before roll-out: verify forecast accuracy, device durability, and compliance. Train support staff. Prepare public communication materials that emphasise informed choice, not prescriptions.

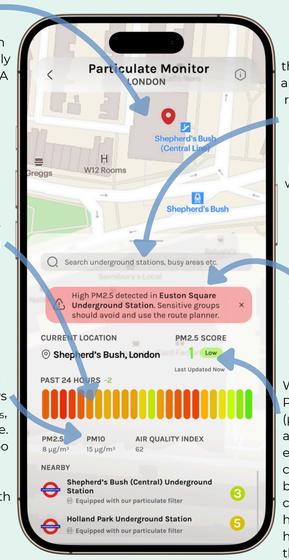
10. Long-Term Monitoring and Iteration
Post-launch, continue collecting anonymised data (opt-in) for effectiveness evaluation and periodic updates. Plan filter replacement cycles and possible hardware/software upgrades based on sustained usage patterns.

TLA COMPANION APP

Live location of the user shown and detects when entering a station or highly populated area where TLA monitoring services are present.

Displays the $PM_{2.5}$ score for the last 24 hours in an easy to read and simple manner. Allows the user to know the history of the particulate levels in that area, giving them a well-rounded scope compared to just a single score for that day.

For those wanting more information about the PM levels in the area, TLA shows them the raw data for $PM_{2.5}$, PM_{10}, and also the AQI score. By doing this we prevent too much abstraction of data, and ensure as much transparency as possible with the data we monitor and store.



The user can search ahead of time for live monitoring in an area they intend to pass through or visit. This also allows them to plan their route better by seeing if there are alternative ways to reach their destination without passing through areas with a poor $PM_{2.5}$ score.

Live alert system for all users when a particular area or underground station in London has been identified to have a dangerously high level of $PM_{2.5}$. This also sends a push notification to all companion app users.

We use the most recent $PM_{2.5}$ data readings (μg/m³) and map them to a discrete 1–10 scale using established UK DEFRA categories - these are based on the daily mean concentration for historical data, latest 24 hour running mean for the current day.