Mobile Monitoring Deployment Strategy

Introduction

The Breathe London strategy for collecting mobile air quality data required that roads be sampled repeatedly over the span of the project to approximate a central tendency of air pollution at each sampled location. On the basis of previous mobile monitoring campaigns conducted by Environmental Defense Fund (EDF) in Houston and Oakland, 15 repeat drives was the estimated target number for each road segment (defined as approximately 30 metre [m] road intervals). However, due to local conditions like traffic congestion the spatial coverage and repeat drives were less than initial estimates. In the end, Breathe London required a minimum of five visits for each road segment in order to report a median value. More about the central tendency analysis and results from the mobile monitoring campaign can be found in the Mobile Hyperlocal Insights report.

The Breathe London project team created a mobile deployment strategy to sample as much of the road network as possible across Greater London. While also satisfying this minimum repeat criterion. The deployment strategy defined areas ("polygons" or "transects") to be driven repeatedly throughout the campaign.

- Polygons are the unique geographic boundaries defined by the project where mobile data collection was conducted. Polygons were selected to cover representative areas like town centres
- Transects are drives across the city (i.e. east to west profile) or between polygons that allowed mobile data collection whilst commuting between two locations

Over the course of the project, modifications to the deployment strategy were made in an effort to ensure sufficient drive coverage in each of the polygons in order to support the highest priority objective of obtaining an understanding of the baseline air pollution in the Ultra Low Emission Zone (ULEZ).

This document summarises the phases of mobile data collection in the Breathe London mobile monitoring campaign.

TABLE 1

Summary of mobile data collection phases

Phase 1 (28 Aug 18 – 5 Feb 19)	All polygons, full road coverage (Inner London emphasis)
Phase 2 (5 Feb 19 – 24 Apr 19)	Intensively drove only sub-polygons in lead up to ULEZ implementation on 8 April 2019
Phase 3 (24 Apr 19 – 21 Aug 19)	Inside ULEZ full road coverage in sub-polygons, reduced road coverage in all other locations Outside ULEZ all but one Inner London polygon driven with reduced road coverage *Discontinued driving in Outer London polygons*
Phase 4 (21 Aug 19 – 31 Oct 19)	Inside ULEZ full road coverage in sub-polygons, reduced road coverage in all other locations Outside ULEZ sub-polygons with reduced road coverage

Phase 1

Phase 1 of driving represents the initial mobile deployment strategy and occurred between 28 August 2018 and 5 February 2019. This covered all selected polygons and transects, according to the following criteria:

- Full coverage within the ULEZ boundary
- Outside of the ULEZ, polygons were selected using a stratified sample of high/low deprivation[1] and high/low modelled NO_2 concentration from CERC's ADMS-Urban model output
- Additional polygons were selected to cover some town centres and low-emission neighborhoods
- Transects and mini-transects were selected to obtain coverage in boroughs without a polygon

This initial phase included a total of 51 driving polygons, as well as several transects, with at least one polygon or transect in each London borough (n = 32 plus the City of London). Sampling occurred on all roads within a given polygon except for dead-end streets, which were removed to prevent vehicle self-sampling and reduce time spent turning the car around.

All polygons, transects and mini-transects that were initially selected were driven at least once during Phase 1.

[1]English Indices of Deprivation 2015 https://www.gov.uk/government/statistics/english-indices-of-deprivation-2015

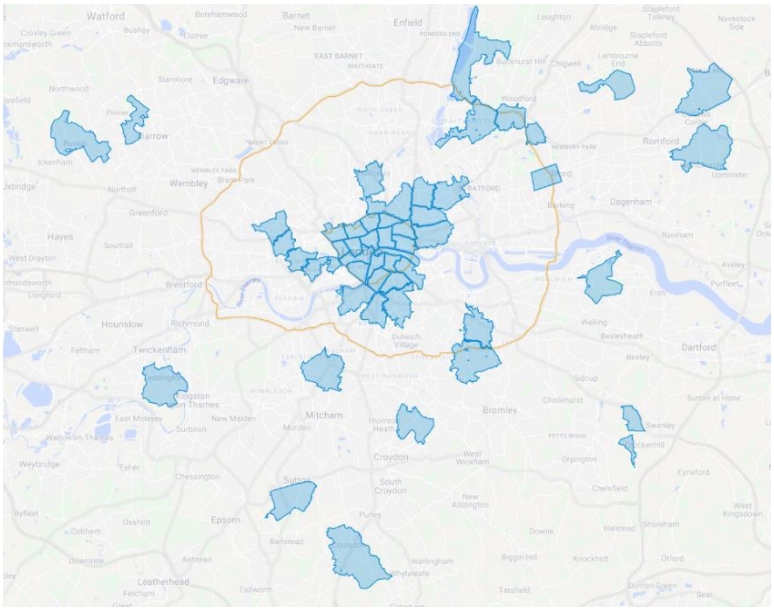

FIGURE 1

Map of Greater London showing Phase 1 deployment strategy, excluding transects. Polygons where all roads within the boundary were driven are indicated by the blue shaded areas. For reference, the orange line represents the North and South Circular ring roads around Central London and other main roads are indicated by the lighter lines.

Phase 2

As the driving campaign extended into 2019 and we reviewed the initial coverage, we observed more down time and fewer completed polygons per shift than expected. This was due to congestion, which caused longer commutes between the National Physical Laboratory (NPL) offices where the Google Street View cars were parked each night and the polygons. This increased the time needed to drive assigned roads within polygons. In an effort to obtain essential data in and near the ULEZ boundary prior to implementation (i.e. a target of 15 visits per polygon prior to ULEZ implementation), the project team developed Phase 2 of mobile data collection. This phase began on 5 February 2019 and extended through 24 April 2019.

During Phase 2, mobile data collection was limited to a reduced set of sub-polygons prioritised using the criteria below. All roads within these sub-polygon areas were driven during this phase.

Phase 2 sub-polygons were selected which:

- Contained either a Breathe London AQMesh or existing London air quality regulatory monitor
- Were expected to exhibit a range of impacts from ULEZ implementation
- Included areas outside of the ULEZ to serve as controls
- Had the highest number of completed drive passes at the time of selection

In an effort to increase the number of polygons covered, the project team also hired a fourth driver, who started on 8 April 2019.

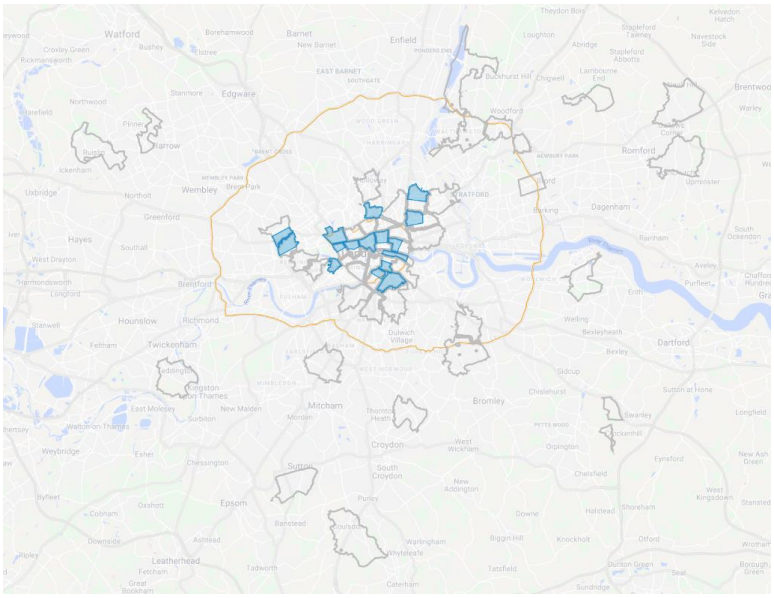

FIGURE 2

Map of Phase 2 deployment strategy, excluding transects. Polygons where all roads within the boundary were driven are indicated by the blue shaded areas and polygons with no active driving in Phase 2 are indicated by the hollow polygons. For reference, the orange line represents the North and South Circular ring roads around Central London and other main roads are indicated by the lighter lines.

Phase 3

After ULEZ implementation, the project team expanded mobile data collection to cover most of the Phase 1 polygons within Inner London but excluded polygons in Outer London and excluded the coverage of transects. During this Phase 3, which began 24 April 2019 and extended to 21 August 2019, mobile data collection was conducted across the entire ULEZ, with full road coverage in sub-polygons (smaller regions of polygons), and thinned road coverage in all other locations. (Using road classifications in the Google Street View system, we were able to remove smaller roads from the drive plan, leading to a road network thinned by ~25% in an effort to expedite polygon coverage.) Phase 3 polygons outside the ULEZ were covered using the thinned road network.

Obtaining 15 repeat passes per road segment under the Phase 3 spatial coverage (intermediate to Phases 1 and 2) was ambitious at the rates obtained in Phase 2. However, with a fourth driver, a modestly thinned road network, and a possible 2-month extension of the driving campaign, our forecast suggested we could come close. As we had in Phase 1, we planned to continue tracking our progress and allow for further adjustments to the driving plan.

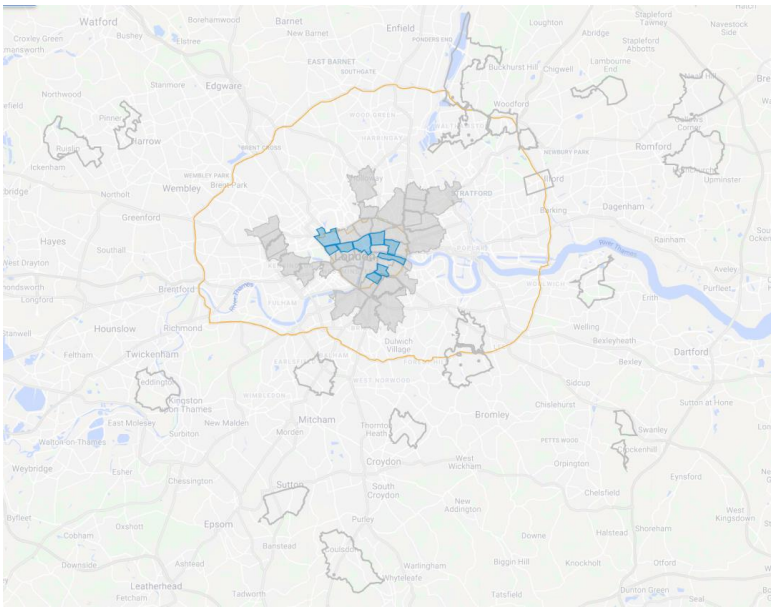

FIGURE 3

Map of Phase 3 deployment strategy, excluding transects. Polygons where all roads within the boundary were driven are indicated by the blue shaded areas, polygons with no active driving in Phase 3 are indicated by the hollow polygons, and polygons with reduced driving are indicated by the grey shaded areas. For reference, the orange line represents the North and South Circular ring roads around Central London and other main roads are indicated by the lighter lines.

Phase 4

Due to higher than expected downtime in Phase 3, our monthly rate of polygon coverage did not substantially change. In order to obtain the target number of passes prior to the project's completion, we moved to a Phase 4 of driving starting in late August 2019. In this phase, driving within the ULEZ zone was unchanged from Phase 3 (full road coverage in sub-polygons and reduced road coverage in all other polygons). Driving in the Inner London polygons was scaled back to include only the sub-polygons driven in Phase 2, with thinned road coverage.

With this phased approach to driving, the project was able to adapt to driving conditions to collect enough data for analysis. In future, projects we recommend to regularly assess coverage, as we did in Breathe London, to ensure data objectives are met and that adjustments can be made, as necessary.

FIGURE 4

Map of Phase 4 deployment strategy, excluding transects. Polygons where all roads within the boundary were driven are indicated by the blue shaded areas, polygons with no active driving in Phase 4 are indicated by the hollow polygons, and polygons with reduced driving are indicated by the grey shaded areas. For reference, the orange line represents the North and South Circular ring roads around Central London and other main roads are indicated by the lighter lines.