Ultrafine Particles (UFP) - What they are, and how to measure them



Brian Stacey, Heathrow Air Quality Working Group

UKACCs annual meeting, 13 October 2026

Heathrow

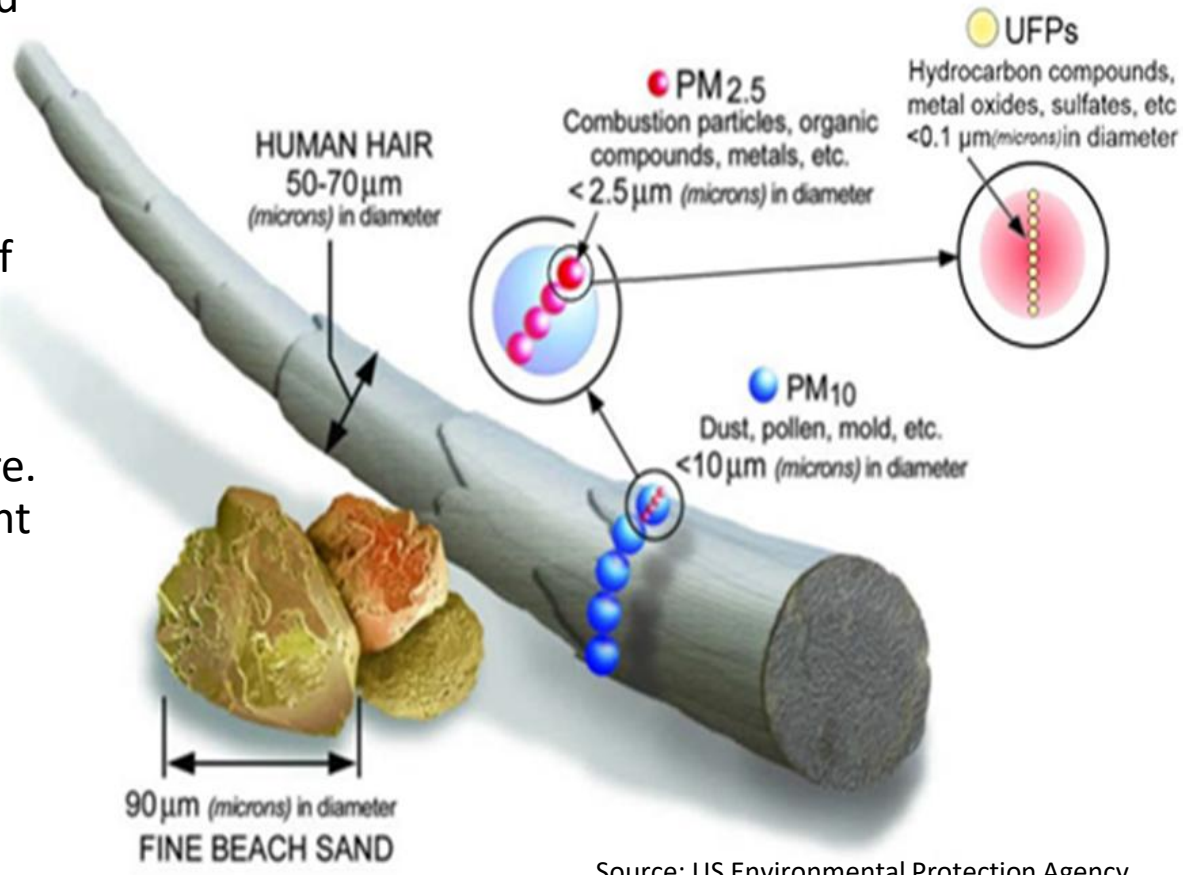
BRIANAIR

Agenda

- UFP – what is it?
- Measurement of UFP – the scale of the challenge
- Airport UFP – it’s not “typical”
- UFP – legislation?
- Key takeaways

UFP

- Ultra Fine Particles (smaller than $PM_{0.1}$). UFP can be reported as total particle number concentration and/or particle size distribution.
- Why is UFP important? They have very little mass, but lots of them in the atmosphere. Links to adverse health effects
- Only WHO guidance for what high and low concentrations are. Not enough medical evidence to set limits (yet). (Requirement to monitor in EU AAQD). Composition of UFP not currently considered
- Standard method available for particle counting, similar document for particle sizing in preparation.
- Continuing – and sometimes conflicting - research (HAL, LAX, Schiphol, Copenhagen, Boston, etc)



Source: US Environmental Protection Agency

UFP vs PM_{10} and $PM_{2.5}$

$PM_{10}/PM_{2.5}$	Ultrafine Particles
• Weigh all particles smaller than 10 or 2.5 microns in size • Standard method (gravimetry) • Equivalence method for automatic measurements • Very mature technology • Not all particles behave the same	• Count all particles from 0.01 to 1 micron in size. • Can count and / or size particles • Standard method for counting • Technical Specification for sizing • Accepted protocol for field operations • Accepted protocol for calibration • No agreed method to demonstrate equivalence • Still relatively immature technology • Extraordinarily expensive! • Not all particles behave the same

*Note: 1 micron = 0.001 mm. 1 micron = 1000 nanometre (nm). 10 nm = 0.01 micron

BRIANAIR

The scale of the problem

UFP (and PM) is a cocktail of many (many!) components…

- Carbon
- Volatile / Non-volatile
- Organics / Oils
- Anions / Cations?
- Metals?

- Variation in composition and size, depending on source type, location and ongoing physical and chemical processes

- Defra PN network (Marylebone Road, Honor Oak Park, Horley (close to Gatwick Airport), Chilbolton, Auchencorth Moss, plus research locations at Birmingham and Manchester Universities)

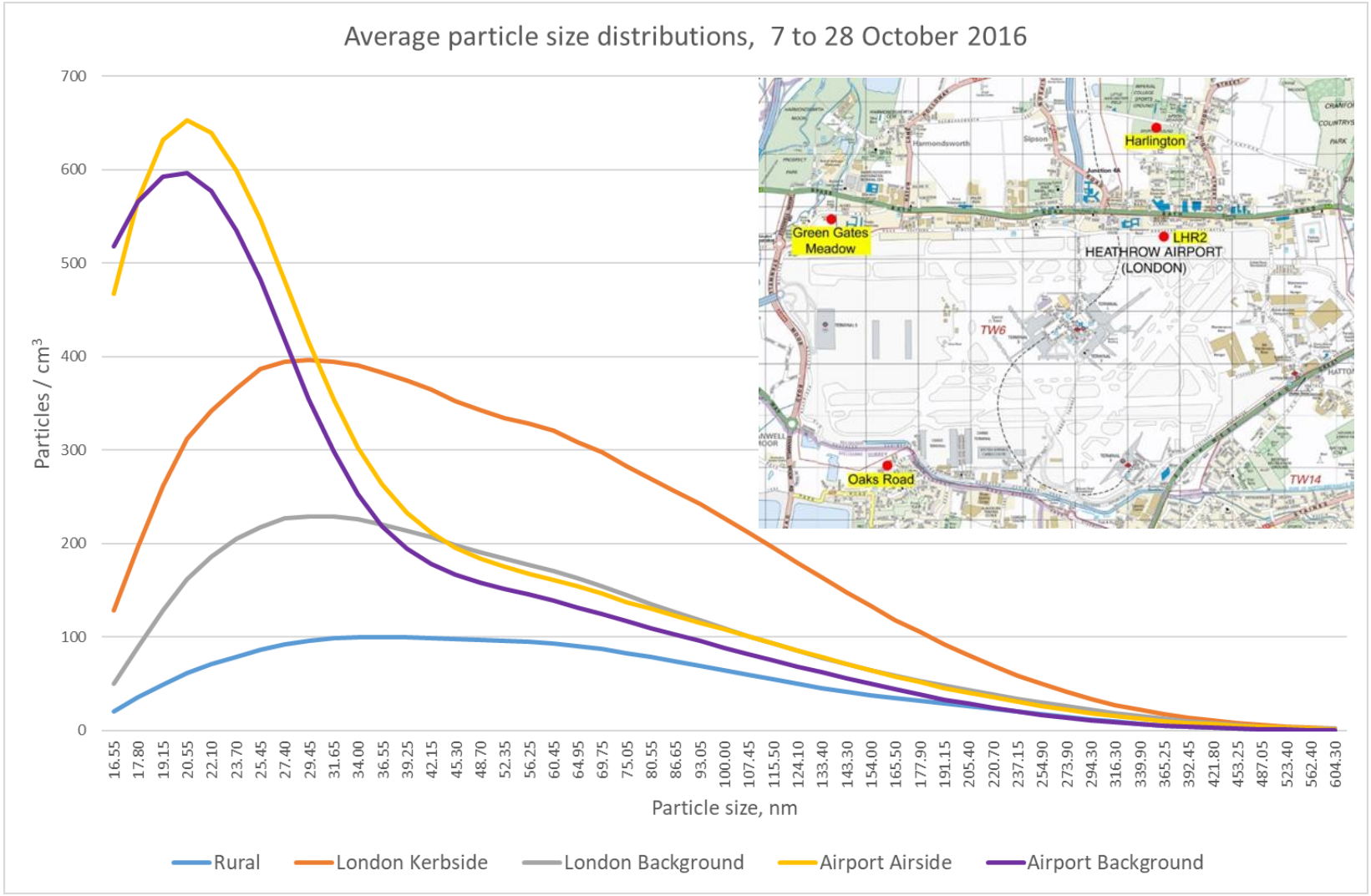


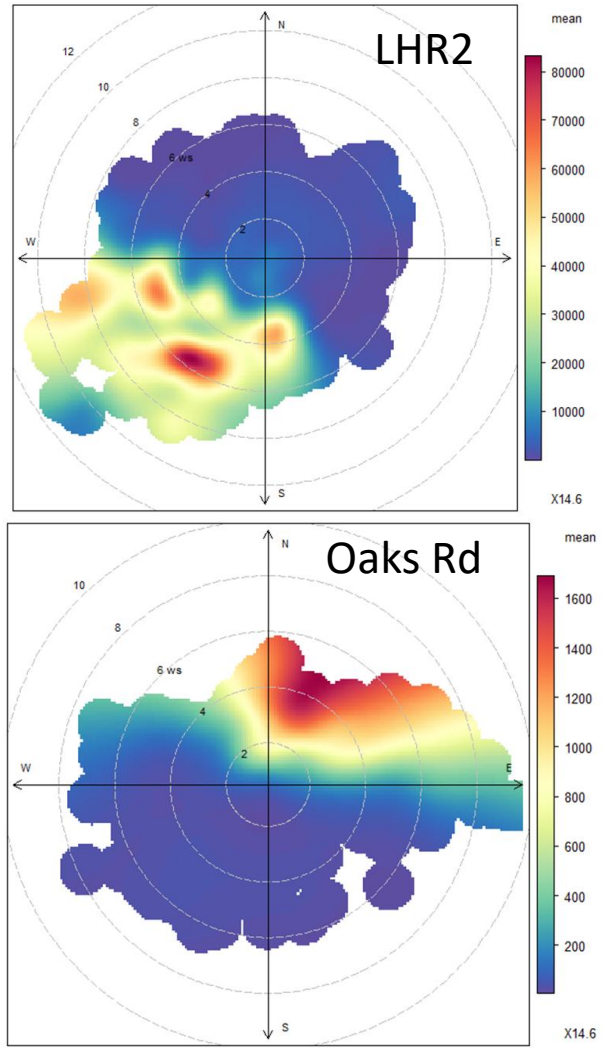
Q: are all instruments able to measure all the components…?

BRIANAIR

Historic UFP measurements at Heathrow Airport

Particle size distribution different at airport, smallest particles clearly originate from airfield





New research at Heathrow Airport

3rd Runway!

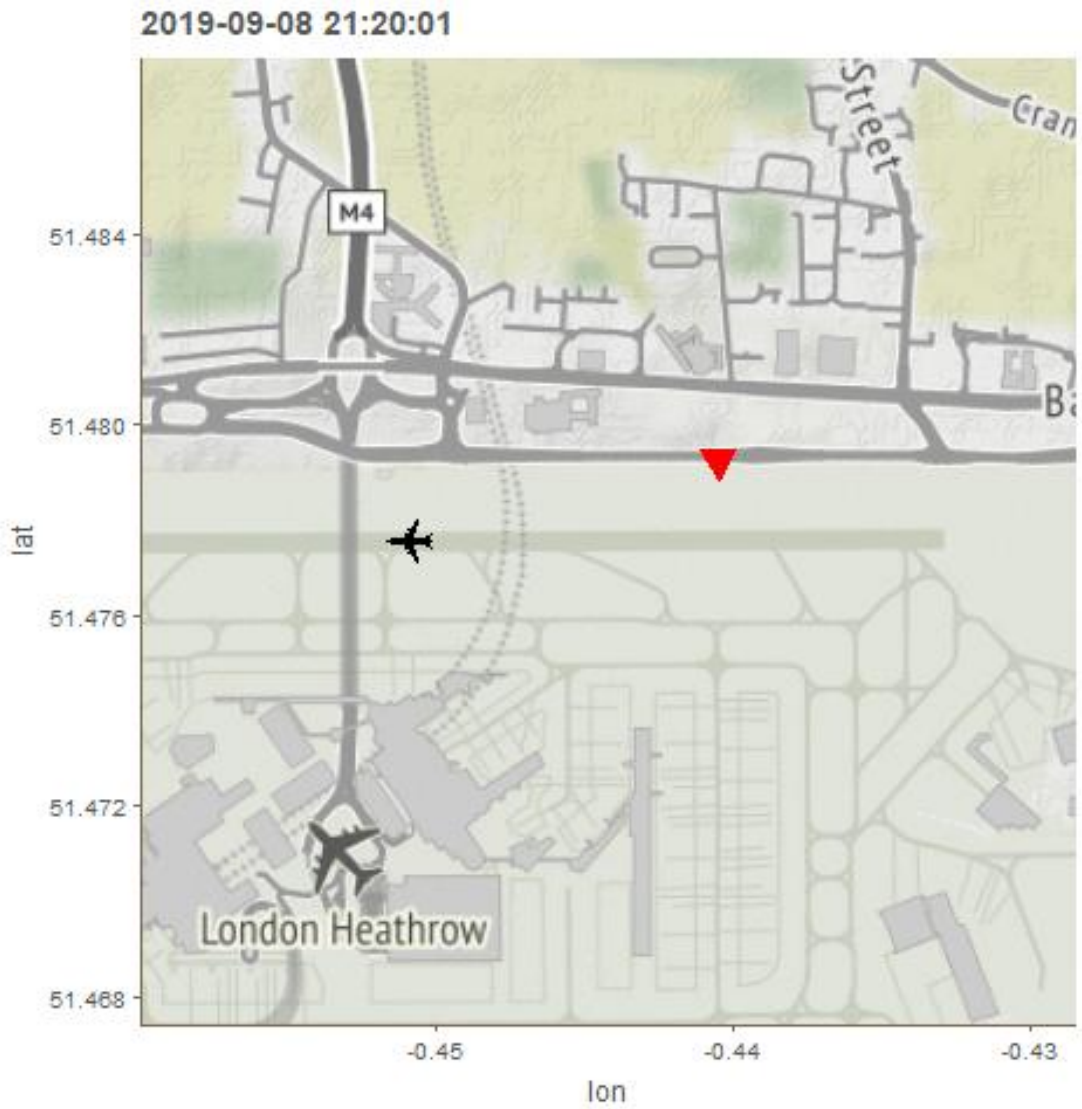
Many-pronged attack:

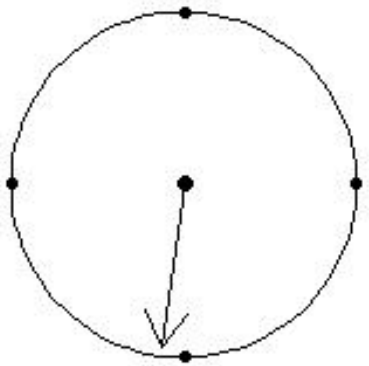
- Look at how different techniques and configurations compare
- Effect of changing fuel composition
- Volatile / non-volatile split
- Concentration gradient
- Changes in PSD profile
- Particle charge
- Rapid measurements

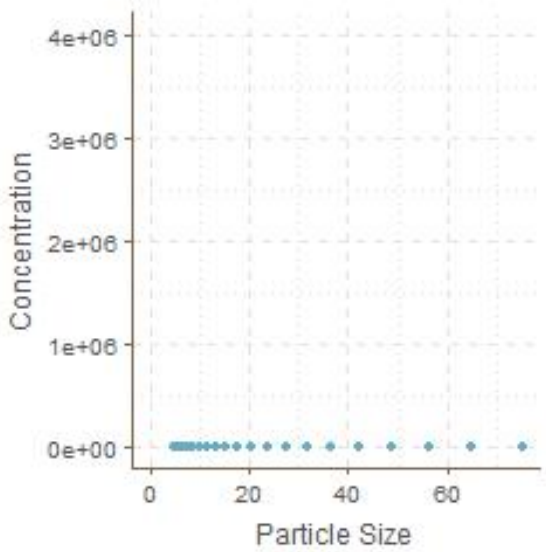


BRIANAIR

Very fast UFP measurement







New research will compare different techniques and add fast gas measurements e.g. CO_2

More data will be collected in 2026 and 2027

BRIANAIR

Why all the interest in aircraft UFP?

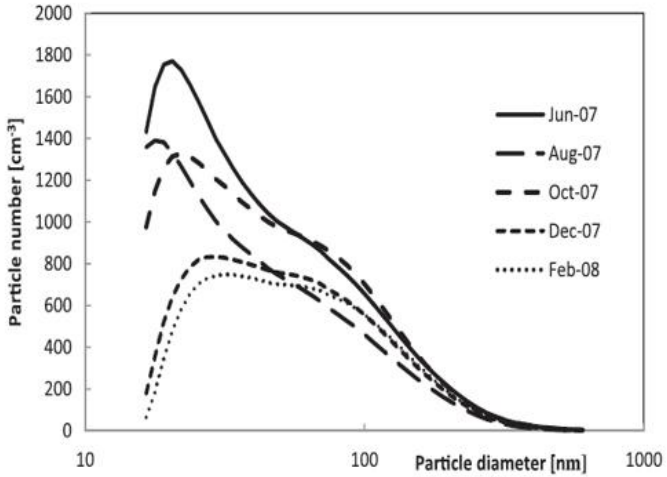


Fig. 7. Marylebone Road - monthly mean particle number size spectra.

Source: Jones et al, Atmospheric Environment 50 (2012), 129-138

- Developing knowledge of health impact of UFP exposure
- Aircraft emissions are a known major source of UFP
- Aviation community actively researching mitigation strategies (low sulphur, low aromatic fuels, sustainable aviation fuel)
- Improved fuels likely to reduce UFP concentrations and the probability of contrail formation



BRIANAIR

Novel sensing technologies

- Reference method instruments are very expensive, complicated and require lots of expert user interaction. Data processing is equally challenging…

- Can sensors provide an alternative solution for UFP measurements? Electrometers (both portable and rack mounted) and miniature CPCs are available (and cheaper)



Legislation

- No mandatory limit values or targets that regulate exposure to UFP. WHO has provided best practice guidance for particle number concentrations over 1 hour and 24 hour periods
- EU Directive EU/2024/2881 will require European Member States to undertake UFP measurements from 2027, but no target values are specified. This is NOT applicable in the UK
- Standard methods are configured to count particles larger than 10nm – but we know that aircraft emit large quantities of smaller particles
- UK Air Quality Expert Group (AQEG) are writing a position paper specifically for airport related UFP
- Non-standard methods are (very!) likely to report differently (e.g. water CPC, electrometer, effect of particle size / composition)
- Calibration! Traceability!! Repeatability!!!
- Ongoing QC really important if data quality is a key driver

WHO Guide	Concentration (#/cm^3)
Low (day)	Less than 1000
High (hour)	More than 20,000
High (day)	More than 10,000

BRIANAIR

Key takeaways

- This is a changing topic area
- UFP at airports are smaller in size and higher in concentration than “normal” environments
- Measurement (and definition) is evolving and challenging!!!
- There is considerable ongoing research; the aviation industry has a keen interest to be a part of this process
- More cost effective measurement will help to improve knowledge
- Definitely a growing interest in measuring UFP, not just at airports
- QA/QC important if defensible data is required (help is available!)
- Defensible data needed to establish exposure / health links (and set limits)

Useful links / documents

- https://assets.publishing.service.gov.uk/media/6a338de5e590e5e061c9a1f2/air-quality-support-for-review-of-anps-review-of-airside-emissions.pdf
- https://etheses.bham.ac.uk//id/eprint/13013/
- Ricardo UFP Literature review for LCY (2026 – freely available on request)
- https://www.sustainableaviation.co.uk/publications-and-resources/our-publications/ultrafine-particles-white-paper/
- https://uk-air.defra.gov.uk/networks/network-info?view=particle
- https://eur-lex.europa.eu/eli/dir/2024/2881/oj/eng
- https://iris.who.int/server/api/core/bitstreams/551b515e-2a32-4e1a-a58c-cdaecd395b19/content

(EN16976 (PNC) and TS17434 (PSD) available to purchase from BSI)

BRIANAIR

Thanks for listening!



BRIANAIR