

HARMO 11 – Airports session

Modelling airport air quality – broader policy context

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The importance of modelling

- Airport air quality modelling is a vital means of understanding the effects of airport operations on pollutant levels in nearby communities
- Modelling airport emissions is highly complex given the large number of sources but much depends upon the results of modelling
- Modelling for predicting air quality futures is increasingly important – as the stakes rise, accuracy and reliability are paramount

Who relies upon modelling information

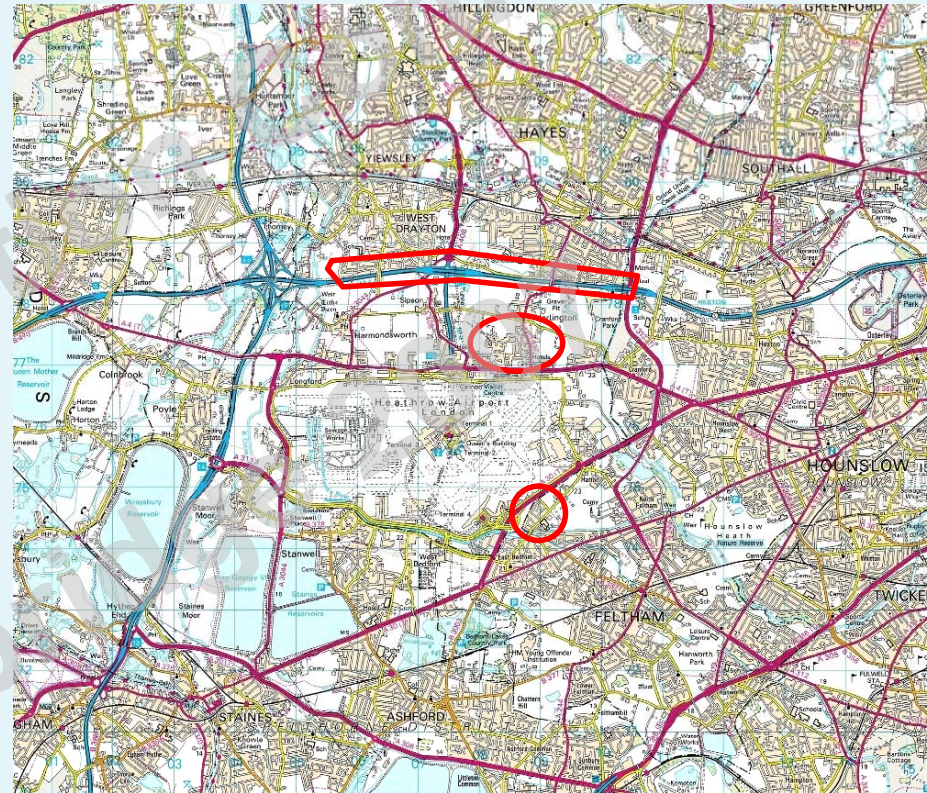
- Government – compliance and policy planning purposes
- Local authorities – air quality management planning
- Airports - for policy and mitigation strategies, including charging
- Airlines – fleet and operational sensitivities
- Airside operators – as above

And of course.....

- The public – safe air to breathe

A lot is riding on modelling.....

Increasingly seen as a major part of the process of strategic development planning, environmental impact assessment (EIA), the formal planning processes..... and that will only more pointed as standards are either tightened or come under pressure from growth.

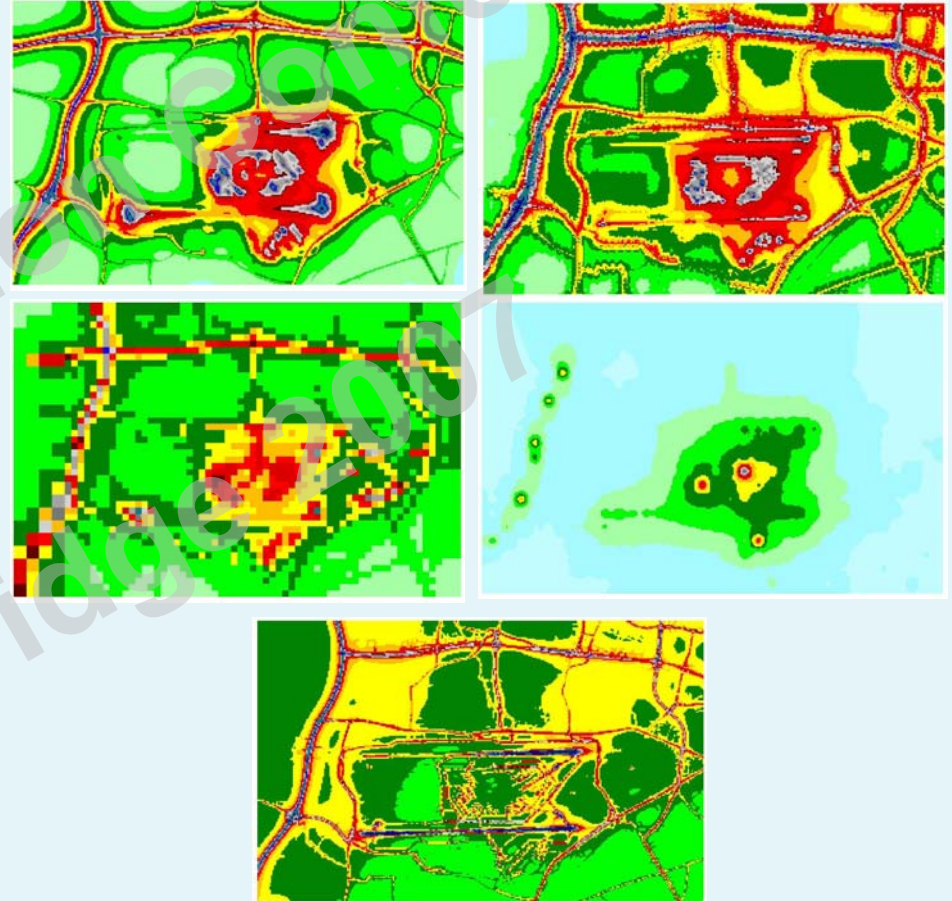


Realities of the airport emissions debate

- Its getting harder to reduce key emissions
- Pollutant standards are tightening
- The reality of trade-offs
- Pressures are growing disproportionately on aviation
- Public expectations are increasing
- Growth is threatened
- Challenge is more likely.....
- 'INFORMATION IS KING'

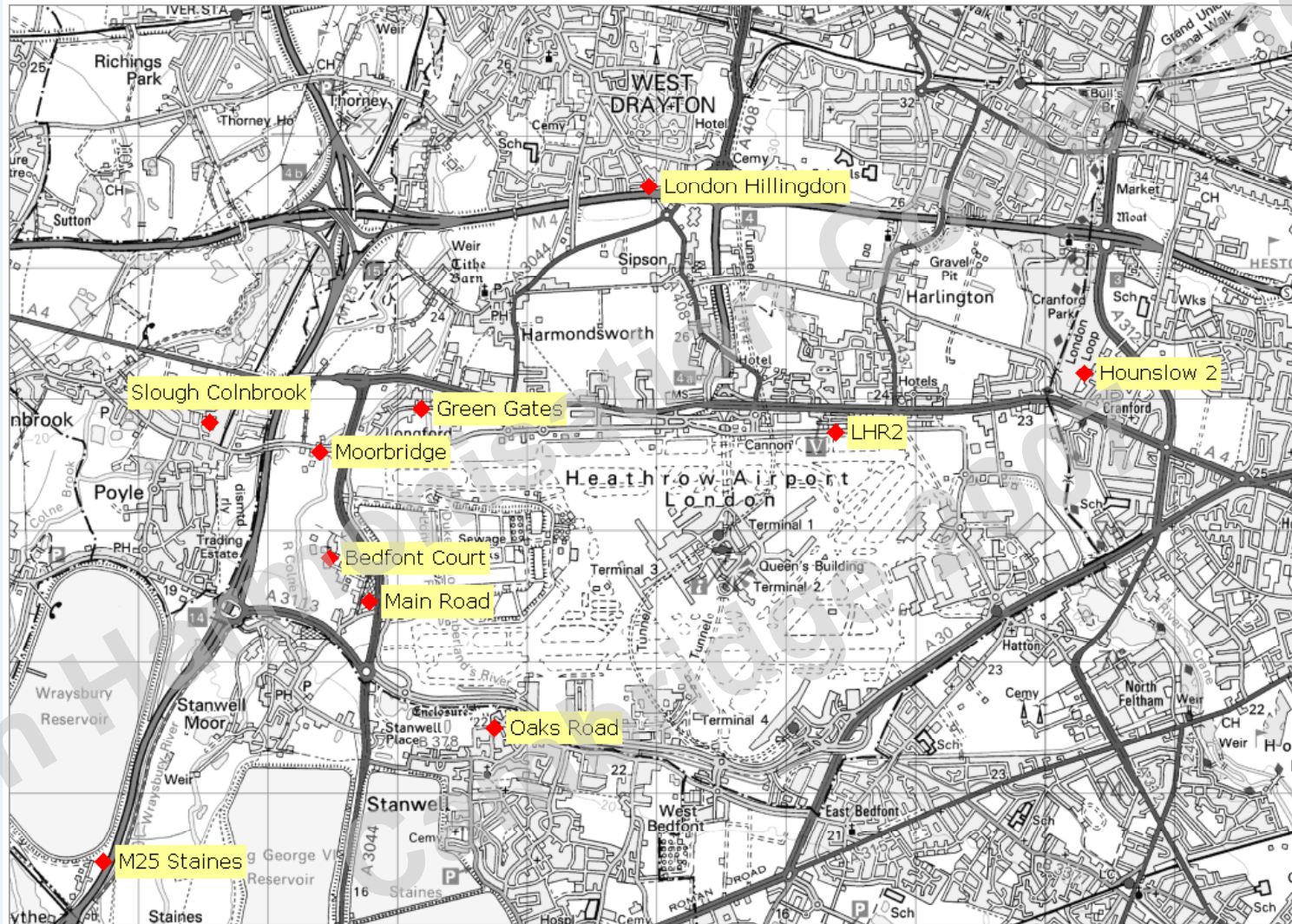
Confidence in results

- As pressures increase, modelling will be viewed as a legal battleground
- Modelling approaches can be pitted against each other so...
- Transparency, QA and validation become ever more important – need to have a visible audit trail



Take the Heathrow example

- Already exceed NO₂ 2010 level but is subject to strong growth and plans for 3rd runway
- Most densely monitored urban air quality in Europe
- Subject to DfT, local authority, BAA and BA air quality modelling before and after Air Transport White Paper
- Project for the Sustainable Development of Heathrow (PSDH) technical panel process
- Much depends upon the results of predictive modelling of growth scenarios
- Heathrow's pressures will soon be felt elsewhere



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A partnership to meet the environmental challenge of aviation growth

Difficulties looming

- Cars getting cleaner so aviation looms larger
- Predicted demand pressures
- Pace of technology response
- Aircraft size growth adds complexity
- Air transport system structure and business models
- Containment within airport boundary?
- Measurement and modelling become decisive tools

Attribution

- Targeting the right sources at specific locations – poor information can cost big money
- Modelling output may only be as good as the inventory input and the source codes but the need for solid information that unpicks the various sources is essential
- Airports can have dozens of contributing sources
- Getting the background level right also matters

Modelling amid other improvements

Continuous improvement expected in **ALL** areas

- Improved emissions source characterisation
- Technology advancing – aircraft & other sources
- Airport air quality planning greatly enhanced
- Wide range of mitigation strategies
- Smarter operations
- Better predictions
- **Better monitoring and modelling**

The future matters as much as the present

- Modelling has a large role to play in future assessments of aviation impacts
- Horizons are 25+ years – DfT White Paper, ICAO goals
- Difficulty in knowing how the emission sources perform but also.....
- Future meteorology and ozone trends, background emissions, etc



Increasingly international perspective

- International Civil Aviation Organisation (ICAO) uses AQ modelling for:
 - Examining the need for tightening source emission standards
 - The trade-offs debate (between emissions, with noise and with altitude emissions impacts)
 - Progress checking against long-term goals



Comparison and verification

- Similar to Heathrow PSDH, ICAO has undertaken a model inter-comparison exercise for a 'sample problem'
- Checking model operation, capabilities and application
- Getting groups and developers together
- Next step is to develop ICAO Air quality guidance on modelling (and measurement)
- Further scrutiny of how modelling works and how it is applied

Areas of uncertainty

- Initial dispersion of aircraft emissions, especially during take-off and landing
- PM emissions from several sources
- Refinement of attribution analysis



...and to finish

How does Omega fit in?

- UK Government supported knowledge transfer activity that strengthens the academic contribution to addressing key aviation sustainability questions
- Goals: understand problems, advance solutions, enhance sustainability
- 9 universities working with key stakeholders on air quality noise and climate - study, dialogue and innovation
- 17 studies so far, more to come
- Raise the knowledge threshold and provide core information

Omega AQ studies

Main thematic area: Science

Aircraft Plume Analysis Facility (ALFA) Secondment

Summary
Omega is funding acquisition of core expertise from Germany on particle measurement and analysis to support optimum development and utilisation of the world-class ALFA aircraft plume and analysis facility. The enhanced capability, in place by September 2007, will be deployed to help answer open questions on the physics of aircraft emissions dispersion.

Background
One of the biggest uncertainties in assessing the impact of airports on local air quality is the composition of aircraft exhaust, in particular, gaseous and particulate emissions. Until now, in Europe there has been limited capability to measure these kinds of emissions in the dynamic environment of the aircraft exhaust plume because of the lack suitable sampling equipment.

About the aircraft plume analysis facility
The facility, being developed at Manchester Metropolitan University (MMU), will develop a world class plume analysis capability and is the first of its kind in Europe. It will enable improved understanding of plume composition and local dispersion. In particular, it will facilitate:

- building of a database of operational aircraft emissions;
- a better understanding of the complex physics and chemistry within the plume;
- development of insights into the environmental impacts of operational controls such as reduced thrust and fuel modifications including bleedless.

A secondment from the German DLR (Institute for Atmospheric Physics) to MMU will be funded to draw in key expertise in particle measurement and analysis.

Lead partner: Manchester Metropolitan University Duration: 3 months



Omega into Wedge transfer. Secondments are an important element in Omega's knowledge transfer philosophy and it is expected that this project will strengthen expertise and help communicate findings to stakeholders like airports.

The secondment will provide a bridge between the design of the probe – used to sample engine exhaust emissions – and the measurement equipment. In particular, the secondment will use sophisticated Aerodyne high resolution mass spectrometer to measure particulate matter.

Data derived from ALFA with the expertise through the international support will represent a step forward in understanding available to Omega stakeholders in the critical area of plume dispersion and its effect upon modelled air quality concentrations. It will assist Omega in becoming the European leader in aircraft plume analysis. The facility will contribute towards more accurate modelling and hence remove uncertainty that is affecting the development potential of the aviation sector at a regional, national and international level.

Main thematic area: Science

Aviation Emissions and Their Impact on Air Quality (AETI)

Summary
This study constitutes a major advance in the measurement of air quality at airports. It will involve the measurement of the dispersion and evolution of emissions released from aircraft engines both while aircraft are on the ground and in flight.

Background
Emissions produced at airports affect the level of pollutants in neighbouring areas. Air quality is impacted by a variety of airport sources, with pollutants being emitted by aircraft, airside service vehicles, power and heating plants, and road traffic accessing or servicing the airport. One of the objectives of this study is to improve the methodologies or assessing the contribution of aircraft. In their take-off run, aircraft constitute a strong and intermittent source of emissions, making it difficult to establish their impact on mean pollutant concentrations nearby. This lack of understanding greatly hinders airports who need to develop air-pollution mitigation strategies.

Work package
The study will harness academic expertise in engine performance, aeronautics, environmental fluid dynamics and atmospheric physics and chemistry.

Series of field measurements will be carried out on a passenger jet aircraft at Cranfield University. The dispersion and evolution of emissions released from the aircraft's engines as it executes take-off and landing operations will be measured using a range of techniques.

Lead partner: Manchester Metropolitan University Duration: 12 months

A complementary series of studies place at British Airways Engineers Heathrow Airport. BA is a stakeholder study and their Environmental Ma Heathrow is being seconded to this project.



Aircraft in maintenance at Heathrow their engines test run through a test power settings in a noise-suppressing environment. This standardised environment will set of repeatable air-quality measurements to be obtained over a range of air. Data collected will complement all physical and chemical measurements exhaust plumes from aircraft obtained last two years at Heathrow at Manchester Airports.

Significance of results
Airport growth is conditional on co with national and international direct air quality. This study will provide data on aviation emissions and their dispersion and evolution at airport validation of regulatory and other models. It will also advance the data available to airports for the routine monitoring of air quality.

Understanding initial dispersion of engine emissions:

- modelling the dispersion of aircraft engine efflux in proximity to airports in an atmospheric boundary layer wind tunnel
- prediction of the mixing of engine exhaust gases
- jet-vortex interaction

This project examines the nature of the aircraft engine efflux, in terms of its gaseous and particulate emissions. With three discrete components to the work, it will examine aircraft emissions at all stages of operation – ground idle, taxi, take-off, climb, cruise and landing – in order to analyse and model the way emissions disperse and enable an in-depth analysis of pollutant levels.

Modelling engine exhaust gases
To produce accurate models for pollutant dispersal, part of the study will focus on building a precise picture of aircraft plumes during cruise (high altitude pollution) and for landing and take-off cycles (for local air quality assessments). Efflux from a jet engine is a very complex flow of hot fast gas and cold, slower moving gas. It is non-uniform, highly turbulent and has various velocity scales and chemical reactions.

Using computational fluid dynamics (CFD) – a process whereby numerical methods and algorithms are used to calculate and analyse fluid and gas flows – the project will construct an accurate model of the flow immediately down stream of the exit of engine and of the mixing process. It will result in a much better understanding of how the efflux from a jet engine forms into a mixed plume, and of the composition of the plume itself.

Jet vortex interaction
During take-off and landing the wings of an aircraft produce lift which in turn generates powerful trailing vortices. These vortices interact with the exhaust plumes from the engines and the way that jet efflux disperses as a result is altered. At present there is limited understanding of this phenomenon. Another element of this project will investigate the interaction between vortices and exhaust plumes.

Lead partner: Cranfield University Duration: 12 months

Main thematic area: Science

Researchers will develop a CFD model that is able to predict the combined jetvortex flowfield for distances of a kilometre or more behind the aircraft.



Modelling engine efflux in wind tunnel
The final element of the project will develop a sub-scale model of efflux dispersion in an atmospheric boundary layer wind tunnel. This simulates the conditions of an aircraft engine in flight so that the plume can be analysed in the context of atmospheric wind and upwind conditions. Very few data are available relating to the use of this technique for simulating aircraft engine exhaust plumes. This study will make it possible to assess key factors influencing plume trajectory and concentration levels in a number of simulated wind conditions and for a range of aircraft operations.

Understanding the factors that determine pollutant concentration levels around airports is a key objective. The three elements of this study will all contribute to a better understanding of the behaviour of aircraft engine efflux and thus how aircraft technology affects the atmosphere.

Characterising near-surface aircraft particulate emissions

Main thematic area: Science

Background
A key factor in the government's refusal to approve the building of a third runway at Heathrow was the additional emissions this would create. Pressures are greatest on ambient nitrogen dioxide (NO₂) levels around airports but particulate emissions are of growing concern. Mandatory EU standards for NO₂ from 2010 are focusing attention on improved understanding of source emissions and their dispersion. EC proposals to tighten standards for particulate emissions – 10 µm down to 1 µm – raise the stakes for source contributors at airports especially as PM from road traffic reduces. There is a need to know more about specific PM composition, number and size as this is of relevance to the health debate that underpins standards.

Project objectives
This project will enhance knowledge about aircraft PM through development and use of a cheap portable instrument to provide the capability to measure the size, composition and number of particles, in a size range relevant for human health (0.1 to 10 µm), in real time. No such instrument is available commercially. This instrument will be used to characterise aerosol and inform modelling in an airport environment and it will enable:

- a better understanding of the processes in engine emission and plume; this is essential if the actual apportioning of their impact on air quality is to be assessed;
- the taking of measurements to see if enhanced peak aerosol concentrations occur as aircraft induced vortices dissipate near the ground in the areas close to the airport. These measurements are required to verify dispersal models and identify pollution sources.

Knowledge transfer
This project combines academic knowledge and measurement with the expertise of airport stakeholders. An academic instrument used for engine tests provides opportunity to measure the emission characteristics of a different aircraft engines. This gives, for the first time, the particulate composition and engine type.

Given that the latest research on particulate composition, size and plume; this is essential if the actual apportioning of their impact on air quality is to be assessed.

Apart from providing airport stakeholders with a complete description of particulate emission project links with Omega act knowledge of wake and vortex dispersion of emissions. In it refine modeling capabilities and future predictive assess air quality.

Lead partner: University of Oxford Duration: 24 months

Conclusions

- Concentrate on getting a full understanding of what is produced by source and where it goes
- Refine models, especially on initial dispersion – **Omega** helping
- Continued comparison exercises help to improve all tools but don't expect harmonisation
- Models and modelling will increasingly need to be bullet-proof

Thank you for your attention

Any questions?

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