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UK AVIATION AND AIR QUALITY

An information paper: Our contribution, the challenges and opportunities

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Foreword

I am delighted to share this new Sustainable Aviation (SA) paper with you. It explores the effect of UK aviation on local air quality, illustrating the range of activities currently underway throughout the industry to minimise emissions. We also consider new opportunities to further reduce aviation emissions that affect local air quality.

This paper is a substantial body of work and I wish to thank the SA Air Quality Working Group and particularly the individuals, organisations and companies that took part in preparing it.

I am excited by the diverse and extensive range of activities already underway throughout the UK aviation industry to address our direct and indirect emissions. The range of innovative projects currently in progress also gives longer term confidence that significant improvements are feasible. The challenge will be how we all work together to realise these.

I look forward to working with Government and other stakeholders to realise opportunities to reduce UK aviation's contribution to local air quality. I welcome Government's recent consultation outlining their plans to incorporate aviation fuels within the existing incentive regime for renewable transport fuels to 2030. I am encouraged that the policy sets out a framework to 2030, providing much needed certainty in this area, and urge Government to embody this in UK statute to encourage inward investment.

Beyond this, SA believes there are further opportunities to review and improve policy in this important area so that in partnership we reduce aviation emissions further. I look forward to developing the opportunities highlighted in this paper with Government in the coming years.

Ian Jopson
Chair, Sustainable Aviation

Advisory Board Comment

The Sustainable Aviation (SA) Advisory Board works with Sustainable Aviation consortium to provide independent advice and feedback. It provides rigorous challenge to the SA Council in order to enable it to reach its cleaner, quieter, smarter goals effectively and efficiently.

The Advisory Board welcomes this paper by SA on how the industry both contributes to and seeks to minimise poor air quality around airports. After 10 years of SA action to strengthen the UK aviation industry's sustainability, it is appropriate to take stock of what the sector is doing on air quality and can do going forward.

This paper makes clear the wide range of activities that are being taken by the aviation industry nationwide to combat air pollution. Progressively over the years, this has moved from locally initiated actions that arose from discussions with local authorities to a more systematic sector wide approach to identify and implement best practice. From being a lower priority topic for many airports, it is clear that air quality improvement is now embedded with all airports both as part of their sustainability strategy and community engagement work. Engine manufacturers have long been focused upon pollution reduction and that trend continues but, despite a gradually improving air quality situation around airports, there remains a strong health-based imperative to maintain and increase that push. Good progress has been made with aircraft ground operational emissions reduction alongside flight operational procedures on take-off and approach.

As the first SA report on air quality, this paper sets out the range of current industry-led actions and commitments. Moving forward it will be important to seek the adoption of these actions across all airports and to innovate to maintain the positive trend. Specifically, having defined four valid areas for future attention - surface access emissions, airport specialist fleet performance, promoting adoption of sustainable alternative fuels and expanding research - SA should consider setting goals for airport and wider sector emissions improvement. It will be important to drive these and other initiatives forward, working with Government and local authorities, both at the SA and member levels so that the industry plays its full part in improving air quality. This paper makes clear that the UK aviation industry has established a good platform from which to progress that journey to cleaner, quieter and smarter aviation in the UK.

Roger Gardner
Sustainable Aviation Advisory Board

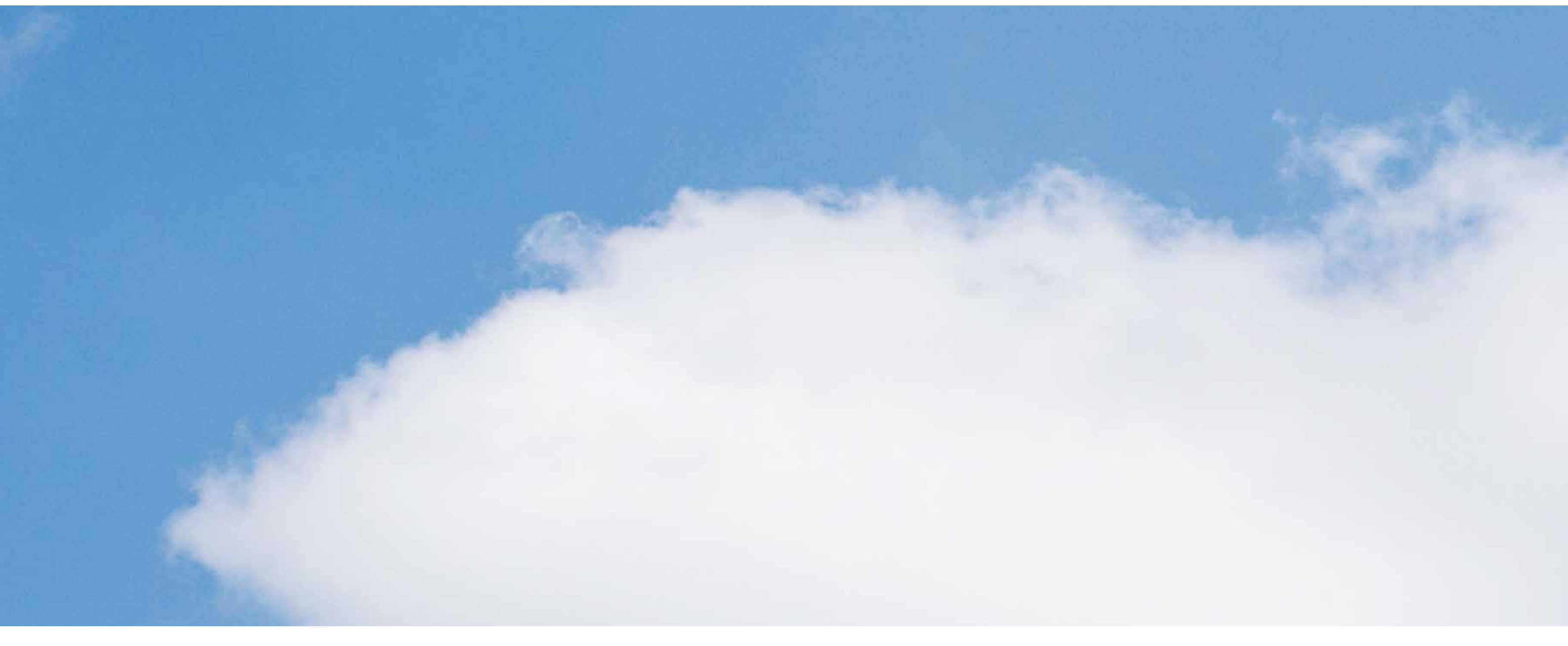
Executive Summary

For 10 years Sustainable Aviation (SA) has brought together all parts of the UK aviation industry. By working together we are stronger and we aim to build a more sustainable future for our industry. Aviation playing a full part in improving air quality around airports is one of our seven strategic goals.

With society increasingly concerned about the health impacts of poor air quality, and the issues increasingly under the media spotlight, this paper is a significant contribution to the air quality debate. Using an objective and evidence-based approach, we set out the emissions from aviation and how they impact air quality at and around airports. We also consider how the industry is responding to the challenge of minimising emissions. As Government continues to refine and improve its policy framework, we hope that this paper will provide a valuable input.

Nationally, emissions of key air pollutants are falling and are below Government's legally binding emission 'ceilings', however much remains to be done. Air quality is an important issue, across the UK over 600 locations have been identified by local authorities where health-based air quality objectives are not being met – just one top ten UK airport is located within any of these. The pollutants of most concern are small particulate matter (PM) and oxides of nitrogen (NO_X), in particular nitrogen dioxide (NO_2). Both are associated with combustion activities. Road transport is the emission source of greatest concern, contributing directly to poor air quality, particularly in congested urban areas where more people are exposed to poorer air quality.

Emissions at airports contribute only a very small proportion of overall UK emissions, with aircraft contributing 1% of UK NO_X emissions and 0.1% of UK PM_{10} emissions. At airports, which are generally located outside of cities, aircraft operations are the most significant source of emissions, with support vehicles and equipment, as well as vehicles accessing the airport also contributing.



The UK aviation industry has already delivered a wide range of emission reduction initiatives. These include changes to the way we operate, which can often deliver consequential benefits in other areas such as noise reduction or carbon saving. The UK is at the leading edge of aviation technology, manufacturers and airlines have introduced new aircraft with engines that generate fewer emissions by burning cleaner, and airports have promoted public transport as an alternative to the car.

Sustainable Aviation believes that it is important to focus on aggressively reducing emissions to improve air quality where it matters most. We welcome the focus Government places on reducing road transport emissions, and believe this is key to reducing overall UK emissions as well as those from road access to and from airports. A Government framework for well-connected airports, with high-quality 24-hour public transport opportunities, will reduce emissions and improve journeys for passengers and staff. We also welcome Government's policy support for 'off the shelf' ultra-low emission road vehicles, if this support were extended to specialist airport vehicles and equipment, such as electric aircraft push back tugs, it could help to further reduce emissions at airports.

Current aerospace research and technology goals are ambitious, targeting a 90% reduction in NO_x emissions from new aircraft by 2050. In addition, SA members are working to ensure UK airspace is used more efficiently and that the wide range of real-time flight information is used intelligently to reduce delays, improving passenger experience and reducing emissions.

To deliver these improvements we will need to continue to work collaboratively across all parts of the aviation industry. SA provides us with the platform to do so. We also need to work closely with other stakeholders, particularly Government. We ask Government to work with us in overcoming current barriers to cutting emissions which affect air quality. These include:

- Focussing on road transport and helping to improve surface access to airports;
- Expanding low emission vehicle policy support to specialist airport vehicles;
- Providing policy certainty so that the private sector will invest in alternative aviation fuels (including the extension of the Renewable Transport Fuel Obligation to jet fuel); and,
- Ensuring that research and development programmes continue to be supported during and after the process of the UK leaving the European Union to continue the excellent work we have underway.

Image: Airbus

Contents

Useful terms

Additive layer manufacturing	Additive manufacturing (sometimes also known as 3D printing) is a modern fabrication process that can use a range of materials to create three-dimensional parts that are built up layer by layer. This way of building parts offers great flexibility and opportunities for creating new products at low cost, whilst reducing the carbon footprint associated with manufacturing.
Air quality action plan	Air quality action plans are required to ensure that air quality objectives in a particular area where exceedances are occurring are met as quickly as possible.
Air quality limits	Limit values are legally binding parameters that must not be exceeded, and are set for individual pollutants. They are made up of a concentration value, an averaging time over which it is to be measured, the number of exceedances allowed per year, if any, and a date by which it must be achieved. Some pollutants have more than one limit value covering different endpoints or averaging times.
Air quality management area	If a local authority finds any locations where air quality objectives are not likely to be achieved, it must declare this as an air quality management area and draft an air quality action plan to achieve objectives as soon as possible.
Air quality strategy	The national strategy sets out a framework to achieve cleaner air that will bring health and social benefits, and identifies the key measures that are required and identifies where further work is needed.
Air quality objectives	The air quality objectives set targets for levels of certain pollutants in air and dates by which these must be met.
Air traffic movement	A single arrival or departure of an aircraft.
Airport consultative committee	In order for airports to communicate openly and effectively with their local communities and users of the airport about the impact of their operations, airport consultative committees have become a well-established way in which airports engage with key stakeholders in the local area and beyond.
Alternatively fuelled	Fuelled by a non-fossil-based fuel.
Co-benefits	Benefits obtained in other areas, above those expected in a target area.
Combustion plant	Engines, boilers or other plant where fuel is burned to provide power or heat.
Combustion process	The process by which a fuel (fossil or non-fossil) is burnt to provide some form of energy.
Concentrations of pollutants	The mass of a pollutant that exists in a specified volume of the ambient air.
Consolidation centre	Centres where deliveries are received, security screened and stored prior to being bundled together with other deliveries into as few deliveries as possible to airport sites.

Distributed propulsion	Distributed propulsion fully integrates the propulsion system within the airframe so that the aircraft experiences the full benefits of coupling airframe aerodynamics and the propulsion system. This aim is for larger aircraft to be powered by a large number of electric motors.
Emissions	A substance that is released into the environment – in this paper, from a man-made source affecting air quality.
Emissions ceiling	The total amount of a substance that is allowed to be released into the air over a given time period.
Emissions inventory	A summary of emissions by type (e.g. pollutant) and source.
Flightpath 2050	The EU's vision for aviation in 2050, which details how and where the European research priorities should be set to preserve EU growth and competitiveness worldwide, whilst meeting market needs as well as energy and environmental challenges.
Fossil fuels	Fuels derived from fossil sources such as petroleum and coal.
Ground level air quality	Ambient air quality as measured at nominal adult head-height.
Hybrid	Uses two or more distinct types of power, such as an internal combustion engine and an electric motor.
Interdependencies	The influence that changes to one environmental impact has on another. These can either be positive-positive (i.e. win-win), or positive-negative, where trade-offs may need to be considered.
Internationally agreed engine standards	Aircraft engine emissions standards, agreed by the International Civil Aviation Organisation's Committee on Aviation Environmental Protection.
Local air quality	In the context of this paper, ambient air quality near to the airport.
Reduced thrust take-off	Airlines have implemented take-off procedures involving a reduction in engine thrust settings to the minimum level required to take off based on the aircraft take-off weight, weather conditions and the length of the runway available.
Stakeholders	Individuals, groups or organisations that are interested in the activity of aviation or airports.
Surface access	Methods of access to the airport, not by aircraft, for passengers, staff and goods.
Sustainable aviation fuel	Fuel used by aircraft that has a lower carbon footprint than fossil-based kerosene and that meets other sustainability criteria.
Sustainable fuels	Fuel that has a lower carbon footprint than those derived from fossil sources
Syn-gas	Syn-gas is an abbreviation for synthesis gas, which is a mixture comprising of carbon monoxide, carbon dioxide, and hydrogen. The syn-gas is produced by gasification of a carbon containing fuel, such as woodchip, to a gaseous product that has some heating value.

Useful acronyms

ACARE	Advisory Council for Aviation Research and innovation in Europe
A-CDM	Airport collaborative decision making
APU	Auxiliary power unit
AQAP	Air quality action plan
AQG	Air quality guideline(s) recommended by the World Health Organisation
AQMA	Air quality management area
AQO	Air quality objective
AURN	Automatic urban and rural network (national air quality monitoring)
AVGAS	Aviation gasolene
CAD	Computer aided design
CDM	Collaborative decision making
CEM	Collaborative environmental management
CHP	Combined heat and power
CO	Carbon monoxide
CO_2	Carbon dioxide
COMEAP	Committee on the Medical Effects of Air Pollutants
CVP	Clean vehicle partnership
DEAP	Distributed electrical aerospace propulsion
Defra	UK Government Department of Environment, Food and Rural Affairs
DfT	UK Government Department for Transport
DP	Distributed propulsion
EU	European Union
FEGP	Fixed electrical ground power
HGV	Heavy goods vehicle
ICAO	International Civil Aviation Organisation
IT	Information technology
iTEC	Interoperability through European collaboration

LAQM	Local air quality management
LTO Cycle	ICAO Reference Landing and Take-off Cycle
NAQS	National Air Quality Strategy
NATS	National Air Traffic Services
NO	Nitric oxide
NO_2	Nitrogen dioxide
NO_X	Oxides of nitrogen
O_3	Ozone
OLEV	UK Government Office for Low Emissions Vehicles
PAH	Polycyclic aromatic hydrocarbons
PCA	Pre-conditioned air
PM	Particulate matter
PM_{10}	Particulate matter smaller than 10 micrometres in diameter
$PM_{2.5}$	Particulate matter smaller than 2.5 micrometres in diameter
R&D	Research and development
RET	Reduced engine taxiing
RTFO	Renewable transport fuel obligation
S106	Section 106 planning agreement (contains planning conditions)
SA	Sustainable Aviation
SAFED	Safe and fuel efficient driving
SESAR	Single European sky air traffic movement research
SO_2	Sulphur dioxide
TEOM	Tapered element oscillating microbalance (type of PM monitoring equipment)
UFP	Ultra-fine particles
UK	United Kingdom of Great Britain and Northern Ireland
VOC	Volatile organic compounds
WHO	World Health Organisation

1. Introduction

For 10 years Sustainable Aviation has brought the UK aviation industry together, to work towards a sustainable future for UK aviation.

The Government's Air Quality Strategy shows an improving picture regarding air quality generally but poor air quality still exists at some locations, predominately in busy urban areas, mostly as a result of road traffic. The Strategy identifies the key air pollutants of concern – at airports nitrogen dioxide and particulate matter are considered most relevant.

Members of Sustainable Aviation manage and improve local air quality, often in collaboration with local authorities and other stakeholders.

The Sustainable Aviation Advisory Board has provided independent rigorous challenge to our work, and has overseen to the production of this paper.

MEMBERS

SIGNATORIES

1.1 Sustainable Aviation

Launched in 2005, Sustainable Aviation (SA) brings together the main aviation players – from UK airlines and airports, manufacturers and air navigation service providers – to set out a collective and long-term strategy to ensure a sustainable future for UK aviation. For the last ten years, SA has been entirely focused on finding collaborative ways of improving environmental performance and ensuring sustainable growth.

The SA work programme is focused around seven strategic goals. Since 2005, SA has recognised the importance of improving air quality around airports by reducing emissions and ensuring that aviation's contributions are effectively monitored and managed.

SA Local Air Quality Strategic Goal

Industry to play its full part in improving air quality around airports.

Through its Progress Reports, SA has regularly reported on the work carried out throughout the UK aviation industry to reduce emissions that affect air quality. These Reports are available on the SA website. This work is broad-ranging and will be explored throughout the rest of this paper.

The members and signatories of SA represent over 90% of the UK aviation industry, with many having a global reach.

1.2 Air quality

The last UK Air Quality Strategy (Defra, 2007) painted a positive picture, reporting progress and improving air quality over recent decades. Air in the UK is now cleaner in overall terms than at any time since the industrial revolution. However, this does not negate the fact that poor air quality does still exist in some areas with potentially serious adverse effects, both to human health and ecology.

Government estimates that air pollution reduces the life expectancy of every person in the UK by an average of 7-8 months. In recent months the Committee on the Medical Effects of Air Pollutants (COMEAP), who advise the Government on the health effects of air pollution, has concluded that evidence associating nitrogen dioxide (NO_2) with health effects has strengthened in recent years (Public Health England, 2016). The Department for Environment, Food and Rural Affairs (Defra) have identified impacts of poor air quality upon animals, plants, biodiversity and crop yields (Defra, 2013).

Like many nations, the UK is facing difficulties in meeting air quality objectives for concentrations of NO_2 alongside some of the UK's busiest roads (Defra, 2015). As a result, much of the interest in UK air quality has centred on urban areas where poor air quality has been driven predominantly by road traffic. Interest in air quality has recently heightened, with considerable media attention focusing on vehicle emission testing scandals and legal challenges regarding the Government's approach to air quality objectives.

A number of studies have reviewed the impact of emissions from aviation at all levels, including emissions from aircraft at cruise level and also locally to airports. The United Nations International Civil Aviation Organisation (ICAO) has identified that emissions from aircraft operations are only a ground-level air quality concern when they occur below 1,000 feet above the ground (ICAO, 2011) – typically within a few miles of an airport. However, it is customary for airport emission inventories to consider the emissions from aircraft operations on the ground and in the air up to 3,000 feet or 1,000 metres above ground level.

Although the industry is working collectively to reduce emissions in all phases of flight, the management of air quality is a local matter overseen by airports – in partnership with other stakeholders including local authorities. Supporting the principles of Government's Aviation Policy Framework (DfT, 2013), this approach is consistent with the aviation industry's ambition to implement local solutions to local challenges, as well as with the scope of aviation's impact in terms of air quality.

Within that context, this paper sets out the current understanding of air quality issues related to airports in the UK, how air pollution is measured and actions being taken by the industry to reduce emissions of potential pollutants. The paper also highlights opportunities to deliver further emission reductions in the future.

1.3 Pollutants of concern

Historic air pollution, such as smoke and sulphur dioxide (SO_2), resulted from the use of fossil fuels for industrial and domestic purposes. The impact of these has, however, declined with improving technology. Currently the main sources of local air pollution are exhaust emissions from petrol and diesel vehicles, as well as emissions from housing and industry, which generate a range of emissions to air. Appendix A highlights a number of pollutants identified as important by Government within its Air Quality Strategy (Defra, 2007).

Despite significant improvements in air quality, concerns remain regarding a small number of pollutants in particular. NO_2 is the principal pollutant of concern, with further considerable interest also in particulate matter (PM). This is the result of some locations in the UK not currently meeting objectives for NO_2 and/or PM (specifically PM_{10} – particles smaller than 10 micrometres in diameter).

Both NO_2 and PM_{10} are considered relevant to air quality at and near to airports, principally because both result from airport activities. Other air pollutants identified within the Air Quality Strategy, are less relevant. As such, this paper focuses on NO_2 and PM_{10} at and around airports.

Nitrogen dioxide (NO_2)

Oxides of nitrogen (NO_x) are created by combustion processes, particularly cars and lorries and, as such, are a key pollutant to consider at airports in relation to surface access, with the main UK source being road transport. Aircraft engines, boilers and backup generators also produce NO_x. Nitrogen dioxide (NO_2) and nitric oxide (NO) are both oxides of nitrogen and together are referred to as NO_x.

Particulate matter (PM)

PM is made up of a variety of materials arising from different sources. It can be formed directly from combustion process and indirectly from chemical reactions in the air. PM is a mix of human-made and natural sources (such as Saharan dust). PM is categorised on the basis of particle size: PM_{10} refers to particles with a diameter of less than 10 micrometres; and, $PM_{2.5}$ particles with a diameter of less than 2.5 micrometres.

2. Context

Air quality legislation is based on air quality guidelines recommended by the World Health Organization on the basis of research into the impacts of pollutants on health. The guidelines are based on research into the effect pollutants have on people's health and are intended to help governments set air-quality standards that should apply in their countries.

Government has established legally binding emission 'ceilings' that limit total emissions of four main air pollutants, including nitrogen oxides (NO_X). Other targets aim to improve air quality by limiting concentrations of certain air pollutants. The UK Government regularly reports on progress made in improving air quality and has identified difficulty in meeting objectives for nitrogen dioxide (NO_2).

By law, local authorities must review air quality in their area and designate an air quality management area where air quality objectives are not expected to be met. There are currently 604 air quality management areas AQMAs in the UK. These are typically in busy urban areas, reflecting the principal source of concern, which is road transport.

Local authorities must develop air quality action plans, which aim to improve air quality and meet objectives. Airports which are members of Sustainable Aviation actively contribute to such plans, often through strategies which are developed and implemented by individual airports.

2.1 Framework for reducing emissions and improving air quality

Air quality is an important issue, challenging policymakers in both developed and developing nations. International research has led to the development of air quality guidelines by the World Health Organisation (WHO). Poor air quality is recognised to increase the number of people who suffer from, and severity of, respiratory and other illnesses. These guidelines, have been specifically developed to protect both people's health and the natural environment and provide the framework for UK and European air quality policies.

Legally binding targets have been set to both reduce total emissions of key pollutants, and to limit their concentrations in air within the UK (National Emission Ceilings Regulations, 2002) and other European countries (European Directive 2001/81/EC, 2001).

The framework for managing air quality in the UK is provided as Appendix B, and summarised in Figure 2.1.

Air quality guidelines

The World Health Organisation has set these research-based guidelines to protect people's health.

EU Air Quality Directives

These Directives, based on the World Health Organisation's air quality guidelines, set limits for eight air pollutants.

UK Air Quality Regulations

These regulations incorporate EU air quality directives into UK law, and introduce air quality objectives. Under the UK Air Quality Regulations, Government must keep within limits set by EU Air Quality Directives for eight pollutants, and must report results to the European Commission.

Environment Act 1995

Under the Environment Act 1995, local authorities must review air quality. If they find that the air quality objectives in a particular area are not expected to be met, they must designate that area as an air quality management area.

Air quality action plans

Each local authority must develop an air quality action plan setting out measures to improve air quality and meet the air quality objectives in any air quality management area.

Figure 2.1 Air quality management framework

2.2 UK air quality

For nitrogen dioxide (NO_2) and particulate matter (PM_{10}), UK air quality objectives (AQOs) are aligned with limit values driven by the European Air Quality Directive. Government has ultimate responsibility for achieving European air quality limits and has tasked local authorities with reporting local air quality to the Department for Environment, Food and Rural Affairs (Defra). Where AQOs (Figure 2.2) are not met, local authorities are required to declare an air quality management area (AQMA) and develop an air quality action plan (AQAP).

Defra produces an annual report on air pollution in the UK (Defra, 2015). This outlines the challenges the UK is facing in meeting air quality objectives for concentrations of NO_2 and PM_{10}, principally within urban areas as a result of emissions from road transport. Local Authorities have designated a total of 604 AQMAs where NO_2 AQOs are exceeded, compared to 95 for PM_{10} and 7 for sulphur dioxide (SO_2) (Defra, 2016). Only one of these AQMAs contains a top ten UK airport.

Pollutant	**Annual objective (mean limit)**	**Short term objective (max events per annum)**
NO_2	40	18 hours > 200
PM_{10}	40	35 days > 50
$PM_{2.5}$	25	N/A

Figure 2.2 UK Air Quality Strategy objectives, micrograms per cubic metre (Defra, 2007)

3. Air emission sources at and near to airports

Emissions at an airport contribute only a small proportion of overall UK emissions. A range of activities contribute to air emissions within the airport boundary. Aircraft operations are the most significant source of nitrogen oxides and particulate matter emissions at an airport, with other emissions from support vehicles and equipment, as well as vehicles accessing the airport.

Road transport is a major national source of both nitrogen oxides and particulate matter. Due to the mobile nature of air pollutants, both airport-related and non-airport-related road traffic both contribute to emissions around airports.

Sustainable Aviation has a 10-year history of delivering environmental improvements. Our members work collectively to develop new technologies and implement more efficient operating procedures. At a local level, airports have delivered a range of initiatives to reduce emissions, including developing sustainable surface access options for passengers, staff and local communities alike.

3.1 Air emissions at airports

The principal sources of airport-related emissions include aircraft, ground service equipment such as power units and vehicles at the airport or using airport approach roads. Of these, the largest share of total airport-related emissions is from aircraft operations on the ground (such as on-stand power, taxiing, and take-off) and in the air below 3,000 feet or 1,000 metres above ground level, unless otherwise stated.

A number of Sustainable Aviation (SA) member airports periodically produce air quality emission inventories. Emissions inventories aim to quantify emissions by source across an airport, to support air quality management and mitigation planning. Using data from two of the most recent emission inventories – prepared by Gatwick and Heathrow airports – it is possible to provide a broad overview of on-airport emission sources for oxides of nitrogen (NO_x) and particulate matter (PM_{10}).

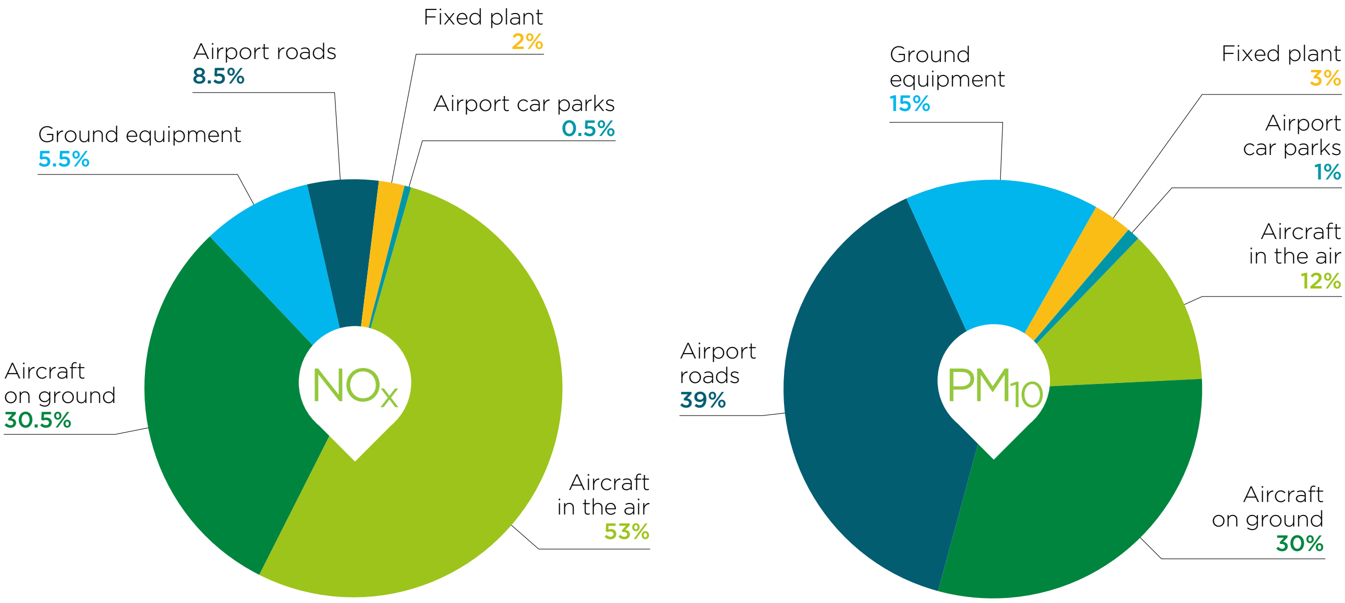


Figure 3.1 On-airport emission sources for oxides of nitrogen (NO_X, left) and particulate matter (PM_{10}, right), based on emission inventories for Gatwick (2010) and Heathrow (2013) airports

The estimation of aircraft emissions is particularly difficult, especially as emissions take place above ground level and they therefore represent a three-dimensional source. The International Civil Aviation Organisation (ICAO) provides information about emissions from specific engine models, within a reference landing and take-off cycle (LTO cycle), which are necessary to compare different engine technologies for certification. However, these emissions figures do not reflect day-to-day conditions, such as weather and the wide range of operational techniques SA members employ. The ICAO Airport Air Quality Manual (ICAO, 2011) provides a number of methodologies, from simple to sophisticated, for estimating aircraft emissions – the more advanced methods being more accurate, but requiring progressively more detailed information as input. In general, both the ICAO "Simple" and "Advanced" methods, result in levels that are likely to overestimate actual emissions and, for the "Simple" method, this can be quite significant.

Government is committed to reducing absolute emissions, including those of NO_X. The UK has met its targets to do so for all pollutants every year since 2010. To put airport emissions in perspective, the Government's national emission inventories report that emissions from aircraft contribute around 1% to total UK NO_X emissions and 0.1% to total UK PM_{10} emissions (National Atmospheric Emissions Inventory, 2014). Total on-airport emissions are, however, slightly higher, as they include emissions from other sources such as ground equipment as well as airport roads and car parks. Despite this increase in scope, emissions from Heathrow and Gatwick Airports (the two largest UK airports) come to around 1% of UK NO_X and 1% of UK PM_{10} emissions. Aviation therefore makes a very small, but still important, contribution to UK emissions.

Industry is delivering a wide range of emission reduction programmes, implemented successfully through its collaborative approach. Sustainable Aviation (SA) is at the heart of this cross-industry approach, our members not only co-ordinate operational improvements but also develop cleaner aircraft and engines for the future. Many of these actions, outlined in Figure 3.2, are overseen locally by SA member airports who work consistently to deliver proactive local emission reduction strategies. Airport-level partnerships, involving airlines, handling agents and other service partners deliver best practice, reducing emissions through more efficient operating procedures and technology.

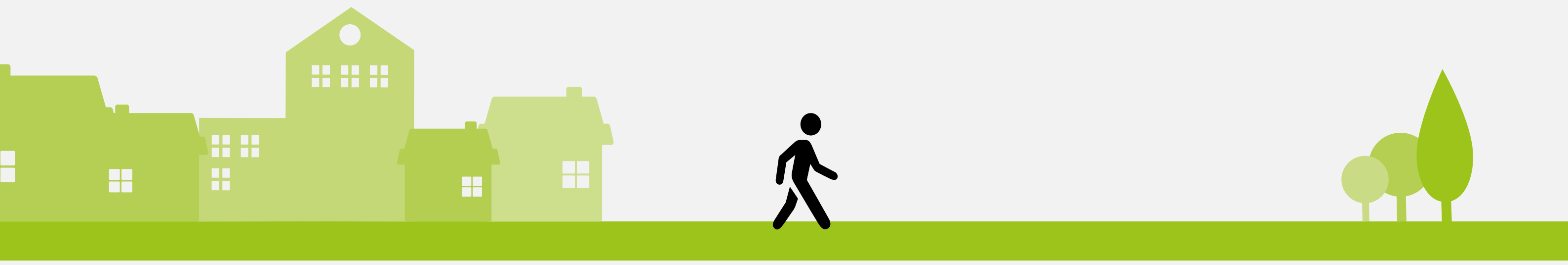
Collaborative environmental management at Manchester Airport

Working with Eurocontrol, Manchester Airport developed and implemented the European specification for Collaborative Environmental Management (CEM). Bringing airport teams together with airlines, air traffic control and handling agents, CEM provides a platform for environmental improvement.

The Group has improved uptake of the SA Arrivals and Departures Codes of Practice and implemented a number of local improvement projects. These have included the development of reduced engine taxiing (RET) procedures and the demonstration of 'perfect' flights. Collaborative Environmental Management provides a range of environmental benefits, including reducing emissions that affect air quality, and has become a requirement at other European airports.

Manchester's approach to CEM assisted the implementation of reduced engine taxiing procedures for aircraft arriving at and departing from the airport.


Image: Manchester Airport



3.2 Reducing air emissions at airports

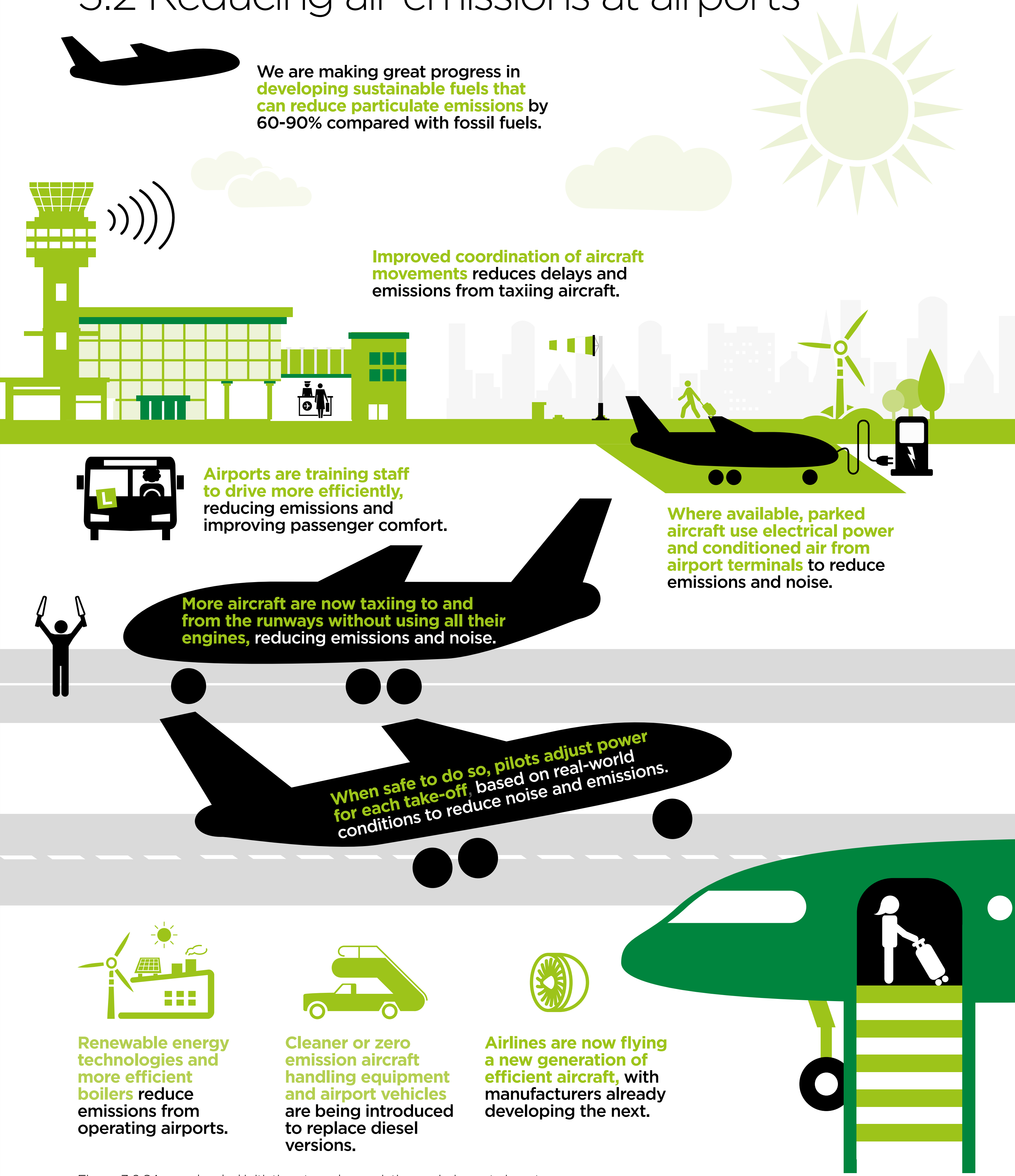


Figure 3.2 SA member led initiatives to reduce aviation emissions at airports

3.3 The contribution of road transport to emissions near airports

Nationally, road transport contributed 32% of NO_x and 18% of PM_{10} emissions in 2013 (National Atmospheric Emissions Inventory, 2014). Some UK airports are located outside city boundaries with few major roads or motorways in the vicinity while others are located in busy urban settings that include extensive road and motorway networks. Emissions from non-airport-related road traffic, driven by the proximity of an airport to major road networks, is therefore an additional issue to be considered.

Depending on location, emissions of non-airport-related road traffic near to airports vary greatly – for example at Gatwick, non-airport road traffic accounts for about 14% of NO_x emissions in the vicinity of the airport, but 27% at Heathrow.

Airport-related traffic, such as cars, buses and delivery vehicles, also contribute. At Heathrow and Gatwick Airports, airport-related traffic contributes around 9% of airport NO_x emissions and around 38% of PM_{10} emissions. Airports work closely with local and highways authorities to manage airport approach roads, minimising congestion to reduce delays and emissions for both airport-related and non-airport-related traffic.

Promoting sustainable transport is an important priority for airports, both for staff and passenger surface access. Airports invest significantly in public transport infrastructure and facilities, including: rail and light rail; bus and coach; electric vehicle charging points; cycle routes and facilities; and, consolidated airport goods and cargo delivery centres. Figure 3.3 details actions taken by SA members to reduce surface access emissions.

3.4 Reducing surface access emissions

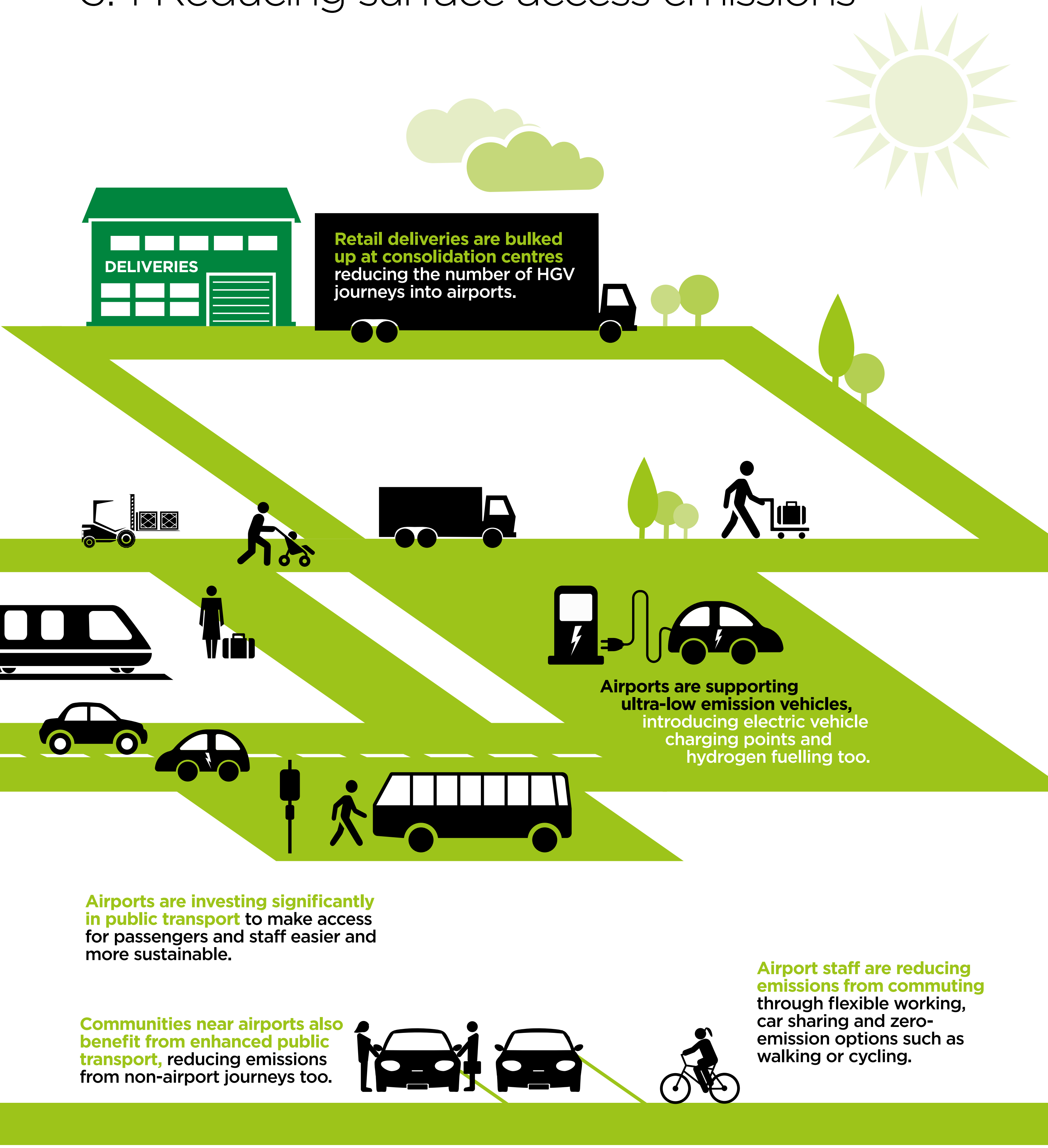


Figure 3.3 SA member initiatives to reduce emissions from accessing airports

4. Air quality near to airports

Air emissions are mobile, with air quality near to an airport impacted by emissions from both the airport itself and also, importantly, other emission sources. As a result, the impact of airport-related emissions reduces significantly once outside the boundary of the airport.

Airports have wide-ranging air quality monitoring programmes, often designed and implemented in partnership with local authorities. Results of these monitoring exercises are shared with stakeholders and are available online – many airports also share real-time air quality monitoring results.

Local authorities are required to designate an air quality management area where air quality does not meet national objectives. Of the top ten UK airports only one is within an air quality management area, with four near to air quality management areas.

4.1 Air quality

Air quality is a measure of the concentration of air pollutants at a given location. Air emissions are mobile and trans-boundary, therefore local air quality is impacted by emissions at a given location, and those from further afield – principally due to weather and wind moving air pollutants from their emission point. Computer models enable the impact of emissions from aviation and other sources to be predicted in terms of air quality, and are used by local authorities when they declare air quality management areas (AQMAs).

The contribution airport-related emissions make to local air quality reduces substantially with increasing distance from the airport boundary, dropping by around a factor of four by a kilometre away.

Modelling air quality at Heathrow Airport

While it is possible to measure concentrations of pollutants, it is impractical to have enough monitors to provide a full picture of local air quality at all locations. Therefore, computerised dispersion modelling is used to provide a complete picture of air quality.

A modelling study has several benefits. Firstly, modelling fills in the gaps between monitors, allowing air quality to be assessed at all locations of interest (for example, the concentrations at individual properties can be predicted).

It is also possible through modelling to see how much individual emission sources contribute to air quality at a given location. Modelling also enables forecasting future air quality – for example, to take into account infrastructure projects or changes in the number and types of aircraft using the airport, or road vehicles passing by. Air quality modelling supports action planning, helping to understand whether proposed measures are likely to be effective and cost-effective in improving air quality.

The latest Heathrow air quality study showed that aircraft make a dominant contribution to emissions of nitrogen oxides (NOx) at the airport, however these emissions do not exert a strong effect on concentrations outside of the airport perimeter. Road traffic emissions are a more important source in determining concentrations at properties in the vicinity of the airport: just 1 kilometre from Heathrow Airport, airport related NO_x emissions (which include those from road traffic travelling to or from the airport) contribute 13-16% to local air quality.

Information about the air quality modelling methods used by Heathrow Airport is available on the website www.heathrowairwatch.org.uk.

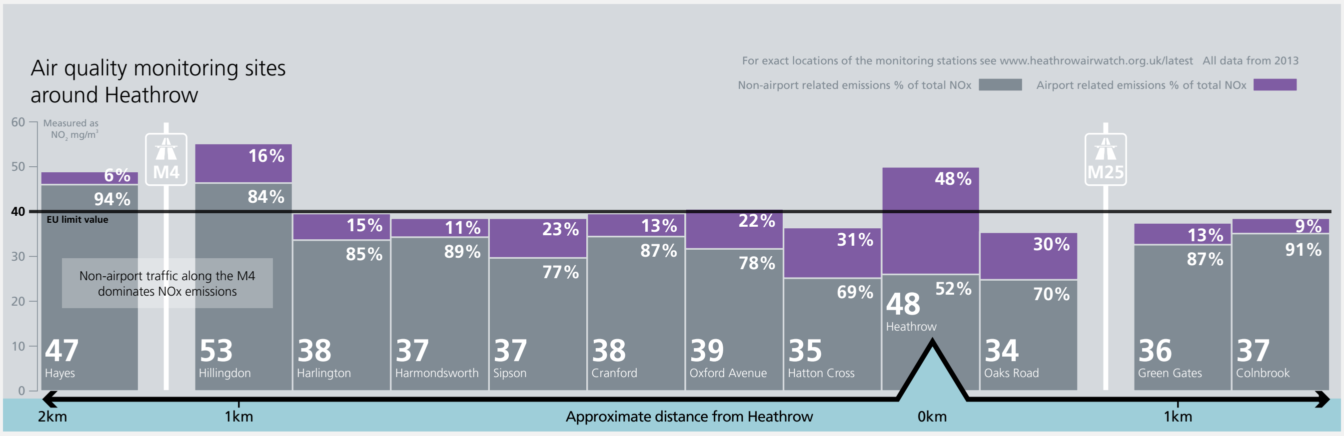


Image: Heathrow Airport

4.2 Air quality monitoring

The Sustainable Aviation (SA) Air Quality Working Group includes representation from the ten busiest UK airports. All of these airports undertake regular monitoring of air quality.

Government guidance (Defra, 2016) supports several methods of monitoring air quality. The selection of the most appropriate monitoring method is usually determined by an airport in consultation with its local authority. An airport's location, size, surroundings, proximity to other emission sources and the anticipated duration of air quality monitoring are considerations when deciding the most appropriate monitoring method. Airport-specific air quality guidance is also provided by the International Civil Aviation Organisation (ICAO) in its Airport Air Quality Manual (ICAO, 2011).

Airports undertake air quality monitoring in a number of fixed locations to enable comparative monitoring and reporting. Typical locations include:

- On the airfield, at the end of runways where, depending on wind direction, aircraft are landing or taking off;
- At on-airport or near-airport locations with significant airport-related ground vehicle traffic;
- In adjacent residential areas.

Monitoring methods and sites deployed by SA Air Quality Working Group member airports are listed in Appendix C, and results presented as Appendix D.

Air quality monitoring methods

Automatic monitoring

These monitors produce real-time measurements of pollutant concentrations. Automatic analysers provide continuous data, with service personnel typically checking them monthly and servicing required biannually. These monitors are more complex to install and sustain, but are very useful for measuring concentrations of nitrogen dioxide (NO_2) and particulate matter (PM) at locations where detailed monitoring is required and power and communications are available. Automatic monitors are helpful to improve and validate the accuracy of modelling data. Airports are also working with the manufacturers of automatic monitors to support the development of innovative new monitors.

Automatic air quality monitoring station
Image: Heathrow Airport

Non-automatic monitoring

These methods measure average concentration levels over longer exposure periods, typically weekly or monthly, and involve sample collections using a diffusion tube or filter. These methods are used to monitor NO_2 and also for hydrocarbons such as benzene. Diffusion methods collect pollutants by molecular diffusion along the tube to an absorbent material which, after exposure for a specified time, is chemically analysed to produce concentrations. Diffusion tubes are quick and easy to deploy compared to automated air quality monitoring and are particularly useful for monitoring long term trends.

Nitrogen dioxide diffusion tube
Image: Manchester Airport

4.3 Sharing information about air quality at and near to airports

4.3.1 Air quality working groups and partnerships

All of our member airports host airport consultative committees, which typically have an independent chair and representation from local authorities and local public interest groups. The purpose of these committees is to facilitate open and effective communication between airports and local communities and airport users about the impact of airport operations. Consultative committees typically meet quarterly, and may have a steering group as well as sub-groups on specific issues. Several SA member airports discuss annual air quality data, trends and initiatives with their airport consultative committee or its environment or air quality sub-group.

Further working groups exist between many airports and their respective local authorities. This type of partnership approach ensures airport and local plans deliver air quality improvements consistently.

4.3.2 Air quality reporting

Members of SA believe it is important to share information about air quality at airports. That is why member airports share the results of air quality monitoring with the public and their local authorities. The types of reporting and forums used to do so vary by airport, reflecting local stakeholder requirements.

Most of our members produce – or co-produce with their local authorities – air quality reports which are published online. These reports are often technical in nature and very lengthy – presenting the results of monitoring as well as discussion of long-term trend analysis. Shorter summary documents are usually also produced; and summary data and analysis also included in airport sustainability reports. Published reports typically include annual average NO_2 and PM_{10} concentrations, whether Government's annual mean air quality objectives have been exceeded and the number of exceedances per year of the short-term objectives.

In addition, several of our member airports also share real-time air quality monitoring information on the internet.

A partnership approach to air quality at Birmingham Airport

Birmingham Airport discusses air quality and monitoring data regularly with its Airport Consultative Committee, on a quarterly basis. The airport hosts the only automatic air quality monitoring site in the Solihull Metropolitan Borough Council area and shares monitoring results online in near real-time. As the airport grows it is working increasingly closely with partners to provide information about air quality.

The Birmingham Airport Health Group enables the airport to embed the consideration of community health issues and opportunities into airport operation and development. With a particular focus on health, the group reviews air quality and monitors the effectiveness of the mitigation and community support initiatives in partnership with public health teams from the Solihull Metropolitan Borough Council and Birmingham City Council.

4.4 Air quality action plans

An AQMA is designated by a local authority where locations fail to meet air quality objectives. Figure 4.1 shows the location of AQMAs, which are focussed on urban areas and, at a local level, generally follow motorways and main roads. The figure also shows the location of the ten busiest UK airports, which collectively handle 85% of UK passengers and 90% of UK air cargo (Civil Aviation Authority, 2016). Of these airports only one, Heathrow, is within an AQMA – with four (Birmingham, Edinburgh, Gatwick and Manchester) near to AQMAs.

Local authority air quality action plans (AQAPs) are important regional strategies, primarily working to improve air quality but offering a range of secondary benefits – such as improvements to public transport and support for green spaces. Airports are important contributors to local policies, working alongside local authorities to support AQAPs by introducing measures to reduce emissions at the airport – often delivered through airport's own emission reduction strategies.

Heathrow Airport is located within the Hillingdon AQMA, declared for NO_2. Birmingham Airport is located within 1 kilometre of the Birmingham AQMA, declared for NO_2 and PM_{10}. Edinburgh, Gatwick and Manchester airports are respectively located within 1 kilometre of the Glasgow Road, Horley and Greater Manchester AQMAs, declared for NO_2.

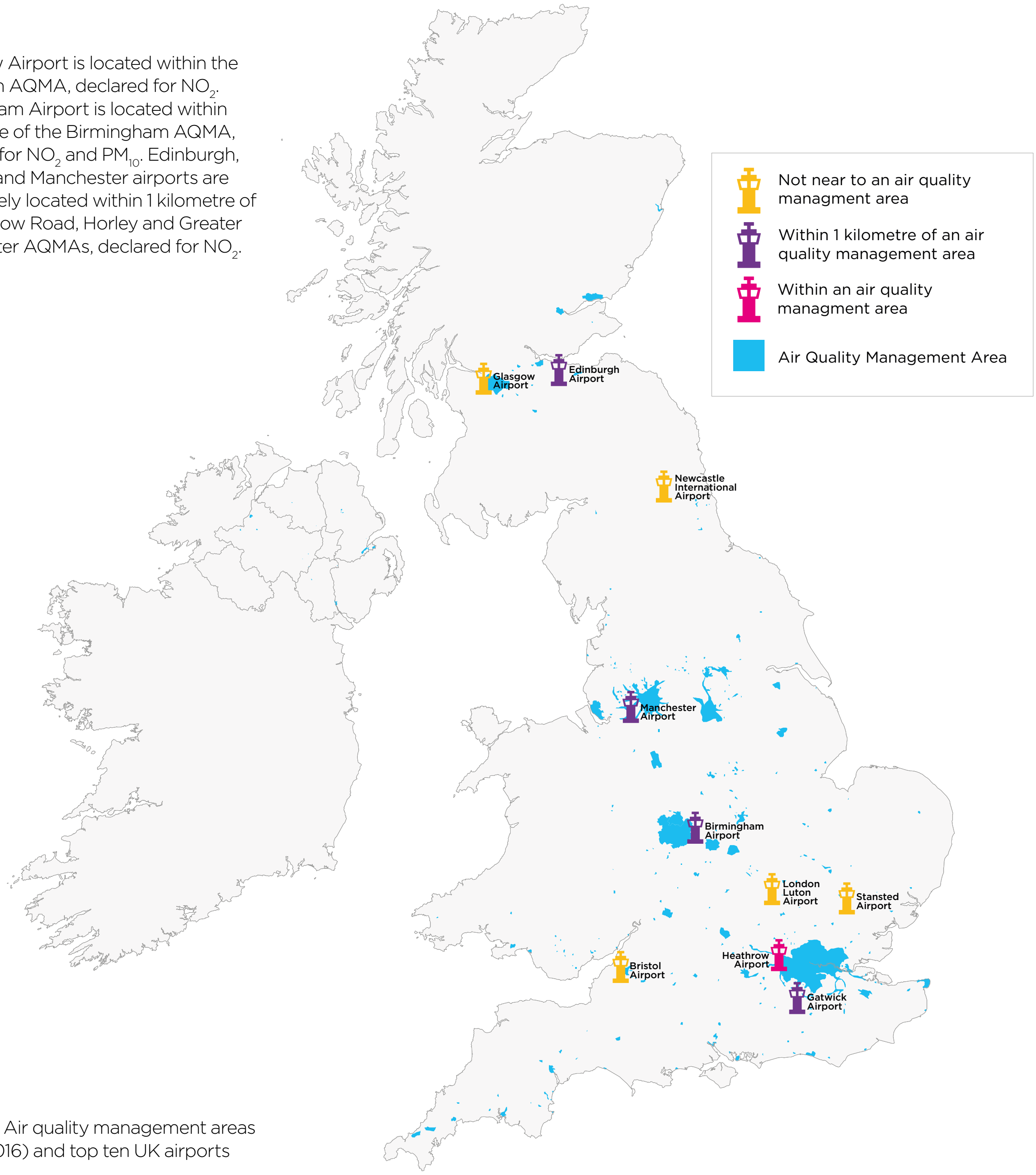


Figure 4.1 Air quality management areas (Defra, 2016) and top ten UK airports

5. Initiatives to reduce air quality emissions

Sustainable Aviation Members are committed to reducing emissions and driving air quality improvements. Achieved by collaborative work through Sustainable Aviation, and with local stakeholders, airports have implemented a range of policies that support the introduction of sustainable surface access and the development of low emission infrastructure.

Manufacturers have delivered new, more efficient and lower-emission engines and aircraft – and are working to introduce sustainable and cleaner fuels which provide further air quality benefits. Airports and airlines have also invested in low emission equipment, enabling a switch from fossil fuels to electrical power.

A wide range of operational controls have also been implemented, providing air quality benefits as well as other environmental gains such as reduced noise and carbon dioxide emissions.

Looking to the future, Sustainable Aviation members are leading the way on research and development – bringing forward the next generation of aircraft, powered by sustainable and cleaner fuels which will operate within more efficient airspace. Current aerospace research and technology goals are targeting a 90% reduction in emissions of nitrogen oxides from new aircraft by 2050 (Advisory Council for Aviation Research and Innovation in Europe). Continued industry and Government support towards these goals as well as delivering airspace modernisation, improving surface access to airports and introducing low emission aircraft fuel and ground vehicles will be critical to realising the sustainable development of UK aviation.

5.1 Industry collaboration to improve air quality

Building on many years of progress in reducing environmental impact, for the last ten years Sustainable Aviation (SA) members have worked to deliver environmental improvement across the UK aviation industry. An overview is included in the report “A Decade of Progress 2005 – 2015” (Sustainable Aviation, 2015). This has been achieved through the unique approach our members take to working collectively, and has been implemented through a number of industry working groups. For example, members of the Sustainable Aviation Operational Improvement Group – consisting of manufacturers, airlines, airports and air traffic controllers – work consistently to deliver, implement and quantify efficiency opportunities.

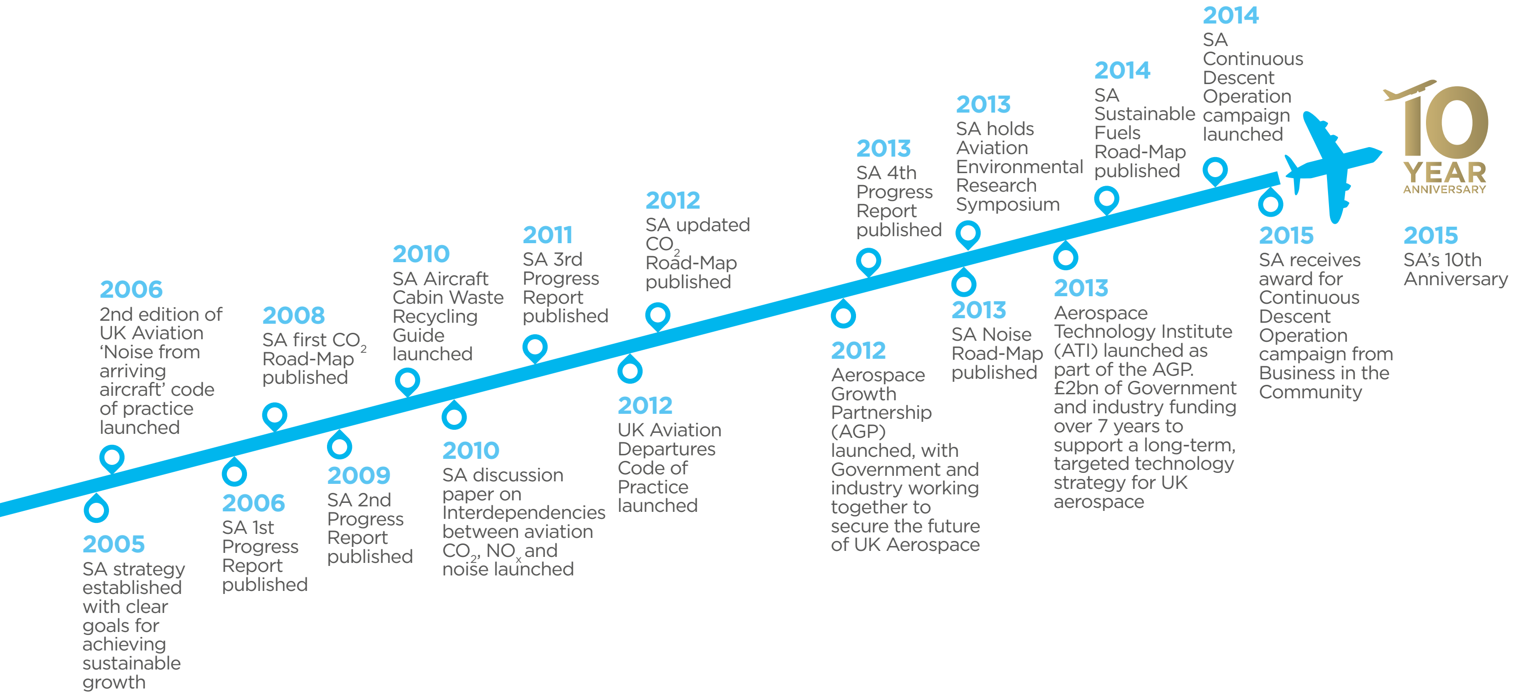
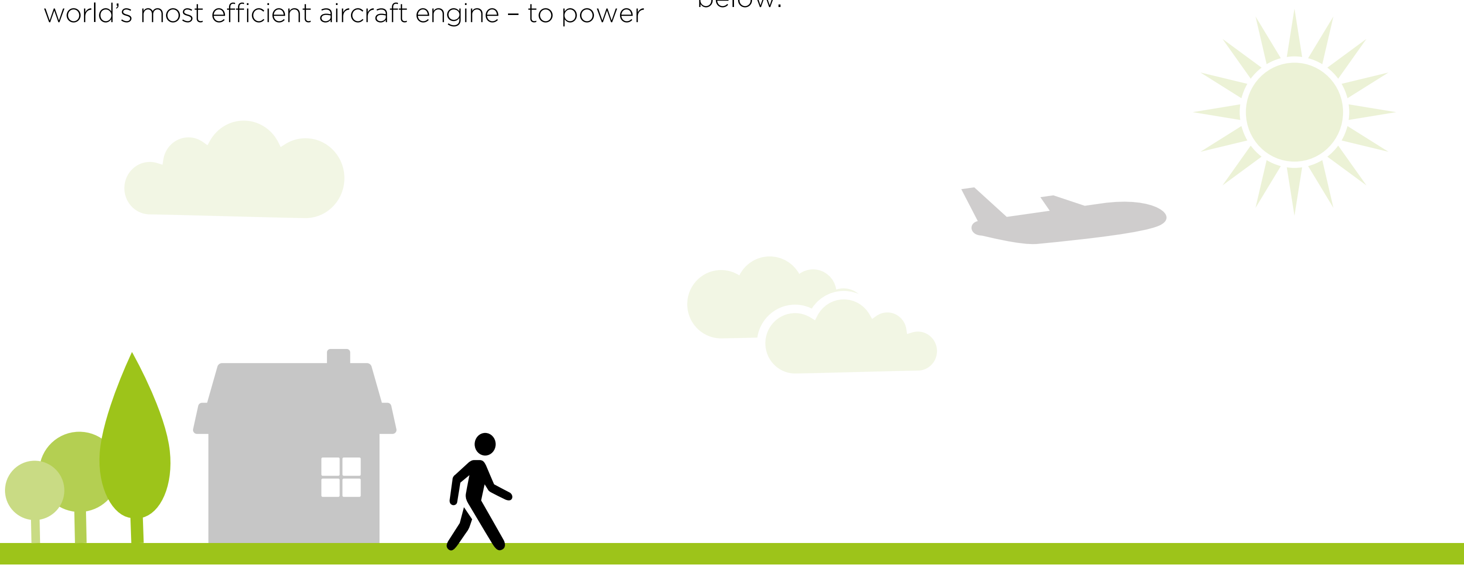


Figure 5.1 Sustainable Aviation, ten years of progress

The progress made in reducing emissions is evident at all stages of a passenger's journey, even before they reach the airport for a flight:

- Since 2006, 11 million extra passengers are using public transport to access 8 major UK airports (over a 5% increase).
- Birmingham and several other airports have introduced electric vehicle charging stations and the industry is encouraging staff to commute sustainably – at Stansted, 45% of staff now do this.
- At Bristol Airport driver training is reducing emissions from airport buses by 12%, and alternatively fuelled vehicles eliminating these from other vehicles.
- Rolls-Royce has introduced the Trent XWB – the world's most efficient aircraft engine – to power the Airbus A350, an aircraft which is made from 53% lightweight carbon fibre and 70% advanced materials.
- Airports have introduced supplies of electricity to power aircraft parked at the terminal, reducing aircraft emissions in these areas substantially (e.g. 47% since 2008/09 at Heathrow).
- More efficient operating procedures are being adopted by airlines. By taking actual aircraft weight, runway length and current weather conditions into account Thomson Airways are reducing emissions by cutting take-off thrust by up to 33%.

In addition to the infographics contained in Chapter 3, a range of case studies are presented below.



5.1.1 Working together to reduce airport-related emissions

In addition to industry-level collaboration fostered by SA, member airports lead their own approaches to working with local stakeholders to develop and implement emission reduction strategies, as well as communicate on air quality. This approach is particularly important given airports are themselves directly responsible for only a small part of overall airport operations – they are therefore dependent upon guiding and influencing a wide range and number of other organisations to reduce overall airport emissions.

Airport collaborative decision making at Gatwick

Gatwick began implementing airport collaborative decision making (A-CDM) in 2012 as an important component of their airfield performance transformation program. By 2014, 100% of commercial departures from Gatwick Airport were running under Gatwick's A-CDM procedures, with conversion to wider network CDM in November 2014. A-CDM is about gathering and sharing real time information about the progress of an arriving flight, and the preparation of an aircraft for departure.

At Gatwick A-CDM has a strong focus on aircraft turn-round and the pre-departure sequencing process to ensure on-time departures. This focus improves customer service and operational efficiency, decreasing aircraft fuel burn and emissions. A-CDM also enables pilots to deliver further emission reductions through reduced engine taxiing which is supported because accurate expected take-off times are provided to pilots who can decide when to start remaining engines in readiness for an on-time departure.

Talking air quality at Manchester Airport

Through a partnership with Manchester Metropolitan University, Manchester Airport hosted air quality awareness sessions for airside colleagues ranging from aircraft cleaners to fleet managers.

As part of the Natural Environment Research Council Summer of Science, the event brought together academics and local authority Environmental Health Officers with airport environment and airfield operations colleagues to raise awareness of air quality. Airport staffs were encouraged to make behavioural changes to reduce emissions at the airport and during their commutes.

5.1.2 Operating aircraft more efficiently

Sustainable Aviation has developed codes of practice, documenting environmental best practice for aircraft operations. The Arrivals Code of Practice (Sustainable Aviation, 2006) and Departures Codes of Practice (Sustainable Aviation, 2013) support member airports in implementing low emission airfields. They include a range of procedures designed to make aviation more sustainable by reducing emissions to air as well as other environmental impacts such as noise and carbon emissions.

Reducing on stand aircraft emissions at Heathrow Airport

Heathrow Airport has invested £20 million installing fixed electrical ground power (FEGP) and pre-conditioned air (PCA) at most gates so that aircraft don't need to run their on-board generators, Auxiliary Power Units (APUs). With FEGP and PCA now available at over two thirds of gates, on-stand aircraft emissions are in most cases avoided.

In addition, tighter restrictions on APU run-times were also introduced at the beginning of 2011. As a result, between 2008/09 and 2013 annual APU emissions decreased by over 47%.

National Air Traffic Services optimising aircraft taxiing

National Air Traffic Services (NATS) have been working with airport air traffic controllers and airlines to promote smooth taxiing and avoid unnecessary stop/starts. By providing early information so that pilots plan for expected ground routings, air traffic controllers help avoid unnecessary stops at taxiway junctions and as a result reduce fuel burn and emissions. Putting this in context, a Boeing 737-300 burns around 13 kilogrammes of fuel per minute during ground taxiing – the cost of a taxiway stop/start is around £50 in fuel. Taxiway stop/start for a long-haul aircraft can cost £200 in fuel compared to a smooth continuous taxi operation.

Virgin Atlantic powering down to reduce emissions

Virgin Atlantic has updated operating procedures to significantly reduce emissions from aircraft taxiing to and from the runway.

Aircraft are designed to provide the high levels of thrust required for power-intensive stages of flight such as take-off. This means that not all engines need to be running to taxi on the ground. Depending on the aircraft type, either one or two engines can be shut down for taxiing before take-off and after landing. Not only does this save fuel but it also reduces emissions at the airport.


Image: Virgin Atlantic

Thomson Airways reducing take-off emissions

Thomson Airways uses reduced take-off thrust on the majority of flights, reducing emissions and improving local air quality.

Thomson have implemented procedures to reduce take-off thrust across their fleet. To illustrate the reductions achieved, Thomson's 737-800 aircraft can reduce take-off thrust by up to 33%. The actual reduction in thrust is determined by aircraft weight, weather conditions and runway length.

Reduced thrust take-offs increase engine life by reducing the peak engine temperature, and also offer a significant improvement to local air quality, as engines produce significantly fewer nitrogen oxides (NO_X) at lower power settings.

Image: TUI Group

5.1.3 Introducing efficient new technology

Engine and aircraft manufacturers have developed new designs which are being introduced to airline fleets. These new families of aircraft are cleaner and quieter than their predecessors and reduce NO_X emissions relative to internationally agreed engine standards. Airports are also playing their part, reducing emissions from the operation of airport terminals.

Reducing boiler emissions at Heathrow

To reduce emissions from combustion plant, Heathrow Airport, has prioritised a move from a large number of small, oil-fired boilers to fewer large gas-fired combined heat and power (CHP) installations with additional gas boilers. In addition, two older gas-fired boilers have been decommissioned and replaced with syn-gas fired CHP; syn-gas is generated from wood chip gasification. The balance of heating demand is provided by natural gas or gasoil boilers.

The new plant increases energy efficiency and generates more on-site electricity. As a result of these changes, NO_X emissions from heating plant were reduced by 70% between the 2008/09 and 2013 Emissions Inventories.

New technology to reduce engine and aircraft emissions at Airbus

Airbus is continually striving to make innovative improvements to new and existing aircraft that reduce their environmental impact in operation. Weight reduction is a big contributor to fuel savings and reductions of carbon dioxide (CO_2), NO_x and particulate matter (PM). The A350 XWB is made of 53% light weight carbon fibre and 70% advanced materials including titanium alloys, with some parts now made by 3D printing (also called Additive Layer Manufacturing).

Additive layer manufacturing "grows" products from a fine base material powder – such as aluminium, titanium, stainless steel and plastics – by adding thin layers of material in incremental stages, which enables complex components to be produced directly from computer-aided design information.

This new technology used by Airbus is beginning to shape the future of aircraft component manufacture for its jetliners. 3D-printing results in lighter parts, with shorter lead times, fewer materials used during production and a significant reduction in the manufacturing process' environmental footprint.

For the A350 XWB aircraft, Airbus already has produced a variety of plastic and metal brackets, whose material and structural properties have been tested and validated. 2,700 plastic parts have been produced for the A350 XWB programme and by the end of 2016, 300 parts will be manufactured this way for each A350.

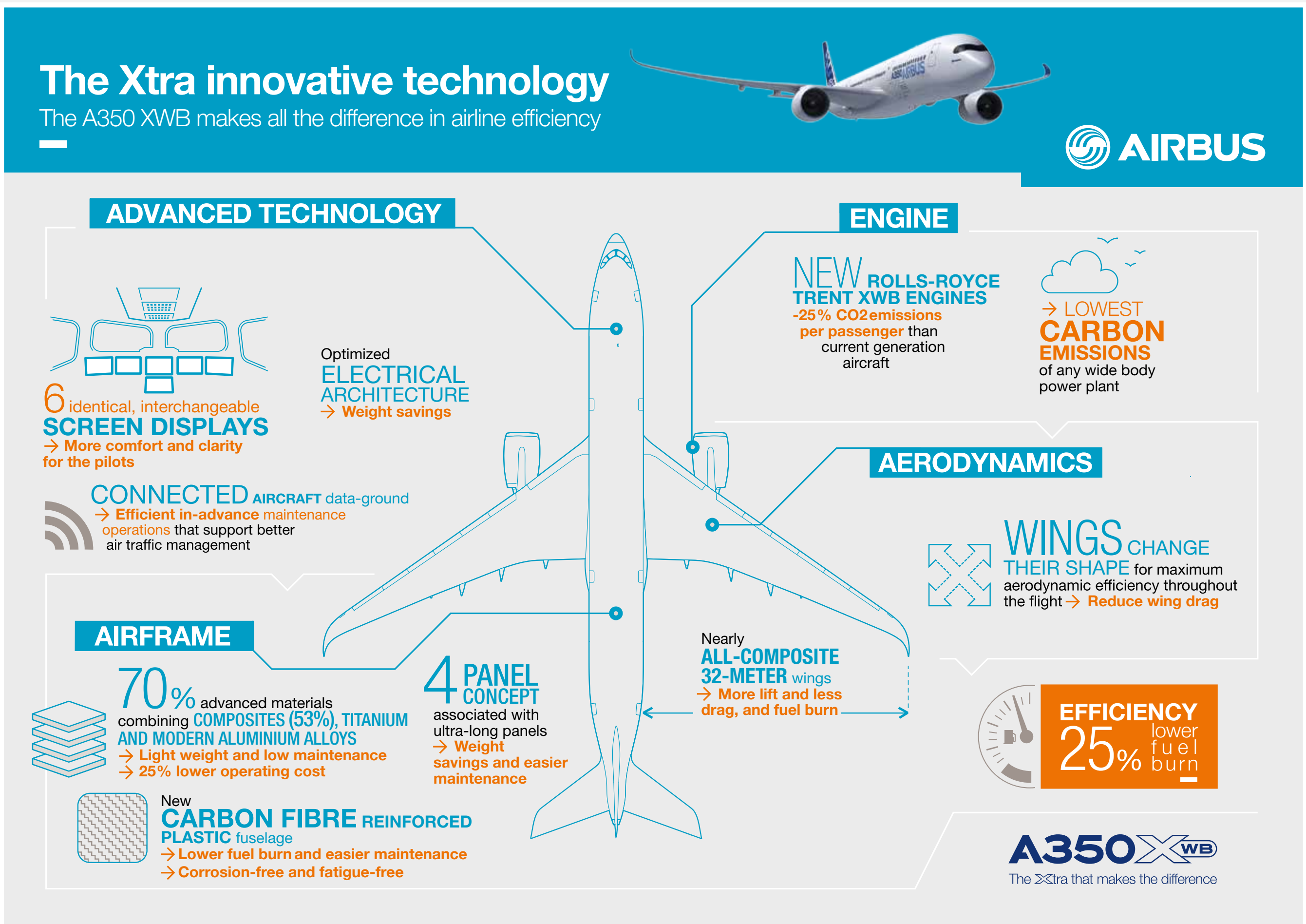


Image: Airbus

5.1.4 Reducing vehicle emissions within the airport boundary

A range of vehicles and equipment are operated at airports, some of which are very specialist. These generate a small but important portion of emissions at airports. Members of SA have undertaken initiatives to reduce emissions from existing fleets, introduce new types of equipment and ways of working, and also work with other on-airport operators to drive more efficient third-party operations.

Driving efficiency at Bristol Airport

Bus drivers at Bristol Airport have undertaken Safe and Fuel Efficient Driving training, developing driving skills and knowledge regarding both road safety and fuel efficiency.

As part of the training, drivers undertook pre- and post-training driving assessments, including fuel consumption and driving technique monitoring. Upon completion of the training, fuel efficiency increased by 12%, also reducing emissions that affect air quality.

In addition, the airport's information technology team and engineering teams each drive ultra-low emission electric vans, reducing their emissions from journeys around the airport site to zero. This is complemented by electric charging points for team vehicles and passengers.

Consolidating retail deliveries at Manchester Airport

Manchester Airport operates a consolidation centre which receives deliveries destined for the airport complex from retailers' own suppliers. These deliveries are security screened with goods from a number of suppliers consolidated into fewer airport deliveries, with priority given to perishables. On average the consolidation centre makes one delivery to the airport site for every four deliveries it receives.

This approach, which supports Greater Manchester's wider aspiration for local consolidation centres, reduces the number of goods vehicle movements at and around the airport by an average of 32 deliveries per day – with corresponding emission reductions. In addition, this approach reduces congestion on local roads, at busy airport security posts and loading bays

Working together to reduce vehicle emissions at Heathrow Airport

Heathrow Airport funds and coordinates the Heathrow Clean Vehicles Partnership (CVP) that, for more than 10 years, has provided fleet consultancy and emissions calculation, zero and low emission vehicle trials and best practice seminars for fleet operators at the airport.

The CVP encourages collaboration and best practice sharing between over 20 companies operating at the airport. In 2014, a new requirement was introduced for all vehicles operating on the airfield to be fitted with telematics – enabling more precise fleet evaluation with a view to improving fleet efficiency in terms of vehicle numbers and emissions. It is estimated that as a result of improvements in operational practice, NO_X emissions from airside vehicles and Ground Support Equipment at Heathrow reduced by 28%, between 2008/09 and 2013.

5.1.5 Sustainable surface access

Airports invest significantly in developing and promoting public transport and other low-emission means of getting to and from the airport. These efforts also facilitate wider emission reductions, through the development and support of a number of public transport options. These connections, which enable increasing numbers of passengers and staff able to travel to the airport sustainably, are also vital to communities along public transport routes which otherwise may not be sustainable.

Promoting public transport to access Gatwick Airport

In 2015, 44% of Gatwick Airport's passengers used public transport to travel to the airport – sustaining a trend above 40% even as passengers have grown by a third since 2010.

Gatwick is the best rail-connected European airport, with over 129 direct station connections. Gatwick's dedicated integrated rail station, the first of any global airport, provides a convenient link from train to plane – enabling 38% of passengers to arrive by rail, the highest rail modal share of any major UK airport. In addition to rail, Gatwick works closely with bus and coach companies to enable a wider range of public transport routes to and from the airport. For passengers who choose to travel by car, the airport has introduced electric vehicle charging solutions – promoting the uptake of ultra-low emission vehicles.

Image: Gatwick Airport

Birmingham Airport plugs in to the electric highway

Birmingham Airport has introduced fast charging stations to enable e-drivers to rapidly charge their electric vehicles at the airport if they are picking up, dropping off, or on their way in and out of the country.

Working with green energy company Ecotricity, Birmingham Airport powers the chargers with 100% renewable energy – enabling 35 different models of electric and plug-in hybrid cars to recharge in between 20 and 30 minutes. Electric cars do not emit exhaust pollutants, providing both air quality and climate change benefits.

Image: Birmingham Airport

Sustainable travel planning at Stansted Airport

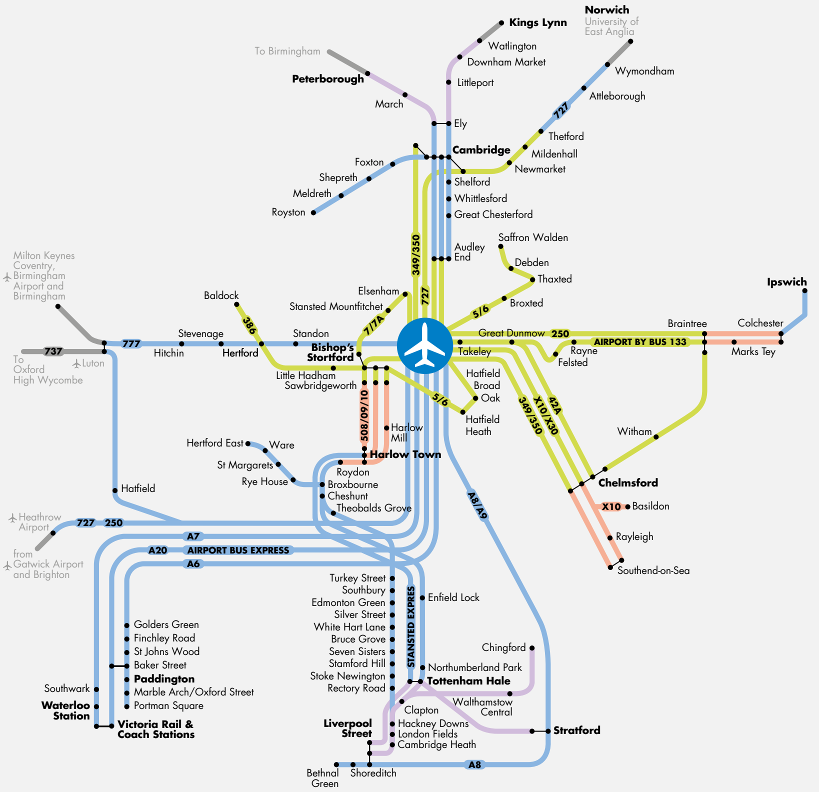


Image: Stansted Airport

Colleagues joining the team at Stansted Airport are engaged in sustainable travel planning from the start of their 'journey'. Stansted's support of car share schemes, cycle facilities and development of 24-hour rail, bus and coach routes provide workers a real alternative to single occupancy car commuting.

Through a range of promotional techniques, 45% of airport workers travel using a sustainable mode of transport, with 27% travelling on public transport. In support, Stansted provides discounted Airport Travelcards – which are held by 25% of airport staff.

Bristol Airport working to reduce local community travel emissions

Public transport to the villages and hamlets surrounding Bristol Airport can be poor. However, Bristol Airport has developed a highly successful express bus service to the City Centre, some 8 miles from the airport. The 24 hour bus service, made possible by airport support, runs as frequently as every 8 minutes and is used by 14% of airport passengers. It also provides a convenient alternative to cars for local residents.

To support wider uptake of the "Flyer" service, the airport offers concessionary passes for local people. Over 600 local residents now hold concessionary passes, with more than 1,000 return journeys made each quarter – supporting commuters and those travelling to the city for leisure to leave their cars behind and reduce traffic emissions in and around Bristol.

Image: Bristol Airport

5.2 Environmental interdependencies

Many of the initiatives delivered by SA members provide a number of environmental benefits. For example, reducing take-off power settings significantly reduces NO_x emissions, but also reduces noise close to the airport – without impacting upon CO_2 emissions. It is therefore important to consider interrelationships between air quality, climate change and noise, as well as other factors such as the effects on airspace and runway capacity when considering the benefits new technology and operational improvements deliver.

Interdependencies are, however, not always clear cut. At the design stage, manufacturers endeavour to increase jet engine efficiency by increasing thermal and propulsive efficiencies, reducing fuel burn and CO_2 emissions. While reducing fuel burn and CO_2 emissions, higher combustion temperatures can increase chemical reaction rates and production of NO_x. Therefore, achieving higher thermal efficiencies without increasing NO_x emissions is a significant challenge for engine manufacturers, who must strike a balance between the requirements to minimise both CO_2 and NO_x emissions.

The paper "Inter-dependencies between emissions of CO_2, NO_x and noise from aviation" (Sustainable Aviation, 2010), provides more detail on the links between noise, climate change emissions and air quality within aviation.

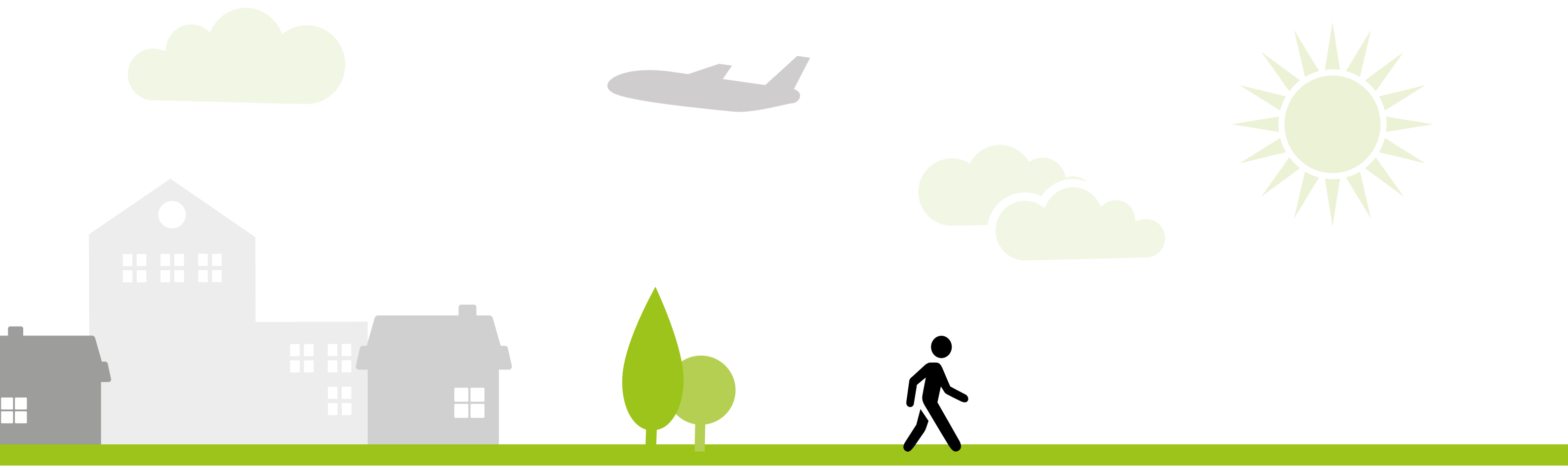
Reduced power take-off procedures environmental co-benefits: Air quality, climate change and noise

Airlines have implemented take-off procedures which reduce engine thrust settings to the level actually required to take off given the aircraft take-off weight, current weather conditions and the length of the runway available.

This certified technique is now built in to aircraft flight management systems as standard. As a result of the relationship between take off power settings and NO_x emissions it provides a significant reduction in NO_x emissions during take-off.

Despite a significant air quality benefit, the impacts of this procedure on noise are complex. The reduction in power setting reduces noise close to the airport but means that an aircraft will be slightly lower along its flightpath. As a result, whilst the overall noise impact will reduce, the noise levels under the flightpath may be slightly increased.

The effect of the procedure on fuel burn and CO_2 emissions is small. Depending on the individual aircraft and actual circumstances the procedure can result in a slight increase or decrease in CO_2 emissions.



5.3 Future opportunities

In addition to the diverse range of current activities to reduce emissions from aviation that affect air quality, SA members are currently exploring a number of future opportunities. The majority of these opportunities involve stimulating innovation or delivering step changes in operating techniques to reduce emissions.

Ensuring emission reduction opportunities are realised requires a long-term, collaborative commitment to resource and funding, involving academic research, pioneering innovators, the aviation industry, Government and private equity financing.

Key opportunities which SA members are exploring include:

Electric and alternatively fuelled ground service vehicles

This will include finding new ways to power airport support vehicles with non-fossil fuel sources. Hybrid, electric and hydrogen powered vehicles are being explored. The challenge is adapting or replacing bespoke vehicles that do not have "off the shelf" replacements from the commercial motor industry. It is therefore necessary to develop the right financial and policy solutions to accelerate the use of these vehicles.

Deriving sustainable aviation fuel from waste materials

Developing non-fossil-based aircraft fuel has been scientifically proven. There are emerging products developing around the globe, but commercial scale-up and production costs currently make this alternative fuel very expensive. There is an urgent need to overcome these barriers; further details are included within the SA Sustainable Fuels Road-Map (Sustainable Aviation, 2014).

Developing hybrid aircraft propulsion and power systems

New, innovative ways to power aircraft beyond the current jet engine design is an important focus for the aerospace and airline industries. There are a number of exciting and innovative ideas emerging. Realising these will require a sustained commitment and focus from both industry and Government.

Sharing data automatically to optimise air traffic movements

Through more sophisticated electronic data systems, there are a number of emerging opportunities to improve the efficiency of how aircraft traffic flows are managed both in the air and on the ground to avoid aircraft queueing, minimise delays and prevent unnecessary emissions. Continued support of these collaborative programmes to develop new IT systems is required both within and outside the UK.

These opportunities are explored in more detail through the following case studies.

Electric ground service equipment at Manchester Airport

In a UK first, Manchester Airport has been working with aircraft handling agents to demonstrate the feasibility of new, electric, specialist equipment for loading and towing aircraft. Powered by 100% renewable electricity, the push back tug, belt loader and multi-purpose cargo tractor ensure there are zero emissions from the ground handling equipment compared to the use of traditional diesel fuelled equipment.

In support, the airport introduced an intelligent rapid charging point which both extends battery life and charges equipment in less than an hour – with one charge lasting several days. For passengers, electric equipment means a smoother pushback from the terminal whilst also providing a cleaner and quieter working environment for staff working at the airport and those living nearby.

Image: Manchester Airport

EasyJet using hybrid systems to power aircraft ground operations

In February 2016 easyJet unveiled plans to use hydrogen fuel cells on its aircraft to save up to 50,000 tonnes of fuel a year, cutting both carbon and air quality emissions. The airline hopes to trial technology in the next few years.

EasyJet's "hybrid plane", originating from a competition run with Cranfield University would use a hydrogen fuel cell stowed in the aircraft's hold. This would capture energy generated by brakes on landing and could charge the system's lightweight batteries on the ground – a similar system to one developed in Formula 1 cars. The aircraft would also use electric motors in their main wheels when taxiing.

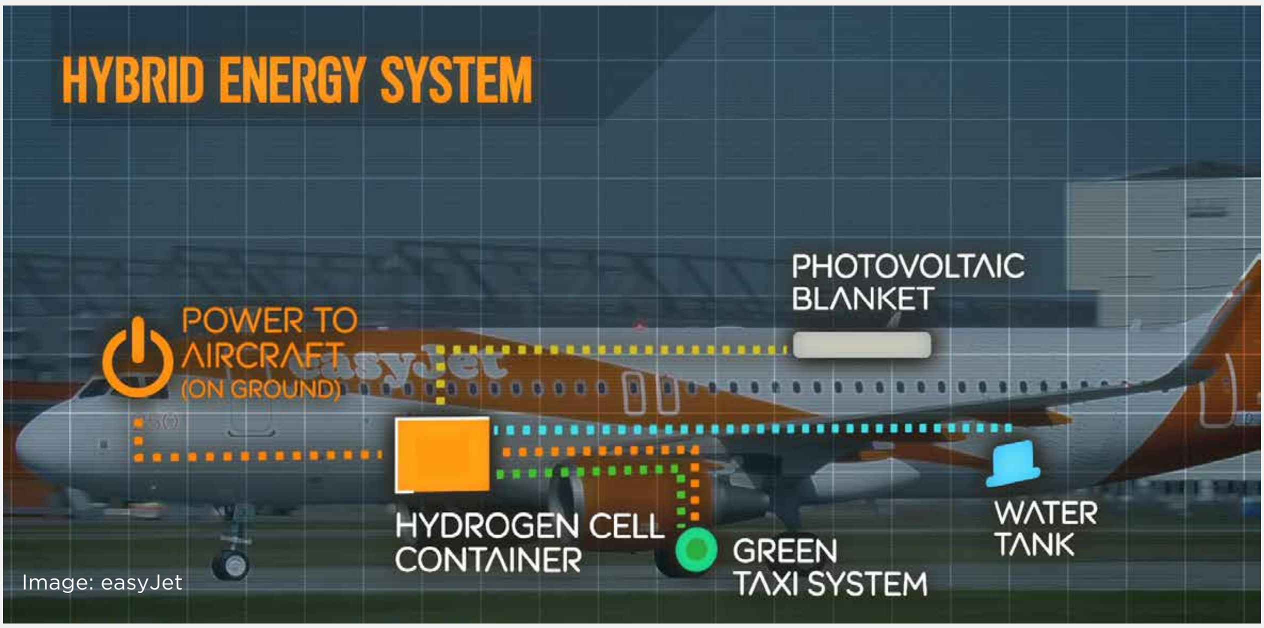


Image: easyJet

Airbus and Rolls-Royce developing low emission aircraft engines

Airbus Group Innovations and Rolls-Royce, with Cranfield University as a partner, are jointly engaged in the Distributed Electrical Aerospace Propulsion (DEAP) project. The project is co-funded by InnovateUK (an executive non-departmental public body, sponsored by the Department for Business, Innovation & Skills). The Department for Business, Energy and Industrial Strategy project researches innovative technologies to enable improved fuel economy, fewer exhaust gases and reduced noise for aircraft of the future by incorporating Distributed Propulsion (DP). DP will require a higher level of integration with airframe designs than that of today's aircraft.

The DEAP project is working to deliver a breakthrough in future aircraft design, significantly reducing air emissions and other environmental impacts. Rolls-Royce will develop an optimum electrical system propulsion plant, while Airbus Group Innovations will design the electrical system and work with Airbus to optimise airframe design.

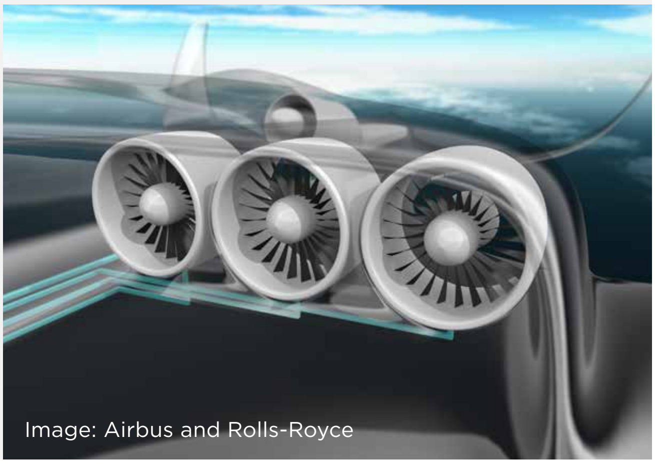


Image: Airbus and Rolls-Royce

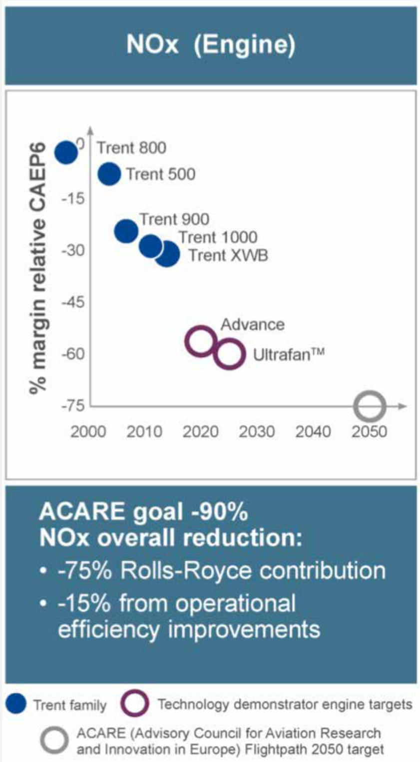
Developing and designing low emission engines at Rolls-Royce

Each year, Rolls-Royce spends £1bn on research and development and designing engines that reduce noise and emissions. This investment has already advanced combustion technology on Trent 900, Trent 1000, and Trent XWB engines – reducing NO_x emissions well below international standards.

Rolls-Royce continues to innovate, currently developing two new generation engine designs. The first, Advance, will offer at least 20% better fuel burn and CO_2 emissions than the first generation of Trent engine and could be ready by 2020. The second, UltraFan™, is a geared design with variable pitch fan system and could be ready for service from 2025, offering at least 25% improvement in fuel burn and emissions.

A new combustion system which drastically reduces emissions is currently being developed by Rolls-Royce. ALECSYS, the Advanced Low Emissions Combustion SYStem, builds upon existing air-spray fuel injector technology, developing it further through a nested, dual air-spray fuel injector design. The result is a significant reduction in NO_x and PM emissions. ALECSYS technology has been selected as an integral part of the Rolls-Royce Advance and UltraFan™ engine strategies.

Rolls-Royce is now preparing for flight demonstration to mature the system, which will lead to a smooth service introduction on the next new large civil engine product.



Emissions from new Rolls-Royce engines, compared to the international aircraft engine emission standard "CAEP6"

Image: Rolls-Royce

Introducing sustainable and cleaner fuels to reduce aviation emissions

Over the last ten years five different production methods for synthetic fuels have been approved, allowing a new generation of sustainable fuels to be used in commercial aircraft. These fuels can be made sustainably from non-fossil raw materials, such as plant based biomass, algae, used cooking oil and solid or gaseous wastes. A number of studies have concluded that these synthetic fuels are cleaner burning than conventional fossil fuels and reduce aircraft engine emissions.

There is also a shorter term opportunity to reduce the emission of PM by lowering the level of sulphur and of aromatics in existing fossil-based fuels. The best UK opportunity lies in the production of sustainable fuels using waste feedstock such as Municipal Solid Waste (MSW), agricultural wastes, forestry wastes and industrial gaseous wastes such as carbon monoxide from steel making. These sustainable fuels can not only reduce lifecycle carbon dioxide emissions by more than 90% compared to fossil fuel equivalents, but also burn more cleanly with lower sulphur oxide (SO_x) and PM emissions because they do not usually contain high levels of aromatic hydrocarbons or sulphur. They can also reduce NO_x emissions as they tend to burn at slightly lower temperatures.

However, sustainable fuels currently have to be mixed with conventional fuels so that they are compatible with aircraft systems and meet current certification requirements. Industry is also working to increase the proportion of sustainable fuel allowed and develop engines and aircraft systems that in the long term (2050+) will be able to operate using a 100% sustainable fuel. By the end of 2015 over 2,000 flights had operated using sustainable fuel. Some airlines are now using these sustainable fuels on regular commercial flights.

Using UK airspace more efficiently

Current UK airspace structures are over 50-years old and have evolved over time to meet growing air traffic demand at UK airports. There is now an urgent need to re-design this airspace structure to make better use of the current aircraft performance capabilities and air traffic technologies.

NATS have developed a new iTEC system which makes use of data from many sources, including from aircraft, giving very precise 4D trajectories. By understanding where an aircraft will be, and when it will be there, NATS are able to plan optimal profiles, potentially increasing UK capacity by 40%, by enabling aircraft to pass each other with minimum separation.

This evolution, combined with airport collaborative decision making (A-CDM), will present opportunities to reduce delays and emissions from aircraft both in the air and also taxiing, or queueing on the ground. Optimising the benefits will require close collaboration with neighbouring air traffic control bodies, particularly those throughout Europe.

Image: NATS

6. Realising the opportunities by working together

Sustainable Aviation is bringing together the UK aviation industry to ensure it plays its full part in improving air quality at and around airports. There are a number of opportunities for the aviation industry and Government to work together to reduce aviation emissions. A key priority will be to agree how we deliver these opportunities, particularly following the UK's decision to leave the EU.

6.1 Sustainable Aviation's commitment

The UK aviation industry is committed to its strategic goal of playing its full part in improving air quality around airports. Sustainable Aviation (SA) members have already delivered wide-ranging emission reduction programmes and are engaged in a number of innovative projects to further reduce emissions in the future. Some of these projects are discussed in this paper.

Sustainable Aviation Local Air Quality Strategic Goal:

Industry to play its full part in improving air quality around airports.

SA Surface Access Strategic Goal

Industry playing its full part in an efficient, sustainable multi-modal UK transport system.

Members of SA will:

- Continue to engage with local and national stakeholders, to identify and implement further opportunities to reduce emissions;
- Work to improve the sustainability of passenger and staff journeys, to and from airports;
- Support and invest in research to develop technological improvements and to better understand emissions by refining emission calculations;
- Provide the information needed to develop robust and effective policy, and continue to support further research into air quality; and,
- Include details of our work to reduce emissions and improve air quality in our regular progress reports.

6.2 Opportunities to work together

Realising the opportunities this paper has set out will require a focus by all stakeholders, including the aviation industry and central, devolved and local governments.

National emissions inventories confirm the relatively small contribution aviation makes to overall UK emissions. Only one top-ten UK airport is included within any of the 604 air quality management areas established by local authorities where air quality does not meet objectives. Nevertheless, members of SA are working to deliver efficiencies and reduce emissions that impact upon air quality at airports.

Through SA, the aviation industry is committed to making its contribution to reduce emissions. Whilst manufacturers deliver the current generation of more efficient, lower-emission aircraft and engines, research into the next is already underway – with the aim of delivering further environmental enhancements. Sustainable, lower-emission fuels have been developed for use in aircraft, and industry is working to scale up production and supply. A step change in the design and management of UK airspace will support lower-emission aircraft operating procedures, and airport-led initiatives will enable a shift towards ultra-low emission airport vehicles and equipment.

To deliver air quality improvements, these priorities require a variety of levels of support from clear policies and targets to incentives to change established behaviours as well as sustained investment in innovation. Sustainable Aviation is committed to working with Government to achieve this.

The primary emission source of concern to UK air quality is road traffic. Sustainable Aviation therefore believes it is critical to prioritise actions that reduce emissions from road transport to achieve the quickest air quality benefits. In an aviation context, we look forward to working with Government to further develop and promote public transport, and other sustainable transport modes, for passengers and staff traveling to and from airports.

6.3 Identifying the next steps

Members of SA believe that progress in reducing emissions could be made by working on four specific areas. These are:

Focussing on road transport and helping to improve surface access to airports

Many UK airports have published detailed surface access strategies which seek to improve passenger journeys to and from the airport. These strategies include actions to reduce road traffic congestion around airports and improve public transport. Devolved and local government identify similar priorities in their strategic transport plans. National strategic transport policies also include consideration of policies on road and rail infrastructure. Sustainable Aviation believes that efficiencies and emission reductions are possible by better integrating these different strategies.

Expanding low emission vehicle policy support to specialist airport vehicles

Reducing emissions from vehicles presents the biggest opportunity to address local air quality. It is therefore very important that the number of ultra-low emission vehicles in use across the UK grows as quickly as possible. Sustainable Aviation believes that incentives which encourage greater use of alternatively fuelled vehicles could be improved and is keen to work with Government to see what role the aviation industry can provide. Current policy support exists for "off the shelf" private and commercial vehicles, but does not extend to the bespoke commercial vehicles and equipment used at airports – for example, electric aircraft push back tugs that are also available "off the shelf".

Providing policy certainty so that the private sector will invest in sustainable aviation fuels (including the extension of the Renewable Transport Fuel Obligation to jet fuel)

When developing the Sustainable Fuels Road-Map (Sustainable Aviation, 2014), SA quickly identified that the innovation required to produce sustainable fuels for aircraft, which reduce emissions, already existed. The challenge however, is the cost of developing technology to commercial-scale production. Requirements to gain planning permission, purchase land, develop the facilities which will make fuel and actually get fuel to aircraft add very significant cost. To achieve private investment to cover these costs, certainty must be given to investors that they will receive a return on their investment. This requires clear and long-term signals of support from Government. There remain areas where the aviation industry and Government need to provide more certainty, supporting investment in this proven low emission innovation.

Sustainable Aviation believes current UK low emission policies need to be improved. The Renewable Transport Fuels Obligation (DfT, 2012) is a very effective policy for increasing the use of biofuels in diesel and petrol for ground vehicles – but does not extend to aviation. There is a need to develop a similar approach for aviation and SA looks forward to the pending UK Government consultation on this issue.

Ensuring that research and development programmes continue to be supported during and after the process of the UK leaving the European Union to continue the excellent work we have underway

Members of SA currently nurture innovation themselves, as well as working collectively through the UK Aerospace Technology Institute which is an independent company established by Government and industry (Aerospace Technology Institute, 2016). This collaborative approach has already secured research and technology investment of over £2 billion. Broader innovation support for vehicles is provided through the Government Office for Low Emission Vehicles. There is an opportunity to learn from both these innovation support bodies and work with Government to improve the delivery of innovation leading to low emission innovation in aviation.

Beyond this there are a number of important technology research projects currently underway to reduce aviation emissions which are currently jointly funded through the EU Horizon 2020 research programme (European Commission, 2016). They include Flightpath 2050 aerospace projects, 'Single European Sky' projects and broader non-aviation low emission technology innovation work. Sustainable Aviation welcomes the confirmation from Government that European funding already secured will be protected following the vote to leave the EU. There is an urgent need to provide long term clarity in how current and future innovation research programmes will also be supported.

6.4 Further discussion

Sustainable Aviation welcomes views from stakeholders to this paper and we now look forward to working with others to address the barriers to addressing aviation air quality emissions.

We will report progress on this work in our bi-annual progress report.

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Appendices

Appendix A – Important air pollutants in the UK

Important air pollutants in the UK, as identified within the UK Air Quality Strategy (Defra, 2007)

Oxides of Nitrogen (NO_X)	Created by combustion processes, particularly cars and lorries, oxides of nitrogen (NO_X) are a key pollutant to consider at airports in relation to surface access, with the main UK source being road transport. Aircraft engines also produce NO_X. Nitrogen dioxide (NO_2) and nitric oxide (NO) are both oxides of nitrogen and together are referred to as NO_X. In sunlight, NO_2 converts to nitric oxide (NO) and an oxygen atom (O). This single oxygen atom then combines with naturally occurring oxygen (O_2) to produce ozone (O_3). For this reason, while actions can be taken to control emissions of NO_X, the conversion to secondary products cannot be directly controlled.
Particulate Matter (PM as PM_{10} and $PM_{2.5}$)	Particulate matter (PM) is categorised on the basis of the size of the particles, PM_{10} refers to particles with a diameter of less than 10 micrometres and $PM_{2.5}$ particles with a diameter of less than 2.5 micrometres. Materials arising from a variety of different sources make up PM. It can be formed directly from combustion process and indirectly from chemical reactions in the air. Particulate matter is also a mix of human-made and natural sources (such as Saharan dust). Combustion processes form an important source of PM, so it is considered a key pollutant to consider at airports.
Ozone (O_3)	While not emitted directly from any human-made source, O_3 can be formed through chemical reactions between air pollutants (primarily NO_X) and Volatile Organic Compounds (VOCs), initiated by strong sunlight.
Sulphur Dioxide (SO_2)	Emissions of sulphur dioxide (SO_2) are dominated by combustion of fuels containing sulphur, such as coal and heavy oils. Sulphur emitted by aircraft is in the form of SO_2 and is directly related to the amount of sulphur in fuel. In the atmosphere SO_2 is converted to PM.
Polycyclic aromatic hydrocarbons (PAHs)	Emitted by a range of sources, UK objectives use benzo[a]pyrene (B[a]P) as a marker pollutant as it is considered the most hazardous polycyclic aromatic hydrocarbon (PAH) species. B[a]P is emitted by domestic burning of coal and wood and larger scale burning processes such as coke production. While road transport is the largest source for total PAHs, this source is dominated by species thought to be less hazardous than B[a]P.
Benzene(C_6H_4)	Has a variety of sources, but primarily arises from domestic and industrial combustion and road transport.
1,3-butadiene	Derives mainly from combustion of petrol in motor vehicles.
Carbon monoxide (CO)	Formed from incomplete combustion of carbon containing fuels. The largest source is road transport, with residential and industrial combustion making significant contributions. Aircraft engines emit carbon monoxide (CO) at low power conditions.
Lead (Pb)	Emitted from the combustion of coal and metal processing. Road transport was a large source before the introduction of unleaded fuel. No lead (Pb) is added to commercial aircraft fuel, however a leaded fuel referred to as 'AVGAS' is used in a few small aircraft types.
Ammonia	Mainly from agricultural sources, a smaller proportion is emitted from sources such as transport and waste disposal. No ammonia is emitted by aircraft engines but sulphur and NO_X emissions from aircraft can interact with ammonia to form particulate matter in the air such – for example ammonium nitrate and ammonium sulphate.

Emerging Research

Ultra-fine particulates (UFP)	In addition to the pollutants discussed in the above, for which there is a strong and established evidence base, a smaller type of PM – ultra-fine particulates (UFP) – are an emerging scientific interest. These particles are a sub-set of the emissions above. Scientific research into UFP is still in its infancy, however Airports Council International has published a report (Airports Council International Europe, 2013) which provides an overview of available information on UFP and current understanding in an aviation context. This report was supported by airports that are members of Airport Council International. The report concludes that current understanding of average, long-term concentrations of UFP at airports, particularly in terms of dose effect is insufficient to establish any relationships. A review of studies of UFP concentrations shows that concentrations of UFP at airports are not significantly higher than results from non-airport locations. Airports will continue to support further research in this area.

Appendix B – Science-based air quality objectives

Air quality targets

The European National Emissions Ceilings Directive (European Directive 2001/81/EC, 2001) came into force in 2001, and is transposed into UK legislation as The National Emission Ceilings Regulations 2002. The Directive sets national emission limits or “ceilings” for the four main air pollutants: sulphur dioxide (SO_2); nitrogen dioxide (NO_X); volatile organic compounds (VOCs); and, ammonia (NH_3). These ceilings, which are different for each Member State, should have been met by 2010. Emissions of these pollutants impact on local air quality or air quality further from their source, which is known as transboundary air pollution.

Legislation such as the Emissions Ceilings Directive (European Directive 2001/81/EC, 2001) seeks to reduce pollutant emissions to tackle the effects of their concentrations in the air. One of the most important effects of atmospheric pollution is the impact that it has on human health. The World Health Organization (WHO) has established concentration guidelines (World Health Organisation, 2005) for several pollutants based on research into their impacts on people’s health. The WHO air quality guidelines (AQGs) are intended to help national governments determine national air quality standards by balancing health risks, technological feasibility, economic considerations and various other political and social factors. For certain pollutants, as research has not identified thresholds below which adverse effects do not occur, the AQGs cannot fully protect human health. Much of the recent focus on regulation of air quality in the UK has been on nitrogen dioxide (NO_2) and PM (PM_{10} and $PM_{2.5}$).

UK air quality management framework

In order to improve ambient air quality and protect human health, the European Union (EU) has set legally binding targets to limit concentrations of certain pollutants. The UK Government is responsible for ensuring that the UK meets European targets and has also introduced regulations which place responsibility on local authorities to review air quality and develop action plans where improvement objectives will not be met.

Compliance against air quality objectives

Each year, Government publishes a report on air pollution in the UK (Defra, 2015) which includes an assessment of whether the UK is complying with the EU Limit Values. For the compliance assessment, the UK is divided into 43 zones and agglomerations. The latest report concluded that in 2014, all zones and agglomerations within the UK complied with the limit values for SO_2, carbon monoxide (CO), benzene and lead. All zones met the limit value for annual mean concentration of PM_{10} and the limit value for daily mean concentration of PM_{10}, after subtraction of the contribution from natural sources. Nitrogen dioxide poses the biggest problem for compliance in the UK. A total of 38 zones exceeded the annual mean limit value of 40 micrograms per cubic metre.

As a result, in December 2015, Government published plans to improve air quality in the UK focused on “Tackling nitrogen dioxide in our towns and cities” (Defra, 2015). The document sets out the UK’s approach to meeting European NO_2 limit values in the shortest time possible.

The plans are in the form of an overarching national plan and individual local plans for each of the 38 zones currently exceeding the annual mean limit value for NO_2. The national plan recognises that road traffic is the most important source of NO_2 with measures targeted accordingly. It is also recognises that UK airports have strategies in place to reduce emissions of NO_X. Specific measures are discussed in the plans for individual zones and agglomerations.

The plans for individual zones and agglomerations recognise the central role of local authorities in achieving improvements in air quality. They detail measures that have been undertaken, are underway or are planned by local authorities. These zone and agglomeration plans are supported by measures detailed in the air quality strategies of individual airports.

Air quality management areas

Under the local air quality management system, if a local authority identifies that any air quality objective is not likely to be achieved in any particular area, it is required to declare an air quality management area (AQMA) and prepare an air quality action plan detailing how it will work towards reducing concentrations.

NO_2 poses the biggest problem for compliance with air quality objectives. In the UK, 604 AQMAs have been declared as a result of exceedance of NO_2 objectives, compared to 95 for PM_{10} and 7 for SO_2 (Defra, 2016). Of the top ten airports in the UK, one is within an AQMA, and four within 1 kilometre of an AQMA:

- Heathrow Airport is within the Hillingdon AQMA, declared for NO_2 from a mixture of road types
- Birmingham Airport is near to the Birmingham AQMA, declared for NO_2 and PM_{10} from a mixture of road types
- Edinburgh Airport is near to the Glasgow Road AQMA, declared for NO_2 from unspecified road transport
- Gatwick Airport is near to the Horley AQMA, declared for NO_2 from a mixture of road types

Appendix C – Airport air quality monitoring

Methods of monitoring air quality, and monitoring sites at UK airports

	Air quality monitoring methods		Air quality monitoring locations			
Airport	**Automatic (continuous)**	**Non-automatic (diffusion)**	**Airfield**	**Landside at airport**	**Near-airport**	**Nearest residential area**
Birmingham	●		●			
Bristol	●	●	●	●	●	●
Edinburgh		●	●	●	●	
Gatwick	●	●	●	●	●	●
Glasgow		●	●	●		
Heathrow	●		●		●	
Luton	●	●	●	●	●	●
Manchester	●	●	●	●	●	●
Newcastle		●	●	●		
Stansted	●	●	●	●	●	

Methods of sharing information about air quality at UK airports

Airport	Annual air quality report	Online real-time monitoring results	Air quality meetings and/ or working groups
Birmingham	●	●	●
Bristol	●		●
Edinburgh			●
Gatwick	●	●	●
Glasgow	●		
Heathrow	●	●	●
Luton	●	●	●
Manchester	●	●	●
Newcastle			●
Stansted	●		●

Appendix D – Air quality monitoring results

The following pages display air quality reports published by the following airports:

- Birmingham Airport
- Bristol Airport
- Gatwick Airport
- Glasgow Airport
- Heathrow Airport
- Luton Airport
- Manchester Airport
- Stansted Airport

Birmingham Airport undertakes air quality monitoring at a dedicated Automatic Air Quality Monitoring Station located airside. Air quality has been monitored by a dedicated AQMS since 1995. Real time air quality monitoring data is made available online at http://www.airqualityengland.co.uk/.

An annual report is published on the Birmingham Airport website at: https://www.birminghamairport.co.uk/about-us/community-and-environment/environment-management/air-quality/

The site monitors oxides of nitrogen (nitric oxide and nitrogen dioxide), ozone, carbon monoxide, sulphur dioxide and PM10. The PM10 data were measured using a Tapered Element Oscillating Microbalance (TEOM).

The following table shows a summary of the results from Birmingham Airport's AQMS in 2015.

	O3 (μg/m^3)	NO (μg/m^3)	NO_2 (μg/m^3)	NO_x (μg/m^3)	PM10 (μg/m^3)	CO (μg/m^3)	SO_2 (μg/m^3)
Maximum 15 minute mean (SO_2)	-	-	-	-	-	-	19
Maximum 8 hour (CO, O_3)	178	-	-	-	-	1	-
Annual Max	190	248	109	486	118	1	16
Maximum daily mean	140	69	61	167	54	0	8
Annual mean	50	6	21	31	15	0	2
Data capture	94.8%	98.5%	98.5%	98.5%	89.7%	98.9%	88.7%

The UK AQS hourly mean objective for NO_2 is 200 μg/m^3, with no more than 18 exceedances allowed each year. The monitoring site has registered no exceedances of this value during the year, and therefore met this objective for 2015. The annual mean AQS objective for NO_2 is 40 μg/m^3. This objective was also met in 2015; an annual mean of 21 μg/m^{3}was measured. This value is slightly lower to the one measured in 2014 (25 μg/m^3), showing a small decrease in concentration for this pollutant.

PM_{10} may exceed the 24-hour mean limit of 50 μg/m^3 no more than 35 times per year to meet the AQS objective. During 2015, three exceedances of the limit value were registered at the site. This AQS objective was therefore met in 2015. The annual mean AQS for PM_{10} is 40 μg/m^3. This objective was met at Birmingham Airport.

The UK AQS objectives for ozone state that the limit value for this pollutant is of 100 μg/m^3, not to be exceeded more than 10 days a year. The ozone levels measured at Birmingham Airport monitoring station show that this pollutant had 67 exceedances of the limit value in 11 days during 2015. The AQS objective for ozone was therefore not met in 2015. However, ozone is a transboundary pollutant which is difficult to control by local measures: it is therefore not currently included in the Local Air Quality Management regime.

The AQS objectives for CO and SO_2 were met at Birmingham Airport in 2015.

The Table below compares the annual mean concentrations at Birmingham Airport with other air quality monitoring sites in Birmingham. The sites selected are all part of the UK's national Automatic Urban and Rural Network (AURN) and are as follows:

- Birmingham Tyburn: An urban background site, located within the car park of council owned offices.
- Birmingham Tyburn Roadside: An urban traffic site located on the south side of the A38 in Tyburn outside council owned offices, and approximately 700 metres to the north of the M6 motorway.
- Birmingham Acocks Green: Another urban background site, located within the grounds of an annex to a large school near Shirley road.

Pollutant	Birmingham Airport 2	Birmingham Tyburn	Birmingham Tyburn Roadside	Birmingham Acocks Green
PM10 (µg/m^3)	15	19	17	-
NO2 (µg/m^3)	21	30	45	19
O3 (µg/m^3)	50	45	35	47
SO2 (µg/m^3)	2	1	-	-
CO (µg/m^3)	0	-	-	-

The annual mean concentration of PM_{10} measured at the Birmingham Airport site in 2015 was comparable with those measured at the other Birmingham sites. As in previous years, the annual mean concentration of SO_2 at Birmingham Airport was low, though slightly higher than that measured at Birmingham Tyburn. The annual mean concentration of NO_2 and O_3 measured at Birmingham Airport were comparable with the ones measured in Acocks Green, an urban background site located far away from busy roads.

Elevated annual means of O_3 are typical from rural areas, far away from strong local emission sources (responsible for ozone scavenging processes). The ozone exceedances seen at Birmingham Airport are still comparable to the wider air quality and therefore, the failure of meeting the AQ targets is not a direct result of Birmingham Airport Activities.

These statistics together indicate that the pollution levels registered at Birmingham Airport were low in 2015. Previous year's data at Birmingham airport is summarised in the table below:

Pollutant	Annual Mean(µg/m^3)					
	2015	**2014**	**2013**	**2012**	**2011**	**2010**
NO_2	21	25	24	24	24	28
PM10	15	18	19	17	21	19
O_3	50	45	47	41	49	41
CO	0	0.2	0.4	0.2	0.2	0.2
SO_2	2	2	1	2	2	2

Bristol Airport
Amazing journeys start here

Air Quality Report 2015

Bristol Airport monitors air quality 24 hours a day from a dedicated onsite air quality station.

The main airport sources come from vehicle traffic (staff and passenger journeys and airport operational vehicles), aircraft engines (during taxiing, take-off and landing), energy generation (diesel generators and gas boilers), fugitive emissions (evaporation - during fuelling of aircraft and vehicles) and other activities such as fire training.

Reporting Objectives

This report considers air quality at Bristol Airport during 2015, comparing recorded concentrations with the UK's Air Quality Strategy and against the commitments contained within Bristol Airport's S106 Agreement with North Somerset Council. The National Air Quality Strategy (NAQS) forms the legislative basis for air quality in the UK, stipulating long and short term objectives to ensure air quality does not result in health issues.

Monitoring Methodology

Monitoring of air quality is undertaken continuously, with real time monitors recording levels of both NO_2 and PM_{10} at the airport site. Additionally, passive diffusion tubes are deployed to monitor average monthly NO_2 concentrations at nine locations across the airport site, including the location of the continuous air quality monitor.

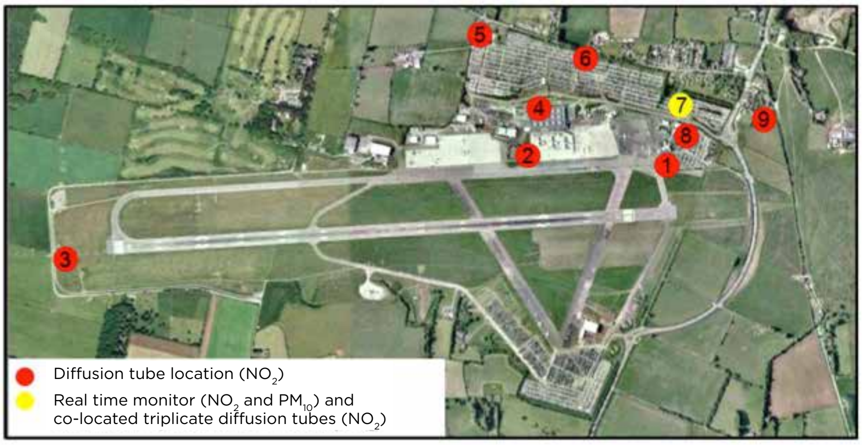
National Air Quality Strategy Objectives

Pollutant	Annual objective (mean limit)	Short term objective. (max events per annum)
NO_2	40 µg/m³	18 hourly means > 200 µg/m³
PM_{10}	40 µg/m³	35 daily means > 50 µg/m³

Section 106 Agreement

- Highlight air quality monitoring locations where monitored levels exceed 90% of the National Air Quality Strategy limit
- Report significant deterioration in air quality, defined as an increase in average annual concentration of more than 15% compared to the average levels recorded between 2008 – 2012 (NO_2) or particulate levels exceeding 50 µg/m³ in more than 15 days in a calendar year (PM_{10})

Location of Air Quality Monitors



N.B. Five year baseline data is derived from historic monitoring prior to 2012. The current air quality monitoring programme includes a number of sites which were not monitored prior to 2012 and therefore a five year baseline is not available at all locations.

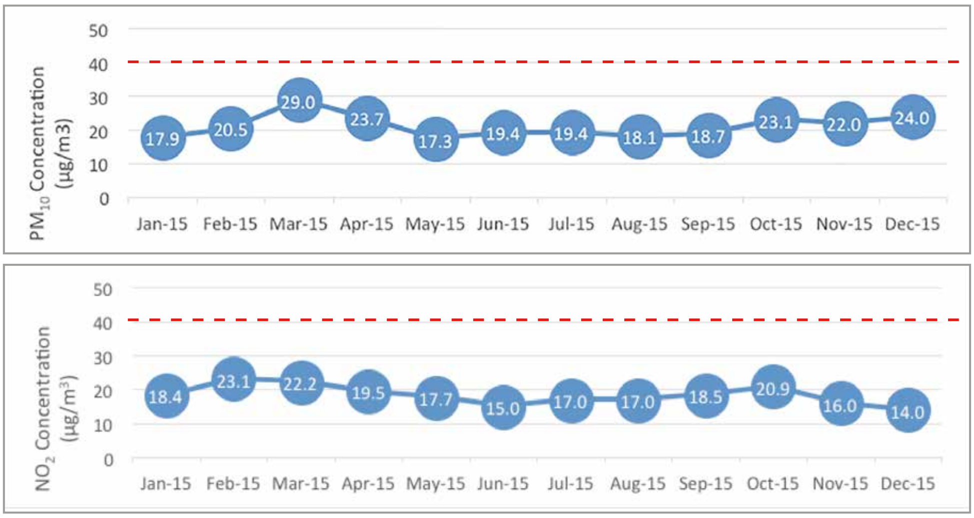
Ambient concentrations of NO_2 and PM_{10} recorded by real time monitoring are shown in Table 1 with analysis against NAQS and S106 objectives.

Table 1. Analysis of continuous monitoring data against NAQS and S106 requirements

	5yr Baseline (µg/m³)	Recorded Annual Mean (µg/m³	NO_2 – Hourly Means > 200µg/m³ PM_{10} – Daily Means > 50µg/m³	NAQS Compliant	Annual Mean <90% NAQS Objective	Significant Deterioration
NO_2	N/A	18	0	Yes	Yes	N/A
PM_{10}	N/A	21	4	Yes	Yes	N/A

Monthly ambient concentrations recorded by real time monitoring are detailed in Figure 1.

Figure 1. Average monthly NO_2 and PM_{10} concentrations recorded by real time monitors.



NO_2 levels recorded by diffusion tube monitoring are shown in Table 2 with analysis against NAQS and S106 objectives.

Table 2. Analysis of NO_2 diffusion tube results against NAQS and S106 requirements

Monitoring Location	5yr Baseline (µg/m³)	Recorded Annual Mean (µg/m³)	NAQS Compliant	Annual Mean <90% NAQS Objective	Significant Deterioration
1	34	25	Yes	Yes	No
2	39	27	Yes	Yes	No
3	16	9	Yes	Yes	No
4	N/A	11	Yes	Yes	N/A
5	38	29	Yes	Yes	No
6	N/A	17	Yes	Yes	N/A
7	N/A	19	Yes	Yes	N/A
8	50	27	Yes	Yes	No
9	N/A	17	Yes	Yes	N/A

N.B. Five year baseline data is derived from historic monitoring prior to 2012. The current air quality monitoring programme includes a number of sites which were not monitored prior to 2012 and therefore a five year baseline is not available at all locations.

YOUR LONDON AIRPORT Gatwick

Gatwick

We take our responsibilities on air quality seriously and maintain a strong relationship with the Local Authority to continually monitor and manage air quality impacts.

We are proud that air quality at and near Gatwick has never exceeded annual air quality limit values. Those limits are set by UK standards based on EU regulations.

As we develop and grow the airport into the future, we and our local authorities continue to identify nitrogen dioxide (NO_2) as the airport related emission requiring the closest management.

Our continuous monitoring of air quality at and around the airport has been on-going since 1992.

On-airport continuous monitoring is done year-round at the eastern end of the runway.

Off-airport continuous monitoring at three sites near the airport is conducted year-round in partnership with Reigate and Banstead Borough Council (RBBC). These three monitoring sites near the airport are part of the Horley Air Quality Management Area (AQMA) established by RBBC in 2002.

MEASURES IN PLACE AT GATWICK TO IMPROVE LOCAL AIR QUALITY

- Restrictions in place governing the use of aircraft auxiliary power units
- All stands are equipped with fixed electrical ground power thus removing the need for continued aircraft auxiliary power unit usage
- Full implementation of Airport Collaborative Decision Making (ACDM) resulting in less ground holding of aircraft and increased use of single engine taxiing
- Gatwick Direct consolidated logistics centre implemented, which reduces airfield ‘final mile’ delivery traffic
- Regular random checks undertaken of vehicles in use on the airfield to ensure emissions compliance
- Electrical charging points installed for electric baggage vehicles
- Age restriction in place for vehicles introduced to the airside environment
- Airport Surface Access Strategy in place to further encourage the use of public transport for passengers and staff travelling to the airport (presently 44% and 40% respectively).

YOUR LONDON AIRPORT
Gatwick

AIR QUALITY MONITORING AND REPORTING

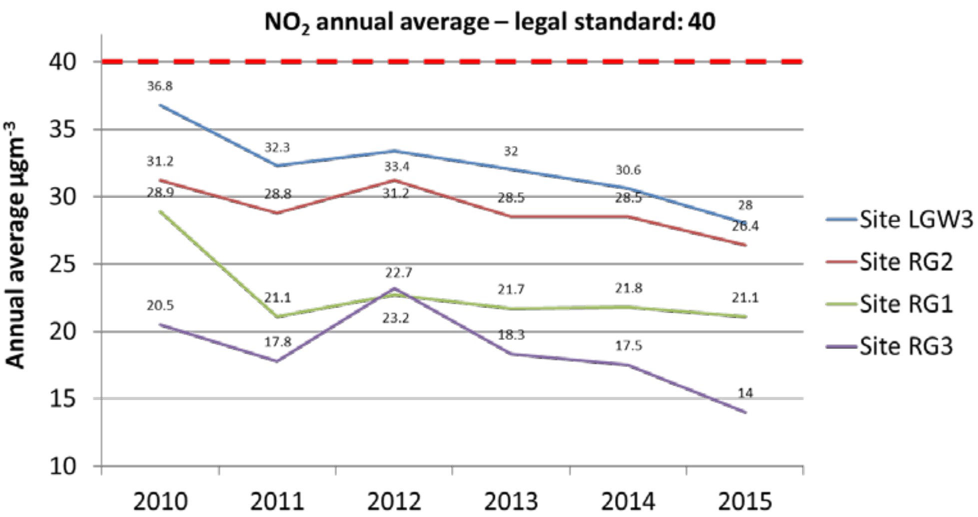
Every year, Gatwick and RBBC prepare and publish an Air Quality Monitoring Joint Report to the Gatwick Airport Consultative Committee (GATCOM) Steering Committee. This Report is discussed by GATCOM and published on the GATCOM and GAL websites.

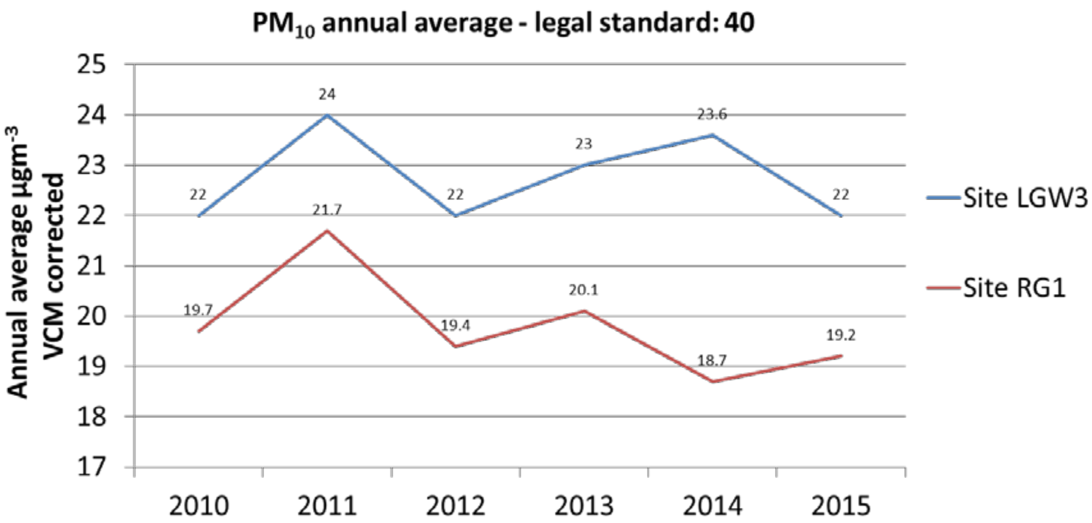
We maintain regular dialogue with RBBC on local air quality monitoring and management and contribute £65,000 per annum, and replace equipment as required, in support of this programme.

Our emissions performance since the creation of the Horley AQMA has been very good; the latest annual air quality data highlights a continual trend of reducing NO_2 and PM_{10} with none of the permanent monitoring sites recording an exceedance of the annualised average limit of 40 microgramme.

The tables below report our performance since 2010 for the permanent monitoring sites:

- LGW3 located on-airfield at the eastern end of the runway
- RG1 and RG2 located in Horley Gardens Estate (north east of the airport)
- RG3 located in Poles Lane, Crawley (south west of the airport)



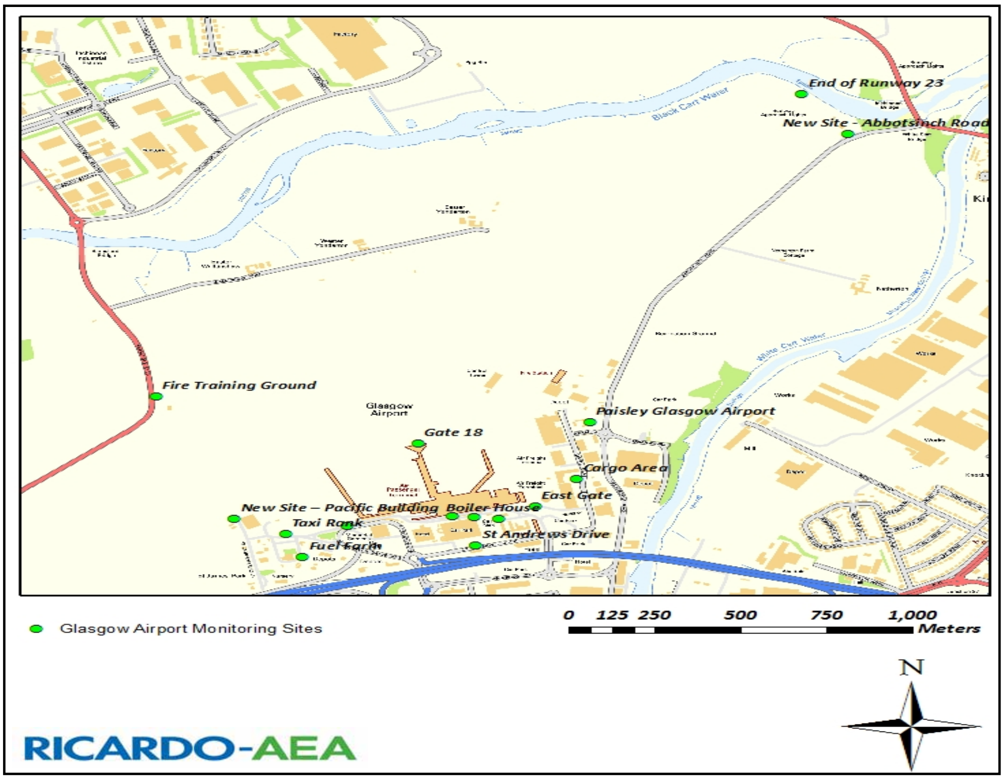


Glasgow Airport Air Quality Monitoring Summary

Glasgow Airport undertakes air quality monitoring across multiple campus locations on a 3 yearly rolling programme which has been in place since 2003/4 and is carried out by Ricardo Energy & Environment.

The programme focuses on the monitoring of nitrogen dioxide (NO_2) via the passive diffusion tube methodology across 16 separate airside and landside locations, with a consecutive sampling period of 6 months. To improve data accuracy all results are biased adjusted using triplicate diffusion tubes collocated with an automatic chemiluminescent NO_x analyser; the Scottish Air Quality Database site at Glasgow Airport (Paisley) was used for this purpose. Figure 1 shows the sampling locations used across campus during the 2013/14 survey.

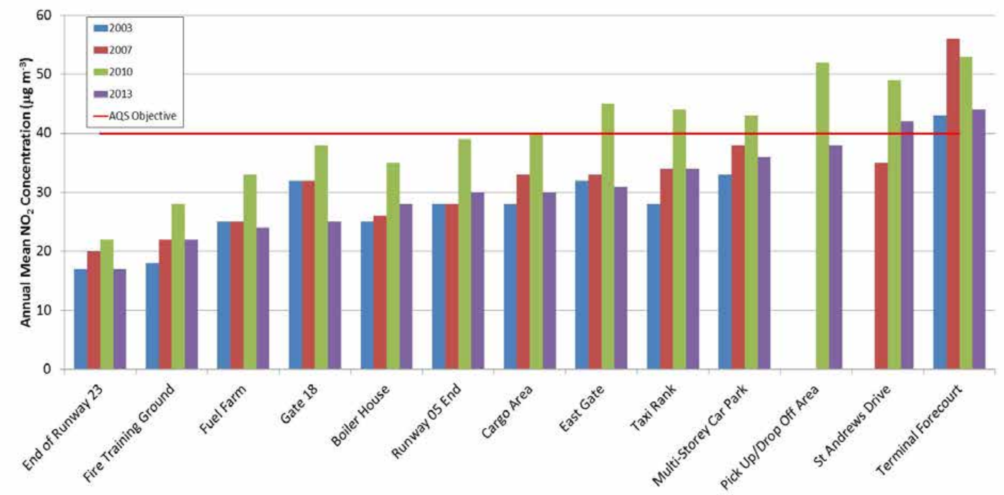
Figure 1: Glasgow Airport NO_2 sampling locations



Monitoring data is compared against the UK AQS annual and hourly mean objectives of 40 and 200 $\mu g/m^3$, respectively.

Figure 2 shows the annual mean NO_2 concentrations measured across the different sampling locations used since 2003. A decrease in annual average NO_2 concentrations was seen when compared to the 2009/10 survey with values recorded across all sites dropping to 2006/7 levels; at 29 $\mu g\ m^{-3}$.

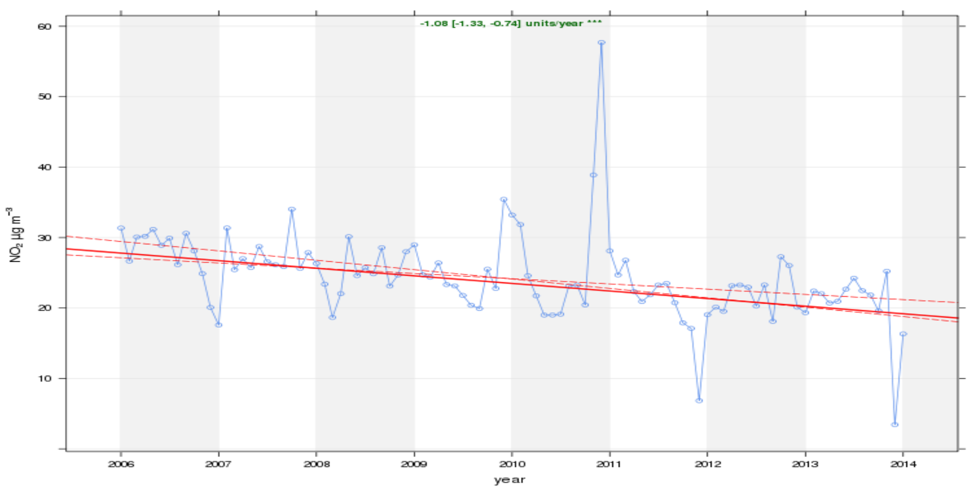
Figure2: Annual Mean NO_2 Concentrations 2003/4 – 2013/14



Mean concentrations close to or slightly above the objective level of 40 $\mu g\ m^{-3}$ were measured at four sites (GLA12, GLA13, GLA14 and GLA19) with values of 36 $\mu g\ m^{-3}$, 44 $\mu g\ m^{-3}$, 42 $\mu g\ m^{-3}$ and 38 $\mu g\ m^{-3}$ recorded respectively. These sites are not considered relevant exposure when comparing to the annual mean objective and therefore, this objective has not been breached at any location during 2013/14. Monitoring data also indicates that the hourly NO_2 objective of no more than 18 exceedences in a year of 200 $\mu g\ m^{-3}$ is not likely to have been exceeded at any location.

Figure 3 shows a trend plot of data from the Glasgow Airport (Paisley) SAQD site between 2006/7 and 2013/14. A downward trend in NO_2 concentrations has been seen at this location with the elevated NO_2 concentrations seen during 2010 attributed to climatic factors.

Figure 3: NO_2 *Data Trend at Glasgow Airport (Paisley) Monitoring Site for the Period 2006/7 – 2013/14*



Air Quality at Heathrow Airport

Q4 2015 briefing and end of year summary

Background

Heathrow Airport Ltd (HAL) began an air quality monitoring programme in 1993. Today HAL owns and operates one on-airport monitor and three other monitors around the airport. Data from HAL's four continuous monitoring stations, as well as 17 other continuous monitors operated the local authorities and DEFRA in the vicinity of the Airport, are shared and summarised on HeathrowAirwatch.org.uk. Data from the on-airport monitor and the 11 total stations located within 2km of the airport are regularly tracked are reported on within this end of year summary.

Air quality management is a key priority for HAL and we continue to work in partnership with our key stakeholders – especially local authorities and national Government – to reduce emissions from all sources in the area in order to meet the EU & UK limit values. The main pollutants of concern around Heathrow are measured at all stations –nitrogen dioxide (NO_2) and particles (measured as PM_{10} and $PM_{2.5}$).

Headlines

Key information for this 2015 is:

- Annual average for NO_2 remained below the EU limit values at 9 of the 11 monitoring sites within 2km of Heathrow
- Only Hillingdon and Hayes stations remain above EU limits, north of M4 (airport emissions from all sources contribute 16% and 6% of total NOx at these stations, respectively)
- There was one exceedence of the daily average PM_{10} limit value at HAL's LHR2 monitoring site in Q4 2015. 35 exceedences are allowed per year before the limit value is breached for a given station; none of HAL's stations recorded more than five daily exceedences of PM_{10} in 2015

Measured concentrations

Locations of the air quality monitoring sites around Heathrow

The locations of air quality monitoring sites local to the airport are shown in Fig. 1, which also shows the provisional annual average NO_2 concentrations measured at each site in 2015 overlaid on modelled NO_2 concentrations for 2013. Table 1 provides a summary of each station within 2km of Heathrow's boundary as well as the type of source environment its measurements represent. Fig. 2 presents historic annual average NO_2 measurement trends at monitoring close to the airport.

Fig. 1. 2015 annual average NO2 values at monitoring sites within 2km of Heathrow showing and 2013 modelled concentrations (EU/UK annual average limit value of 40µg/m³)

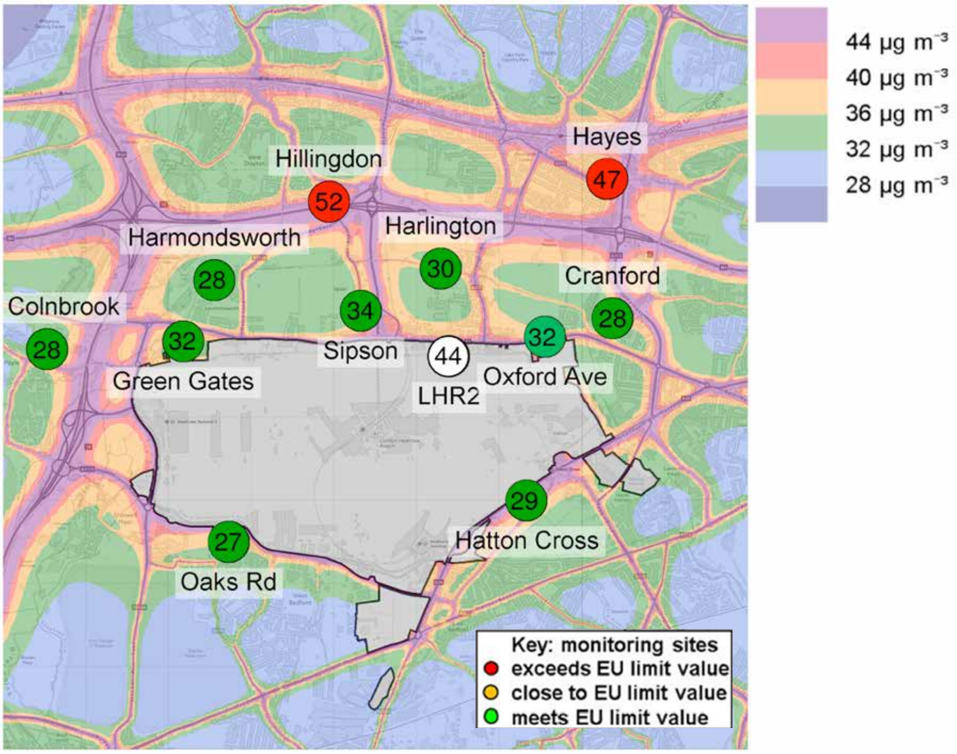


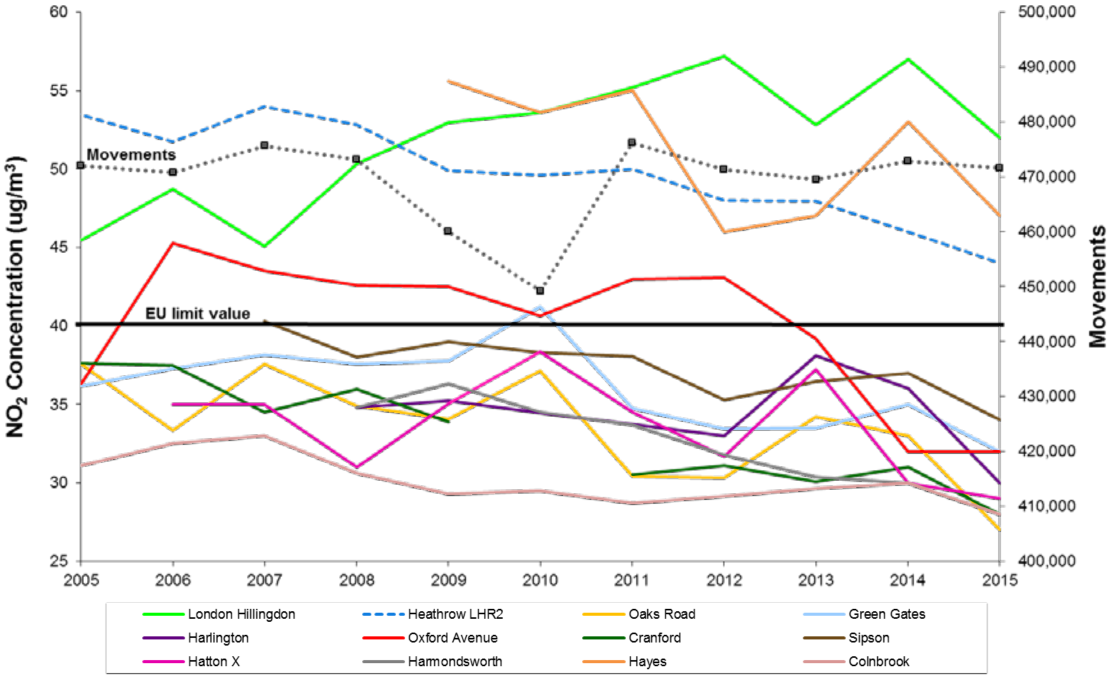
Table 1. Summary of continuous monitoring sites within 2km of Heathrow and provisional results in 2015

Monitoring station	Resp. party	Source Type	2015 average NO_2 (µg/m³)	Hourly exceedences NO2 (hours)	PM exceedences (days)
Heathrow LHR2	Heathrow	Airport	44	2	3
Harlington	Heathrow	Urban industrial	30	0	5
Green Gates	Heathrow	Airport	32	0	3
Oaks Road	Heathrow	Airport	27	0	5
London Hillingdon	Defra	Urban background	52	0	N/A
Hayes	Hillingdon	Roadside	47	2	14
Harmondsworth	Hillingdon	Urban background	28	1	4
Oxford Ave	Hillingdon	Urban centre	32	2	3
Sipson	Hillingdon	Urban background	34	3	N/A
Hatton Cross	Hounslow	Roadside	29	0	1
Cranford	Hounslow	Suburban	28	0	1
Colnbrook	Slough	Urban background	28	0	1

*Annual statistics prior to ratification of data

Nitrogen dioxide (NO_2) monitoring trends (EU/UK annual average limit value of 40µg/m^3)

Fig. 2. Measured annual average NO_2 concentrations around Heathrow since 2005 and annual air transport movements (ATMs)



Key trends and considerations from Fig. 2:

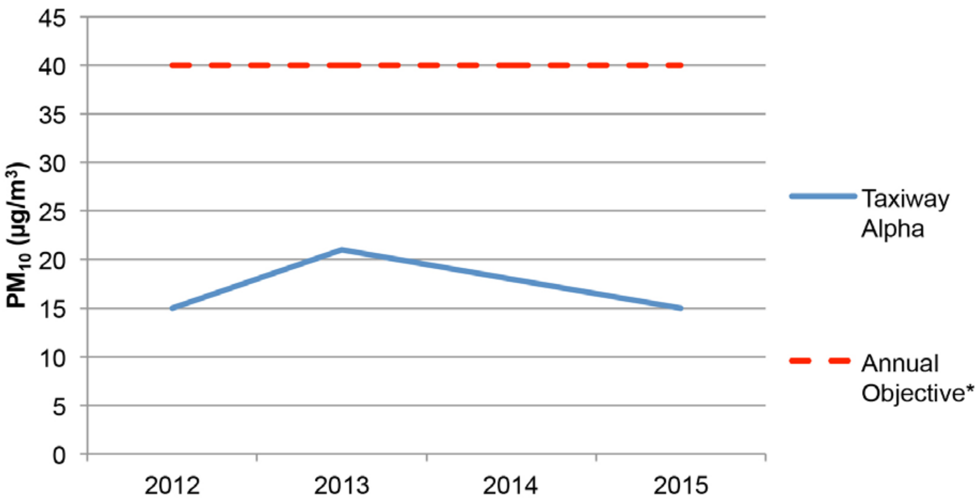
- Two sites exceeded the limit value outside of Heathrow:
  - London Hillingdon (light green) is mainly affected by emissions from traffic on the M4. Concentrations have decreased in 2015 to approximately 52 µg/m^3. All airport-related emissions (including airport-related traffic) are approximately 16% of measured NO_X concentrations at this site.
  - Hayes (orange), located 1.9 km to the northeast of the airport, also saw a decrease from 2014 to an annual average of 47 µg/m^3 in 2015. Emissions at Hayes are also dominated by road traffic. Heathrow emissions represent less than 6% of total NOx measured at this site.
- LHR2 (blue dotted line), located on the airport next to the northern runway, has shown a steady decline in concentration since installation in 1993, even though air transport movements (ATMs) have increased over the same period. Annual average NO_2 was 44 µg/m^3 in 2015, the lowest level measured since the site's installation. The EU limit values for ambient air quality are not applicable at LHR2 as members of the pubic do not have access to the site.

London Luton Airport Air Quality Data

London Luton Airport has been monitoring air quality in and around the airport environment since 2003. Air quality data collected at LLA is integrated into a monitoring programme incorporating data collected by the surrounding Local Authorities, with a monthly report available to view online at www.ukairquality.net The key parameters measured are PM_{10} and NO_2, and results are compared with objective levels detailed in the UK's Air Quality Strategy.

PM_{10}

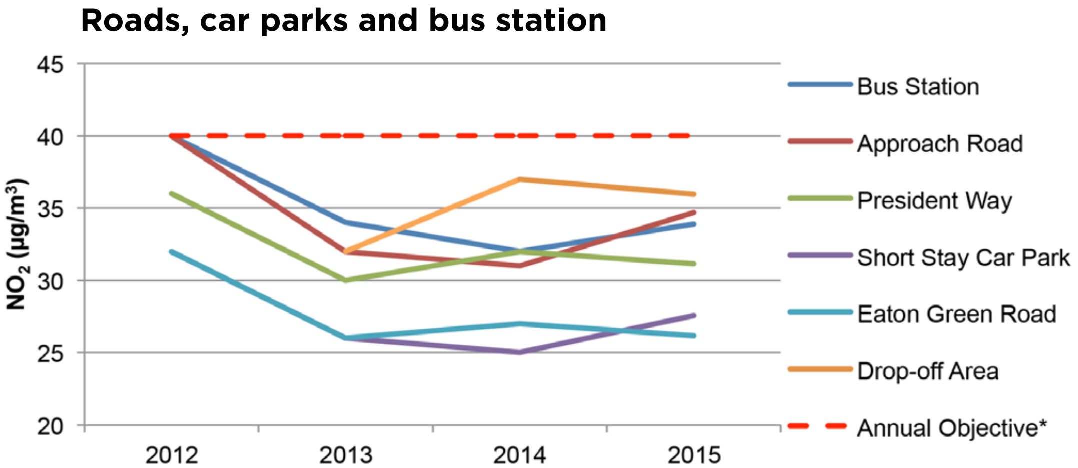
PM10 is monitored continuously from one location in the middle of the airport site. Annual averages are presented in the graph below, illustrating that the readings have remained well within the annual mean local air quality objective of 40μg/m³, and are decreasing over time. There were no pollution occurrences exceeding 50μg/m³ during 2015.

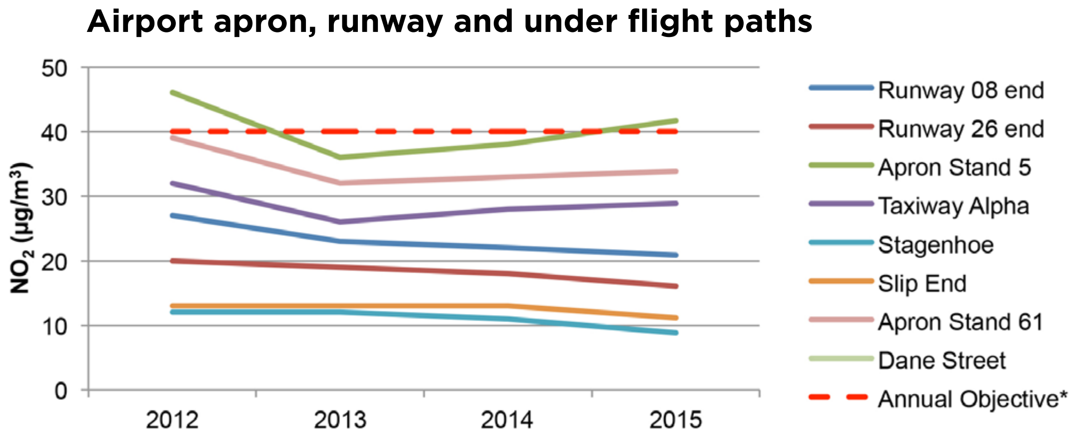


* Annual Objectives taken from the Air Quality Strategy (Defra 2007)

NO_2

NO_2 is monitored at 14 locations on and around the airport site. Levels at the closest residential receptors to the Airport, and also along the aircraft flight paths are significantly below the objective level laid out in the UK's Air Quality Strategy. Levels monitored by the roads around the Airport, in the car parks and on the apron are a little higher, with one location on the main apron slightly exceeding 40μg/m^3. A project is underway to standardise and modernise equipment on the apron which will help reduce pollution levels. All results have had a bias adjustment factor applied as per the Defra guidance.





* Annual Objectives taken from the Air Quality Strategy (Defra 2007)

Air Quality Report - 2015

manchester airport

PART OF M.A.G

Air quality can be affected by a number of pollutants that in high concentrations may pose harm to human health. Combustion processes produce both Nitrogen Dioxide (NO_2) and Particulate Matter (PM) with the main airport sources coming from vehicle traffic (staff and passenger journeys and airport operational vehicles), aircraft engines (during taxiing, take-off and landing), energy generation (diesel generators and gas boilers), fugitive emissions (evaporation - during fuelling of aircraft and vehicles) and other activities such as fire training.

Reporting objectives

This report considers air quality at Manchester Airport during 2015, comparing recorded concentrations with the UK's Air Quality Strategy.

The National Air Quality Strategy (NAQS) forms the legislative basis for air quality in the UK, stipulating long and short term objectives to ensure air quality does not result in health issues.

National Air Quality Strategy Objectives

Pollutant	Annual objective (mean limit)	Short term objective. (max events per annum)
NO_2	40 µg/m^3	18 hourly means > 200 µg/m^3
PM_{10}	40 µg/m^3	35 daily means > 50 µg/m^3
$PM_{2.5}$	25 µg/m^3	N/A
SO_2	N/A	35 15min means > 266 µg/m^3, and 24 hourly means > 350 µg/m^3, and 3 daily means > 125 µg/m^3
O_3	N/A	10 8hr means > 100 µg/m^3

Monitoring methodology

Monitoring of air quality is undertaken continuously in partnership with Manchester City Council. Real time monitors record levels of NO_2, PM_{10}, $PM_{2.5}$, Sulphur Dioxide (SO_2) and Ozone (O_3) adjacent to the airport site. Additionally, passive diffusion tubes are deployed to monitor average monthly NO_2 concentrations at 13 locations across the airport site, including the location of the continuous air quality monitor.

Location of Air Quality Monitors

Monitoring results

NO_2 levels recorded by diffusion tube monitoring are shown in Table 1 with analysis against NAQS objectives.

Table 1. Analysis of NO_2 diffusion tube results against NAQS objectives

Monitoring Location	5yr Baseline ($\mu g/m^3$)	Recorded Annual Mean ($\mu g/m^3$)	NAQS Compliant
1	45	37	Yes
2	37	29	Yes
3	38	27	Yes
4	33	27	Yes
5	40	29	Yes
6	30	23	Yes
7	19	14	Yes
8	15	9	Yes
9	19	15	Yes
10	26	20	Yes
11	56	45	No
12	75	65	No
13	42	30	Yes

NB. Diffusion tube monitoring results are reported following the removal of anomalous data and bias adjustment in line with Defra Guidance. The baseline data is based on data collected between 2010 and 2014. Data shown for Site 10 is a mean value for the three co-located diffusion tubes.

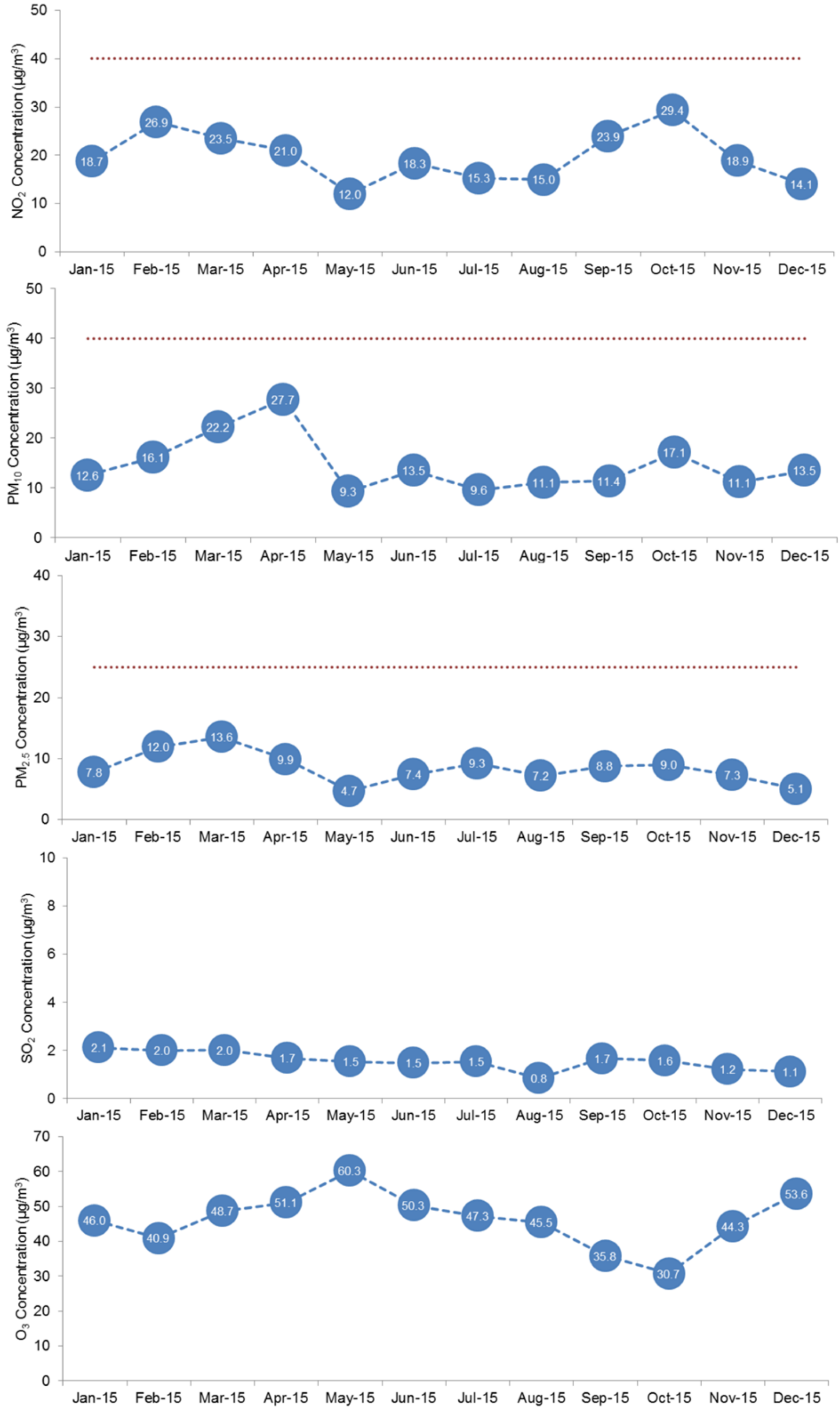
Ambient concentrations of NO_2, PM_{10}, $PM_{2.5}$, SO_2 and O_3 recorded by real time monitoring are shown in Table 2 with analysis against NAQS objectives.

Table 2. Analysis of continuous monitoring data against NAQS objectives

	5yr Baseline ($\mu g/m^3$)	Recorded Annual Mean ($\mu g/m^3$)	Short Term Objective Exceedances	NAQS Compliant
NO_2	24	20	Hourly Means > 200 $\mu g/m^3$ = 0	Yes
PM_{10}	15	15	Daily Means > 50 $\mu g/m^3$ = 4	Yes
$PM_{2.5}$	10	8	N/A	Yes
SO_2	-	2	15min Means > 266 $\mu g/m^3$ = 0 Hourly Means > 350 $\mu g/m^3$ = 0 Daily Means > 125 $\mu g/m^3$ = 0	Yes
O_3	43	46	8hr Means > 100 $\mu g/m^3$ = 4	Yes

Monthly ambient concentrations recorded by real time monitoring are detailed in Figure 1.

Figure 1. Average monthly concentrations recorded by real time monitors (showing annual mean objectives)



Stansted Airport Air Quality Monitoring

Stansted Airport is London's third busiest international airport, The airport is situated approximately 40 miles north of London, in north east Essex. It is situated outside the general urbanised area of Greater London, and its surroundings are rural. Stansted Airport Ltd is required, under the terms of its Section 106 Planning Agreement with the Local Authority (Uttlesford District Council), to carry out monitoring of oxides of nitrogen and particulate matter at agreed locations. Prior to 2006, monitoring was required for three months per year; from 2006 onwards, continuous monitoring throughout the year has been required.

Ricardo Energy & Environment was contracted by Stansted Airport Ltd to carry out the required programme of air pollution measurements during 2015, the tenth full year of continuous monitoring.

Summary of findings for 2015:

The aims of the programme are to monitor air pollution around the airport, to assess compliance with relevant air quality objectives, and to investigate changes in air pollutant concentrations over time.

Automatic continuous monitoring was carried out at two locations, referred to as Stansted 3 and Stansted 4. Stansted 3 was located to the south-east of the airport at High House, and Stansted 4 was located to the north of the runway. Both sites monitored oxides of nitrogen (nitric oxide and nitrogen dioxide); PM10 particulate matter was monitored at Stansted 3 only. Measured PM10 concentrations were adjusted using the King's College London Volatile Correction Model to correct for potential losses of volatile and semi-volatile components from the Tapered Element Oscillating Microbalance (TEOM) particulate monitor.

In addition to automatic monitoring, indicative monitoring of nitrogen dioxide was carried out using diffusion tubes. These were co-located with the continuous automatic monitor at Stansted 3 and also used at four other sites, to the north, south, east and west of the airport.

The minimum applicable data capture target of 90% was achieved for the pollutant at Stansted 4 (NOx) and achieved at Stansted 3 for PM10. A data capture target of 90% was not achieved for NOx at Stansted 3 (88.9%) due to various data gaps explained within the report.

The UK AQS hourly mean objective for NO2 is 200 µg m-3, with no more than 18 exceedances allowed each year. (Where data capture is below 90%, the 99.8th percentile of hourly means must be within 200 µg m-3). Stansted 3 met this objective, with no hourly means recorded above the objective. Stansted 4 recorded six hourly means above the objective, all on January 3rd, when a generator next to the site was turned on.

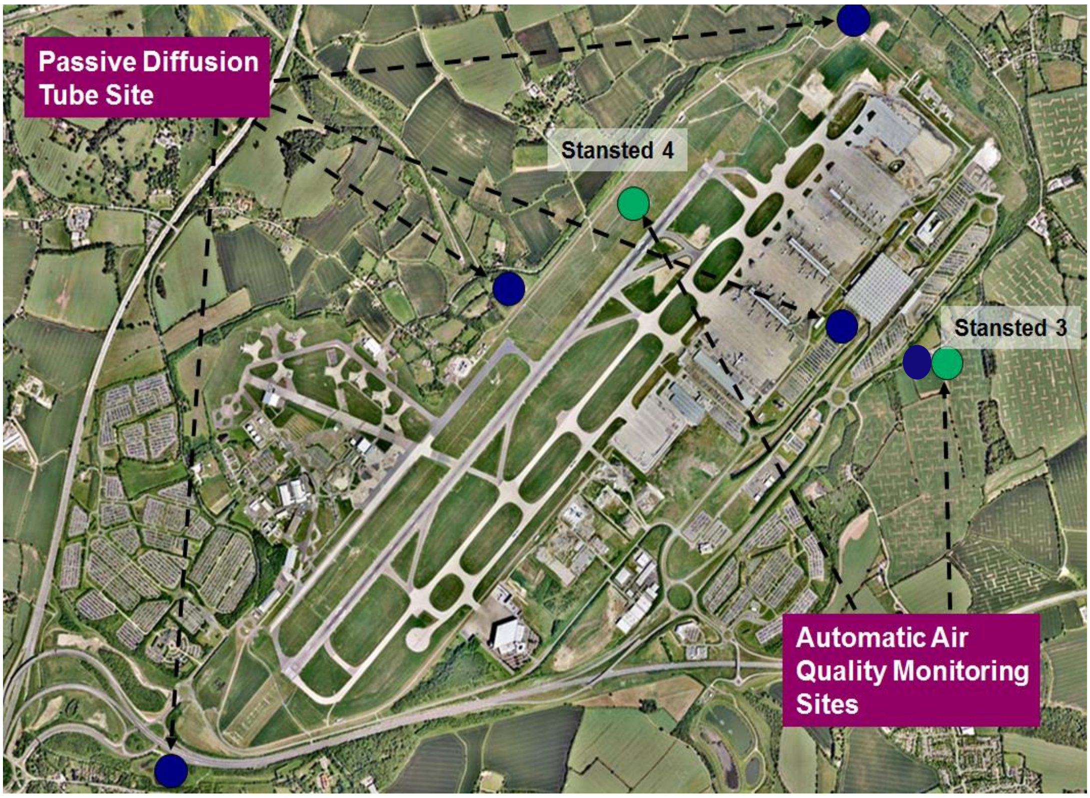
The annual mean AQS objective for NO2 is 40 µg m-3. This was met at Stansted 3, Stansted 4, and at all five of the diffusion tube monitoring sites.

PM10 may exceed the 24-hour mean limit of 50 µg m-3 no more than 35 times per year to meet the AQS objective. The annual mean AQS for PM10 is 40 µg m-3. These objectives were met at Stansted 3, with only four instances of concentrations exceeding the 24-hour mean value.

Wind speed and direction data provided by Stansted Airport Ltd were used to produce bivariate plots showing hourly mean pollutant concentrations against the corresponding weather conditions. The bivariate plots for NO and NO2 for Stansted 3 show elevated concentrations when wind speeds are low, prevailing from the west, indicating sources are close possibly being attributed to airport activity and the A120 road. The initial bivariate plot for PM10 at Stansted 3 showed a source to the south-east of the site, possibly arising from agricultural activities, however when discounting this PM episode the bivariate plot shows an elevated source from the west when wind speeds are moderate, indicating a potential source from the M11 motorway. The bivariate plots for NO and NO2 at Stansted 4 generally show elevated concentrations when wind speeds are calm to moderate and prevailing from the south and south east, indicating sources being attributed to airport activity and the A120 road.

Several episodes of high concentrations for NOx and PM10 occurred during 2015. At Stansted 3, particularly high concentrations of NOx and PM10 were recorded on the 17th March, 8th and 9th of October, and 27th and 28th December. Local emissions, combined with trans-boundary atmospheric transport of dust from the Sahara and calm atmospheric conditions are the origin of these high concentration episodes.

Average NO2 concentrations are broadly similar to those from comparable urban background monitoring sites and have remained lower than those for London Heathrow Airport. PM10 levels at Stansted 3 have declined from a peak in 2006, although slightly increased from 2014.



The full 2015 report can be found:-

http://www.stanstedairport.com/community/local-environmental-impacts/air-quality/

UK AVIATION AND AIR QUALITY

An information paper: Our contribution, the challenges and opportunities

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