CLEANER

QUIETER

SMARTER

SUSTAINABLE AVIATION

Cleaner. Quieter. Smarter.

SUSTAINABLE AVIATION A DECADE OF PROGRESS

2005›2015

10 YEAR ANNIVERSARY

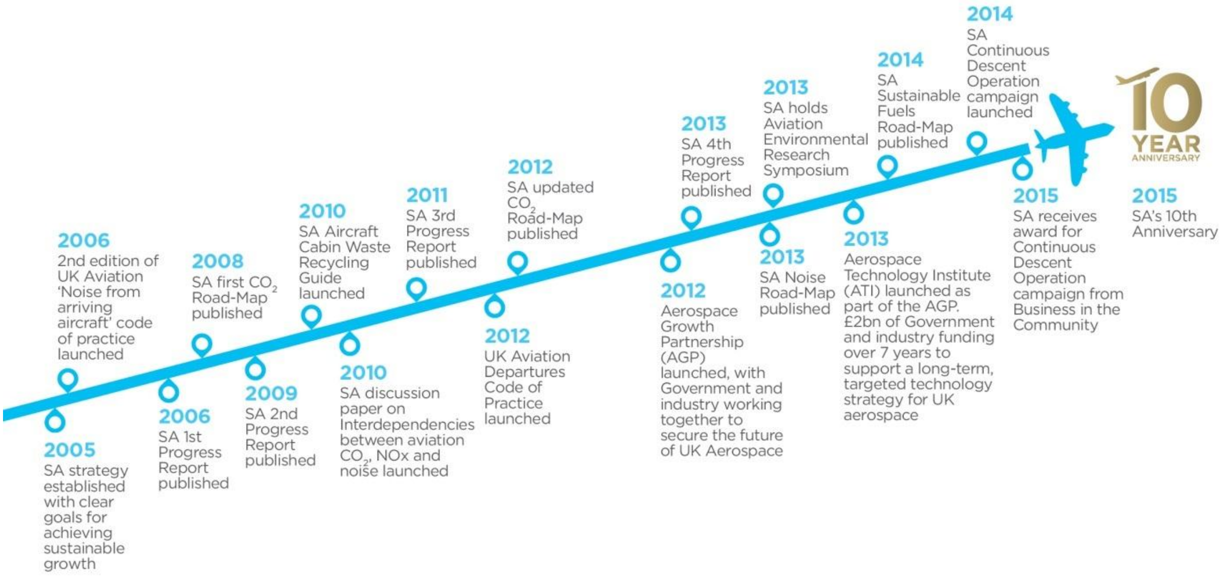
www.sustainableaviation.co.uk

Executive summary

In 2005 the UK aviation industry was a world first in coming together to establish Sustainable Aviation (SA) committed to working together towards a sustainable future. In 2015, 10 years on, the industry remains committed to making a positive contribution to the British economy, and meeting the needs of society for air transport whilst minimising environmental and social impacts. In this time, significant steps have been taken to reduce UK aviation's environmental impacts - for example reducing SA airline carbon emissions by 20 million tonnes since 2005 whilst carrying 19% more passengers.

This is SA's 5th Progress Report highlighting 10 years of achievement by this unique coalition of UK industry. Our progress against the seven key goals of the SA strategy is presented in this report with the key highlights presented in the infographic on the next page.

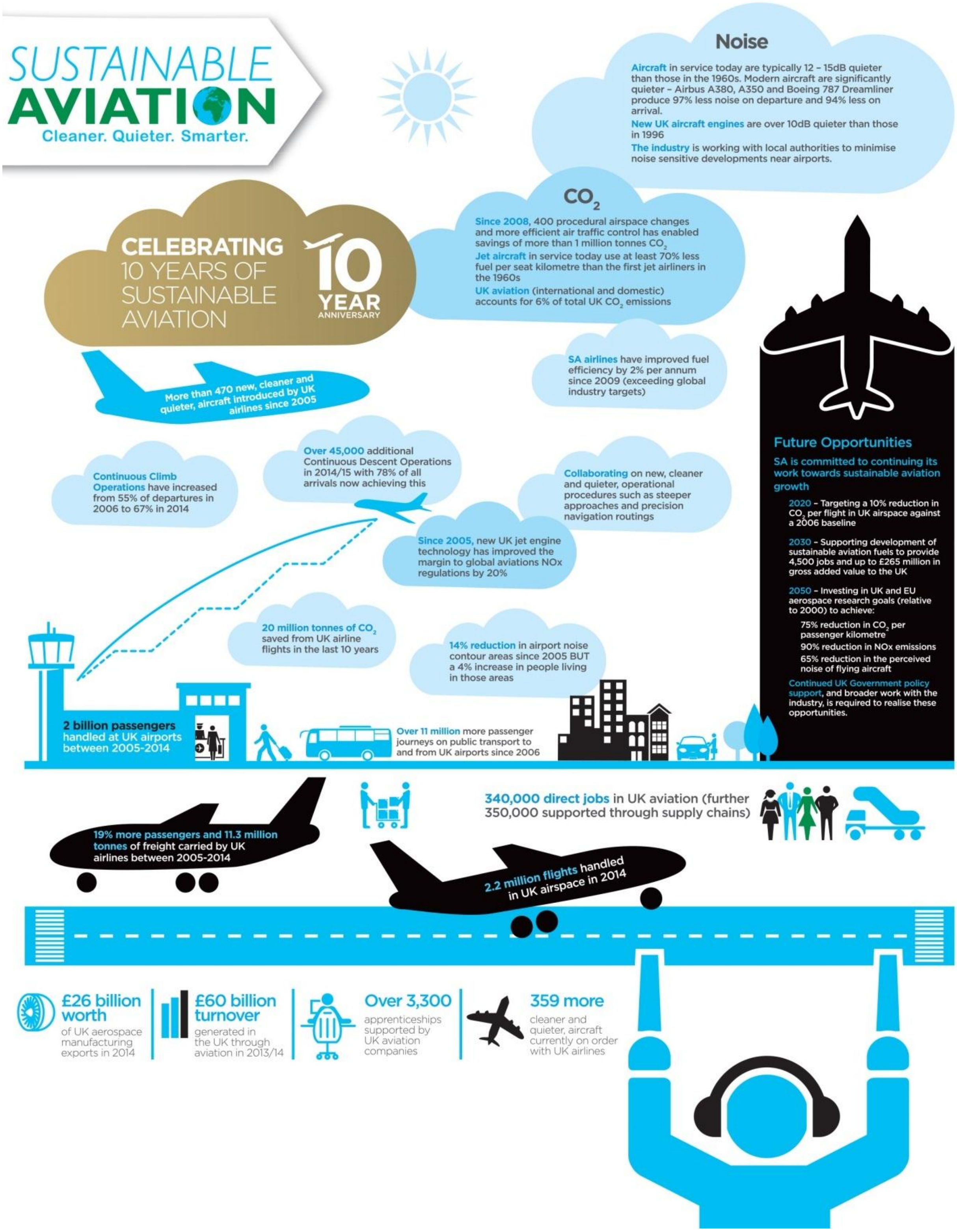
The timeline below and infographic overleaf, summarise key highlights from SA's work.



SA will continue its focus on working together to reduce environmental impacts, including:

- Updating the SA CO_2 Road-Map
- Publishing discussion papers on air quality and the social-economic impacts of the industry
- Working with the UK Government to realise the opportunities shown in our Road-Maps. Specifically this will involve;
    - Maintaining financial investment in UK aerospace research and development
    - Enabling airspace modernisation in the UK
    - Supporting the development of sustainable fuels for aviation in the UK

SA looks forward to working with a wide range of stakeholders in delivering this future work, from both within and outside the aviation sector. If you would like to get involved or would just like to learn more, please contact us.



10th Anniversary Progress Infographic

Contents

1 Chair's Review

This is the 10th year of SA, having been established in 2005 with members from the airline, airport, aerospace manufacturing and air traffic control sectors, largely in recognition that addressing our environmental impacts is an industry challenge and best achieved through working collaboratively.

So 2015 has been a good opportunity for us to look back and reflect on the progress we have made over these last ten years.

On climate change we have focused our efforts on our Carbon Road-Map, first produced in 2008 which depicts how we believe we can play our part in achieving the global aviation industry's commitment to reducing net emissions by 50% relative to 2005 levels by 2050. Over this time we have improved our carbon efficiency by over 11% and since 2010 this has improved by 1.9% pa exceeding the industry goal of 1.5 % per year.

This has been largely achieved through the acquisition of 470 new aircraft valued at US$50 billion, with these aircraft being up to 20% more fuel efficient than the aircraft they replace. This has resulted in a saving of 20 million tons of CO_2 over this time period. The UK aerospace manufacturing sector has played a key role in delivering these more fuel efficient aircraft through large scale investments in research and development. The Aerospace Technology Institute (ATI), formed with considerable support from the UK government, has made a made a significant contribution to this.

At SA we recognise that to achieve our 2050 target we will need the support of a global market based measure and since 2005 there has been good progress to develop this mechanism through ICAO to enable the industry to achieve its interim target of carbon neutral growth from 2020. From 2012 EU aviation was included in the EU Emissions Trading Scheme for all intra-EU flights and since then UK airlines have reduced their net carbon emissions by an additional 6 million tonnes through surrendering carbon credits acquired through the scheme.

We have also made good progress in relation to sustainable alternative fuels with SA members embarking on two industry leading projects - British Airways and its waste to jet fuel plant in the UK and Virgin Atlantic and its waste gases to fuel project in China.

As well as making impressive progress regarding our carbon emissions there has also been good progress regarding our noise performance. Since 2005, the combined noise contour area at 6 major UK airports has reduced by 14% again achieved through the acquisition of new aircraft that have a reduced noise footprint area of 50% compared to the aircraft that they replace. In addition, there has been an improvement in the operating procedures to reduce noise including more than 40,000 additional continuous descent approaches per annum across the UK and the launch of steeper approaches at Heathrow airport.

I am proud to have supported SA over the last ten years and been the Chair over the last two years and I congratulate all our partners for their significant contributions in helping UK aviation demonstrate that we can grow our industry and deliver greater economic and social benefits while managing our environmental impacts.

Jonathon Counsell

Chair, SA 2014-2015
Group Head of Sustainability, International Airlines Group (IAG)

2 SA Advisory Board Comment

This 10th Anniversary report highlights the progress made by SA. It demonstrates the value added of SA, showing that more can be achieved collaboratively and collectively when the UK aviation sector combines to work together to achieve shared goals.

Since the last Progress Report the Advisory Board has deepened its engagement with SA through the Working Groups, encouraging a higher level of ambition and specific action. We have seen good results with this approach through several working groups including climate change, sustainable fuels and noise.

We have also broadened and strengthened the membership of the Advisory Board in order to build on this success going forwards. I would like to thank Tim Johnson at AEF for his commitment and tireless work as Chair of the Stakeholder Panel over the last few years. I am delighted to be taking up the role of Chair of the strengthened Advisory Board.

We encourage SA to build on the progress of the last decade and raise both its ambition and speed over the decade to come. We commit to support the development of ambitious work-plans to achieve the goals. We recognise the need for the work-plans to be backed by sufficient resources, in order to support the sector to tackle the on-going challenges. The need to reduce CO_2 emissions and develop alternative fuels is ever more pressing, along with the international work on market-based measures.

Catherine Cameron

Chair SA Advisory Board
Director, Agulhas: Applied Knowledge

The SA Advisory Board:	
Catherine Cameron	Chair SA Advisory Board and Agulhas Applied Knowledge
Tim Johnson	Aviation Environment Federation
Owen Bellamy	Committee on Climate Change
Professor Piers Forster	University of Leeds
Roger Gardner	University of Southampton
Dr Darren Rhodes	Civil Aviation Authority
Colin Potter	UNITE the Union
Martin Schofield	Aerospace Technology Institute
Marc Dittmer-Odell	Confederation of British Industry

3 Introduction

This 5th progress report from SA highlights the progress made against each of our seven strategic goals, since SA was formed in 2005. These goals are summarised below with more information on SA's governance, membership and approach presented in appendix 1.

Goal 1: Social and Economic
A competitive aviation industry making a positive contribution to the UK economy, and meeting the needs of society for air transport, whilst maintaining constructive relationships with stakeholders.

Goal 2: Climate Change
Previous Goal *- Aviation incorporated into a robust global policy framework that achieves stabilisation of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous man-made interference with the climate system.*

New Goal agreed in 2015 - To identify, create and develop opportunities to reduce UK aviation climate change emissions and enable sustainable growth.

Goal 3: Noise
Limit and, where possible, reduce the impact of aircraft noise.

Goal 4: Local Air Quality
Industry to play its full part in improving air quality around airports.

Goal 5: Surface Access
Industry playing its full part in an efficient, sustainable multi-modal UK transport system.

Goal 6: Natural Resources
Environmental footprint of UK aviation's ground-based non-aircraft activities contained through effective management and reduction measures.

Goal 7: Implementation
Full industry commitment to sustainable development and communicating fully the role of aviation in society in order to support a better understanding of its contributions.

The next chapter details our performance against each goal. The focus has been on activities achieved by the SA coalition. Broader sustainability initiatives and developments made by SA members are highlighted in the case studies presented in appendix 2.

Following the presentation of SA's performance against goals, the report concludes by considering the future work priorities for SA, set out by the incoming SA chair, Ian Jopson.

4 Performance against Goals

4.1 Goal 1: Social and Economic

A competitive aviation industry making a positive contribution to the UK economy, and meeting the needs of society for air transport, whilst maintaining constructive relationships with stakeholders

Despite the fluctuating economic climate over the last ten years SA and its signatories have continued to offer significant economic and social benefits to the UK.

4.1.1 Key Facts(1):

	2005	2014	Total between 2005 and 2014
Terminal Passengers handled by SA airports[2]	201.2 million (87% of all UK airports)	211.9 million (88% of all UK airports)	2 billion
Passenger flown by SA Airlines[3]	110.4 million (89% of all UK airlines)	132.1 million (94% of all UK airlines)	1.2 billion
Freight and cargo flown by SA Airlines	933,190 tonnes (84% of all UK airlines)	885,389 tonnes (82% of all UK airlines)	9.4 million tonnes
Flights handled in UK airspace	2.3 million	2.2 million	22.5 million

Despite the wider global economic turndown following the financial crisis in 2007-08, SA airlines and airports have bounced back and are now handling at least 5% more passengers than in 2005.

4.1.2 UK Aviation Wider Economic Impacts

In addition to the direct effect of flights handled by SA airlines and airports, in November 2014, Oxford Economics produced a report looking at the broader economic impact of UK aviation[4]. The key findings from this report show:

[1] Figures are derived from the UK Civil Aviation Authority published airline and airport statistics. http://www.caa.co.uk/default.aspx?catid=80&pagetype=90

[2] SA Airports are defined as UK airports that are either a member or signatory to Sustainable Aviation

[3] SA Airlines are defined as UK airlines that are either a member or signatory to Sustainable Aviation

[4] See http://www.bata.uk.com/wp-content/uploads/2015/03/Oxford-Economics-2014.pdf

UK Aviation's Contribution to UK GDP

The aviation sector contributes £52 billion (3.4%) to UK GDP (Gross Domestic Product). This total comprises:

- £22.3 billion contributed through the output of the aviation sector (airlines, airports and ground services, aerospace) itself;
- £16.7 billion indirectly contributed through the aviation sector's procurement from its domestic supply chain; and
- £12.9 billion contributed through the wage-financed spending by the employees of the aviation sector and its direct supply chain.

Major employer

The aviation sector supports 961,000 jobs in the UK. This total comprises:

- 341,000 jobs within the aviation sector itself;
- 350,000 jobs indirectly supported through the aviation sector's purchase of inputs from UK suppliers; And
- 269,000 jobs supported through its payment of wages which stimulates consumer spending.

High productivity jobs

The average air transport services employee generates £84,000 in GVA (Gross Value Added) annually, which is over 60% higher than the whole economy average in the UK.

Contribution to public finances

The aviation sector pays nearly £8.7 billion in tax in the UK. Taxes paid by aviation firms and employees, contributes around £5.9 billion, and Air Passenger Duty (APD), a specific departure tax paid by passengers, a further £3.2 billion. It is estimated that an additional £6.3 billion of government revenue is raised in the aviation sector's supply chain and £4.9 billion through taxation of the activities supported by the spending of employees of both the aviation sector and its supply chain.

Impacts of international tourists who arrived in the UK by air

- Spending by foreign tourists who arrived by air supported a £19.6 billion GVA contribution to UK GDP.
- Their expenditure also supported 477,000 people in employment in the tourism industries, their supply chains and through wage consumption impacts.

4.1.3 Scale of UK Aerospace Manufacturing

In addition to the numbers of passenger journeys facilitated by UK airports, airlines and air navigation service providers, the UK aviation industry has a very significant role in aerospace manufacturing. Despite the UK's relatively small geographic size, our aerospace manufacturing industry is the second largest in the world with 17% of the global market share. The following facts add further context to this.

- UK aerospace manufacturing industries generated £29 billion turnover in 2014, a 27% growth since 2010.
- The industry generated £26 billion of exports in 2014 and the market is estimated to be worth $5 trillion over the next 20 years
- Currently UK Aerospace Manufacturing has 111,000 direct employees and 3,300 apprentices
- The Aerospace Growth Partnership (AGP) has recently awarded its 500th bursary for postgraduates studying for an MSc in aerospace engineering
- The ATI, a joint initiative of the UK Government and industry to guide investment in aerospace R&D, has supported over 100 projects, involving more than 134 organisations to date. In its Autumn Spending Review (November 2015) the Government announced an additional funding commitment of £900m to extend the ATI's remit to 2026. This means that the total joint funding now managed through the ATI is £3.9bn over 13 years

4.1.4 UK Aviation Social Contributions

SA organisations continue to deliver a wide range of social benefits covering areas such as:

- Apprenticeship schemes
- Graduate management schemes
- Skill development and job specific training schemes
- Charitable fund raising and volunteer work

There are a vast range of examples of this work from all the SA organisations and more details can be found by visiting their websites. The following list gives a flavour of some of this work.

- **Airbus** supports a variety of education and charity projects in the UK. Airbus in the UK has an award winning apprenticeship programme responsible for enrolling around 4,000 apprentices over the last three decades. More than 450 apprentices are currently in the scheme
- **Birmingham Airport's** Community Trust Fund makes grants of up to £3,000 to community groups in areas most affected by the Airport's operations. Each year they invest £75,000 in the Trust Fund, to which any charges made to airlines which breach the airport's night noise regulations are added
- **Boeing** supports community and STEM learning projects in the UK, such as The Schools Build-a-Plane Challenge in partnership with The Royal Aeronautical Society (RAeS) xl clubs and Get Into Product Design with The Prince's Trust
- **Bristol Airport** has given donations over £340,000 to charity by the airport's staff and their Business Partners over the past 10 years. Bristol Airport also works alongside Airbus and the Bristol and Wessex Flying Club with the aviation charity fly2help to hold an annual Air Smiles Day, which gives local young people a chance to take to the skies in a light aircraft courtesy of volunteers from the local pilot community
- **British Airways'** Flying Start charity, in partnership with Comic Relief, aims to raise money to help children in the UK and around the world. Since June 2010, the generosity of BA customers

and staff has raised £12 million. The airline also supports more than 30 charities through its Communities and Conservation programme. British Airways has this year recruited 175 apprentices and 50 graduates to its programmes across the airline. The airline also runs the British Airways Future Pilot programme. Open to anyone from 18 to 55, with no previous flying experience, it this year sought to recruit and train up to 100 potential pilots

- **East Midlands Airport's** on-site education centre, Aerozone, provides young people from Foundation stage to University age, the opportunity to get a real insight into life at the airport. Since opening in 2010 they have welcomed over 9,000 young people through organised visits and community events
- **Gatwick Airport** spent approximately £419,000 in 2015 on a wide variety of charitable donations including a matched giving scheme, a matched fundraising scheme, corporate donations to staff-chosen charities (Cancer Research UK, The Chestnut Tree House and Gatwick TravelCare), sponsorships for the Gatwick Airport Charitable Trust and supporting events and projects within our local communities. This also includes passenger donations of £45,000 which is split between our three charities
- **Glasgow Airport's** FlightPath Fund was set up in 2010 to provide financial support to charities and community groups committed to improving facilities and services available to local people. Since launching, the total sum granted to projects and activities has amounted to over £850,000
- **Heathrow Airport's** Heathrow Academy has trained more than 3,500 people and more than 2,500 have progressed into work via the Heathrow Academy since it was established in 2004
- **Liverpool Airport's** chosen charity is the Alder Hey Children's Hospital, which was selected by staff via an employee vote
- **Luton Airport's** Community Trust Fund made 23 grants in 2014 totalling £50,000 to support a range of local charities and community organisations
- **Manchester Airport** supports Childflight, a children's charity established in 1987 to provide flights and holidays for sick and deserving children who might otherwise miss out, including children who need medical treatment overseas or who are socially deserving
- **NATS** Footprint Fund donated £31,000 to 53 local causes in 2014, totalling £190,000 to 328 charities since launch in 2008. In addition 8% of our staff made 'Give As You Earn' donations using the company payroll giving scheme, donating £133,500 to the charities they care about
- **Rolls-Royce** actively works with schools and universities to increase interest and encourage diversity amongst those taking Science, Technology, Engineering and Maths (STEM) subjects. They have set themselves a target to reach 6 million people through their STEM education programme and activities by 2020
- **Stansted Airport** donated over £100,000 to local projects and initiatives in 2013/14 through the Stansted Airport Passenger Community Fund and Stansted Airport Community Trust
- **TUI Group** fundraising raised £1.25 million for charity in 2014. Thomson & First Choice staff and customers took part in a range of activities both in the UK and abroad, raising more money than ever before
- **Virgin Atlantic** launched a new annual programme in 2014 specifically designed to create the next generation of pilots. The Future Flyers Programme is a unique opportunity for people from diverse backgrounds to become a long-haul pilot on some of the most technologically advanced aircraft

4.1.5 Summary

SA will continue to focus on finding ways to improve how the industry manages environmental effects of aviation, to enable the on-going social and economic benefits that air travel generates for the UK.

4.2 Goal 2: Climate Change

***INITIAL GOAL:** Aviation incorporated into a robust global policy framework that achieves stabilisation of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous man-made interference with the climate system.*

***REVISED GOAL SINCE 2015**: To identify, create and develop opportunities to reduce UK aviation climate change emissions and enable sustainable growth.*

SA has prioritised its work over the last 10 years on reducing CO_2 emissions and noise from UK aviation. This section details our progress on reducing CO_2. Our work has focussed on initiatives to reduce CO_2 emissions from aircraft and airport operations as we see this as our area of expertise. SA has not spent time looking at climate adaptation issues but is aware that the majority of our members have developed their own adaptation plans.

4.2.1 Key facts

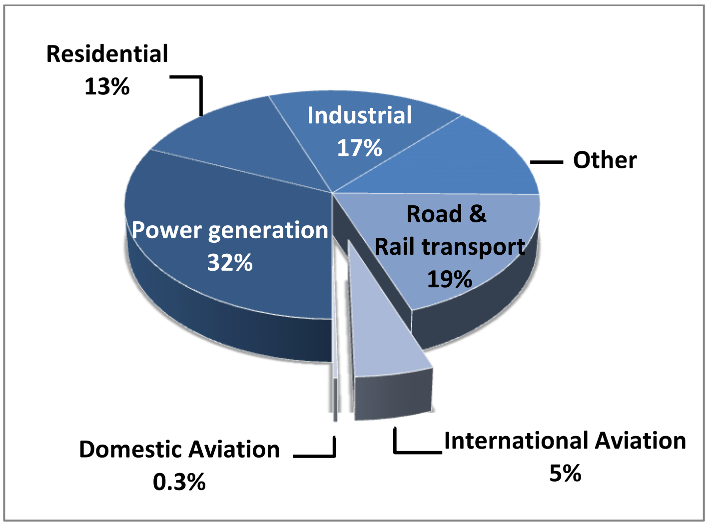
- UK aviation currently accounts for 0.1% of global anthropogenic CO_2[5]
- Two SA Road-Maps on CO_2 and Sustainable Fuels produced
- SA Airlines have improved their fuel efficiency by almost 12% since 2005. This equates to a saving of 20 million tonnes of CO_2 over the 10 years
- Since 2009 Airlines have improved their fuel efficiency by almost 2% per annum, exceeding the global airline industry target for fuel efficiency improvement
- Since 2005, UK airlines have introduced more than 470 new aircraft into service representing an investment of over $49.6Bn at 2014 prices
- UK domestic & international aviation account for less than 6% of total UK CO_2 emissions in 2013[6]. UK Department for Transport forecast that CO_2 emissions from flights departing from UK airports will increase from 33.3 Mt CO_2 in 2011 to 35-52 Mt CO_2 by 2050[7]
- Since 2012, 6 million tonnes of CO_2 emissions credits have been surrendered by UK airlines through the EU emissions trading scheme[8] (ETS)

---

[5] United Nations Statistics Division, CDIAC, Data last updated on 29 July 2014.
[6] www.gov.uk/government/statistics/final-uk-emissions-estimates data tables 3 and 8.
[7] Department for Transport, UK Aviation Forecasts, July 2013.
[8] See http://ec.europa.eu/clima/policies/transport/aviation/index_en.htm

4.2.2 Context of UK aviation CO_2 emissions

According to UK Government national greenhouse gas statistics, UK domestic & international aviation accounted for less than 6% of the UK's total CO_2 emissions in 2013[9]



UK CO_2 emissions by sector in 2013

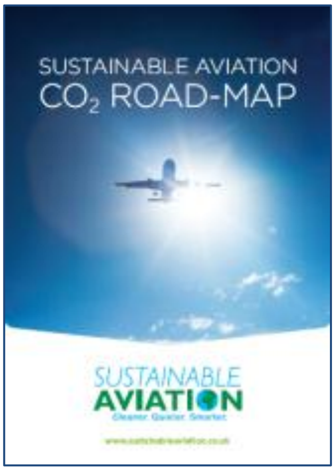
Note: Assumes international bunker fuels are included in the UK inventory.

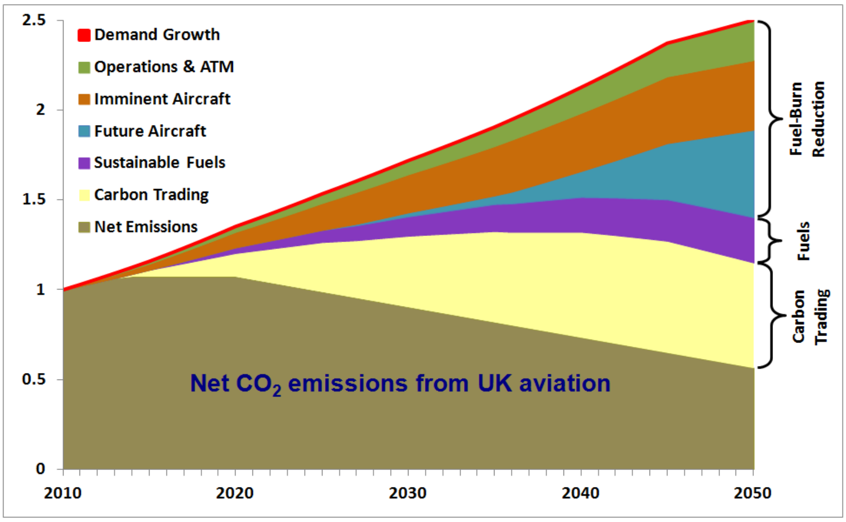
4.2.3 The SA CO_2 Road-Map 2012

The first SA CO_2 Road-Map, published in December 2008, set out for the first time the UK aviation industry's consensus view regarding the future trajectory of its CO_2 emissions. The Road-Map showed that, contrary to the claims being put forward at the time by some, UK aviation CO_2 would not grow to occupy the majority of the UK's carbon allowance by 2050.

An update was issued in March 2012, taking account of new information and developments, and showing how fleet efficiency had improved in practice relative to the view put forward in the first CO_2 Road-Map of 2008[10]. From the updated analysis, SA concluded that UK aviation can "*accommodate significant growth to 2050 without a substantial increase in absolute CO_2 emissions*"**.** In that update we also chose to illustrate the scale of contribution that would be required from market-based-measures if UK aviation was to reduce its net CO_2 emissions in 2050 to half of 2005 levels.

[9] www.gov.uk/government/statistics/final-uk-emissions-estimates data tables 3 and 8.
[10] http://www.sustainableaviation.co.uk/road-maps/





2012 SA CO_2 Road-Map

In both cases, the overall aim was as follows:

- To establish a trajectory of demand-growth that CO_2 emissions would follow in a "hypothetical no-improvements" scenario.
- To consider categories of CO_2 mitigation, providing in each case:
  - an overview of the efforts the industry is making and achievements so far
  - an estimate or calculation of the extent of mitigation that could be expected in the future, and over what timescale
- To combine the above to produce a view of the likely future trajectory of CO_2 emissions from UK aviation.

4.2.4 The SA Fuels Road-Map 2014

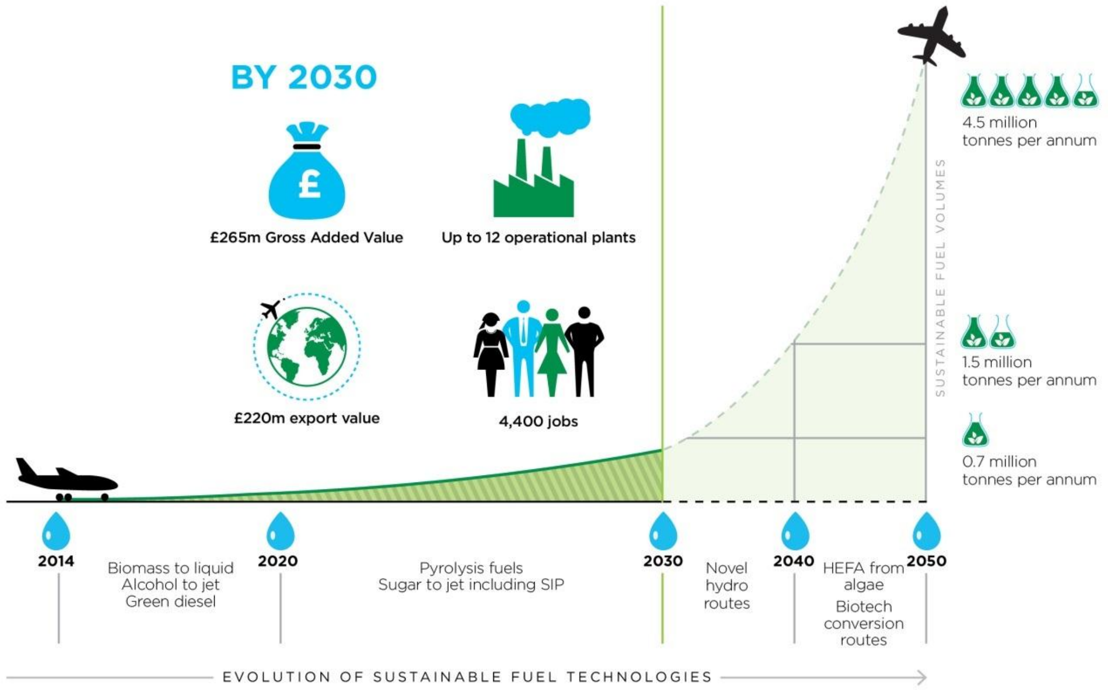
In 2014 SA worked with an independent organisation to explore the potential for developing sustainable fuel production for aviation and realising the CO_2 reductions set out in the SA CO_2 Road-Map. The result of this work was published as a Sustainable Fuels Road-Map with the independent research[11] indicating that the UK has the potential for between 5 and 12 operational plants producing sustainable fuels by 2030.

Benefits from adopting the Sustainable Fuels Road-Map:

- CO_2 emissions from UK aviation cut by up to 24% by 2050
- UK Gross Value Added (GVA) of up to £265 million and an export value of £220m in 2030
- 3,400 direct jobs and a further 1,000 jobs in global exports

A graph showing this was produced and published with the Road-Map in 2014.

[11] See http://www.e4tech.com/sustainable_aviation.html8753



UK Potential for Sustainable Aviation Fuels
(Taken from the SA Sustainable Fuels Road-Map 2014)

SA members are currently pioneering this work and since the Road-Map was published members of the SA Fuels working group have taken part in the UK Department for Transport's Transport Energy Taskforce[12]. This was a mechanism for stakeholders to help the Government to examine and formulate options for policy regarding transport energy. Specifically the Task Force were asked to consider how the EU 2020 greenhouse gas emissions reduction and renewable transport fuel targets should be reflected in UK policy and determine how low carbon fuels can help reduce greenhouse gas emissions from UK transport in the period to 2030 and beyond. A final report from the taskforce was published in March 2015 and is now being considered by the Government.

Case studies from SA organisations working to enable sustainable aviation fuels can be found in Appendix 2.

4.2.5 Progress in addressing UK aviation CO_2 emissions

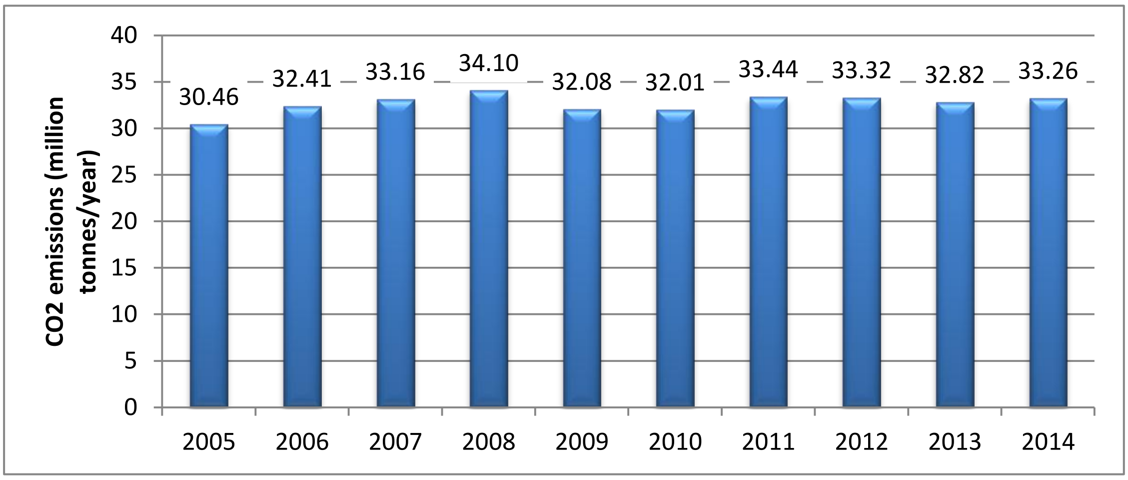
The rest of this section reviews progress in reducing CO_2 emissions. It starts with presentation of data from SA airlines and how their emissions have changed since SA began in 2005. UK airport reduction in CO_2 emissions follows this. The subsequent sections look in detail at work undertaken by SA to provide technical reports on aviation carbon work and specific initiatives undertaken to develop low carbon solutions.

4.2.5.1 SA Airline CO_2 Performance

Total CO_2 emissions produced by SA airlines in 2014 were 33.3 million tonnes. This is a 9% increase since 2005. From 2008 onwards however, total emissions have reduced, despite 9% more

[12] See http://www.lowcvp.org.uk/projects/transport-energy-task-force.htm

passengers being carried. This is primarily due to the introduction of new, more fuel efficient, aircraft.

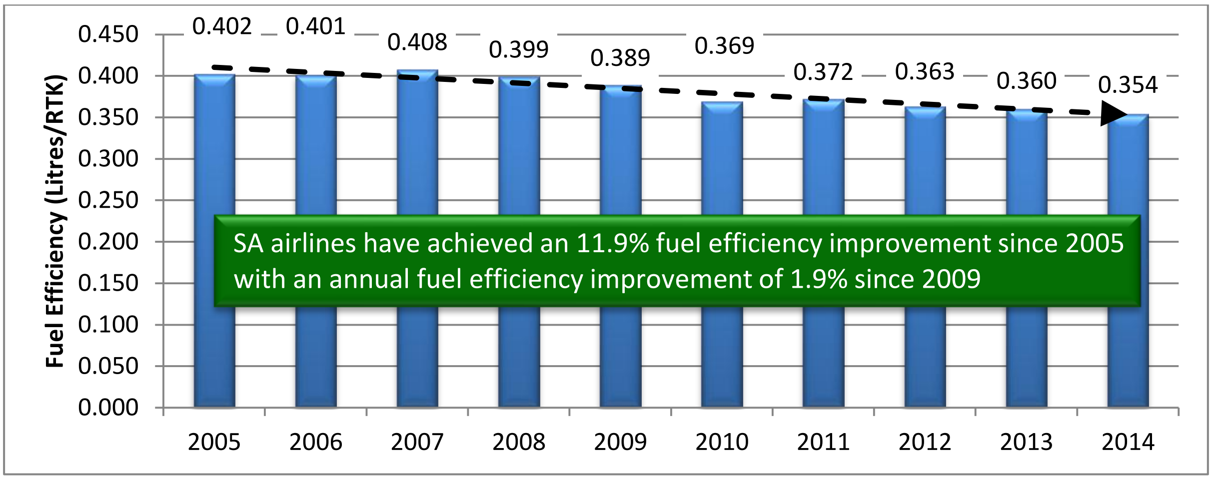


Absolute CO_2 Emissions from SA airlines

Data derived from aggregated, actual fuel burnt by SA airlines per annum

This performance was delivered as SA airlines carried an additional 21.7 million passengers (19% increase)[13]. This result is in line with the projections made in SA's CO_2 Road-Map.

Looking at fuel efficiency per revenue tonne kilometre flown by SA airlines, it can be seen that over the last 10 years there has been an improving trend in airline fuel efficiency. The chart shows that nearly a 12% improvement in fuel efficiency has been achieved since 2005. This change reflects the growing airline fleet replacement programmes, replacing older, less fuel efficient aircraft with newer ones and on-going aviation industry operational fuel efficiency initiatives.



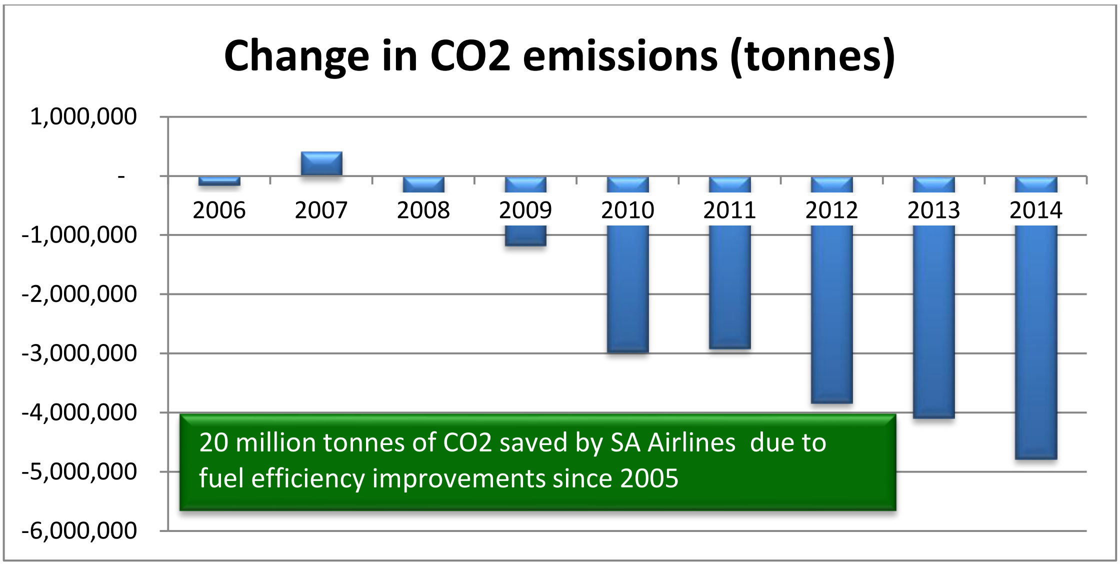
SA Airline Fuel Efficiency

Data derived from aggregated, actual fuel burnt and revenue tonne kilometres (RTK) produced by SA airlines per annum

[13] These figures are calculated from the CAA Airline Statistics for SA member airlines. See http://www.caa.co.uk/default.aspx?catid=80&pagetype=88&pageid=1&sglid=1

SA airlines have outperformed the airline industry target of a 1.5% average improvement in fuel efficiency per annum between 2009 and 2020[14], achieving an improvement of 1.9% per annum between 2009 and 2014.

To demonstrate this achievement in another way, the next chart shows the CO_2 emissions saved per year, from 2006 onwards. The calculations are derived from actual fuel burn figures achieved each year since 2005, compared to predictions of fuel burn assuming no improvement from the airline fuel efficiency performance being achieved in 2005. **The result shows that 20 million tonnes of CO_2 emissions have been saved through airline fuel efficiency improvement work and investment in new, more efficient aircraft since 2005.**



SA Airline CO_2 Emissions Avoided Per Year

Finally, a further 6 million tonnes of CO_2 emissions reductions can be attributed to UK airlines through the EU emissions trading system (ETS)[15] , introduced for flights within Europe from 2012 onwards. The system caps aviation at 95% of its 2005 CO_2 emissions. Emissions above this cap must be traded for reductions in other sectors. The effect of carbon trading is that total net CO_2 emissions from SA airlines in 2014 are only marginally (1.5%) above emissions in 2005.

4.2.5.2 SA Airport CO_2 Performance

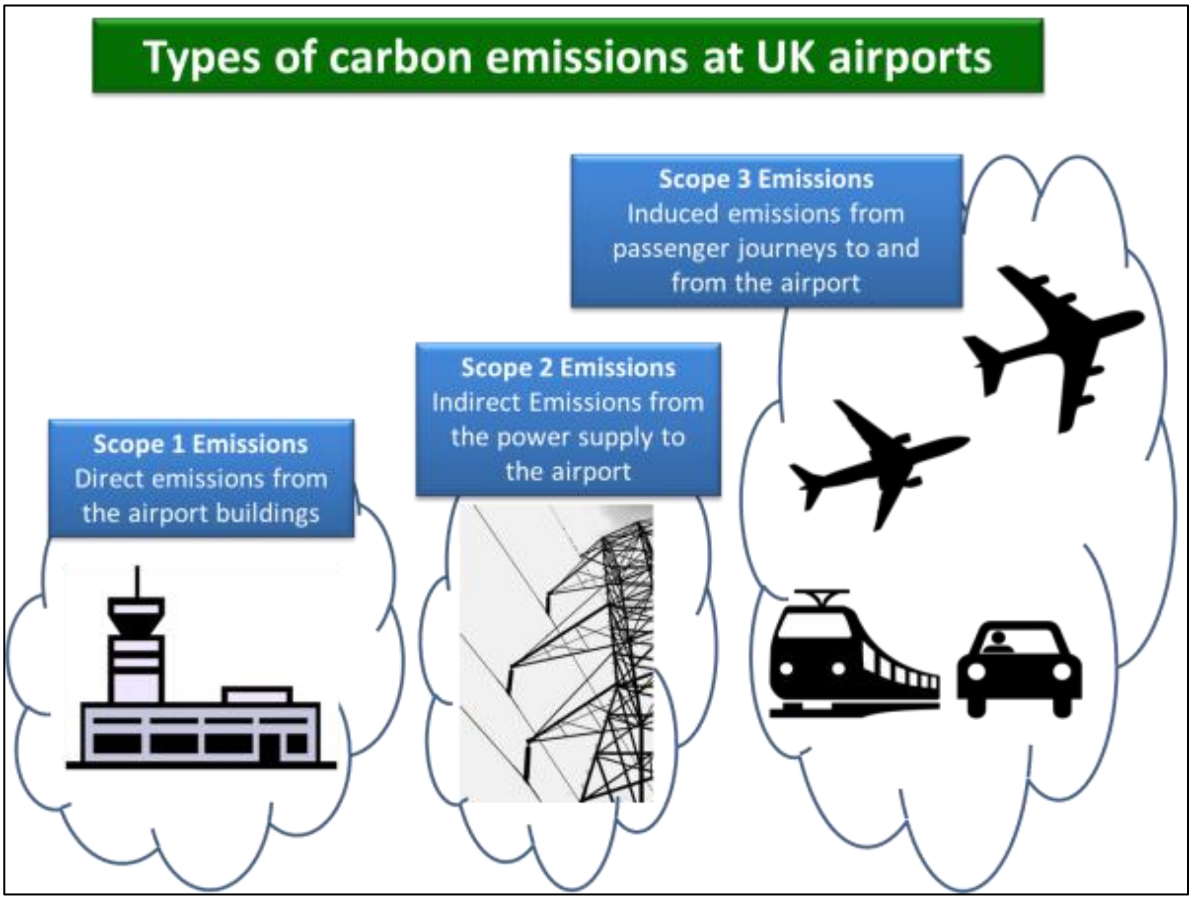
In 2014 the Airport Operators Association, (AOA), produced a report on sustainable airports[16]. This report looked at detail at the work underway in UK airports to reduce their carbon footprints.

Carbon emissions around UK airports arise from a mix of sources. Whilst aircraft emissions dominate, substantial emissions also arise from vehicles coming to and from the airport plus those operating at the airport. A further significant source is from emissions generated in heating and providing power at the airport.

---

[14] See https://www.iata.org/policy/environment/pages/climate-change.aspx
[15] See http://ec.europa.eu/clima/policies/transport/aviation/index_en.htm
[16] See http://www.aoa.org.uk/wp-content/uploads/2014/09/AOA-Sustainable-Airports-Report.pdf

These different emission sources are classified as direct, indirect or induced reflecting the airport's ability to manage. This is depicted in the next diagram.



Calculating CO_2 emissions at UK Airports

A significant number of UK airports also take part in the ACI Europe Airport Carbon Accreditation scheme which assesses how airports manage and reduce their carbon emissions through four levels of certification:

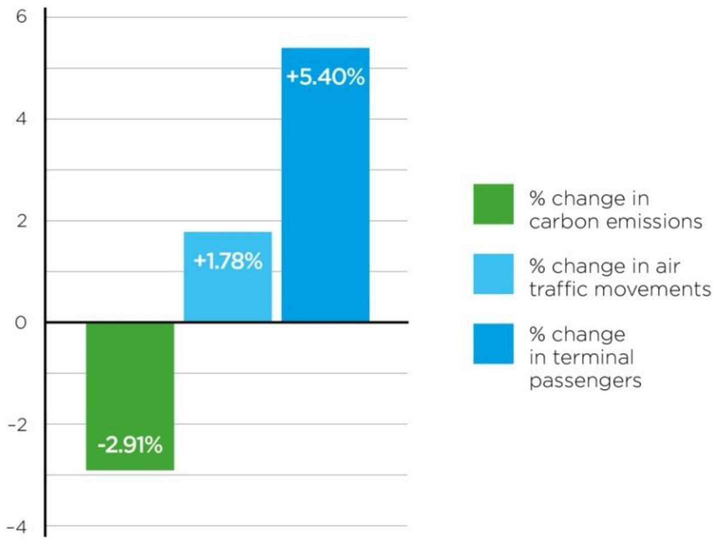
1. Mapping – Internal monitoring and reporting of emissions
2. Reduction – Internal target setting to reduce emissions
3. Optimisation – Working with other business partners to report and reduce emissions
4. Neutrality – Combination of the other three levels plus paying for their internal emissions

More information on the scheme can be found here: http://www.airportcarbonaccredited.org/

The AOA report shows the result of eighteen UK airports which shared their individual carbon emission figures for 2010 and for 2012. The total carbon emissions in 2012 were reduced by 2.91% compared to 2010; at the same time, passengers at the airports increased by 5.4% and their flights increased by 1.78%. This is depicted in the following diagram.

Airport carbon emissions in 2010 and 2012

18 biggest airports in UK	2010	2012	Change	%
Total annual CO_2 (tonnes)	4,015,160	3,898,488	-116,672	-2.91%
Terminal passengers	201,667,719	212,560,735	+10,893,016	+5.40%
Air traffic movements	1,794,000	1,826,000	+32,000	+1.78%



Source: AOA Sustainable Airport Report 2014

The AOA report also provides details on specific activities occurring at a range of UK airports that has led to this overall result from improving energy management to working in partnership with others to improve surface access to the airports.

4.2.5.3 Developing technical papers to address CO_2 emissions

Since publishing the SA strategy in 2005 a number of key documents and information papers have been produced by SA's climate change technical working group. A summary of these key pieces of work are presented below.

Position Paper: Inter-Dependencies between CO_2, NO_x and Noise

This position paper, published in 2010, described situations in which measures to reduce noise can increase fuel-burn, and circumstances in which measures to reduce fuel-burn may present challenges to meeting noise and emissions regulations. We also identified several operational techniques with the potential to reduce noise, and/or CO_2 and other emissions with no trade-offs, and described progress made so far towards their characterisation or implementation[17].

[17] http://www.sustainableaviation.co.uk/resources/

The Airbus A380 is a good example of this. As well as improving the fuel efficiency of this aircraft compared to the aircraft it is designed to replace, it was also optimised to achieve specific noise restrictions at Heathrow Airport. Had this not been the case further fuel efficiency gains could have been achieved. Further details on this issue are covered in the interdependencies paper.

Climate Impacts of Aviation's Non-CO_2 Emissions

Updated in 2014, this SA paper summarises the climate impacts of aviation's non-CO_2 emissions, taking account of recent developments in scientific understanding. It discusses the mechanisms through which aviation's non-CO_2 emissions can result in a warming or cooling effect, and where possible provides an estimate of the scale of the effect[18].

Aviation Environmental Research Workshop

In December 2013, SA hosted an aviation environment research event. The purpose of the event was two-fold:

- To hold a joint aviation industry and academic symposium to capture information on the current range of aviation environment research being carried out in UK universities and;
- To explore the future potential for closer links between the UK aviation industry and academia

Over 100 people attended the event from the UK aviation industry, academia both in the UK and US, UK Government advisors, aviation regulators and other interested parties and NGOs.

Discussions took place on the emerging concepts for producing sustainable aviation fuels as well as reviewing the issues arising from, the then emerging, Intergovernmental Panel on Climate Change (IPCC) 5th Assessment Report[19].

Opportunities for Reducing CO_2 Emissions from Aircraft on the Ground

While aircraft ground operation CO_2 emissions are small relative to air operations they are still significant and this study showed that there are real opportunities to achieve material reductions.

This programme offered practical guidelines to airports working with partners to cut aircraft ground movement CO_2 emissions and improve local air quality. It captured best practice across the industry today with potential for greater efficiency improvements in the future[20].

4.2.5.4 Operational Initiatives to reduce CO_2 emissions

As shown in the SA CO_2 Road-Map, there are significant opportunities to reduce CO_2 emissions through improving the efficiency of airspace structures and exploring new ways to operate aircraft. The results of these efforts are summarised below.

---

[18] http://www.sustainableaviation.co.uk/wp-content/uploads/2015/09/SustainableAviation__nonCO2_Paper_May_2014.pdf

[19] See http://www.ipcc.ch/

[20] See http://www.sustainableaviation.co.uk/resources/

- From 2008, 400 procedural airspace changes and more efficient air traffic control have enabled savings of more than 1 million tonnes CO2

- **Continuous Descent Operations (CDO)** have increased in the UK from an average of 56% of arrivals in 2006 to 78% in 2015. This has been a long standing area of focus with SA organisations since the launch of the Arrivals Code of Practice[21] in 2006. An SA led campaign to reinvigorate this low fuel and noise approach was launched[22] in 2014. Since then over 45,000 additional CDOs have been achieved. From 2006 to 2015 NATS estimate savings to be in excess of 6,300 tonnes of fuel and over 20,200 tonnes in CO_2 emissions. The campaign continues to operate and was recently recognised in the 2015 Business in the Community annual awards. (See case study for more information).

CASE STUDY: The SA CDO Campaign

The SA Continuous Descent Operations (CDO) Campaign is a great example of cross-industry collaboration that is delivering tangible benefits for all involved. By keeping aircraft higher for longer, continuous descents offer triple benefits: reduced noise of up to five decibels below the approach path, reduced CO_2 emissions and reduced fuel costs.

The campaign brings together 7 UK airlines, 22 airports and 15 air traffic approach units to collectively deliver the improvements. The aim is to achieve a 5% increase in CDOs across the UK, deliver over 30,000 individual quieter arrivals, and save around 10,000 tonnes CO_2.

The UK aviation industry is already delivering CDOs really well in some areas, and is regarded as a pioneer of this technique, but SA has identified the opportunity to make this consistent across the country and to begin considering descent profiles from higher altitudes too. Results from the first year of the campaign: July 2013 to May 2014 versus July 2014 to May 2015:

- Being able to measure CDO performance at a national scale is a world first.
- Change in absolute number of CDOs across all airlines at 22 participating airports is 45,708 additional CDOs.
- Change in absolute number of CDOs across the seven participating SA airlines at 22 participating Airports is 16,506 additional CDOs, of this increase 10,471 were from easyJet.
- Percentage change to date across 22 airports and all airlines is a 0.5% increase
- Across SA 7 participating airlines the percentage change is a 0.5% improvement
- These increases are in the context of traffic growth of c.5%.
- Note: 78% CDO achievement across all airlines at 22 UK airports is an exceptional achievement

- **Continuous Climb Operations (CCO)** This report provides the first update to our baseline report on CCO performance, and offers a view of change in the climb efficiency of UK flights between 2010 and 2015. While some flights have had an improvement in the ground to

[21] See 'Noise from Arriving Aircraft – An Industry Code of Practice http://www.sustainableaviation.co.uk/resources/

[22] See http://www.sustainableaviation.co.uk/sustainable-aviations-continuous-descent-operation-campaign/

25,000 feet (FL0 – FL250) band, the airports may have remained within the same banding. However departures from all airports have achieved more continuous climbs than in 2010, offering substantial fuel and emissions savings, estimated by NATS to be in excess of 7,100 tonnes of fuel, over 22,600 tonnes CO_2 emissions between 2006 and 2015. The table below shows the change in percentage of departing flights achieving continuous climb from FL0 to FL250 between 2010 and 2015 for each airport included in the study.

Airport	Difference between 2010 and 2015	2010 Rank	2015 Rank
ABERDEEN	+2.18%	High	High
BELFAST	+7.19%	High	High
BIRMINGHAM	+11.73%	Medium	High
BRISTOL	+21.81%	Medium	High
CARDIFF	+1.79%	High	High
EDINBURGH	+3.08%	High	High
FARNBOROUGH	+9.50%	Low	Low
GATWICK	+12.57%	Medium	Medium
GLASGOW	+2.24%	High	High
HEATHROW	+7.75%	Medium	Medium
LONDON CITY	+0.38%	Low	Low
LUTON	+8.71%	Medium	Medium
MANCHESTER	+14.66%	High	High
SOUTHAMPTON	+14.97%	Low	Medium
STANSTED	+6.23%	Medium	Medium

- **Perfect Flight (2010 onwards)** – In 2010 an optimised British Airways, Heathrow to Edinburgh flight demonstrated an 11% fuel saving compared to non-optimised flights on the same route. This demonstrated the opportunity to reduce fuel through removing inefficiencies with UK airspace structures and taxi congestion at airports. Since then SA organisations have been working to explore wider potential for this work. Further optimum flight trials have taken place with details presented in the case studies in Appendix 2.

- **Departures Code of Practice (2012 onwards)** – A series of initiatives were combined into a best practice guide in 2012 to support more efficient aircraft operations on the ground. These include concepts such as reduced engine taxi, optimum taxi routes to and from the runway and use of ground based electrical supplies and pre conditioned air whilst the aircraft is parked at the airport. *(See the Air Quality performance section for more information).*

- **The Controller-Pilot Environment Forum.** (2009) – Since 2009, NATS, through SA brought together controllers and pilots to discuss environmental performance and understanding. More information on Forum can be found in SA's 2011 Progress Report.

4.2.5.5 Evolution in Airframe and Engine technology

In addition to specific SA work to support CO_2 emission reduction, significant aerospace manufacturing improvements have been achieved over recent years with jet aircraft in service today using at least 70% less fuel per seat kilometre than the first jets in the 1960s[23].

The new aircraft entering UK airline fleets are more fuel efficient than those they replace:

- A320neo (new engine option) is up to 15% more efficient than the A320
- A350 powered by the new Rolls-Royce Trent XWB engines generates 25% lower CO_2 emissions[24] compared to aircraft it is designed to replace
- A330neo will deliver fuel savings of up to 14% compared to today's A330
- Boeing 787 is more than 20% more efficient than the Boeing 767
- Boeing 737 MAX – 14% reduction in CO_2 emissions compared to the Boeing 737 NG

Case studies detailing the latest aircraft and engine innovations are presented in Appendix 2.

4.2.5.6 Upgrading Airline Fleets

Over the past 10 years, SA member airlines have retired older aircraft types and replaced them with current and/or next-generation aircraft types, as the following charts show, enabling a progressively greater proportion of aviation activity to use quieter, more fuel-efficient aircraft. Specifically, since 2005, UK airlines have introduced more than 470 new aircraft into service representing an investment of over $49.6Bn at 2014 prices[25].

Over the next ten years we can expect "imminent"[26] aircraft types to occupy a steadily increasing share of total aircraft operations and to account for a greater proportion of available seat kilometres. As at March 2015, SA airlines had outstanding orders for 359 aircraft worth $53Bn at today's prices, to replace aircraft in their existing fleets. World-wide, Airbus and Boeing have future orders for over 12,000 new aircraft.

[23] www.atag.org/facts-and-figures.html, last accessed on 29 July 2014
[24] See http://www.airbus.com/aircraftfamilies/passengeraircraft/a350xwbfamily/
[25] Derived from Airbus and Boeing websites; aircraft delivery and order details
[26] In the context of our CO_2 Road-Map, "imminent" aircraft types are the Boeing 737 MAX, Airbus A320neo family , Bombardier C Series, Boeing 787, Airbus A350XWB, Boeing 747-8, and Airbus A380

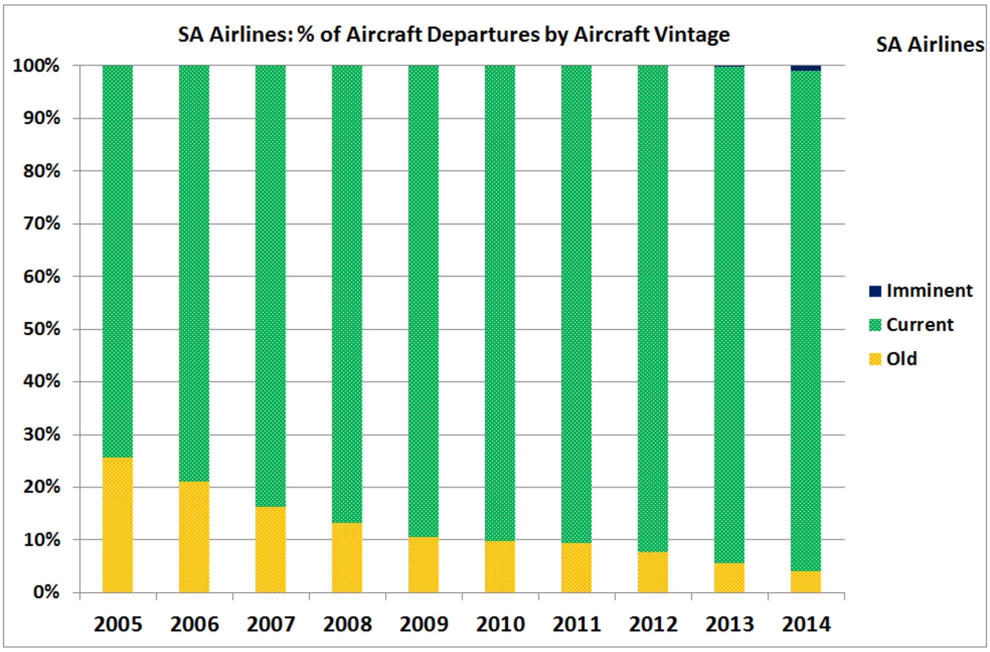


Figure 1 – Proportion of aircraft departures by SA airlines from UK airports, by aircraft vintage.

Scope: scheduled passenger flights. Source: Rolls-Royce analysis of data from OAG

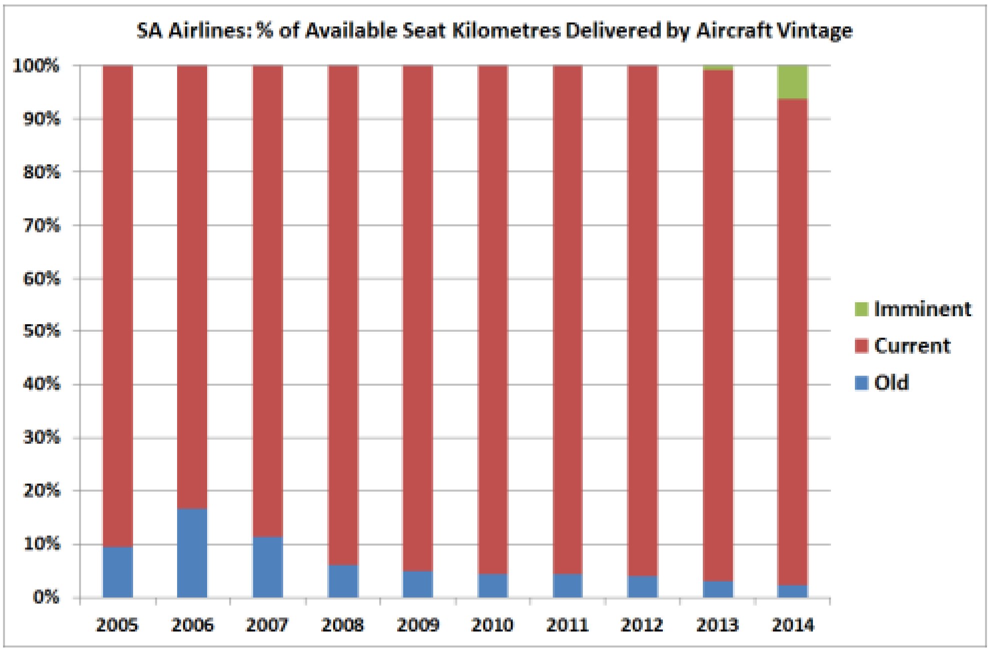


Figure 2 – Proportion of available seat kilometres (ASKs) delivered by SA airlines on flights which depart from UK airports, by aircraft vintage.

Scope: scheduled passenger flights. Source: Rolls-Royce analysis of data from OAG

4.2.5.7 Airline Fuel Efficiency Programmes

Over the last 10 years the airlines have worked on a number of fuel efficiency programmes. These programmes focus on a range of initiatives to reduce fuel burn such as:

- Setting specific fuel efficiency targets for pilots, operations and engineering staff
- Reducing on board aircraft weight
- Improving aircraft airframes and systems to minimise fuel burn
- Optimising aircraft climb, cruise and descent flight profiles
- Working with others to improve airspace routings

These efforts have reaped considerable savings in fuel burn and CO_2 emissions. Case studies for some of these are provided in Appendix 2.

4.2.5.8 Supporting Development of Sustainable Aviation Fuels

Sustainable fuels derive from both biogenic and waste sources and have a lower carbon footprint than fossil fuels. We are not referring to fuels generated from unsustainable first generation crops; our focus is on second generation advanced biofuels which do not cause Indirect Land Use Change[27] and deliver high CO_2 savings.

Fuels progress report 2010

SA produced a report which explored development of sustainable fuels for aviation. It was prepared following the publication of the 2008 SA CO_2 Road-Map with an aim to clarify current developments on this issue and detail activities being under taken by some SA members[28].

Sustainable Fuel flights

Since 2005 a number of SA airlines and manufacturers undertook flights using sustainable fuels, many of which used fuels cleared through the ASTM standards process for technical suitability. These flights were designed to test the effect of using the sustainable fuel in normal operations and assess any modifications that may be required to the fuel characteristics as well as aircraft fuel systems and engines. Details of these flights were provided in preceding SA Progress Reports.

The Sustainable Use of Renewable Fuels (SURF) consortium

This was formed in autumn 2010 by a group of SA signatories, which included Airbus, British Airways and Rolls-Royce, with Cranfield University. Its purpose is to address major considerations for the successful use of fuels from a renewable source like microalgae. ***Source: SA third progress report***

---

[27] Leads to additional pressure on agricultural land leading to induced land use change, e.g. deforestation and an increase in overall carbon dioxide emissions.

[28] See http://www.sustainableaviation.co.uk/resources/

4.2.5.9 Engaging in development of Global Aviation targets

In 2009, international groups representing airlines, manufacturers, airports and air navigation service providers agreed a set of industry goals:

- Average fuel efficiency improvement of 1.5% per annum from 2009 to 2020
- Carbon neutral growth from 2020
- Aspirational goal of 50% net reduction of CO_2 emissions in 2050 relative to 2005

As detailed earlier in this section, SA airlines fuel efficiency performance, since 2009, exceeds these targets and the SA Road-Map projection is in line with the 2050 target.

4.2.5.10 Informing the UK Aviation Climate Change debate

In addition to developing CO_2 Road-Maps, technical papers and internal guidelines to the UK aviation industry, SA has also been active in helping informing political and other stakeholders on aviation's work to reduce CO_2 emissions.

Reporting of Emissions

SA encouraged its member airlines to adopt common reporting of total CO_2 emissions and fleet fuel efficiency by airline, an aim which was met from 2006. ***Source: SA second progress report***

External Engagement

SA signatories worked with UK and European policymakers to develop pragmatic approaches to the design elements for the EU Emissions Trading Scheme (EU ETS). BATA airlines held two emissions trading workshops as preparation for the EU ETS, including input from other sectors. ***Source: SA second progress report***

Presenting evidence to UK Energy and Climate Change Select committee in October 2012 in response to their inquiry looking at how international aviation CO_2 emissions could be best accounted for by the UK Government.

Sharing the work of SA across the wider global aviation industry to inform wider debates on the development of a global market based measure for addressing global aviation CO_2 emissions[29].

SA fully supports the industry efforts through ICAO to deliver a global market based measure at the General Assembly in October 2016 as this is the most cost effective means for the industry to meet its carbon reduction commitments.

[29] See http://www.icao.int/environmental-protection/Pages/market-based-measures.aspx

4.2.6 The Future – What Next?

Considerable achievements in reducing CO_2 emissions from UK aviation have been made through SA and their members since 2005. Looking to the future there are a number of focus areas for SA.

- SA will continue to regularly report on our progress in addressing CO_2 emissions. Through its members, SA will continue to monitor developments in the scientific understanding of aviation's climate-change impact to ensure that SA's initiatives are well-founded and do not create unintended effects.
- SA's manufacturing members will continue to invest in research and development to enable future generations of aircraft and those coming into service to be even more fuel efficient. Looking forward, research goals include reducing new aircraft fuel-burn per passenger kilometre by 75% in 2050 relative to 2000, taking into account improved air traffic management (ATM) and operational practices[30].
- SA will continue to work with the UK Government to;
    - Secure investment in UK aerospace technology research
    - Enable airspace and operational improvements to be implemented
    - Develop sustainable aviation fuels

[30] Advisory Council for Aviation Research and innovation in Europe (ACARE).

4.3 Goal 3: Noise

Limit and, where possible, reduce the impact of aircraft noise.

SA has prioritised its work over the last 10 years on reducing CO_2 emissions and noise from UK aviation. This section details our progress on reducing noise.

QUIETER

4.3.1 Key Facts

- Noise contour areas at major UK airports have reduced by 14% in the last 10 years BUT the population living in those areas have increased by 4%
- In the UK, nearly 3 times as many people are affected by noise from railways and 12 times more are affected by road traffic, than by aircraft. Figures for the EU tell a similar story.

	UK population affected	
	>55 L_{DEN}	***>65 L_{DEN}***
Air	1,084,700	61,000
Rail	2,914,800	712,700
Road	12,504,100	3,730,000

Population affected by transport noise in 2012[31]

- Airbus 380 and Boeing 787 produce 97% (15 dB) less noise energy on departure, and 94% (12 dB) less on arrival than first generation jets
- Looking forward, ACARE research goals include reducing the perceived noise emission of flying aircraft by 65% (15dB) in 2050 relative to a typical new aircraft in 2000[32]
- Novel techniques and slightly steeper approaches in addition to new arrival and departure routings can help to reduce noise footprints at UK airports.

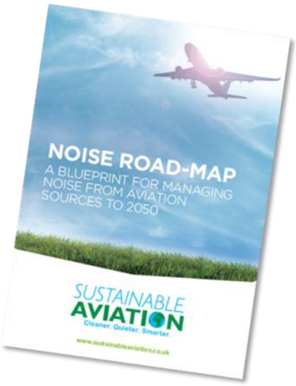
4.3.2 The SA Noise Road-Map

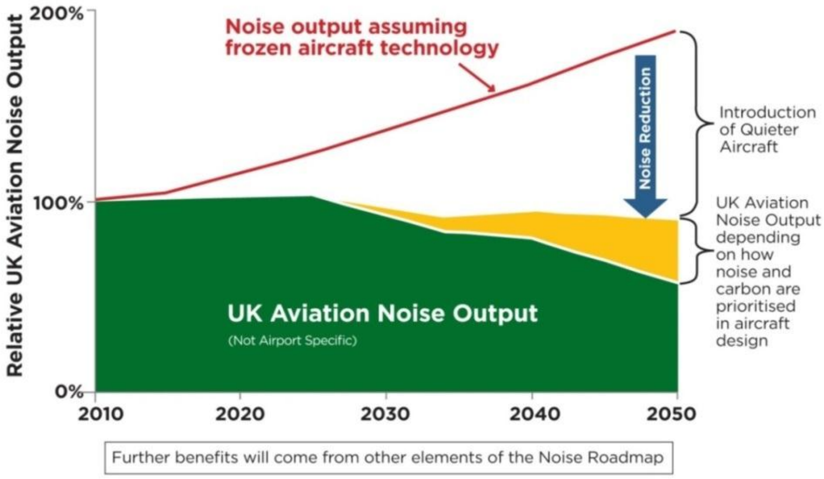
In April 2013 SA published a Noise Road-Map. This gathered a wide range of information from an operational and technology perspective and set out a forecast for how UK aviation noise can change over time. This forecast indicated that **noise from UK aviation could decrease over the next 40 years despite there being a greater number of flights. This can be achieved through the development and introduction of quieter aircraft and propulsion systems, alongside the implementation of better operating procedures and improved land-use planning.**

---

[31] EC, data reported for END mapping http://noise.eionet.europa.eu./viewer.html
[32] Advisory Council for Aviation Research and innovation in Europe (ACARE).

However, it is important to note that one of the most significant challenges in producing the Road-Map, and in the industry's ability to reduce the impact of noise, is its subjective nature. Reactions to and perceptions of aircraft noise is a complex problem that is ill-suited to 'one size fits all' solutions. Therefore as well as reducing noise output, it is critical that we explore how best to consult and engage with local communities to ensure their concerns are understood and addressed.

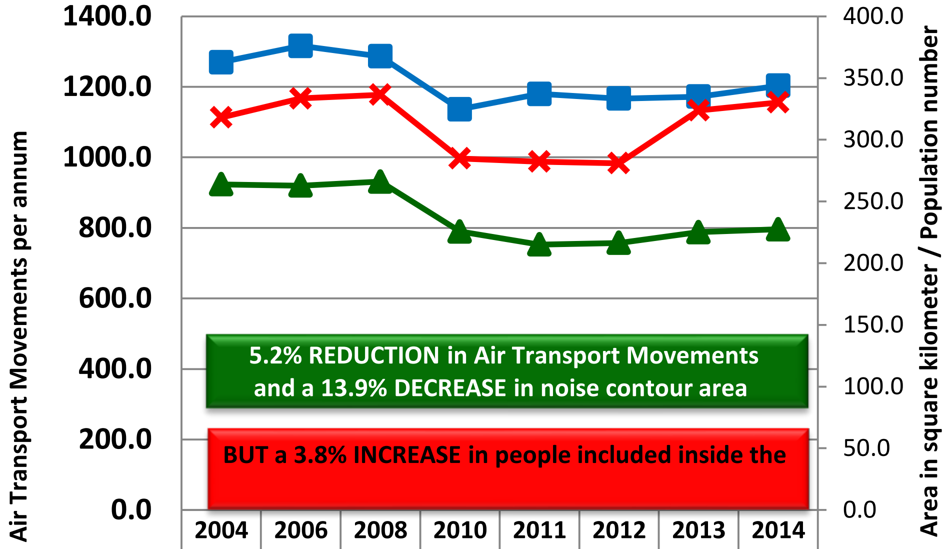




SA Noise Road-Map (2013)

4.3.3 Progress in addressing noise from UK aviation

In the last 10 years, changes in noise from UK aviation can be considered by looking at changes in noise contour data for six major UK airports compared to the total number of air transport movements. This format was developed in the 2013 SA Noise Road-Map. The next chart updates the one produced in the Road-Map with data for 2013 and 2014.



	2004	2006	2008	2010	2011	2012	2013	2014
ATM's (000's)	1269.7	1315.8	1286.7	1136.2	1179.7	1166.5	1172.0	1202.9
Area 57 Leq (km2)	263.9	262.8	266.1	225.6	215.1	216.4	225.1	227.4
Pop within 57 Leq contour (000's)	318.0	333.5	336.4	284.8	282.2	280.9	323.7	330.2

Combined Noise Trends for 6 Major UK Airports - Heathrow, Gatwick, Manchester, Stansted, Birmingham and Luton (2004 to 2014)

NOTE: Results for 2011 and 2012 do not include Birmingham Airport as data is not available

The chart highlights that despite the noise contour areas reducing in size over the last 10 years by nearly 14%, the population living within this contour area have increased by nearly 4%. The need to understand this trend and how it can be better managed will be important for future growth.

Looking at the last two years since the SA Noise Road-Map was published, a similar trend emerges. The number of flights at the 6 major airports has increased by 30,900 (2.6%), but the noise contour areas have only grown by 2.3 km^2 (1%). The population living in the areas, however, have grown by 6,500 (2%). The result does not completely disconnect growth in UK aviation from growth in noise output for these 6 airports. Overall, however, SA remains confident that future growth can be achieved without any increase in total UK aviation noise output. We will continue to monitor and report on progress every two years. Developing and introducing the new, quieter aircraft and increasing the use of quieter operational procedures will be key to achieving this. More details on this work to date are presented next.

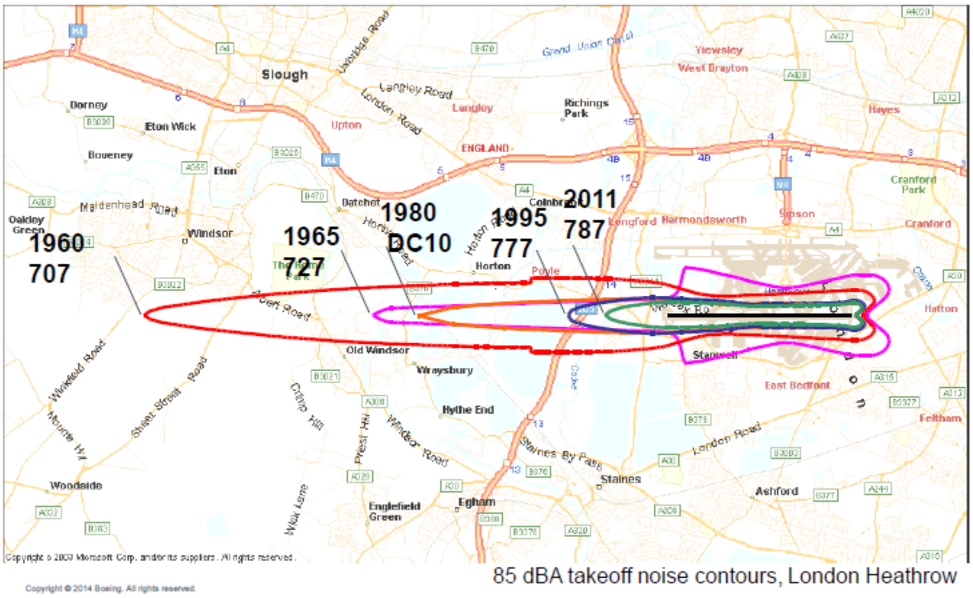
4.3.4 Specific SA work to address aircraft noise

Over the last 10 years SA members have delivered a number of initiatives to reduce noise from aircraft.

4.3.4.1 Noise Reduction from New Aircraft and Engine Technology

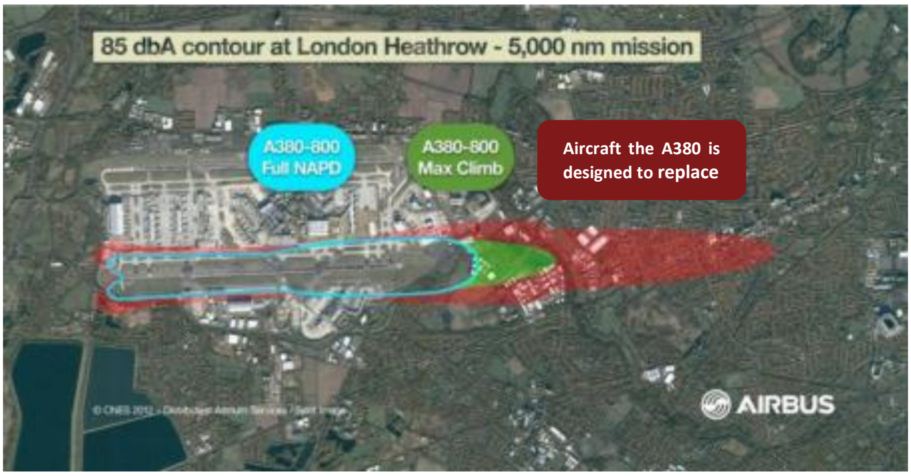
In the last 10 years considerable reduction in aircraft noise sources continues to be delivered from significant ongoing investment by aircraft and engine manufacturers. This has led to the introduction of new aircraft types which are significantly quieter than their predecessors, including the Airbus A380, Boeing 787 and Airbus A350.

The next diagram indicates the visible change in the noise footprint from different Boeing aircraft since the early 1960 jets.



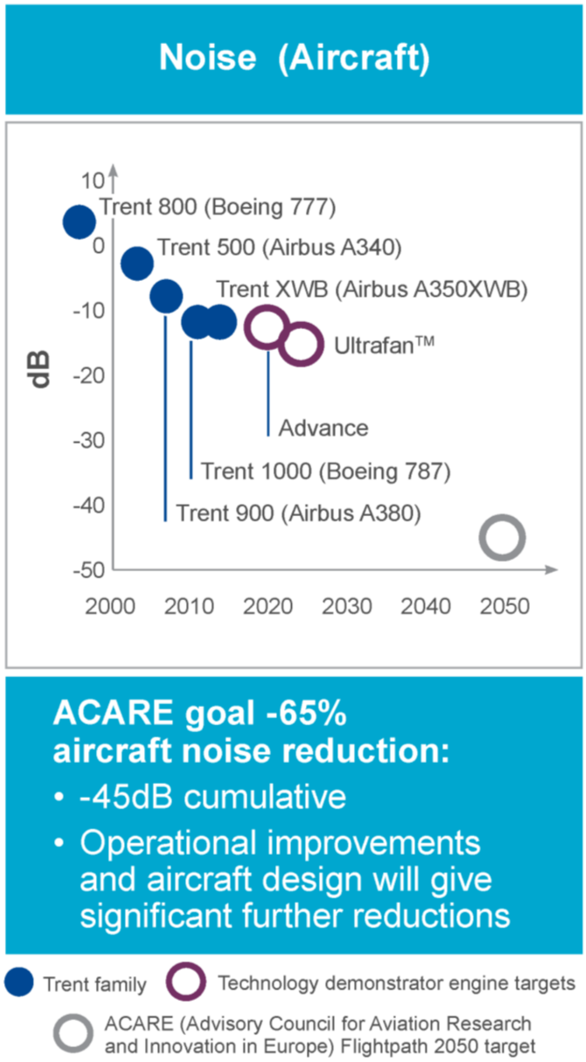
Change in noise footprints by different Boeing Aircraft taking off from Heathrow 1960 to present

A similar picture occurs when looking at the noise footprint of the Airbus A380 compared to aircraft it is designed to replace.



Modern engines, such as the Rolls-Royce Trent family, have progressively introduced advanced design features on all of the main engine components for noise reduction. Over the last 10 years, a rapid growth in computing power has been applied to model the aerodynamic processes that give rise to noise generation, and to give new insights on efficient means of noise control.

The progress Rolls-Royce has made in reducing noise from the continual development of its Trent engines is shown below.



Source: Rolls-Royce

The reduction in certificated noise between the Trent 800 engine produced in 1997 and the latest Trent XWB engine launched in 2014 is **14dB (cumulative for the three certification measurement points).**

The chart above not only shows how Rolls-Royce aero engines have become quieter over time, it also indicates the future plans for continuing to make quieter aero engines. Other SA aero engine manufacturing members are achieving similar results to those shown above.

Further details and specific case studies on new aircraft and aero engine technology can be found in Appendix 2, under the carbon section with greater information available on SA aerospace member websites.

4.3.4.2 Noise reduction from existing aircraft

Whilst noise reduction from new aircraft offer an exciting opportunity, the aviation industry has also continued to work on making existing aircraft operations quieter. This falls into two specific areas:

- Modifying existing aircraft to make them quieter
- Developing new aircraft systems to enable quieter aircraft operations

A good example of an aircraft modification over the last 10 years is work carried out by Airbus to reduce a high pitch whistling noise from their A320 aircraft. The modification was developed in 2014 and offers up to a 9dB noise reduction. It is being fitted to all new A320 family aircraft with a retrofit solution offered for existing aircraft. SA airline operators of A320 family aircraft are taking advantage of this. A case study on this issue is presented in Appendix 2.

Aerospace system manufacturers have also been working to improve the technical capability of the on-board aircraft flight management systems to enable quieter aircraft operations. It is now possible to design airport specific arrival and departure techniques for some aircraft that manage the engine power settings as well as the vertical and horizontal flight profiles. This offers the potential to optimise aircraft operations along arrival and departure routes around UK airports, taking into account noise sensitive areas. Over the last few years a series of trials have been undertaken to determine the potential for reducing noise. A number of these are covered in the next section.

4.3.4.3 Operational initiatives to reduce aircraft noise

The SA Noise Road-Map gave an overview of the range of operational techniques that could reduce noise. It concluded that noise reductions between one and five decibels could be achieved at some airports through the implementation of these techniques. A summary of current work is given next.

- **Continuous Descent operations (CDO)**

As detailed in the operational initiatives CO_2 section, CDO have increased in the UK from an average of 56% of arrivals in 2006, to 78% in 2014/15. The SA CDO campaign will continue to work with airlines, airports and NATS to further improve this performance in future.

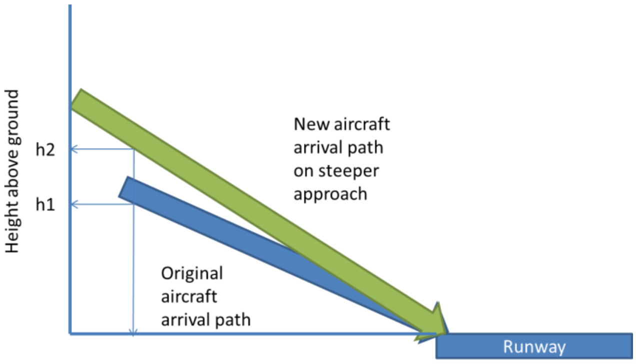
- **Continuous Climb operations (CCO)**

CCO to 10,000ft have increased in the UK from 55% of departures in 2006, to 67% in 2014. Promoting the benefits of Continuous Climb Operations (CCO) and encouraging wider uptake is an area of activity that is being led by SA's Operational Improvements Group. In the short term, this means SA helping to raise awareness of the benefits of CCO and seeking opportunities to make procedural or tactical changes to enable more CCO where airspace and traffic conditions allow.

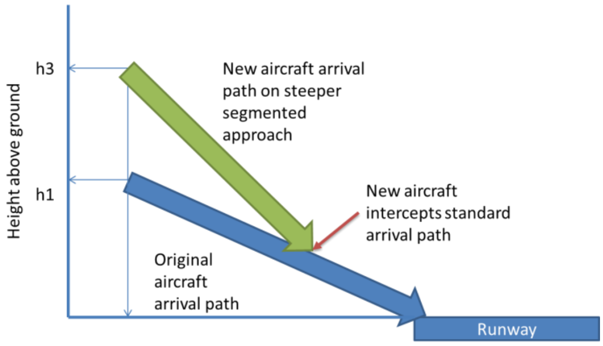
- **Steeper approaches**

A steeper approach is one which achieves environmental noise benefits by flying a steeper than standard approach path to the airport. Airport approach angles are typically 3.0° and current regulations only allow this angle to be increased for operational reasons, for example to provide appropriate clearance from an obstacle under the approach. One example of this is at London City airport, where the descent angle is 5.5° to provide safe clearance for the QE2 towers. However, discussions in recent years at an international level have investigated the potential to allow steeper approaches for environmental reasons, though a change has yet to be agreed.

Steeper approaches offer the scope to move the noise footprint of arriving aircraft towards the airport. This should help to reduce aircraft noise levels for people living under the final approach path. There are currently two approach designs which offer the most promise; slightly steeper approaches, e.g. 3.2°, and "segmented" steeper approaches which involve a steeper initial approach intercepting the standard 3.0° final approach path closer to the runway. These options are shown in the following diagrams.



Slightly Steeper Approach



Segmented Steeper Approach

In the last few years there has been a focussed effort by SA members to trial and formally develop these approaches at some airports. Results of this work are summarised below.

- Flight trials of segmented steeper approaches have been successfully conducted in the UK on British Airways Boeing 777 aircraft. These follow similar trials on a range of smaller commercial aircraft types conducted at Frankfurt Airport.
- In both trials the aircraft started their final approach descending at 4.5° and intercepted the standard 3.0° glideslope at 5 nm from the touchdown point.
- Noise benefits have been calculated as approximately 3 dBA at the start of the approach, when compared to a normal 3.0° approach.
- Small scale trials of 3.2° approaches have been conducted on the Airbus A380 in the UK. These have proved successful and, at the time of writing, a larger trial is underway, available to a wider range of aircraft types.
- Initial analysis has shown a noise benefit of 1 – 2dBA, which is similar to the experience at Frankfurt Airport.
- Aircraft flying a 3.2 degree approach are circa 200' higher than a normal approach, when 10 nautical miles (nm) from touchdown.

- This type of slightly steeper approach could offer a small noise benefit but is an important first step in testing the viability of this exciting concept for future application.
- A trial of slightly steeper approaches is underway at Heathrow Airport for the period September 2015 – February 2016.
- Whilst the design of 3.2° approaches is very similar to those currently used, the same is not true of segmented approaches. This means that segmented approaches are unlikely to be compatible with the very busy daytime operation at major airports. However, segmented approaches can offer significant benefits for the less busy early morning and late night periods.

The last 3 years has seen substantial progress in the development, testing and deployment of steeper approach angles in order to improve noise performance. The evidence appears to show worthwhile benefits and a type of approach which can meet all the required safety and operational standards enjoyed by the current 3.0° approach. Whilst the noise management issues vary greatly between airports, **steeper approach angles are now regarded, by SA, as both feasible, beneficial and at an advanced enough stage to be considered for wider use.**

✈ **Displacing runway thresholds**

The SA Noise Road-Map detailed the number of displaced runway thresholds in use at UK airports. These continue to offer noise benefits as aircraft land further inside the airport boundary, effectively moving the arrival noise footprint closer to the airport.

✈ **Horizontal aircraft noise management**

Horizontal aircraft noise management refers to the ability to change the route an aircraft flies over the ground to try and minimise annoyance to people and is seen as a key area of opportunity in future UK airspace design. In the last 10 years, the increased sophistication of satellite navigation and flight management systems on aircraft has enabled aircraft to fly very accurate routes over the ground. The term commonly used to describe the use of this technology is Performance Based Navigation (PBN). SA members have trialled a number of PBN options in recent years. Some of these are summarised below.

- Departure trial at Stansted Airport to avoid overflying noise sensitive areas just south of the airport. Details were presented in the appendix to the SA Noise Road-Map. Two departure routes trialled saw aircraft departures fly within approximately a 400 metre spread. See case study in Appendix 2 for an update
- PBN arrival and departure trials have also taken place at Birmingham, Edinburgh, Gatwick, Heathrow, Manchester, Liverpool and Luton airports. For more information please see the NATS and SA airport members websites

In recent months a number of airport trials have been stopped following concerns from local communities about changes in noise experienced by those living around the airport and a view that they have not been properly consulted. SA members are taking on board these concerns and exploring better ways to work with local communities in future.

✈ **Operational noise respite**

The accurate aircraft routings now achievable using PBN offer the potential to pre-plan specific routings over noise sensitive areas near airports. This approach can be used to provide predictable breaks or respite to certain areas for specific time periods. An early morning arrival respite trial was conducted at Heathrow airport in 2014 and a noise respite working group including local residents and representatives has been established. See Appendix 2 noise case studies for more information.

4.3.4.4 Initiatives to manage noise from aircraft through improved land use planning controls

As shown in the SA noise performance chart it is clear that, although the geographic area of the 6 major UK airport's noise contours has fallen in the last 10 years, the number of people living in these areas has risen by 6,500.

Many parts of the UK are experiencing an acute shortage of housing. Around 230,000 new households form in the UK every year and there is a backlog of two million households on waiting lists. Meeting this backlog means the number of new homes built every year will need to increase at least threefold to between 300,000 and 330,000. There is understandable pressure on local authorities to enable the development of these new homes, and of the community infrastructure needed to serve new households. Moving new households and communities inside noise contour areas could result in annoyance and conflict. Some people are happy to live near airports; people react differently to noise; and 57dB[33] noise levels will not annoy everyone whilst some others living outside of the 57dB noise contour may be annoyed by aircraft noise. But, SA believes, living near an airport should be a choice and, if people do choose to live within the given 57dB noise contour, they should be made aware of aircraft noise.

In 2014 the Airport Operators Association (AOA) collected the given noise contour (57dB LAeq 16 hour) of 18 airports and assessed the type and number of new buildings granted planning permission and being built within those areas. **Nationally, 5,761 homes have been granted planning permission, started or completed construction in the noise contours of the UK's 18 biggest airports[34].** This is detailed in the next table.

[33] This refers to the 57 dBA LAeq 16hr noise contour.
[34] See http://www.aoa.org.uk/publication/aoa-sustainable-airports-report/

Where are new homes being built?

More than 1,000 homes	Heathrow
	London City
More than 300 homes	Manchester
More than 100 homes	Aberdeen
	Birmingham
	Glasgow
	London Luton
Fewer than 100 homes	Gatwick
	Liverpool John Lennon
Fewer than 10 homes	Bristol
	East Midlands
	Edinburgh
None	Belfast International
	George Best Belfast City
	Leeds Bradford
	Newcastle
	Southampton
	Stansted

This means new homes are being built in areas where the Government expects people can experience annoyance at aircraft noise. More than half of these new homes are being built in the noise contours of airports near London, and four other airports serving cities across the UK are each finding new developments of over 100 homes in their noise contours. Educational and health buildings are also being extended and even newly built in these areas.

In the last 12 months SA airport members have been in discussion with their local authority planning colleagues as well as UK Government departments to explore the potential for developing best practice guidance on land use planning controls around airports. SA remains hopeful that this will result in a better way of managing housing and aviation growth going forwards.

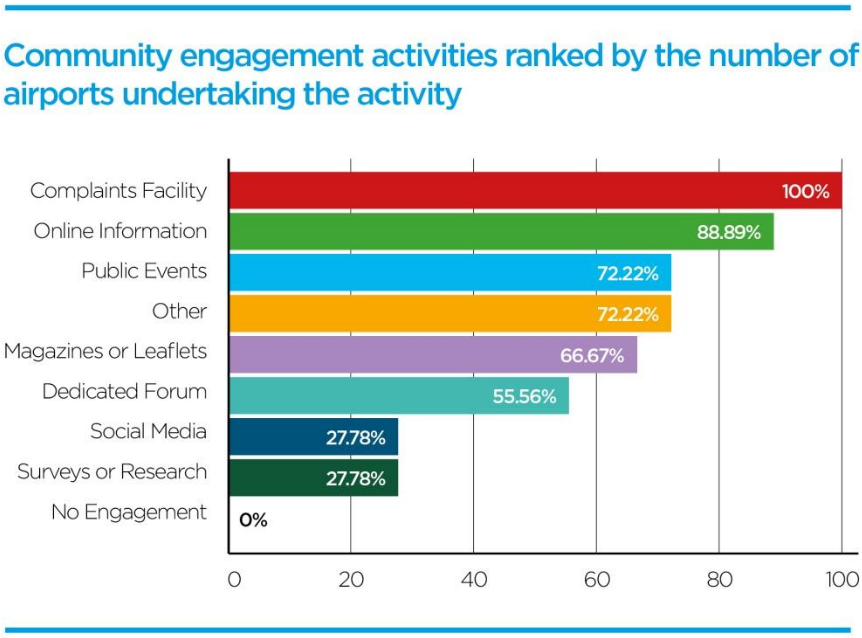
4.3.4.5 Finding ways improve noise communication and Community Engagement

As SA recognised in the 2013 Noise Road-Map, the UK aviation industry has not always been as good as it could have been in listening and working with those local communities affected by aircraft noise.

Since then the SA noise technical working group has supported a number of initiatives to improve how the industry communicates its noise performance and listens and works with local communities.

✈ Survey of UK Airport Noise Engagement

In 2014 the AOA Sustainable Airports report surveyed the UK's 18 biggest airports to find out what activities they undertake regularly through their Noise Action Plans. They also asked them whether they undertook additional outreach work and whether they evaluated the success of their engagement work. The next chart shows the outcome of this work.



✈ Exploring use of audio aircraft noise information

In the last two years SA members have sought to develop aircraft noise clips to share with local communities and policy makers demonstrating how future aircraft noise will compare to current. The 'Sound Lab' by ARUP for Heathrow Airport is a very interesting development of this work and offers opportunities to be used for a range of possible aviation infrastructure development consultations. (See case study in Appendix 2 – Noise section).

✈ Developing SA member specific aircraft noise strategies

Many SA airport members have regularly reported in their annual reports on the work to manage aircraft noise issues. More recently, major UK airports, having more than 50,000 air transport movements a year, have developed formal noise action plans in response to the EU Environmental Noise Directive. These plans can be viewed at SA member airport websites and give significant detail on noise reduction work underway at those airports.

Additionally SA has encouraged its other members to develop clear noise strategies to demonstrate the work they are doing on noise. In 2013 Virgin Atlantic published their 'Noise Management Strategy' detailing their work. (See case study in Appendix 2 – Noise section).

4.3.4.6 Noise Reduction potential through research and development

In addition to the aerospace technology research programmes both in the UK and EU, SA has kept close to other noise research issues. In March 2015 a noise and health workshop was held on to explore the latest research. It was attended by the World Health Organisation and Public Health England as well as the Department for Transport, independent expert consultants and SA members. It is an important area SA will continue to monitor and respond to.

4.3.5 Next steps

SA remains committed to limiting and, where possible, reducing the impact of aircraft noise.

The future aerospace manufacturing noise reduction targets offer significant opportunities, as do the further implementation of operational techniques. SA accepts that there is still room for improvement in how the UK aviation industry works with local communities affected by noise and we will continue to focus on this. However, it is equally critical that the industry and UK Government continue to work effectively in three critical areas.

- Continuing support for aerospace technology research
- Enabling airspace change to enable better vertical and horizontal mitigation of noise
- Supporting local authorities to provide additional housing, schools, hospitals and other noise sensitive buildings close to airports in a way that minimises increases in significant annoyance.

4.4 Goal 4: Local Air Quality

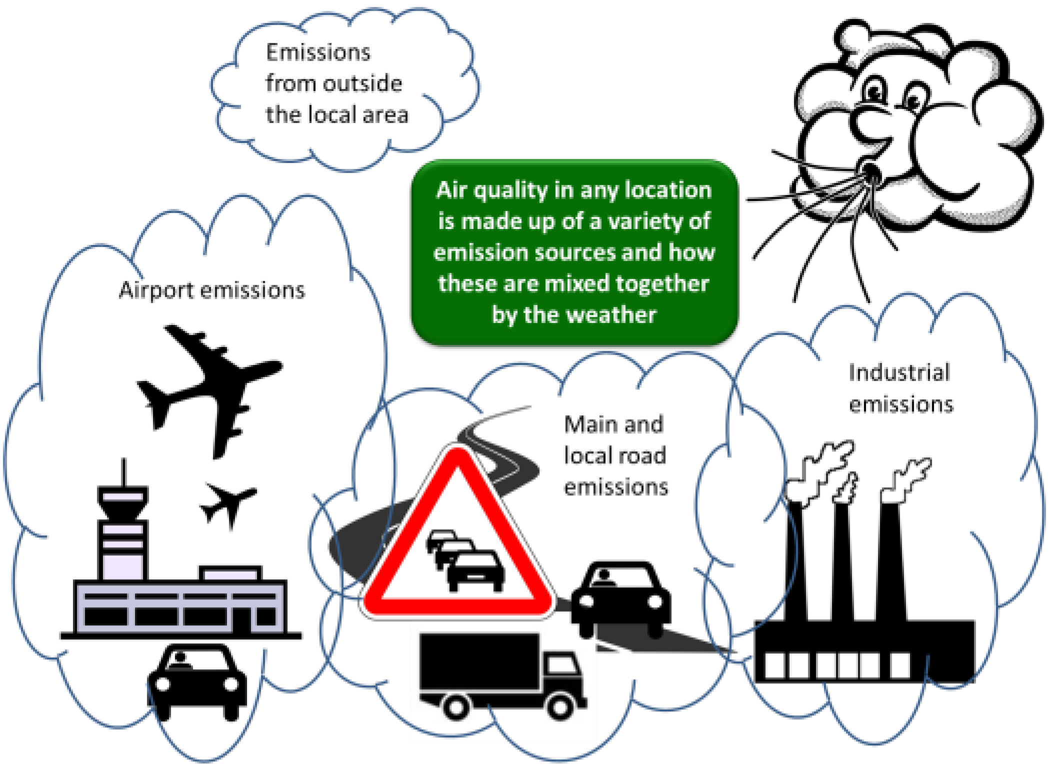
Industry to play its full part in improving air quality around airports.

4.4.1 Key facts

- Aircraft engines are 20% cleaner than they used to be and future developments will improve this by up to 60% by 2025
- Significant improvements have been achieved in the use of aircraft reduced engine taxi by SA airlines
- SA organisations are prioritising ways to reduce air quality emissions by working together both within and outside the aviation industry
- Aviation's emission impact on local air quality is only part of the picture. Solving air quality issues require an integrated approach

4.4.2 Air Quality Context

Air quality in any place is made up from a variety of different emission sources. The following illustration indicates the factors that affect air quality around airports.



Factors affecting air quality around airports

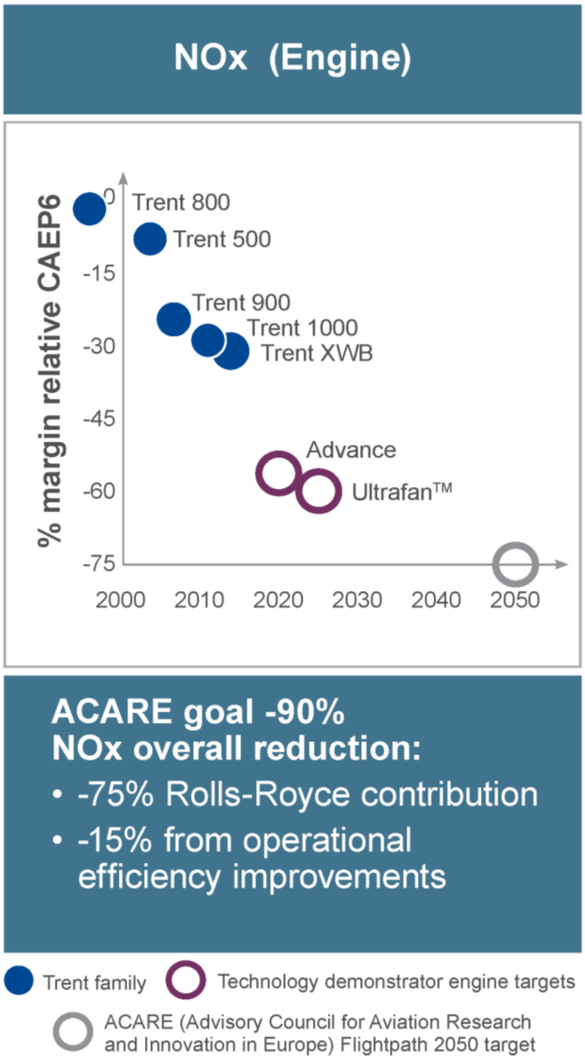
To ensure SA plays its full part in improving air quality around airports a range of activities are undertaken. These are detailed in the rest of this section.

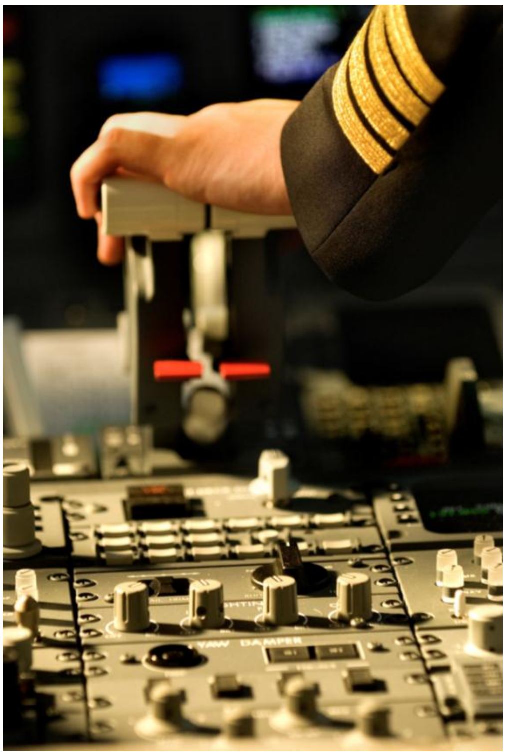
4.4.3 Working across the industry to reduce Air Quality emissions from aircraft

This section details the activities developed and undertaken within the UK aviation industry to reduce air quality emissions from aircraft.

4.4.3.1 Cleaner burning aero engines

Local air quality emissions from aero engines are improving. The chart from Rolls-Royce shows that since 2005, new UK jet engine technology has improved the margin to global aviation oxides of nitrogen (NOx) regulations by 20%. It also shows the potential from future engine developments to improve this margin by up to 60% by 2025.





4.4.3.2 Departures Code of Practice

Launched in 2012, this best practice guide was developed to encourage UK aviation organisations to work together to make aircraft departures cleaner and more efficient. The results are summarised below.

- **Reduced Engine Taxi –** It is possible to taxi to and from the runway with less than all the aircraft engines operating. SA airlines and airports have been working closely with their aircraft manufacturers to increase the use of this procedure for their operations. (See Appendix 2 Air Quality Section for more details).

- **Reduced use of Auxiliary Power Units (APUs) –** APUs burn fuel to provide power to the aircraft when power is not available from other sources, such as whilst it is parked. Airlines have worked with airports and ground handling companies to reduce the use of APUs by providing ground electrical power and pre-conditioned air to aircraft whilst they are parked. Positive progress is now being made but further work is required to optimise this opportunity without disrupting the safety and reliability of aircraft turnarounds.

- **Optimise aircraft taxiing -** NATS have been working with airport tower controllers and airlines to promote smooth taxiing and avoid unnecessary stop/starts. By providing early information to pilots about expected ground routings, controllers can help avoid unnecessary stops at taxiway junctions and as a result reduce fuel burn and CO_2 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.

- **Improve Intersection Departures** NATS in partnership with some airport operators and airlines are encouraging intersection departures. Reduced taxi distance means reduced fuel burn and increased runway capacity. Between 2010 and 2014, NATS estimates the combined benefits of shorter, more efficient taxi times across the 15 airports where it provides the air traffic service in the UK is over 5000 tonnes of fuel. This excludes fuel savings from reduced engine taxiing.

4.4.4 Working with others to tackle air quality

As well as minimising emissions at airports, solving local air quality issues requires an integrated solution involving the aviation industry working with others. This is achieved by sharing air quality monitoring data in differing geographic locations to better understand the complexities of aviation emissions, how they contribute to air quality in local areas and what actions the industry should take to achieve the best results for managing emissions.

Over the last 10 years the UK aviation industry has participated in a number of joint activities with others, including:

- **Internal aviation industry working groups** to share best practice and trial new techniques to reduce air quality emissions. A good example of this is the departures code of practice work discussed earlier.
- **Air quality working groups** – Many UK airports participate with their local authorities and interested parties, sharing air quality data and exploring new technologies and opportunities to reduce emission. The Heathrow Air-Watch approach is a good example. (See Appendix 2 Air Quality section case study).
- **Academic research into air quality emissions and dispersion** – Many SA organisations have worked with universities to better understand the nature of aircraft and airport air quality emissions and how these disperse in the local area. This has involved sharing data from air quality monitoring as well as carrying air quality assessment instruments on aircraft flights.
- **Trialling new and emerging low emission vehicle technology** – A number of UK airports are actively working with innovative low emission vehicle organisations. They are exploring the opportunity to make greater use of low emission vehicles on the airport, in addition to the many electric vehicles used to transport passenger baggage to and from the aircraft. More details can be found on SA airport member websites.
- **Developing global aircraft certification standards for air quality** – SA organisations have worked for many years with global bodies such as the International Civil Aviation Organisation (ICAO) in developing aircraft certification levels for air quality emissions. As part of the certification process, engine manufacturers demonstrate compliance with stringent limits on the amount of emissions, such as CO, NOx, HC and Smoke, which are set by ICAOs Committee on Aviation Environmental Protection (CAEP). The NOx standards have been tightened four times since the original standards were applicable in 1986, with the latest most stringent standard applicable from 2014. Considerable investment in the ongoing development of low emissions engine and combustion system technology has improved the margin relative to this CAEP NOx standard as shown in the earlier chart from Rolls-Royce.
- **Developing and delivering airport air quality strategies** – A number of UK airports have developed specific strategies on air quality. These are developed in consultation with their business partners and local communities. Presenting details of air quality monitoring they set out actions to be undertaken to address emissions over a specified time period. Given the significant contribution from road and vehicle emissions, these strategies are closely aligned with the Airport's surface access strategies which will be discussed later.

Details of specific airport air quality strategies can be found on their respective websites. The next table summarises current UK airport activity.

Airport	Monitoring of Air Quality	Reports on Air Quality	Published strategy
Aberdeen	Yes	Yes	No
Birmingham	Yes	Yes	Yes
Bristol	Yes	Yes	Yes
Gatwick	Yes	Yes	Yes
Glasgow	Yes	Yes	Yes
Heathrow	Yes	Yes	Yes
London City	Yes	Yes	Yes
Luton	Yes	Yes	No
Manchester	Yes	Yes	No
Newcastle	Yes	Yes	No
Stansted	Yes	Yes	Yes

UK Airports action on Air Quality

- **Assessing future air quality during airport development –** As part of developing plans to develop airports, air quality modelling is regularly undertaken. This assesses the current and potentially new or increased sources of emissions and how these are likely to affect air quality at the airport and surrounding areas. The work is used to inform planning conditions and obligations set by local authorities and central Government on UK Airports. These can set a range of specific controls and reporting requirements for air quality at the airport.

4.4.5 Next Steps

4.4.5.1 SA Air Quality Paper

In the last 12 months concerns about poor air quality have increased and stakeholders want to better understand how aviation affects air quality. SA recognises that it is important for UK aviation to provide more information on our work to reduce air quality emissions and to ensure this is seen in context with the wider complexities of local air quality. Reflecting this, a detailed paper on the subject will be produced within the next 12 months.

4.4.5.2 Additional Aircraft Operational Initiatives

In addition to reduced engine taxi, SA members have also been involved in E-taxi initiatives. This development adds electric motors to the aircraft undercarriage enabling it to taxi to and from the runway using electrical power rather than starting the main engines. Due to the added weight to the aircraft, it is only currently viable on short haul aircraft. Investing in this new technology offers the potential to reduce taxiing-related carbon and NOx emissions by more than 50%.

Beyond these specific issues SA will continue to ensure we play our full part in improving air quality around airports.

4.5 Goal 5: Surface Access

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

4.5.1 Key facts

- ✈ Since 2006 over 11 million extra passengers are using public transport to access 8 major UK airports.
- ✈ The percentage of passengers using public transport to access 8 major UK airports has increased by 5.9% since 2006.

4.5.2 Use of Public Transport to access UK airports

The UK Civil Aviation Authority (CAA) carry out annual passenger surveys which capture data on how passengers travelled to the airport. From these surveys a percentage of passengers using public transport to access the airport can be derived. Availability of airport data can vary from year to year but the table below shows the collated results for the most consistently reported airports.

Year	Total non-transfer passengers at airports	Passengers using public transport	% of total non-transfer passengers at airports	Airports Included
2006*	140,956,000	42,357,254	30.0%	BHX, LGW, LHR, LTN, STN, LCY, EMA, MAN Airports
2007	126,459,000	42,324,463	33.5%	LGW, LHR, LTN, STN, MAN Airports
2008	126,846,000	43,855,435	34.6%	LGW, LHR, LTN, STN, LCY, MAN Airports
2009	114,999,000	40,979,947	35.6%	LGW, LHR, LTN, STN, MAN Airports
2010*	128,646,160	45,408,934	35.3%	BHX, LGW, LHR, LTN, STN, LCY, EMA, MAN Airports
2011	133,895,061	48,340,084	36.1%	BHX, LGW, LHR, LTN, STN, EMA, MAN Airports
2012*	136,301,539	50,680,169	37.2%	BHX, LGW, LHR, LTN, STN, LCY, EMA, MAN Airports
2013*	140,293,000	51,143,575	36.5%	BHX, LGW, LHR, LTN, STN, LCY, EMA, MAN Airports
2014*	148,739,000	53,410,941	35.9%	BHX, LGW, LHR, LTN, STN, LCY, EMA, MAN Airports

Notes:
*Comparable data which includes the same 8 UK airports
Derived from CAA Passenger Survey data 2006-2015 (http://www.caa.co.uk/default.aspx?catid=81&pageid=7640)
Passenger figures are for non-transferring passengers only
Total public transport includes passenger use of bus, coach, train or tube to access the airport

The table demonstrates the following:

- Since 2006 over 11 million extra passengers are using public transport to access 8 major UK airports.
- The percentage of passengers using public transport to access 8 major UK airports has increased by 5.9% since 2006.

Further investigation of the CAA survey data shows that, on average, about 40% of passengers in 2014 use public transport to access the five major London airports. This is around a 3% improvement since 2006.

Outside of the London airports however, the situation is different. The percentage of passengers using public transport to access airports outside the south east is less than 25%. Significant improvements are being seen at some airports though, with Manchester and Birmingham seeing a 66% and 27% increase in passengers using public transport at their airports respectively since 2006.

4.5.3 Current Initiatives to improve surface access

The data presented in the previous section indicate that progress is being made to offer passengers the ability to use public transport to get to and from the airports. Despite this SA organisations are committed to further improving this performance.

There are a range of initiatives currently being employed.

- **Airport Surface Access Strategies** – For the larger UK airports, detailed strategies have been developed. These set future improvement targets and run over a fixed time period. Lists of actions are presented across the public transport agenda. Examples of targets for 3 UK airports are given below[35].
  - **Edinburgh -** Edinburgh's goal is to increase the number of passengers using sustainable transport (bus and tram) by a further 7%, rising from 28% to 35% by 2017.
  - **Luton -** London Luton aims to increase the proportion of passengers who travel by public transport to more than 40% by 2017.
  - **Stansted -** As passenger numbers continue to grow at Stansted, the airport aims to maintain the yearly target of 50% of all passengers using public transport. They also aim to grow rail usage from 22% to 25% by 2019, with a renewed focus on reducing journey times from London to the airport by 2021.
- **Airport transport forums** – For UK airports with over 1,000 passenger air transport movements, formal transport forums have been established. Overseen through the Airport Consultative Committees, these forums seek to ensure best practice is shared between airport, local authorities and public transport providers. See a case study for Bristol Bus Flyer Service in Appendix 2.

[35] As reported in the Airport Operators Association Sustainable Airports Report 2014

- ✈ **Company Staff travel plans** – These plans seek to enable staff to get to work more sustainably and can include:
    - o Discounts for bus and train season tickets
    - o Car share schemes to avoid single occupancy car journeys to work
    - o Walk and bike to work schemes including support for buying a bike

4.5.4 Future opportunities

In addition to the existing work to improve surface access, SA organisations are keen to work with Government, to ensure that future investments in new transport infrastructure realise the opportunities to integrate airports into the UK's ground transport.

Some specific examples of these opportunities are:

- ✈ Improved links and stops to airports along the High Speed 2 rail line
- ✈ Luton airport link rail scheme to remove the need for bus journeys from Luton Airport Parkway station to the airport
- ✈ Stansted airport in 30 minutes campaign seeking upgraded performance and capacity on the West Anglia rail line

SA is keen to explore these opportunities with UK Government over the next few years.

4.6 Goal 6: Natural Resources

Environmental footprint of UK aviation's ground-based aircraft activities contained through effective management and reduction measures.

SA members have continued to explore and develop initiatives to improve the industries use of natural resources over the last few years.

SMARTER

4.6.1 Key facts

- Airports and airlines are working hard to increase recycling of aircraft cabin waste
- Airports are achieving high levels of waste recycling for waste produced at the airport during construction or from passengers
- Further work with Government is required to reduce the amount of low risk cabin waste being classified as high risk waste (and therefore unable to be recycled)
- Improving energy efficiency is a key focus area for all SA members

4.6.2 SA waste working group

Since 2005 there have been a number of individual recycling and reducing waste at source initiatives among various airlines (including the development of an on-board can collection methodology by the then First Choice Airways, now Thomson Airways and Thomas Cook Airlines UK) and facilities for separate collections of recyclables have been available for some time at the majority of UK airports. However there are still many barriers to the implementation of larger scale recycling of waste on-board aircraft.

The Aircraft Waste & Recycling Working Group was established in 2009 to work collaboratively to review and overcome these barriers. The Working Group comprises of airlines, airports, cleaners and caterers working together to significantly increase recycling collections by airlines and improve the scale of facilities at airports.

The main objective of the SA Waste Working Group is to develop and implement UK wide protocols and practices to reduce the tonnage sent to landfill and increase recycling of aircraft cabin waste.

In 2010 the Waste Working Group developed an Aircraft Cabin Waste Recycling Guide - a simple practical guide for recycling of aircraft cabin waste into UK airline bases. The Working Group also engaged with DEFRA, the UK Government's Environment Department, which resulted in the positive development of revised guidance on recycling on international flights boosting recycling opportunities by diverting more from landfill.

The composition of aircraft waste can vary considerably, dependent on whether the flight is long or short haul, low cost, full service or charter and dependent on the cabin service provided by each airline. Audits have shown that waste and materials collected from within the cabin there is a high proportion of recyclable material. (See Appendix 2 Natural Resources Heathrow waste case study). Unfortunately recyclable aircraft cabin waste is often treated as a high risk waste - International Catering Waste (ICW)[36]. Diverting low risk waste from very high risk waste streams significantly increases recycling rates, reduces costs with the former outcome being one of the main objectives for the group – the latter outcome can actually go some way to providing financial savings for additional recycling facilities to be provided creating a virtuous circle for airport infrastructure.

Achieving recycling targets is now part of many airlines' and airports' environmental policies. Although there is no direct financial incentive for an airline to segregate waste on board, as outlined above, the airport can recycle revenue from waste materials back into greater recycling infrastructure; this is often seen as something that should be done to demonstrate environmental commitments and good practice. Furthermore, recycling is also increasingly expected by passengers on account of it being a very visible environmental impact. In 2014, waste was segregated on 66% of TUI airline flights across six airlines, up from 58% in 2013.

Main challenges for airline operators include space constrains for waste storage on board, engagement of cabin crew colleagues and development and deployment of new cabin procedures. Other challenges include time constraints during aircraft turnaround activity and inadequate waste disposal procedures and facilities at airports – with no differentiation in disposal methods for waste arriving from non-EU flights (waste that may can contain ICW) and EU-flight (waste that may contain category 3 waste – classed as a low risk material). There remain some challenges and issues to address regarding the differing guidance from local authority/DEFRA Animal Health Officers in various parts of the country as well as difficulties in stakeholder engagement with some groups.

Working together more frequently and intensively has certainly helped to improve clarity on the relationships between various stakeholders, allowing results to be shared and greater opportunity to review potential adjustments to reduce waste arising, divert more waste from landfill and boost recycling rates.

By developing a simple practical guide for recycling - an Aircraft Cabin Waste Recycling Guide, all parties were provided with a set of standard rules for the collection, storage and handling of recyclable material. Airlines were provided with a set of cabin procedures for collecting recyclables that can be successfully used on routes into all UK bases. UK airports were provided with guidance on setting up appropriate waste contracts and facilities to capture segregated material for recycling.

With the exception of a few smaller UK airports (which handle only a few or none non-EU flights) it is usually very difficult to distinguish between waste produced on-board from EU versus non-EU flights once waste has been off-loaded by cleaning companies. Therefore any requirements on ICW disposal are often applied to all aircraft cabin waste.

---

[36] Under Animal By-Product Regulations waste must be considered ICW (a high-risk category 1 animal by-product) if an aircraft travels outside the EU

Review of Animal By-Product Regulations policy guidance interpretation and how these affect airports and airlines is necessary to remove the red tape that is currently constraining waste management and more environmentally beneficial disposal methods. This should include review and approval process for treatment and disposal methods for ICW and where possible approving additional techniques.

4.6.3 Airport waste recycling improving

Over the last 10 years SA airport members have regularly reported on how much waste they are recycling from construction and retail. Significant increases have been achieved through working with airport retailers, tenants, project teams and passengers. Glasgow Airport for instance now recycles 90% of its waste. (See Appendix 2 Natural Resources Glasgow waste case study).

4.6.4 Aircraft end of life recycling

Over the last 10 years aerospace manufacturers have made considerable progress in identifying and promoting the reuse and recycling of aircraft and aircraft components that have come to the end of their operational lives. For instance, at the end of its lifecycle, around 85% of an A320 can be economically recycled in terms of weight. This figure is projected to rise to 95% in the next few years.

The EU has the second largest market for aircraft leaving service and therefore the opportunity for aircraft recycling in Europe is also high being worth about €80M per annum. This market is however changing and components are now becoming viable to recycle earlier as the value of keeping the aircraft as a complete entity declines at a greater rate (in some cases) than the value of the individual components.

Engine manufacturers are already good at taking back scrap materials from MRO, to either reuse or, if not possible, recover the metals and, as a result, the recycling market for aero-engines is already well developed.

The Process for Advanced Management of End of-Life-Aircraft (PAMELA) Project, initiated in 2006, is an enterprise set up by Airbus together with several other industrial partners (including SITA-SUEZ and Sogerma Services) at Tarbes Airport in Southern France. The results enabled the partners to maximise the level of recycling and recovery, and at the same time provided a business model to help justify sustainable industrial development. Airbus estimates that more than 4,000 aircraft will finish active service between 2004 and 2023; a rate of over 200 aircraft per year, and that between 85% and 95% of their components can easily be recycled, reused, or otherwise recovered.

Boeing disassembled an ecoDemonstrator 757 as part of a final recycling research project to better understand what happens at the end of an airplane's service and identify more efficient recycling techniques. The project will enable Boeing to look at using better materials to build the airplane, with recycling in mind, or better design that allows the airplane to be disassembled easier as a result.

4.6.5 Energy, Water and Construction Management

Energy and water use and the materials and methods used in construction are very closely monitored and managed by SA members. They regularly report on progress at reducing consumption and use of hazardous or precious materials. For more information visit SA member websites.

4.6.6 Next Steps

SA will continue to ensure we play our part in supporting the responsible use of natural resources and prioritise minimising their use where possible.

4.7 Goal 7: Implementation

Full industry commitment to sustainable development and communicating fully the role of aviation in society in order to support a better understanding of its contributions.

During the last ten years SA has evolved significantly and its members have equally evolved an increasingly broad range of sustainability plans and objectives.

SMARTER

4.7.1 Implementing SA

In 10 years SA has worked hard to share knowledge and data across the four sectors of the industry to create detailed Road-Maps. These have covered key sustainability issues and define the opportunity, with Government support, to grow the industry sustainably. Supporting the Road-Maps have been a series of technical papers, on key issues and bi-annual progress reports to show how the UK aviation industry is performing against the SA strategic goals.

In recent years SA has evolved the way it is organised to increase our ability to support SA members and aviation stakeholders[37]. Specific changes have been.

- Substantially increasing internal dedicated resourcing by moving to an effective full time Programme Director
- Engaging a public affairs agency, Connect Communications, to support SA's parliamentary engagement activity
- Improving SA's frequency of engagement with our external stakeholders and policy makers
- Investing in a new website
- Finding smarter ways to inform stakeholders of our work through the use of info graphics and video materials and, in 2015, social media
- Reviewing and improving clarity on SA membership
- Improving the effectiveness of the technical working groups by drawing in a greater mix of UK industry experts, including better links with the SA Advisory Board
- Regularly reviewing the terms of reference for all SA groups from the Council down
- Supporting a review of the SA Advisory Board chair, membership and terms of reference
- Continuing to request feedback on our work from internal and external industry stakeholders
- Continuing to monitor external policy developments and assess implications for SA

[37] The governance, organisation and membership of SA is presented in Appendix 1

SA Members implementing SA's Goals and Vision

Achieving sustainable aviation growth has required SA members to adapt in a number of ways, working in a smarter way with others and in many cases acting as leaders for change. Details of this work can be found by visiting SA member websites.

4.7.1.1 Setting clear sustainability strategies

Many SA members have established specific sustainability strategies to focus their delivery against the wider SA strategic goals. At Gatwick Airport for instance they created a 10 point sustainability plan which covered 10 issues and 10 years to achieve them. Details of their performance are provided as a case study in Appendix 2, implementation section.

4.7.1.2 Influencing global discussions

SA members have been busy in the last few years sharing the work of SA at a number of internal and external events to support sustainable aviation growth. These include:

- SA airlines working through the International Airline Transport Association (IATA) to develop global airline CO_2 targets and developed options for the International Civil Aviation Organisation global carbon market based measure negotiations. See https://www.iata.org/policy/environment/pages/climate-change.aspx
- Sharing our work and leading panel based discussions on tackling noise and carbon issues at the Global Sustainable Aviation Summit in Geneva (see http://www.envirosummit.aero/)
- Providing case study information to the global Aviation Climate Solutions document. This is a collection of 100 case studies of aviation's climate action currently taking place across the world. The aim is to inspire aviation partners, around the world, to further increase fuel efficiency and CO_2 reductions and demonstrate that the industry is committed to collaborative solutions. See http://aviationbenefits.org/environmental-efficiency/aviation-climate-solutions/

4.7.1.3 Pioneering research

Some of the key SA member research initiatives are detailed next.

- **AGP and ATI**

Established in 2010, the AGP is a collaboration between Government and industry focused on securing the future of UK Aerospace. It presents a shared vision and plan for the UK Aerospace industry for the next 15 years and beyond. By working together in the AGP, Government and industry have developed a shared vision for UK's aerospace manufacturing industry to:

- Ensure that the UK remains Europe's number one aerospace manufacturer and that it remains second only to the United States globally. This is an ambitious and challenging goal, given intensifying international competition and the rapid pace of innovation in the sector
- Support UK companies at all levels of the supply chain to broaden and diversify their global customer base. This will be critical given the entry into the market of new manufacturers of large civil aircraft across the world

- ✈ Provide long-term certainty and stability to encourage industry to develop the technologies for the next generation of aircraft in the UK.

The ATI was created by Government and industry to guide investment into research and technology projects that will sustain and enhance the UK's competitive advantage. Its Technology Strategy, launched in July 2015, defines the best combination of capabilities, technologies and products to advance next-generation civil aircraft; enabling industry to exploit anticipated global growth, and deliver value to the UK economy through the sector's high productivity and skills.

- ✈ **ACARE Flightpath 2050 – Europe's vision for aviation**

Developed in 2011, ACARE Flightpath 2050 sets out a series of long term targets for aviation in Europe. It has helped shape an EU strategic research agenda for aviation.

There is a vigorous programme of Aeronautics and Air Transport research, which is already delivering important initiatives and benefits for the aviation industry, including: EU collaborative research in Aeronautics and Air Transport (EC's Framework Programme research FP6, FP7 and Horizon 2020), the Clean Sky Joint Technology Initiative, the SESAR Joint Undertaking, national programmes in many Member States and research establishment as well as private company programmes. (See http://www.acare4europe.com/documents/latest-acare-documents/acare-flightpath-2050).

Case studies from Airbus and Boeing on new aircraft technology projects are provided in Appendix 2, implementation section.

4.7.1.4 Exploring the future

In December 2014 the SA Council ran a Futures Workshop for SA members and the SA Advisory Board. Facilitated by Forum for the Future the event focused on the following:

- ✈ Developing insights about the potential futures that aviation in the UK may face, and explore implications for the industry to 2030.
- ✈ Identifying some of the main challenges and opportunities for sustainable aviation in the coming decades.
- ✈ Challenging some current assumptions about the future of aviation.
- ✈ Developing scenarios that can be used to help SA members develop robust and sustainable long-term strategies.

The workshop proved a useful event to challenge thinking and the outputs are being used by SA members in their internal strategic discussions.

4.7.2 Next steps

SA will continue to review our work programmes and resourcing, based on external developments and feedback from all our stakeholders, to ensure our work remains relevant and supports sustainable growth.

5 Future Work Programme and Next Steps

As can be seen in this report, Sustainable Aviation has been very much in action to deliver a cleaner, quieter, smarter industry over the last ten years. This progress is testament to the effort of SA members working together guided by the Council and supportively challenged by the stakeholder Advisory Board. But we are an industry with long term goals and aspirations; the work of the last decade is a great start.

Looking ahead we will continue to focus our joint efforts on re-visiting the SA CO_2 Road-Map, which since it was first published in 2008, has become a reference document for the industry. It is important to review this Road-Map to ensure that we are still on track to deliver the lower carbon future to which we aspire. As an industry coalition at the core of our work is ensuring that we manage our environmental impacts whilst maximising the significant social and economic benefits that the industry brings to the UK and globally. Shortly SA will be publishing the results of our work to evaluate the socio-economic impacts of the industry. And following that we will be focusing on air quality impacts of aviation.

Sustainable alternative fuels have been the subject of much industry effort to achieve our longer term CO_2 goals, this effort will continue over the coming years. But the important role of Government in establishing the appropriate policy framework to enable aviation to develop and access this burgeoning sector must not be underestimated. The modernisation of the invisible infrastructure above our heads – airspace – is another priority that SA members will continue to drive in the coming months and years. But again, the need for clear Government policy and support for this important work will be key to securing the significant noise and emissions benefits inherent in modernising air traffic management over the UK.

At SA, as well as working collaboratively as an industry group, we are committed to continue our work with Government and with our stakeholder Advisory Board to deliver a cleaner, quieter, smarter industry. The last decade has seen good progress, I am sure I can count upon my SA Council colleagues, the Advisory Board and the whole membership to deliver with ambition and pace over the coming months and years.

Ian Jopson

Incoming Chair of SA (2016-2017)
Head of Environmental & Community Affairs, NATS

Glossary

Absolute CO_2 Emissions Actual CO_2 emissions produced

ACARE Advisory Council for Aviation Research and Innovation in Europe

A-CDM Airport Collaborative Decision Making

AOA Airport Operators Association

APU Aircraft Auxiliary Power Unit

ATC Air Traffic Control

ATM Air Traffic Management

BATA British Air Transport Association

CAA UK's Civil Aviation Authority

CCC UK's Committee on Climate Change

CCO Continuous Climb Operation

CDA Continuous Descent Approach

CO_2 Carbon Dioxide

ERCD Civil Aviation Authority's Environmental Research and Consultancy Department

EU ETS European Union Emissions Trading Scheme

FEGP Fixed Electrical Ground Power

IATA International Air Transport Association

ICAO International Civil Aviation Organisation

Net Co2 Emissions CO_2 emissions remaining once carbon trading has been accounted for

NM Nautical Mile

NO_2 Nitrogen Dioxide

NO_X Oxides of Nitrogen

PCA Pre-conditioned air

RNAV Area Navigation

RNP Required Navigation Performance

SA Sustainable Aviation

Appendix 1 SA Governance

SA's strategy and work programme are confirmed by its governing Council, made up of representatives of the member organisations. SA's terms of reference are to concentrate on issues that are most effectively addressed through cross-sector co-operation with most projects delivered by teams comprising airlines, airports, manufacturers and NATS. Additional information on signatories' own individual sustainability programmes is available from their websites.

SA Vision

SA's strategy was agreed in 2005, together with a vision and series of goals to achieve this. Since then we have regularly reviewed both the vision and goals to ensure they are still relevant and meet stakeholder expectations.

VISION: *The UK aviation industry, meeting the needs of society for air travel and transport, while removing or minimising any negative impacts on the local and global environment and maximising the contribution to the UK economy.*

To achieve this, SA brings together the UK aviation industry to develop practical and policy solutions for cleaner and quieter flying. It is the first initiative in the world to bring together airlines, aircraft and engine manufacturers, airports and air traffic managers as part of a formal strategy.

To achieve the long-term goals, priority areas of work are agreed with progress reported every two years. SA focuses its efforts on the issues that rely on joint work between the different parts of the aviation industry to improve performance.

SA engages regularly with policy-makers and opinion formers to communicate its work and to understand their priorities. We aim to be a trusted and credible source of information on environmental issues. The focus is on the UK; however, work takes place in a global context. UK aviation has a global reach and the aspiration is that SA plays a leading role globally in efforts to tackle the industry's environmental impacts.

SA Goals

SA's work programme is developed around seven strategic goals. In 2015 the decision was taken by the SA Council to change the wording of our climate change goal to better reflect the work of SA on this important topic. The wording of each SA goal is presented next, including the previous and new climate change goal.

Goal 1: Social and Economic
A competitive aviation industry making a positive contribution to the UK economy, and meeting the needs of society for air transport, whilst maintaining constructive relationships with stakeholders.

Goal 2: Climate Change
Previous Goal *- Aviation incorporated into a robust global policy framework that achieves stabilisation of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous man-made interference with the climate system.*

New Goal agreed in 2015 - To identify, create and develop opportunities to reduce UK aviation climate change emissions and enable sustainable growth.

Goal 3: Noise
Limit and, where possible, reduce the impact of aircraft noise.

Goal 4: Local Air Quality
Industry to play its full part in improving air quality around airports.

Goal 5: Surface Access
Industry playing its full part in an efficient, sustainable multi-modal UK transport system.

Goal 6: Natural Resources
Environmental footprint of UK aviation's ground-based non-aircraft activities contained through effective management and reduction measures.

Goal 7: Implementation
Full industry commitment to sustainable development and communicating fully the role of aviation in society in order to support a better understanding of its contributions.

SA Members and Signatories

From 2015 SA has chosen to differentiate between those organisations directly funding the work of SA, referred to as 'Members' and those that support SA in other ways, referred to as 'Signatories'.

SA Organisational Structure

Reporting to the governing SA Council are a range of technical and communication groups. These groups are tasked with delivering the SA work programme as set by the Council. A co-ordination group acts as a central facilitating group for the technical groups to ensure best practice is shared across the different groups and that timely progress is made in meeting the Council's work plan. The key work streams during 2014-2015 were:

- Climate change
- Noise
- Sustainable aviation fuels
- Operational improvements
- Communications
- Aircraft waste and recycling
- Socio-Economic
- Research

In addition, an Advisory Board (previously called the Stakeholder Panel) of recognised external sustainability experts provides rigorous challenge to the Council and to the work programme. The Advisory Panel meets both independently, and on a regular basis with the Council in order to track progress against the goals. Please see their comment at the beginning of this report

Appendix 2 – SA Member Case Studies

A range of case studies are collated in this appendix listed under topic specific areas.

CO_2 Case Studies

Aerospace Technology Improvements – New aircraft and aero engines

Airbus A350 XWB

The A350 XWB brings together the very latest in aerodynamics, design and advanced technologies to provide a 25 percent step-change in fuel efficiency.

Over 70 percent of the A350 XWB's weight-efficient airframe is made from advanced materials combining composites (53 percent), titanium and advanced aluminium alloys. The aircraft's innovative all-new Carbon Fibre Reinforced Plastic (CFRP) fuselage results in lower fuel burn as well as less maintenance.

The wings of the A350 XWB have been designed to adapt during the flight, morphing while airborne, changing their shape for maximum aerodynamic efficiency throughout the various phases of the flight.

Work on the engine started in 2005 when Rolls-Royce sat down with Airbus to look at how they could improve the performance of their new A350. Engine certification was achieved and first flight took place in 2013, with revenue flights of the Trent XWB powered A350XWB starting in January 2015.

While design for low fuel-burn and CO_2 emissions is essential, overall life-cycle cost focus has also been at the heart of all design activity, to deliver the right balance between fuel burn and life cycle costs, and ensuring high reliability and durability in all conditions. In grappling with the tough engineering challenges this presents, Rolls-Royce have incorporated the latest technology and materials, and used state of the art design tools and manufacturing processes.

Compressor blisk technology has enabled compression module weight savings of 15 per cent as well as aerodynamic efficiency improvements, while an optimised internal air system reduces cooling and sealing air demand which also reduces fuel burn. The engine has even higher operating temperatures to improve efficiency and reduce fuel burn, while the latest generation material technologies enable this improvement to be achieved without degrading reliability. The swept hollow titanium fan blades have exceptional levels of aerodynamic performance and low noise, while being extremely light and strong

Boeing 787 Dreamliner

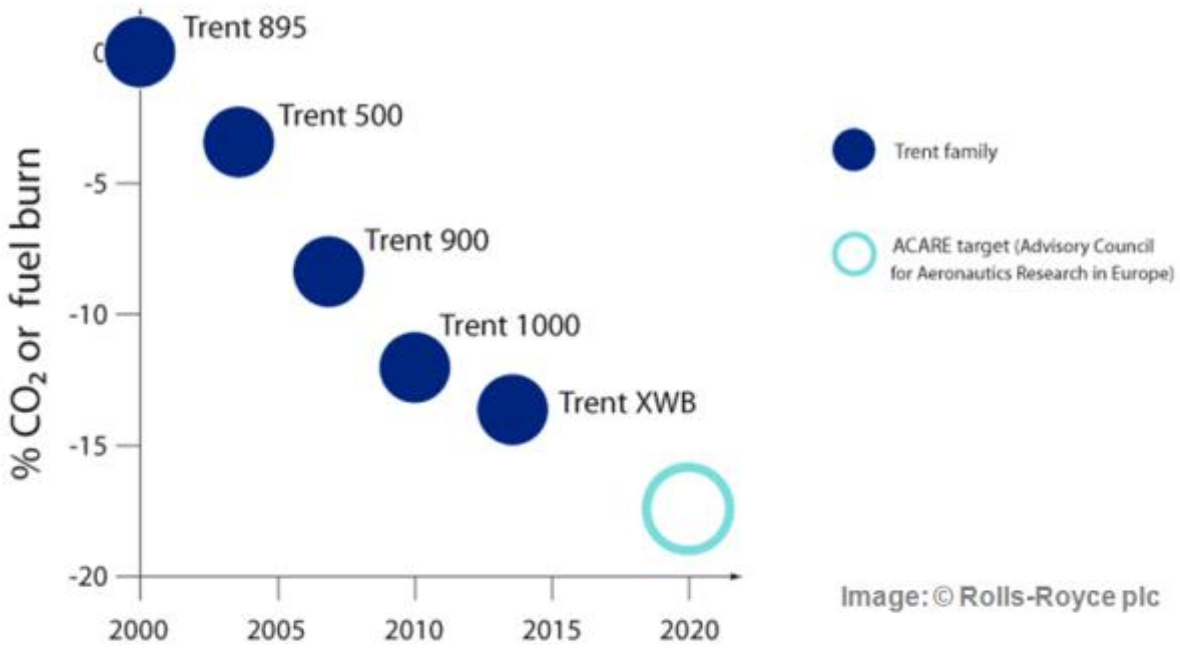
Boeing Commercial Airplanes' first rolled the 787-8 Dreamliner out in 2007. On a Dreamliner with Rolls-Royce engines, UK companies make 25 percent of the 787 by value. Airlines based in the UK (Thomson Airways, British Airways and Virgin Atlantic) have 73 Dreamliners on order. Deliveries began in May 2013 when Thomson Airways received their first 787-8.

New technologies and processes have been developed to help Boeing and its supplier partners achieve the efficiency gains. The aircraft makes substantial use of composite materials, 50% by aircraft weight. Use of these lightweight materials in the wing structure allows the 787 to have a higher aspect ratio and less overall parts. Additionally, manufacturing a one-piece fuselage section has eliminated 1,500 aluminium sheets and 40,000 - 50,000 fasteners. Finally, a clever fly by wire system also allows for the wing configuration to be automatically adjusted minimising fuel consumption.

The Roll-Royce Trent 1000 was the launch engine for the 787-8, which first entered service in October 2011. The Boeing 787 design introduced new challenges for the engine as all of the aircraft systems are run by electrical power. The engine has no aircraft bleed systems to provide cabin air pressurisation, but instead a high level of electrical power is extracted via 2 large generators on each engine. A new design of power offtake system handles this high level of power, but also helps to maintain high efficiency and low fuel burn at all flight conditions. The engine bypass ratio of 10 is the highest of any Trent engine, and helps increase the engine efficiency and reduce engine noise. In addition to the ongoing push to improve turbine and compressor efficiency and material temperature capability to help increase efficiency and reduce weight, new technologies such as compressor blisks, vortex amplifiers to modulate cooling air, and composite fancase dressings have been introduced. The specification of the engine has not stood still since EIS. New technology is still being introduced into the Trent 1000, and the latest version, the Trent 1000 TEN, will enter service in 2016.

The Trent 1000 TEN is 14% more efficient than the first generation Trent engine, and enables a Trent powered 787 to be 20% more fuel efficient than the 767 it replaces, as well as having noise **output** and emissions margins that exceed all current requirements.

CO_2 Reductions from Trent Engine Evolution



E-Thrust – Distributed Electrical Aerospace Propulsion

Airbus Group Innovations and Rolls-Royce, with Cranfield University as a partner, are jointly engaged in the Distributed Electrical Aerospace Propulsion (DEAP) project, which is co-funded by InnovateUK (an executive non-departmental public body, sponsored by the Department for Business, Innovation & Skills). The DEAP project researches key innovative technologies that will enable improved fuel economy and reduced exhaust gas and noise emissions for future aircraft designs by incorporating a Distributed Propulsion (DP) system architecture.

Compared to engines on existing commercial airliners, such a system will require a much higher level of integration with the airframe design than that of today's aircraft.

The DEAP project aims to deliver a preferred electrical DP system for future aircraft that may provide a breakthrough and a significant contribution to mitigating the environmental impact of the projected increase of air traffic. Rolls-Royce will develop an optimum electrical system propulsion plant, taking into consideration speed range, max speed, number of fan motors, efficiency, etc.; while Airbus Group Innovations will design the electrical system and work with Airbus to optimise the integration of the propulsion system in the airframe.

Advance and Ultra Fan ™

Advance evolves the Trent XWB core architecture for further efficiency benefits and future growth of pressure ratio, as well as applying lightweight fan system technologies. The new core architecture results in higher efficiency, delivering an overall pressure ratio of more than 60:1 – the highest ever in a commercial turbofan. Further benefits include fewer parts and lower weight.

A new lightweight Low Pressure (LP) system includes advanced lightweight alloys in the LP Turbine and our new CTi (Carbon and Titanium) Fan System. This will deliver improved propulsive efficiency and a weight saving of 1,500lb on a twin engine aircraft (equivalent to approximately seven or eight passengers travelling "weight free").

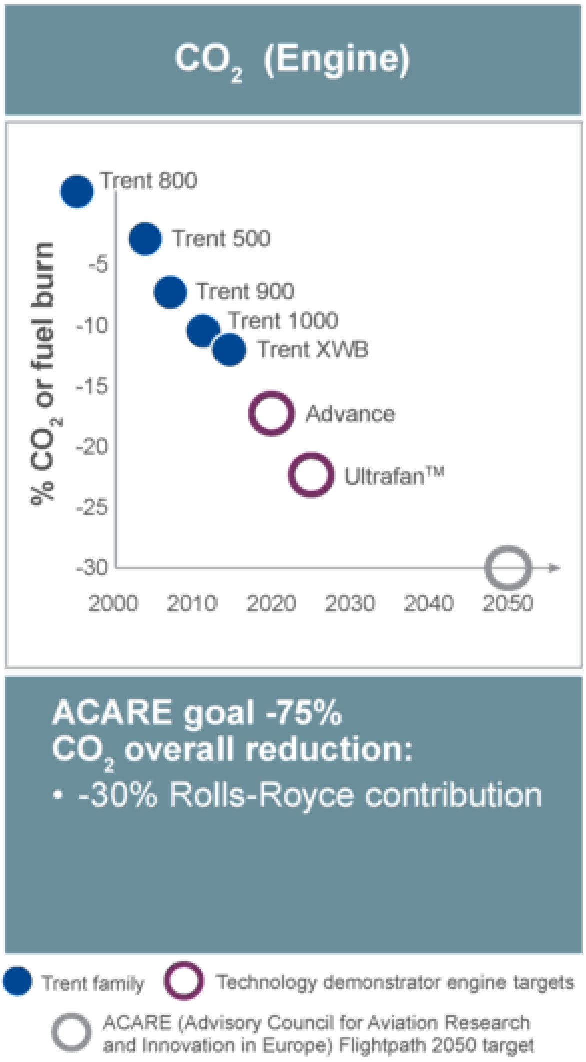
UltraFan™ will utilise the new Advance core architecture enhanced with further technologies and broader application of advanced high temperature materials to push the core overall pressure ratio to more than 70:1. A new geared architecture is employed at a turning point in architecture where engine bypass ratio (ratio of the fan flow to the core flow) exceeds 15:1. A lightweight variable pitch CTi fan system will permit deletion of the thrust reverser, enabling a truly slim-line nacelle system.

The first Advance demonstrator engine is due be tested in late-2016. The CTi fan system in-flight testing has been successfully completed with component rig and full engine/ testing continuing this year. We have since announced the High Temperature 3 demonstrator which will use a Trent XWB to demonstrate high temperature turbine technologies such as Ceramic Matrix Composites. We have already tested the largest 3D printed aero-engine component to date which has recently flown on the Trent XWB-97.

Construction of the Power Gearbox rig for UltraFan™ is underway in Germany and testing will start early 2016.

Rolls-Royce's next generation Advance and UltraFan[TM] engines will deliver an efficiency improvement of at least 20% and 25% respectively relative to the first generation Trent engines. This could equate to relative fuel savings worth around 20,000 tonnes CO_2 per aircraft per year.

The opportunity for reducing CO2 emissions compared to current and historic Rolls-Royce Trent aero engines is shown below.



Airline CO2 reduction work – New Aircraft and Fuel Efficiency work

As of 2014 easyJet's carbon emissions were 82.03g per passenger kilometre. This has been delivered through a young and efficient aircraft fleet which is operated with a high load factor and only direct, short haul routes.

We are investing in 100 new generation A320neo aircraft, entering the fleet from 2017, which are 13% to 15% more fuel efficient than the existing fleet.

easyJet has set targets to further reduce CO_2 g/km per passenger, by 2.5% by 2017 and by 5% by 2022. These are driven largely by the introduction of the new, larger aircraft and assume a similar sector length and route network as today.

Boeing 787 Dreamliner and 737

TUI Group are the only integrated tour operator to fly the Boeing 787 Dreamliner, which emits around 20% less CO_2 per passenger kilometre than comparable aircraft. It also produces considerably less noise pollution – more than 60% less than those of the airplanes it replaces.

TUI airlines were the launch customers for the Dreamliner in the UK, Belgium and the Netherlands.

In the UK we operate eight 787 Dreamliner planes, and this will expand up to 17 aircraft by 2019. We carried one million long-haul passengers on the Dreamliner in 2014 and receive exceptional feedback from our customers on their experience.

TUI airlines 1st airline in Europe to use the innovative split scimitar winglets on our Boeing 737 aircraft, reducing fuel burn by up to an additional 2%

Fuel efficiency programme

British Airways' comprehensive fuel efficiency programme encompasses both flying and ground activities. This is managed by a dedicated fuel efficiency team within British Airways, which includes Flight Operations, Network Operations and Engineering. The IAG group shares best practice across the group companies through the creation of a Fuel Economy Guide and employees are encouraged to submit fuel saving ideas. Pilots have been issued with iPads with access to fuel management software. During 2014, BA's fuel efficiency team managed 16 projects delivering 35,000 tonnes of CO_2 reduction. Two specific examples are:

Wind optimisation: British Airways has this year introduced a new method of optimising the en-route winds on the wide body aircraft. Previously, the crew would climb according to the flight plan, which could be a few hours old and therefore the winds not accurate. The new method involves updating the Flight Management System (FMS) with winds prior to a climb. The FMS then provides information as to when the aircraft should climb to an optimal altitude. The advantage of this procedure is better accuracy of wind and temperature data coupled with the FMS knowing the aircraft actual weight at the time. Savings are in the region of 50-200kgs (150-600kg CO_2) of fuel per flight.

Airbus Sharklets: fitted to ten Airbus A320s and are nearly two-and-a-half metres tall and weigh about 90kgs each. The sharklets are designed to reduce turbulent air at the wing tip, thus reducing drag. The less drag you have, the less thrust you need from the engines. The sharklets have been producing good results with up to 4% fuel savings on the fuel burn for these aircraft.

easyJet has an ongoing programme that looks at how existing aircraft can be flown as efficiently as possible. This covers the following:

- Introducing lightweight Recaro seats that make each aircraft almost 600kg lighter, 26% reduction.
- Using Airbus ‘Sharklet’ wing tips which make the wing more aerodynamic. This technology delivers up to 4% savings in fuel consumption and consequent reductions in CO_2 emissions.
- Adopting a paperless cockpit philosophy. From May 2014 easyJet’s entire aircraft fleet is now fitted with Panasonic Toughpads which replaced laptops and printed navigational charts in all of its cockpits. This removes 27 kg of paper per aircraft per year, equating to around a 2 million kilogram reduction in CO_2 emissions.

- Using an acrylic exterior polish which aims to reduce fuel consumption by 1-2% by smoothing the aircraft's surface.
- Regularly washing the aircraft engine's compressors to ensure they operate as efficiently as possible.
- easyJet's Engineering and Maintenance teams have worked in collaboration with our Ground Handling partners in the use of fixed electrical ground power , which minimises the use of the aircraft Auxiliary Power Unit. The headline figures show a 15% reduction of APU hours per flight from 2008 to 2015.
- easyJet's pilots continue to implement and improve on fuel saving measures such as one engine taxiing, delayed engine starts and continuous descent approach.

TUI GROUP

In 2014, TUI airlines' CO_2 emissions were just 67.6g per revenue passenger kilometre – a reduction of 10.3% over the last six years. Over the past three years, Thomson Airways has improved its fuel and carbon efficiency by 7.4%. 97% of our aircraft are now fitted with fuel-saving blended winglets, reducing fuel burn by up to 5%.

Further initiatives carried out include:

- Reducing weight on our aircraft through lighter catering trolleys, lighter seats and optimising the amount of water and goods we carry on board
- Maintenance efficiencies such as engine wash programmes, lighter paint, and surface sealant applications that reduce drag on the aircraft by stopping dirt and grime adhering to it
- Implementation of an enhanced fuel monitoring and management system in four airlines

BRITISH AIRWAYS NATS

Cross Border Arrival Management Trial (XMAN)

This is a bespoke solution to reduce the amount of time aircraft spend in the airborne holding pattern when arrival delays are unavoidable. British Airways has worked closely with NATS and many other European Air Navigation Service Providers, (ANSP), to refine this process. XMAN works by slowing aircraft down en-route at approximately 350 nautical miles (nm) from destination. By doing so, the amount of time spent in a holding pattern is reduced en-route and this saves fuel. In 2014 British Airways saved approximately 2,200 tonnes of fuel using XMAN. In the near future, this horizon will be extended to 550nm saving even more fuel.

ecoDemonstrator

TUI Group partnered with Boeing for a phase of their ecoDemonstrator Programme, which aimed to accelerate the development and testing of environmental technologies to reduce noise and carbon emissions from commercial aviation.

As part of the project, TUI airline colleagues held dedicated workshops to come up with initiatives to test on the plane. New technologies tested included a wing coating that can protect the leading edge from insects sticking to it, thereby reducing drag on the aircraft. In partnership with NASA, the Boeing team also tested green diesel (a blend of jet fuel with green diesel made from material that included waste animal fats and used cooking oil).

The first test flight took off from Seattle in March 2015, and trials continued throughout the summer. The plane was dismantled and recycled in September using new methods to maximise the value of the materials for aerospace and other industries.

Operational Improvement work

TOPFLIGHT

Topflight is a collaborative project to test sustainable gate-to-gate transatlantic flight optimisation; NATS worked closely with a range of SA partners including Airbus ProSky, Boeing and British Airways, as well as other industry partners including NavCanada and Barco Orthogon. Together the partners have shown that significant savings could be made by implementing a suite of new procedures and technologies currently being worked on through SESAR[38].

The application of this concept showed a potential reduction of fuel and CO_2 emissions of up to 2% for each transatlantic flight, without detriment to other airspace users. That equates to approximately 800kg of fuel and 2,650kg of CO_2 savings *per transatlantic flight* – which translates into huge savings if we deliver it consistently across the operation. The TOPFLIGHT trial closed in May 2014 with learnings taken into other projects such as XMAN.

[38] The Single European Sky ATM Research programme (SESAR) brings together stakeholders from across the European aviation industry to help develop and deploy new technologies and procedures that can improve the performance of European air traffic management (ATM).

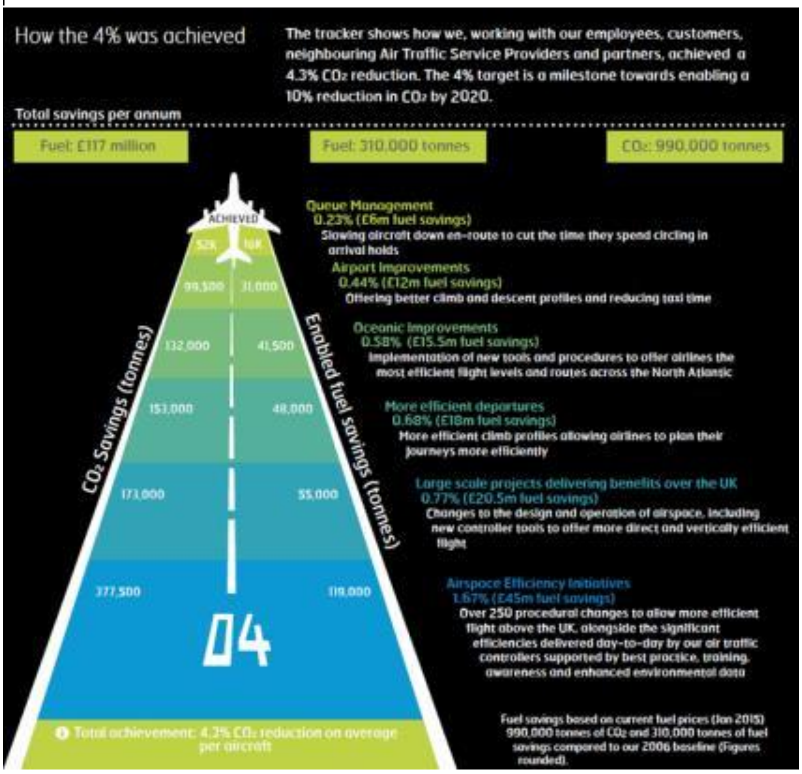
4% CO_2 reduction programme

NATS is targeting a 10% CO_2 reduction on average per aircraft in UK airspace by 2020 (against a 2006 baseline).

Over the four years to December 2014, NATS has enabled a 4.3% CO_2 reduction on average per flight, which equates to over £115 million in fuel savings for airline customers. The 300,000 tonnes of fuel savings (per year) that this programme has saved also equates to a reduction in aviation emissions of almost 1 million tonnes of CO_2 per year.

These savings have been achieved through a combination of creating more direct routes, improving vertical profiles and making changes on the ground at airports where NATS provide the control service. In all, NATS has delivered over 250 individual improvements.

Delivering on NATS commitment required enormous effort across the business and many changes to our operation including significant investment projects such as Oceanic airspace navigation improvements, numerous local initiatives to reshape UK airspace and working with military colleagues to improve the sharing of training and danger areas.



NATS 4% infographic shows how all of these contributions added up towards the total.

The plan set out by NATS back in 2008 was to reduce aviation fuel burn by 10% per flight by 2020. Achieving 4.3% by the end of 2014 puts NATS right on track to do that.

Optimum Flight Trial 2013/14

The Optimum Flight was about optimising regular flights to and from Lanzarote in the Canary Islands.

The largest efficiencies achieved in the Optimum Flight project were with cooperation from air traffic routings and flight management. The air navigation service providers were able to coordinate an efficient climb, cruise and constant descent along the most efficient flight routing, often against regular traffic flows. As a result there was an average of 2% reduction in block fuel burn per flight hour for the Optimum Flights and an average of a 16% decrease in track miles compared to that planned. This significant reduction was achieved by flying against the usual flow of traffic and short cutting regular air navigation routes. Optimum flights which achieved constant descent operations resulted in an average 18% reduction in fuel used over a typical descent into the same destination.

Sharing data with industry partner, Airbus Prosky (Canarias Project) also helped achieve a redesign of an approach to the southerly runway at Lanzarote Airport that was previously over high terrain posing a flight risk. This redesigned approach has been successfully trialled and is anticipated to be available to all airlines for use shortly.

The largest efficiencies identified by the Optimum Flight project were the potential savings if airspace could be more efficiently managed, giving either direct routings or better dynamically managing routings and permitting climbs and descents without intermediate level offs.

SA Fuel Case Studies

Sustainable fuels test programme

Rolls-Royce and British Airways jointly supported a study on the evaluation of novel sustainable alternative aviation fuels. The aim of the programme was to advance the scientific understanding of the performance of new fuels relative to kerosene and to other certified synthetic fuels for use in civil aircraft. The programme, announced in 2010, sought to identify practical alternatives to the current industry standard fuel kerosene (Jet A-1). The results have been shared with industry (and can be found at - http://www.rolls-royce.com/sustainability/performance/case-studies/alternative-fuels.aspx) with the ultimate aim of supporting the certification of an increasing range of sustainable fuels and ultimately reducing aviation's impact on the environment.

More than twenty fuel suppliers responded and nine suppliers were then invited to provide fuels for the initial laboratory-scale testing phase. Four alternative, sustainable fuels went through to the rig testing phase. The fuels were selected based on their technical novelty relative to currently certified fuels, and the prospect of significantly lower life-cycle greenhouse gas emissions relative to conventional kerosene. The rig-testing was carried out at Sheffield University – a Rolls-Royce University Technology Centre, and at Rolls-Royce testing facilities. The tests included emissions testing using an Auxiliary Power Unit donated by British Airways, and simulation of the aircraft system environment to evaluate the fuels' compatibility with current aircraft and engine systems.

The four fuels, provided by Applied Research Associates, Algaeon Inc with Swift Enterprises, Byogy Renewable Inc, and Shell Research Limited with Virent Energy Systems Inc, performed successfully during the rig-testing phase. Fifty per cent of the test programme was funded by the US FAA Continuous Lower Energy Emissions and Noise (CLEEN) programme.

Virgin Atlantic is partnering with LanzaTech, along with Boeing and other technical partners, to pioneer the first of the next generation of low carbon fuels. Their technology uses a microbe to convert waste carbon monoxide gases from steel mills (which would otherwise be flared off direct to the atmosphere as CO_2) into ethanol. The alcohol is then converted to aviation fuel. Analysis suggests that the sustainable fuel will emit 60% less carbon than the fossil fuel it will replace. Importantly, as the process uses a waste-stream, the sustainable fuel produced does not impact on land use or food production.

Two demonstration facilities are now being developed in China, taking advantage of China's large number of steel mills. The two demonstration facilities will have a combined capacity of 100,000 gallons of ethanol per year. The first plant in China will produce enough fuel for Virgin Atlantic to uplift all of its fuel out of Shanghai as a 50:50 mix with fossil fuel, with plenty left over for other customers. In

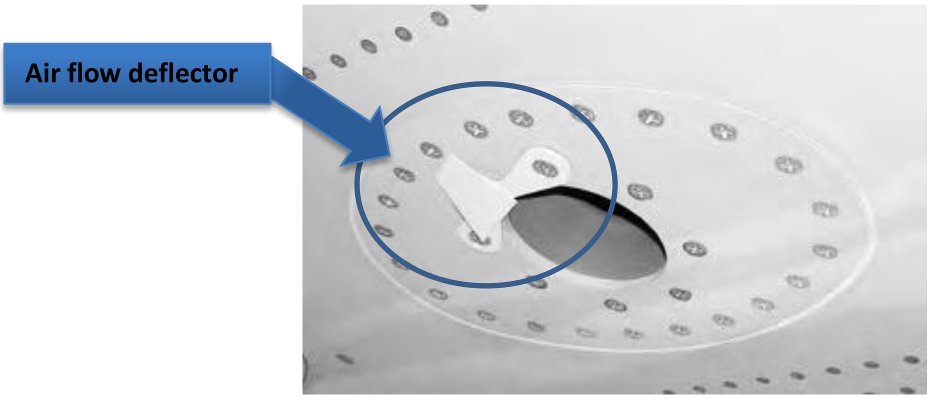
addition, LanzaTech estimates that its process could apply to 65% of the world's steel mills, offering the potential to provide up to 19% of the world's current aviation fuel demand.
The environmental benefits are clear and will take the airline well beyond its pledge of a 30% carbon reduction per passenger km by 2020. There are also considerable economic and employment benefits.

In 2011, working in partnership with SkyNRG, Birmingham Airport and Platinum Fuels, Thomson Airways were the first airline in the UK to undertake a fully commercial flight using sustainable fuels (Birmingham to Arrecife, Canary Islands). The purpose was to demonstrate that a market exists and to encourage investment, bringing forward the commercial scale up of biofuel.

Noise Case Studies

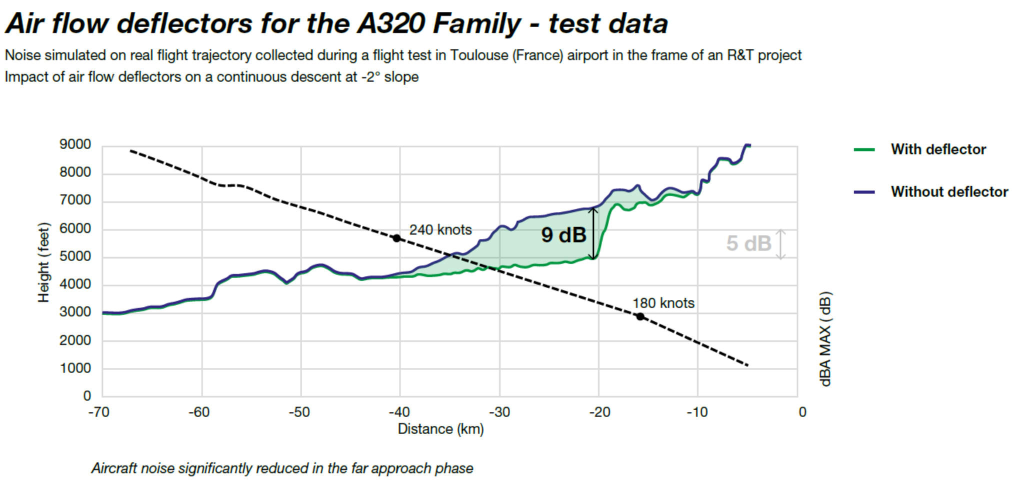
A320 Air flow deflectors case study

Airbus is building on the A320 Family's established reputation for quiet operations, reducing noise levels even further for its popular single-aisle product line with the introduction of small underwing air flow deflectors. Positioned just ahead of underwing cavities for the fuel over-pressure protection system, these devices prevent the cavities from generating a "whistling" sound which can sometimes be heard on the ground when the engines are at idle during final approach.



Picture of the Air Flow Deflector

Air flow deflectors were implemented in production A320 jetliners in the spring of 2014 and are also available as a retrofit modification. With certain conditions, speeds and heights up to 9dB reduction is possible.



Potential Noise reduction from A320 Family Air Flow Deflectors
Source: Airbus

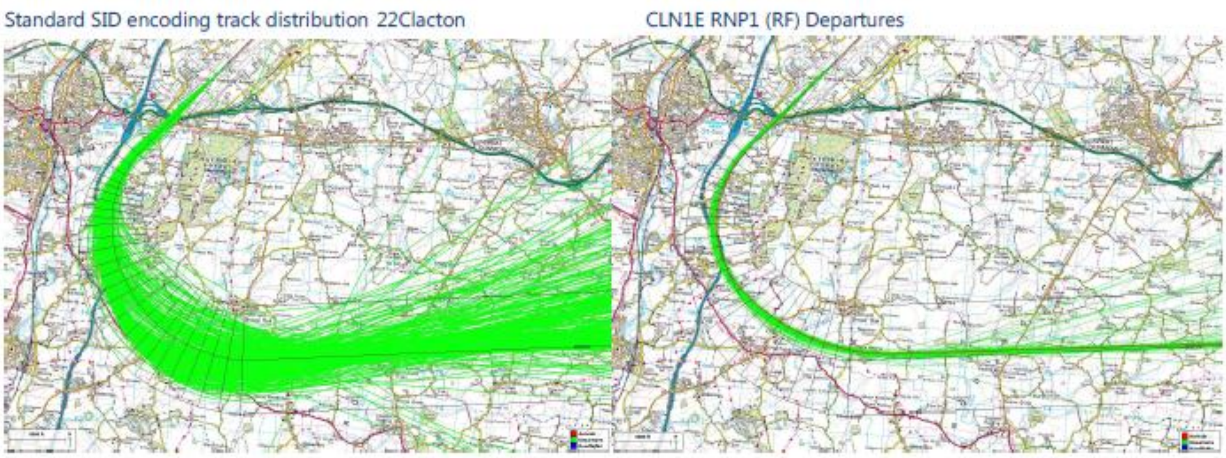
London Stansted Airport Performance Based Navigation Departure Trial

A partnership approach was taken, engaging a number of bodies in the trial. Those involved from the beginning of the trial period included the Civil Aviation Authority (CAA), Stansted Airport, the Environmental Sub-group of the Stansted Airport Consultative Committee, NATS and easyJet.

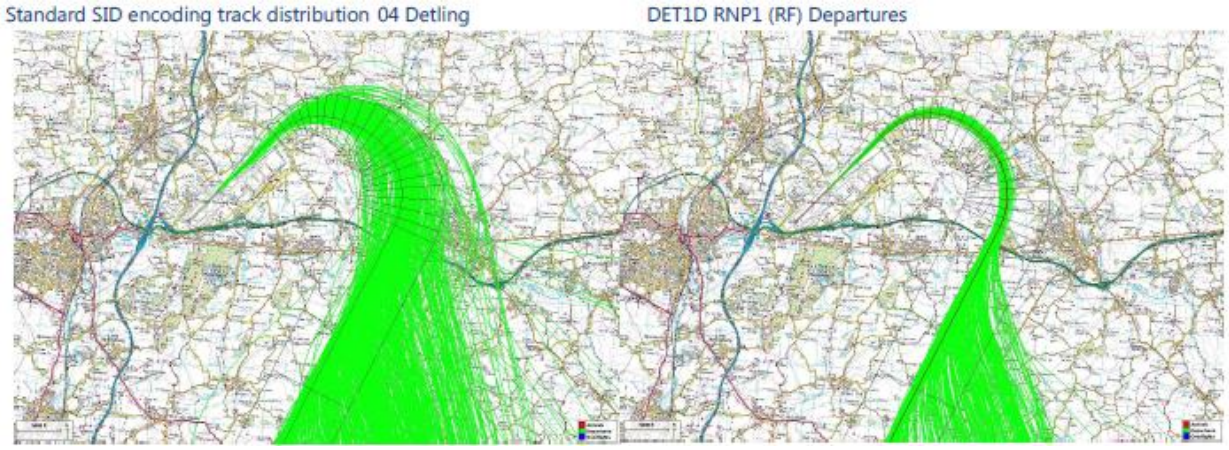
After 18 months of the trial, the results have shown a high degree of accuracy in terms of lateral track keeping when analysed against the performance based navigation (PBN) designed departure routes. Track keeping accuracy has been achieved with a wide range or aircraft types from a Gulfstream GV (SP) G550 to a Boeing 747-8F.

The utilisation of Radius to Fix (RF) turns in the design also better enable a PBN replication of existing Standard Instrument Departure routes (SIDs) that would not otherwise be achieved through RNAV1 or conventional non PBN SIDs. The speed control within the RNP1 (RF) designed SIDs is likely to have contributed significantly to track keeping accuracy.

Data from the trial suggests that the 22Clacton RNP1 (RF) SID non vectored track distribution at the end of the two RF turns is as low as 490m with a 99.7% certainty and 98.2% of aircraft within a 396m swathe, as shown in the images below.



The 04 Detling data suggests 99.8% of aircraft that have not been vectored would be within a swathe of 414m.



As RNP1 regulatory approval and adoption by airline operators grows, the PBN operating environment will be enhanced significantly through RNP1 with RF turns. The implementation of this technology should be encouraged to improve the safe operation of aircraft through increased navigational accuracy.

For an airport such as London Stansted, where it has been possible due to the relatively rural location to design NPRs that avoid overflying larger areas of population, the benefits that RNP1 through the RF capability will enable us to reduce still further the impact of aircraft noise. It can also significantly reduce the numbers of people currently overflown by reducing the width of the current NPRs and providing a high degree of certainty to the track keeping compliance of the designed SID.

For more details see http://www.stanstedairport.com/community/local-environmental-impacts/noise/

Early Morning Arrival and Departure Respite Trials

In 2014 a trial at Heathrow airport was designed to provide defined periods of noise respite to people living directly under the flight path. The concept was formed in partnership with the noise community group HACAN, British Airways, NATS and the airport itself. The trial was focused on the early morning arrival period when people living under the flight path are most affected by aircraft noise.

Following a six month arrivals trial, a trial focused on applying new 'offset' departure trial at Heathrow Airport was started. The trial kept aircraft within the existing departure routes called Noise Preferential Routes (NPRs) whilst flying 'offsets' from the existing centreline of the route. The Offset Standard Instrument Departure (SID) trial utilises modern aircraft precision navigation (RNAV) techniques to fly a precise track one kilometre from the centreline of the current SID which alternates from 'left' to 'right' on a weekly basis. This lateral 'side step' can potentially reduce concentrations of noise beneath existing departure routes, providing a form of predictive noise respite.

Feedback on the Heathrow predictive noise respite arrival trial was mixed, with some community groups perceiving benefits, whilst others felt the trial did not work for them. The trials serve the very important purpose of improving the industry understanding of what communities want from a noise mitigation perspective, based on the trial of ideas turned into reality. The trial was the first of its kind in the world, demonstrating real innovative action by the industry to tackle noise disturbance to communities and will contribute to improve our understanding of the issues around concentrated versus dispersed noise at and around airports.

Heathrow
Making every journey better

ARUP Sound Lab

In Heathrow Airport's conversations with local residents we have often heard that many struggle to relate their own experiences with the way we quantify noise, be it through the concepts of noise contours and 'average noise over a day.' Through this feedback, we have realised that any attempt to define and measure noise has limitations, and that we cannot fully capture the spectrum of personal experiences of noise on paper alone.

Whether we want to talk about our noise mitigation measures today, or in the future, with two runways or three, we know we need to do more to make the effects of our activities on noise known to local residents. We also understand that when it comes to noise, residents value independent and objective sources of communication.

Overall the SoundLab's aim is simple: to allow those who visit to decide what they think and feel about what they hear, and by providing information, eventually inform a dialogue between them and Heathrow. Then we can have better discussions about the choices available in terms of different operational procedures and mitigation options.

Heathrow worked with acoustic consulting engineers Arup in applying their state-of-the-art SoundLab technology to accurately reproduce three dimensional aircraft sound demonstrations in a laboratory setting, with a time aligned visual presentation.

Heathrow commenced dialogue with Arup in 2013 which lead to feasibility and pilot studies before scoping and development of full aircraft sound demonstrations throughout 2014. Two residential locations were selected for recording of three dimensional aircraft sound under arrivals: Hounslow and Richmond.

Heathrow commenced roll-out of the sound demonstrations in 2015 to representatives of local engagement groups such as Heathrow Airport Consultative Committee.

To provide assurance that the SoundLab demonstrations accurately represent aircraft noise, an independent peer review group of experts was established to oversee the methodology and assumptions. The peer review group produced a written statement of validation after completion of their work.

Heathrow is also looking to make the sound demonstrations available for academic research into respite noise management. SA members have participated in the demonstrations and provided helpful feedback to inform its development.

Noise Management Strategy

In 2013 we published our first Aircraft Noise Management Strategy (http://www.virgin-atlantic.com/content/dam/VAA/Documents/sustainabilitypdf/AircraftNoiseManagementStrategy.pdf). Through this document we are committed to:

a) reducing our noise impacts through aircraft investment – working collaboratively to ensure that we are flying the quietest fleet commercially possible,

b) adopting the latest operational techniques – working through SA to ensure that we are continuing to develop and implement new techniques,

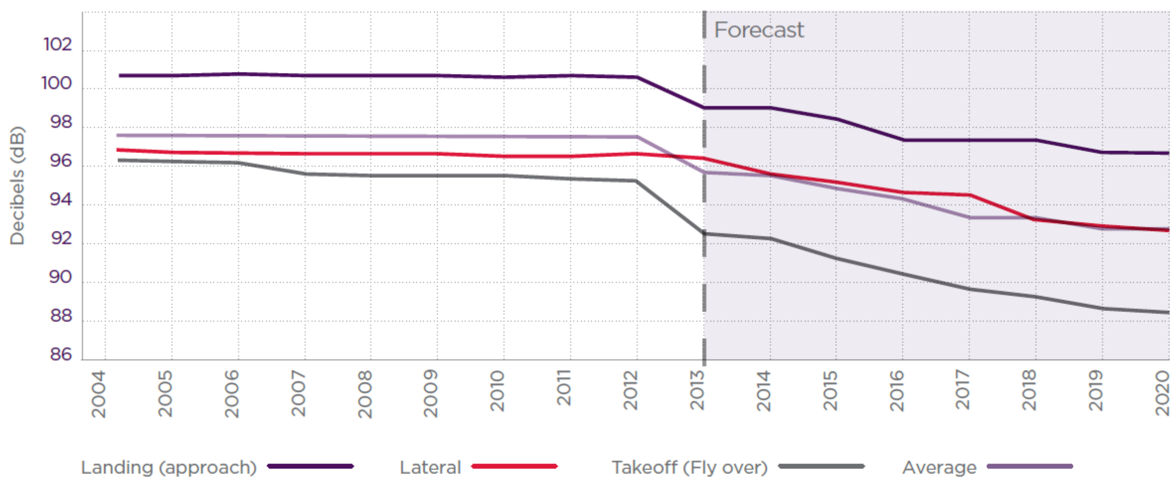
c) land-use planning – continuing to work with the airports from which we operate and through SA to ensure that we continue to mitigate noise for local communities surrounding airports,

d) operating restrictions – aim to minimise late running departures through our company wide focus on on-time performance, and

e) community engagement – developing our engagement with local communities impacted by our operations.

We have set clear absolute targets in terms of noise reduction, and are aiming to achieve a 6dB reduction on average per movement in noise output across our fleet by 2020.

VAA average noise per aircraft movement 2004–2020



Air Quality Case Studies

Reduced Engine Taxi Case Studies

In the last three years British Airways has increased the number of flights using reduced engine taxi out by over 54,000 and those that use reduced engine taxi in by over 35,000

British Airways, working with Airbus, has introduced single engine taxi as a normal procedure on the A320 family fleet. Pilots will start the taxi phase on one engine and then during the taxi out to the runway, start the second engine on the move, ready for take-off. This procedure can be used at all airports where long taxi times are common. At Heathrow, the uptake compliance is 80-85%, with an average saving of 7-8 minutes. This saves 4,100 tonnes of fuel per year at Heathrow alone.

Developing this work further with Airbus and Boeing, the airline has prioritised this approach across its entire airline fleets – long haul and short haul. Formal procedures are now detailed in the Flight Crew Operating Manual on all fleets requiring use of reduced engine taxi to be considered on all arrivals and departures where safe to do so. Improved recording in the use of this procedure shows that there were an additional 37,447 flights using reduced engine taxi after landing and 54,889 additional reduced engine taxis' for departure.

From January 2014 Flybe, working with their aircraft manufacturers, introduced new standard operating procedures promoting firstly single engine taxi in then single engine taxi out, (also known as delayed engine start).

The savings in terms of fuel and money for 10,000 flights a month are in the region of 100 tonnes of fuel, 10 kilogrammes per aircraft movement and £14 million fuel saving per annum.

Thomson Airways

Thomson Airways has introduced single engine taxi as a normal procedure in all UK airports. In 2015 a single taxi engine out trial started on the Boeing 737-800 fleet at London Gatwick Airport.

Heathrow Air Watch

The Heathrow Air Quality Working Group (HAQWG), commenced work in 2003, by the airport and local stakeholders to monitor and address air quality (principally NOx emissions and NO_2 concentrations in the Heathrow area.)

The Group's purpose is to continually improve the accuracy of air quality modelling around Heathrow, using a range of data sources from the airport, airlines and also ad-hoc monitoring exercises. The basis of the group was, and remains, transparent and accurate data sharing to continuously improve air quality modelling and monitoring. To that end, group participants agreed to share continuous air quality monitoring data, which is published 24/7/365 on the Heathrow Airwatch website, funded by the airport.

The exercise has had a very positive effect on relationships between the six members of the stakeholder group – the Heathrow Airwatch website has proved that it is possible to work together to create something that all groups benefit from and has played a part in increasing knowledge in the local, national and international arena with regard to airport air quality modelling, monitoring and assessment.

The full range of data, charts and report are available online at the Heathrow Airwatch website is available at the link http://www.heathrowairwatch.org.uk/

Collaboration has also contributed to the steady decline in NO_2 concentrations in the Heathrow area over the past 20 years and to support Heathrow in achieving a 16% reduction in NOx emissions from the airport 2008/9 – 2013.

Surface Access Case Studies

Bristol Bus Flyer Service

Bristol Airport is located eight miles from the city centre of Bristol in the North Somerset countryside. The area is predominantly rural, and public transport to the villages and small, scattered hamlets surrounding the Airport is poor.

Over the last decade and a half, Bristol Airport has developed a highly successful express bus service between the Airport and Bristol city centre which is now used by 14 per cent of passengers. This service, known as the Flyer, operates around the clock and runs as frequently as every eight minutes during peak periods. In 2014 over 770,000 passengers travelled on the Flyer service.

However, the pricing of the Flyer service - although offering a competitive alternative to the car for passengers flying to and from the Airport - was prohibitive for local people wanting to make use of the service for commuting or social and leisure visits to Bristol.

As part of a comprehensive package of measures accompanying the planning application for future development of Bristol Airport, it was agreed with the local planning authority to put in place concessionary fare scheme for local residents, following extensive local consultation over a period of several years.

The concessionary fare scheme was designed based on postcode areas, with the intention to benefit as many local residents as possible while targeting households close enough to be likely to make use of the Flyer service. Anyone living in the postcode areas described can apply for a discount pass by completing an application form which can be downloaded from the Bristol Airport web site. The pass must then be presented along with photo ID when buying a ticket.

Natural Resources Case Studies

Sorting out Heathrow's waste- a closed loop approach

Heathrow manages around 28,000 tonnes of waste each year, of which nearly half (46%) is recycled. To help the airport understand how much they can recycle, they investigated what is in their bins.

The project analysed over 100 tonnes of waste contained in general waste and mixed recycling compactors from seven different parts of the airport, including Terminals 1, 3, 4, 5, Engineering and waste taken from aircraft. The aim was to generate a credible set of waste data, understand how different parts of the business operate and lead the aviation sector in the recycling of Aircraft Cabin Waste (ACW), which is closely regulated by DEFRA.

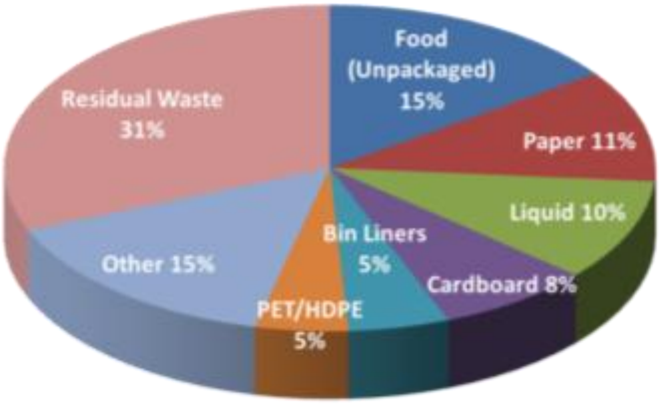
The work was carried out from April to July 2013. They worked with the Environment Agency to approve the use of the facility used to analyse the waste. The facility was run six days per week, with the seventh day used for maintenance and cleaning. The project extended from its original remit of terminal waste to include ACW from Heathrow's key airline stakeholders, including both home carriers (British Airways and Virgin Atlantic).

Working with Closed Loop Environmental Solutions UK Limited and using specialist equipment, the mobile Material Recovery Facility (MRF) they sorted one tonne of waste per hour; recovering up to 10 different waste streams, from plastic bottles and glass to paper and mixed plastics.

They worked closely with DEFRA, who made regular site inspections to ensure strict standards of cleanliness were being met when dealing with aircraft waste in particular.

Aircraft Cabin Waste (ACW) has been traditionally difficult to recycle due to EU Animal-by Product Regulations which require strict management and disposal of this waste by incineration or deep landfill. Through engaging with DEFRA Heathrow was able to include ACW in the study to better understand this waste stream and inform our future infrastructure investment.

The data generated by the study has showed that Heathrow can potentially double its recycling rate based on the make-up of our waste stream by improving capture methods.



Changes are now being implemented at Heathrow to leverage this recycling potential, including specification of material inputs (packaging etc.) used at the airport through the Responsible Procurement requirements in supply chain contracts. The airport is also planning investment in additional airside recycling segregation facilities to increase the recycling rate and engaging closely with their retailers, tenants and airlines to develop a "recycle to save" incentive, which would result in a 'win-win' scenario of further environmental and financial benefits to all by reducing the requirement for incineration.

The study identified a significant cultural change is required in how the airport companies treat end of use products. This will involve engaging with staff, tenants, contractors and other stakeholders as part of an on-going educational and support work stream. For retailers and restaurants, the airport is also working with the Sustainable Restaurant Association to develop a best practice guide for Heathrow, which includes guidance on increasing recycling rates. This work also formed the cornerstone to the airports new Recycling Resource Strategy 2015 – 2020.

GLASGOW AIRPORT
PROUD TO SERVE SCOTLAND

Green savings take flight at Glasgow Airport

Glasgow Airport's recycling rate has soared to over 90 percent since it made the Resource Efficiency Pledge and it is now encouraging businesses on its campus to follow suit by boosting their green credentials.

The Resource Efficiency Pledge is a programme of Zero Waste Scotland which asks businesses to commit to reducing their impact on the environment by making better use of energy, water and raw materials.

Since taking the pledge, Glasgow Airport has introduced a new terminal recycling system, with double bins which separate general waste from recycling. This new system, together with targeted staff awareness training, has not only increased recycling levels but also reduced contamination of recycling bins across the campus, saving the airport over £8,000 per year.

The airport has also introduced a number of new energy efficiency measures including improvements to air conditioning systems, and the incorporation of new LED lighting which has resulted in more than 730 tonnes of annual carbon savings.

Implementation Case Studies

YOUR LONDON AIRPORT Gatwick

Gatwick's Decade of Change

As the world's busiest single runway airport, we are fully committed to operating and developing Gatwick Airport in a sustainable way. In 2010 we out our vision for making Gatwick more sustainable, the 'Decade of Change.'

Now five years into the scheme, and at the halfway mark, Gatwick has already made significant progress towards meeting our targets. This has been against the backdrop of significant year on year growth of over 5% in passenger numbers, with figures expecting to reach 40million passengers this year.

Our progress can be measured across a number of areas including energy usage, water consumption, transport mode shares and air quality.

Energy

Our target for 2020 was for a 20% reduction on 1990 base consumption (240 million kWhs). Already, based on our figures from 2014, we have achieved at 16.7% reduction and we are very confident that we will meet our 2020 target within the next few years. Gatwick has taken an innovative approach to energy reduction, for example in 2012 the airport started using LED lighting technology on our runway, reducing energy use on the airfield by 50%.

Water

We have also made significant strides in reducing our water consumption. We set ourselves an ambitious 20% reduction target by 2020, which we have already met and surpassed. Our 2014 figures show that we have reduced our water consumption by 31.5% already. In 2014 alone our water consumption fell by 6.5% from the prior year. This is due to Gatwick continuing to take a proactive approach to repairing water leaks and also to the significant water main repair undertaken at North Terminal in autumn 2013 which reduced water usage in the North Terminal campus by 30%.

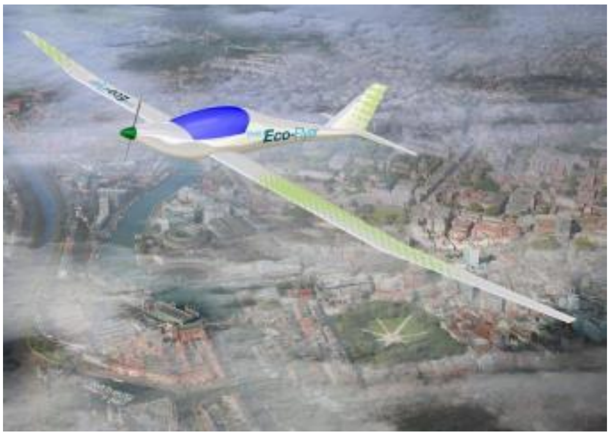
Transport

Increasing our public transport mode share is also incredibly important to the sustainable running of the airport. Our target was to reach a 40% public transport mode share for passengers and staff by the time the airport reaches 40million passengers per annum. Already in 2014, with 38million passengers using the airport, we have achieved a 43% public transport mode share. The addition of platform 7 at the rail station, opened in 2014, has allowed an increase in services passing through Gatwick Airport which in turn has helped improve the rail modal share. Gatwick Airport remains on target to achieve over 40% of air passengers and staff using public transport when the airport reaches 40 million passengers per annum.

Air Quality

Air Quality is also a vital component to Gatwick Airport's sustainability we continue to take our impacts on air quality very seriously and maintain our strong relationship with the Local Authority to continually manage and reduce these impacts where we can. We continue to work with our partners in SA and the industry to identify operational improvements that will reduce aircraft fuel burn and so improve local air quality. Since 2010 the air quality (NO_2) around the airport has improved from 37 micrograms per cubic metre to 31 micrograms per cubic metre in 2014. Gatwick has never breached our annual air quality limits and we will continue to maintain these standards into the future

AIRBUS



Eco Flyer

The Bristol Eco-Flyer is an Airbus graduate and apprentice project to design and manufacture a light, two-seater general aviation aircraft.

This two-seater electric aircraft, using the latest aviation technology will fly in the skies over the city producing zero carbon emissions. The full aircraft eco-lifecycle – design, production, use and end-of-life – will influence every decision in the project. The project brings together skills and tools normally used for large passenger aircraft design at the Airbus facility in Filton to push to boundaries of next generation, eco-efficient, light aircraft design.

The project was launched in 2015 to coincide with the year of Bristol European Green Capital and is a technology demonstrator to inspire ideas and debate on the future of aviation in the city during this year, but also go beyond Bristol and beyond 2015 to inform electric aircraft design and build capabilities for the future.

The choice materials used to build this aircraft are based on trade off decisions considering the aviation regulatory standards required and the full eco-lifecycle. Factors that influence these decisions include source of materials, energy required and minimisation of waste during production, maintenance during use, and disposal at the end of life. For example, the truss structure of the fuselage will be held together by 3D printed titanium nodes, a process which produces complex one off parts without the need to create a jig and with no material waste. Lithium polymer batteries have been chosen for their high power to weight ratio. Room temperature carbon fibre resin curing is being investigated as well as use of natural fibres in place of carbon for non-load bearing sections.

Parallel hybrid-electric propulsion system

Researchers from the University of Cambridge, in association with Boeing, have successfully tested the first aircraft to be powered by a parallel hybrid-electric propulsion system, where an electric motor and petrol engine work together to drive the propeller. The demonstrator aircraft uses up to 30% less fuel than a comparable plane with a petrol-only engine. The aircraft is also able to recharge its batteries in flight, the first time this has been achieved.

The demonstrator is based on a commercially-available single-seat aircraft, and its hybrid engine was designed and built by engineers at Cambridge with Boeing funding support.

The aircraft uses a combination of a 4-stroke piston engine and an electric motor / generator, coupled through the same drive pulley to spin the propeller. During take-off and climb, when maximum power is required, the engine and motor work together to power the plane, but once cruising height is reached, the electric motor can be switched into generator mode to recharge the batteries or used in motor assist mode to minimise fuel consumption. The same principle is at work in a hybrid car.

Rolls-Royce

Progress in engine noise reduction

Considerable reduction in aircraft noise sources continues to be delivered from significant ongoing investment by aircraft and engine manufacturers. This has led to the introduction of new aircraft types which are significantly quieter than their predecessors, including the Airbus A380, Boeing 787 and Airbus A350.

Modern engines, such as the Rolls-Royce Trent family, have progressively introduced advanced design features on all of the main engine components for noise reduction. Over the last 10 years, a rapid growth in computing power has been applied to model the aerodynamic processes that give rise to noise generation, and to give new insights on efficient means of noise control. These efforts have resulted in good progress against industry's Flightpath 2050 targets, for example the cumulative margin against ICAO Chapter 3 limits (for 3 flight conditions) has increased by 8dB in the 10 year period between the introduction of the Trent 500 and the Trent 1000 engines.

Manufacturers will continue to work together during product development to ensure that the most efficient noise design for the aircraft and engine in combination is produced. In addition, there is extensive international collaboration on noise research between industrial, research and university partners, to develop new understanding and to continue to work towards the challenging Flightpath 2050 targets.

www.sustainableaviation.co.uk
020 7799 3171
info@sustainableaviation.co.uk

SUSTAINABLE AVIATION
Cleaner. Quieter. Smarter.