# Climate Change Adaptation and Resilience Progress Report

## July 2016

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Heathrow
Making every journey better

# Contents

## Glossary

| | | |
|---|---|---|
| AOA | | Airport Operators Association |
| APOC | | Airport Operations Centre |
| AR5 | | IPCC Fifth Assessment Report |
| ARP | | Adaptation Reporting Power |
| ASQ | | Airport Service Quality – a quarterly global benchmark |
| ATM | | Air Traffic Movement |
| CAA | | Civil Aviation Authority, economic regulator of airports in the UK |
| CCAR | | Climate Change Adaptation Report |
| CCRA | | Climate Change Risk Assessment |
| CMIP5 | | Coupled Model Intercomparison Project Phase 5 |
| H++ | | High end climate change scenarios for heatwaves, low rainfall, low flows, high rainfall, high flows and windstorms. These scenarios are typically beyond the 10$^{th}$ to 90$^{th}$ percentage range of the UKCP09 and CMIP5 projections |
| H7 | | Heathrow 7 – Heathrow five year business planning period 2019-2023 |
| HAOSB | | Heathrow Airport Operations Stakeholder Board |
| Heathrow | | Heathrow Airport Ltd - the company that operates Heathrow Airport |
| Heathrow Airport | | The geographical place of Heathrow, which Heathrow Airport Ltd has the licence to operate |
| HRP | | Heathrow Resilience Programme |
| IPCC | | Intergovernmental Panel for Climate Change |
| UKCP09 | | United Kingdom Climate Projections 2009 |
| UKCP18 | | United Kingdom Climate Projections 2018 |
| Q6 | | Quinquennium 6 - Heathrow five year business planning period April 2014 to December 2018 |
| L-- | | High end scenario specifically for cold snaps, it represents the opposite end of the scale to extreme warm summer temperature in H++. A similar methodology and conceptual framing as for H++ was used to derive L --. |
| SA | | Sustainable Aviation |

# 1. Executive summary

Heathrow published its first Climate Change Adaptation Report and Risk Assessment in May 2011. The report was produced in response to the direction to report, issued to Heathrow by the UK Department for Environment, Food and Rural Affairs (DEFRA) under the auspices of the Climate Change Act 2008. This progress report has been produced under the second round of voluntary reporting under the Adaptation Reporting Power (ARP). It explains how Heathrow has implemented the actions set out in the 2011 report.

Heathrow is committed to regularly reviewing progress in climate change science, and the risks and opportunities that climate change poses to the operation of Heathrow. This review process will be carried out to coincide with Heathrow's economic regulatory and business planning periods. The most recent comprehensive review of the climate change risk assessment has taken place during 2016. The outcomes of which are feeding into the development of the business plan for the next regulatory period.

This approach aligns with key decision points around Heathrow's investment plans and prepares Heathrow for any future response that may be required by Government. The review cycle will also ensure that Heathrow's approach to climate change adaptation and resilience remains dynamic, responsive and appropriate by ensuring that it reflects latest scientific knowledge on climate change and critical thresholds.

Our commitment to managing climate change adaptation and resilience is stated in our Environment and Energy Policy, and is an important part of helping us to achieve our ambition to be the most environmentally responsible hub airport in the world.

***"Work with our airport partners to ensure that the airport plays its role in respecting environmental limits, and adapting to the effects of a changing climate. "***

Our specific commitment is:

***"90% of our actions in the climate change adaptation risk matrix on track or complete annually."***

The climate change adaptation risk matrix is introduced in Section 3 of this report. Table 1 in section 3.3 gives a summary of our performance against this commitment which shows that for the 34 risks, the 5 actions identified in 2011 are on track. Section 5 outlines the actions we have undertaken since 2011 to address these risks. Section 3.5 outlines our approach to resilience and section 3.6 describes our capacity constraints and how we are addressing these.

In preparation of this progress report, we commissioned Arup to carry out a review of progress in climate change science, data and information published since 2011. The overall conclusion is that the climate change data and information used in the 2011 risk assessment remains valid. Additional and new climate change projections for extreme weather events and mean climate conditions have been included in this report. These are summarised in section 4 and the full report from Arup is provided in appendix 2.

Section 4 and 5 of this report contain six case studies which demonstrate some of the innovative ways we are building our resilience to extreme weather at Heathrow.

Finally, we conclude with next steps that we will take to continue to address climate change impacts on our operational resilience. These are:

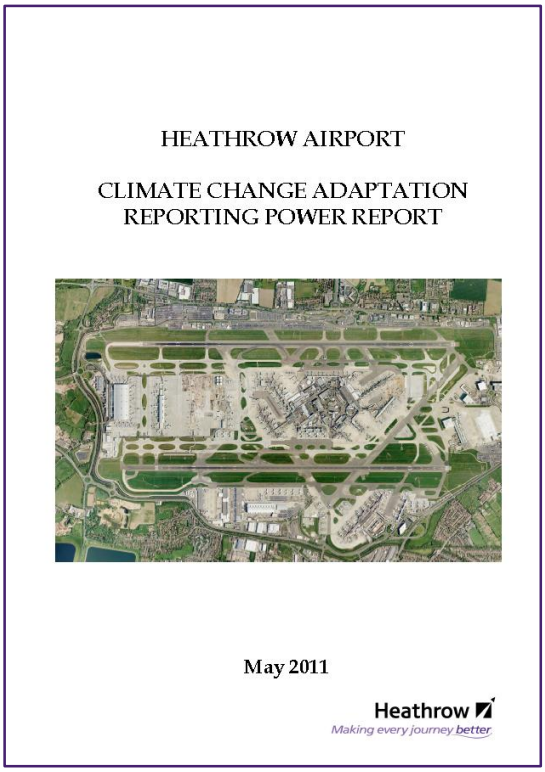
- Continue to review Heathrow's climate change adaptation risk register on a regular basis, monitoring progress against actions, assessing risk status and identifying new risks posed by climate change
- Continue to review and where necessary improve our operational controls to manage the impact of the changing climate on our business resilience
- Continue to incorporate further improvements in climate change adaptation and resilience into our future business plans
- Regular review of progress in climate change science and new information, updating our risk register and operational controls where necessary. In particular reviewing the UK's new set of climate change projections when they are published in 2018 (UKCP18)
- Continue to play an active role in climate change adaptation forums through attendance at:
    - London Climate Change Partnership
    - Environment Agency's Infrastructure Operators Adaptation Forum
- Work with the aviation industry to share learning on climate change adaptation and resilience

## 2. Introduction

**Climate Change Adaptation Reporting Power Report 2011**

Heathrow published its first Climate Change Adaptation Report and Risk Assessment in May 2011. The report was produced in response to the direction to report, issued to Heathrow by the UK Department for Environment, Food and Rural Affairs (DEFRA) under the auspices of the Climate Change Act 2008.

The Government published the first National Adaptation Plan (NAP) in 2013. It includes a specific action for organisations that produced adaptation reports to implement the actions set out in their reports. This is to help meet Objective 7 of the NAP: *To ensure infrastructure is located, planned, designed and maintained to be resilient to climate change, including increasingly extreme weather events.*




**2016 Progress Report**

This progress report has been produced under the second round of voluntary reporting under the Adaptation Reporting Power (ARP). It explains how Heathrow has implemented the actions set out in the 2011 report.

Heathrow is committed to regularly reviewing progress in climate change science and the risks and opportunities that climate change poses to the operation of Heathrow. As stated in Section 11 of our first ARP report, this review process will be carried out to coincide with Heathrow's economic regulatory and business planning periods.

The most recent comprehensive review of the climate change risk assessment has taken place during 2016. The outcomes of which are feeding into the development of the business plan for our next regulatory period.

This approach aligns with key decision points around Heathrow's investment plans and prepares Heathrow for any future response that may be required by Government. The review cycle proposed will also ensure that Heathrow's climate change adaptation and resilience strategy remains dynamic, responsive and appropriate by ensuring that it reflects latest scientific knowledge on climate change and critical thresholds.

**2014 transport resilience review**

Heathrow responded to the Department for Transport's resilience review in 2014, which provided an update on progress with a number of actions included in the 2011 climate change risk assessment. The response is included in Appendix 1.

# 3. About Heathrow

## 3.1 Heathrow

Heathrow is the UK's only hub airport. It is a 1,227 hectare site in West London, with two runways and four operational terminals. 75 million passengers travelled through Heathrow in 2015, using 80 airlines to connect to 183 destinations in 81 countries. Around 66% of international air freight volume (over 25% of the UK's total trade by value) flying into the UK comes through Heathrow.

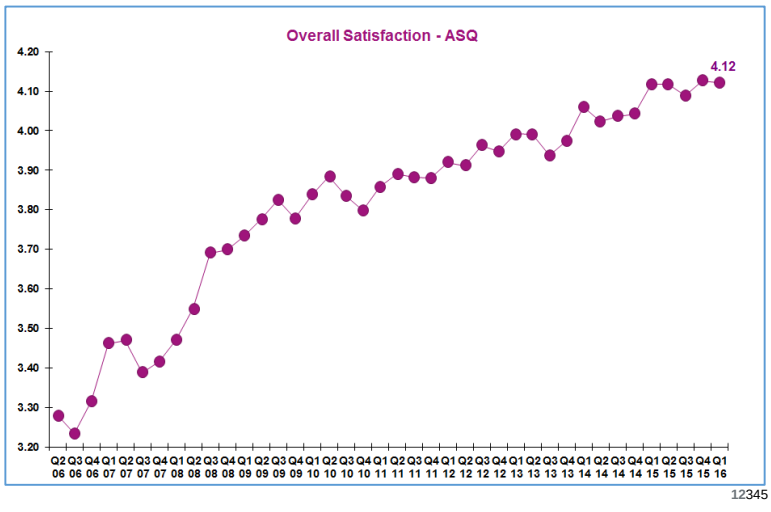
## 3.2 Heathrow's vision

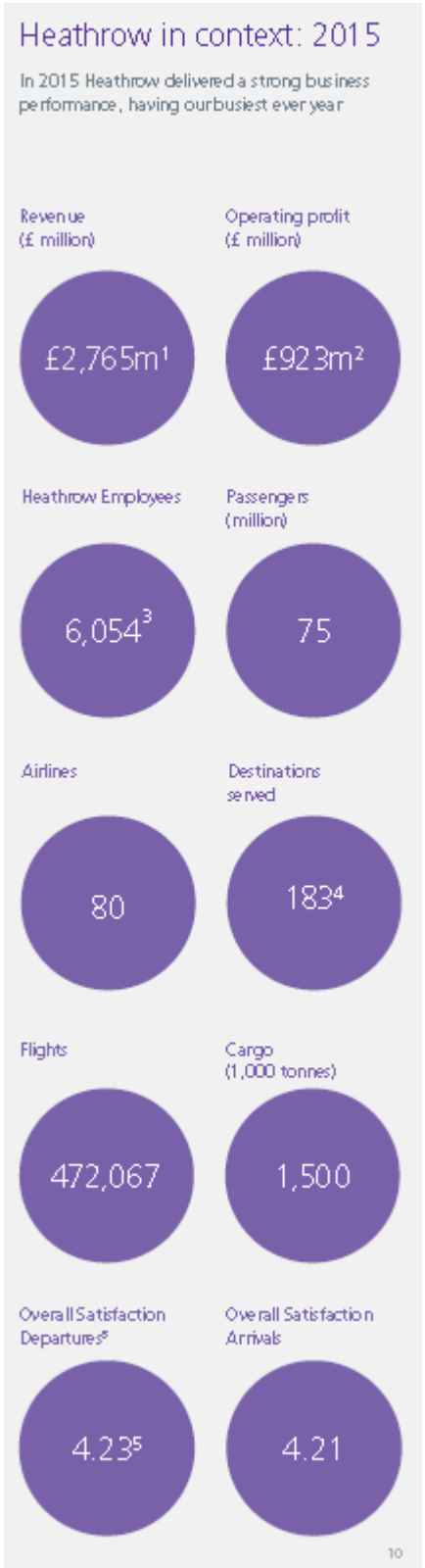
Heathrow's corporate vision is:

***"To give passengers the best airport service in the world."***

We use a quarterly global benchmark called Airport Service Quality (ASQ) to measure passenger satisfaction. Heathrow's service has improved significantly over the last few years (see chart below) and we continue to focus on improving service to our passengers to achieve our vision.

### Heathrow's Airport Service Quality (ASQ) Overall Satisfaction Trend




[1] Source: Heathrow Airport Limited (HAL) audited annual accounts
[2] Earnings before interest, taxes, depreciation and amortization
[3] Figure for Heathrow payroll as at 31 December 2015 and does not include HEX (473)
[4] Includes routes that are operated at least 52 times per year
[5] Heathrow undertakes research into passenger's experience at Heathrow using a Quality Service Monitor (QSM) survey. Around 37,000 passengers participate in the survey each year, which rates specific elements relating to the departure and arrival experience. The rating is based on a scale with 1 = very poor, 5 = excellent

## 3.3 Sustainability

Achieving our vision to give passengers the best airport service in the world relies on managing the airport responsibly. We are working hard to maximise the economic benefits that Heathrow brings, whilst carefully managing our environmental responsibilities and being a good neighbour to our local communities.

Our sustainability strategy - *Responsible Heathrow 2020*[6] - is our commitment to supporting the UK and local economies whilst managing our impacts on communities and the environment.

**Climate change adaptation and resilience**

Our commitment to managing climate change adaptation and resilience is stated in our Environment and Energy Policy, and is an important part of helping us to achieve our ambition to be the most environmentally responsible hub airport in the world.

***"Work with our airport partners to ensure that the airport plays its role in respecting environmental limits, and adapting to the effects of a changing climate. "***

We have further reiterated this commitment within *Responsible Heathrow 2020*, and we report on progress against this in our annual performance report (Table 1). Table 2 summarises our performance against this commitment. Further detail on actions taken can be found in our progress update in section 5.1.1.

**Table 1: Performance against our climate change adaptation and resilience**

| Commitment | Performance measure | 2013 | 2014 | 2015 |
|---|---|---|---|---|
| **climate change adaptation and resilience** | | | | |
| 90% of actions in the climate change adaptation risk matrix on track or completed annually | Adaptation actions on track | New Measure | 100% | 100% |

**Table 2: Status of actions identified in Heathrow's 2011 Climate Change Adaptation Report and Risk Assessment**

| Risk | Status |
|---|---|
| 12a. Ensure appropriate design standards are applied to new buildings to address risks from water ingress/flooding | On-track |
| 12/17b. Investigate and address risks of groundwater flooding to existing critical assets | On-track |
| 16/18a. Continue to liaise with the Environment Agency to develop and implement improvement options for the Pollution Control System, ensuring that the risks identified by this study are considered appropriately | On-track |
| 17a. Sensitivity test airport drainage infrastructure to ensure as robust as practicable to future climate extremes. | On-track |
| 30a. Continue to implement the recommendations of the Heathrow Winter Resilience Enquiry and ensure that planned future contingencies consider future change | On-track |

[6] 'Responsible Heathrow 2020' Available at: www.heathrow.com/responsibleheathrow

**Climate change mitigation**

We recognise that climate change is a significant issue for aviation and are committed to playing our role in addressing it, both from an adaptation and a mitigation perspective.

Advances in technology, operations and alternative fuels are all helping Heathrow to reduce carbon dioxide ($CO_2$) and greenhouse gas emissions from our own buildings and vehicles. We also work with our partners to help reduce emissions that they are responsible for.

Our overall goal for climate change mitigation is to achieve a 34% reduction in $CO_2$ emissions from energy used in buildings from a 1990 level by 2020. By the end of 2015, we had achieved a 27% reduction since 1990 as shown in Table 3. This includes the opening of Terminal 5 in 2008 and an increase in grid emission factors.

**Table 3: Performance against our climate change mitigation commitments**

| Commitment | Performance measure | 2013 | 2014 | 2015 |
|---|---|---|---|---|
| **Climate change mitigation** | | | | |
| 34% reduction in $CO_2$ emissions from energy used in buildings (1990) by 2020 | Total electricity used in our buildings (GWh) | 540 | 539 | 511 |
| | Total $CO_2$ emissions from energy used in our buildings (tonnes) | 272,426 | 291,552 | 263,010 |
| | Total $CO_2$ emissions from energy used in our buildings reduction (1990: 360,437 tonnes) | 24% | 19% | 27% |
| | Total $CO_2$ emissions (tonnes, million) | 2,274 | 2,258 | 2,250 |
| | $CO_2$ Emissions from colleague travel (tonnes) | 195,555 | 151,590 | 128,996 |
| Reduce $CO_2$ from Heathrow Airport Limited's vehicles | $CO_2$ emissions from HAL (owned / controlled) vehicles (tonnes) | 8,013 | 9,804 | 9,050 |
| Work with partners to reduce $CO_2$ from aircraft on the ground, during take-off and landing (to 3,000ft) | $CO_2$ emissions from aircraft on the ground and to 3000ft (tonnes) | 1,235,869 | 1,242,471 | 1,251,180 |
| Maintain Level 3 accreditation from Airport Council International Airport Carbon Accreditation Scheme | Maintain Level 3 accreditation from Airport Council International Airport Carbon Accreditation | Level 3 - Optimisation | Level 3 - Optimisation | Level 3 - Optimisation |

Further information on our approaches to both climate change mitigation, adaptation and resilience, along with our overall sustainability strategy is available on our website: www.heathrow.com/responsibleheathrow

## 3.4 Regulation

Heathrow is subject to economic regulation by the Civil Aviation Authority (CAA). As the economic regulator for UK airports, the CAA assesses the market power of airports and if an airport passes the market power test(s) set out in the Civil Aviation Act 2012, the airport is regulated by means of a Licence. Heathrow has been determined to hold substantial market power (SMP) and therefore operates under a Licence granted by the CAA. The Licence includes a condition imposing a price cap on Heathrow's airport charges. More information is available on our website: http://www.heathrow.com/company/company-news-and-information/economic-regulation

As a regulated airport, Heathrow engages and consults airport stakeholders on the business plan for each regulatory period. During the current regulatory period (April 2014 – December 2018), Heathrow plans to spend £1billion on asset replacement and a further £710 million on improving airport resilience. More information on our investment in airport resilience is available in our Strategic Capital Business Plan: http://www.heathrow.com/file_source/Company/Static/PDF/Investorcentre/strategic-capital-business-plan-2016.pdf

Heathrow has begun the planning process for the next regulatory period (2019-2023). As part of this planning process, Heathrow is reviewing the climate change adaptation risk register and incorporating climate change adaptation and resilience into the business planning process.

## 3.5 Heathrow's approach to resilience

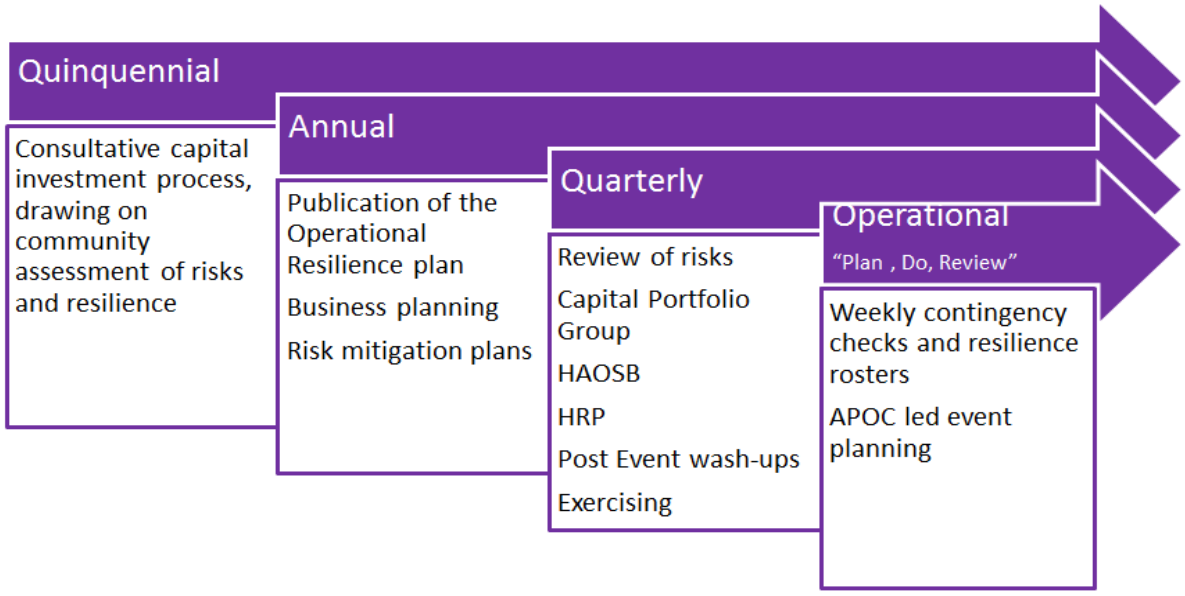
Resilience is about more than climate change. But the risks of climate change and adverse weather events are key aspects of Heathrow's approach to resilience.

As part of the Q6 Licence granted by the CAA there is an Operational Resilience Requirement:

> ***"to secure the availability and continuity of airport operation services, particularly in times of disruption, to further the interests of users of air transport services in accordance with best practice and in a timely efficient and economical manner".***

Improving resilience at the airport is critical to improving passenger experience - by reducing delays, improving punctuality and by ensuring the welfare of passengers during any disruption. Planning for adverse weather related disruption is already a key component of Heathrow's approach to resilience, and will become even more important due to projected climate change impacts. Heathrow recognises the importance and value of being a resilient airport. Every improvement made to the airport's resilience results in less disruption to the passenger journey and better performance for the airport and its stakeholders.

To ensure that operational resilience is correctly focussed, we implement a sequence of activity as detailed below:




*HAOSB - Heathrow Airport Operations Stakeholder Board*
*HRP – Heathrow Resilience Programme*
*APOC – Airport Operations Centre*

Our approach to resilience is risk based. The risk of severe adverse weather, either in the London Terminal Manoeuvring Area or overseas, can result in delayed arrivals or departures or congestion on the airfield and terminals.

Our Operational Resilience Plan[7], available on our website, provides further details on our approach to operational resilience planning.

## 3.6 Capacity

As a hub airport, Heathrow supports frequent and direct long-haul flights, by combining transfer passengers, direct passengers and freight, which means airlines are able to fill long-haul aircraft and serve destinations that cannot be served by airports which rely on local demand alone. As the UK's only hub airport, resilience is crucial to passenger experience.

The greatest challenge to Heathrow's operational resilience is that the airfield operates near capacity. In accordance with a Terminal 5 Planning Condition (A4), the number of air transport movements (ATMs) at Heathrow Airport is limited to 480,000 per year. Of these, approximately 98% of the slots are allocated in any one scheduling season – see Table 4.

When the airport is running smoothly, with no issues or disruption, running at 98% capacity is not a concern. The impacts arise during periods of disruption where the flow of aircraft is not optimal. This means that flights affected by earlier disruption cannot be moved to later in the day because there is no room in the schedule. This in turn leads to delays and flight cancellations.

[7] Heathrow Airport: Operational Resilience Plan, September 2015

**Table 4: Annual air transport movements and percentage capacity**

| Year | Air transport movements | % Capacity |
|---|---|---|
| **2004** | 466,295 | 97.1 |
| **2005** | 469,125 | 97.7 |
| **2006** | 467,937 | 97.5 |
| **2007** | 472,746 | 98.5 |
| **2008** | 470,122 | 97.9 |
| **2009** | 457,365 | 95.3 |
| **2010** | 446,673 | 93.1 |
| **2011** | 473,711 | 98.7 |
| **2012** | 468,918 | 97.7 |
| **2013** | 467,156 | 97.3 |
| **2014** | 468,353 | 97.6 |
| **2015** | 469,660 | 97.8 |

**Taking Britain Further**

In September 2012, the Government announced the creation of an independent Airports Commission, which was tasked with making recommendations to the Government for maintaining the UK's status as an international hub for aviation. At the end of 2013, the Airports Commission recommended that at least one new runway was needed in the South East of England before 2030, at either Heathrow or Gatwick.

In May 2014, Heathrow submitted its revised runway proposal to the northwest of the existing airport site – called Taking Britain Further[8]. As part of our plans, we have made ten commitments that set out what Britain can expect from a third runway at Heathrow – see Table 5. Commitment 10 is to 'reduce delays and disruption - by eliminating the routine use of aircraft stacks and further improving Heathrow's resilience to weather and unforeseen events'.

On 1st July 2015, the Airports Commission unanimously concluded that a third runway should be built to the north west of the existing Heathrow airport, meeting certain environmental and community conditions. An announcement from the Government in response to the Airports Commission recommendation is expected in 2016.

Once the Government reaches a conclusion on airport expansion it will consult on a National Policy Statement. At this point, if the Government supports the Airports Commission recommendation, Heathrow will begin preparation of a planning application. The planning application will seek permission for a new runway and will have a capacity of at least 740,000 flights per year.

Heathrow today is close to its maximum capacity, with inevitable and well-known consequences for the resilience of the operation. An expanded Heathrow will be a much more resilient airport, with far fewer days where operational disruption affects passengers. We will have a much greater ability to recover from any adverse events, including adverse weather that disrupts the operation.

[8] Taking Britain Further. http://your.heathrow.com/takingbritainfurther

**Table 5 Heathrow's commitments relating to third runway proposal**

| | Commitment | Our approach |
|---|---|---|
| 1 | Connecting Britain to economic growth | by enabling airlines to add new long-haul to fast-growing markets |
| 2 | Connect UK nations and regions to global markets | by working with airlines and Government to deliver better air and rail links between UK regions and Heathrow |
| 3 | Create more than 180,000 new jobs nationwide | by developing our local employment, apprenticeships and skills programmes and supporting supply chain throughout the UK, including during construction |
| 4 | Connect exporters to global markets | by doubling Heathrow's freight handling capacity |
| 5 | Build more quickly and at lower cost to taxpayers than building a new airport | by building on the strength the UK already has at Heathrow |
| 6 | Reduce aircraft noise and lessen noise impacts for people under flight paths | by encouraging the world's quietest aircraft to use Heathrow, routing aircraft higher over London, delivering periods with no aircraft overhead and allocating £250m to provide noise insulation |
| 7 | Treat those most affected by a third runway fairly | by proposing compensation of 25% above market value, all legal fees, and stamp duty costs for a new home for anyone whose home needs to be purchased |
| 8 | Increase the proportion of passengers using public transport to access Heathrow to more than 50% | by supporting new rail, bus and coach schemes to improve public transport to Heathrow and considering the case for a congestion charge |
| 9 | Keep $CO_2$ emissions within UK climate change targets and play our part in meeting local air quality limits | by incentivising cleaner aircraft, supporting global carbon trading, and increasing public transport use |
| 10 | Reduce delays and disruption | by eliminating the routine use of aircraft use of aircraft stacks and further improving Heathrow's resilience to weather and unforeseen events |

# 4. Climate risks and uncertainties

## 4.1 Understanding Heathrow's climate risks

**Climate change projections**

Heathrow's first Climate Change Adaptation Report in 2011 used the Met Office's UK Climate Projections produced in 2009 (UKCP09). The Met Office has published a recent study which shows that UKCP09 continues to provide a valid assessment of the UK climate and can continue to be used for climate change adaptation.

However, when considering future changes in summer rainfall, the Met Office now recommends considering Coupled Model Intercomparison Project Phase 5 (CMIP5) projections alongside UKCP09. Although both sets of models project that summer rainfall is more likely to decrease, CMIP5 projects a smaller decrease and includes a possibility that it could remain similar or become wetter than it is today.

DEFRA has commissioned a new set of UK Climate Projections (UKCP18). These will be based on the latest climate change science and will provide information on how the climate of the UK may change over the rest of this century. The new projections will be available from 2018 to inform the Government's third Climate Change Risk Assessment, and will replace the current set of projections (UKCP09) as the official UK Climate Projections.

Heathrow will undertake a comprehensive review of progress in climate change science and projections for Heathrow following the publication of the new set of climate change projections, expected in 2018.

**Summary of new climate change science, data and information**

In preparation of this progress report we commissioned Arup to carry out a review of progress in climate change science, data and information published since 2011 (see Appendix 2). A number of the sources identified contain new science, data and information relevant to the update and review of climate change risks relating to climate variables of interest to Heathrow. The review confirmed that the UKCP09 climate projections for Heathrow used in the first ARP report remain valid. There are a number of studies which contain relevant information for Heathrow in its ARP report update and review of its climate change adaptation risk assessment. These are as follows:

- H++ scenarios publication[9]
- CMIP5[10]
- IPPC AR5 Reports[11]

The most relevant new data and information is summarised below.

### High temperatures

The H++ scenario for heat waves are based on a wide range of observed and modelled data sources including: National Climate Information Centre mean temperature data; Central England Temperature record; gridded surface temperatures; and CMIP5 Multi-Model Ensemble. In this scenario, all measures of extreme heat considered are projected to increase. Annual average summer maximum temperatures

[9] Adaptation Sub-Committee, Developing H++ climate change scenarios for heat waves, droughts, floods, windstorms and cold snaps, 2015 https://www.theccc.org.uk/publication/met-office-for-the-asc-developing-h-climate-change-scenarios/ [Accessed 30th June 2016]
[10] IPCC, Climate Change Synthesis Report, 2014 http://www.ipcc.ch/pdf/assessment-report/ar5/syr/SYR_AR5_FINAL_full_wcover.pdf [Accessed 1st July 2016]
[11] https://ipcc.ch/report/ar5/ [Accessed 1st July 2016]

will exceed 34°C over much of central and southern England. It is also found that absolute temperatures in excess of 40°C on the hottest days in summer are entirely possible (the maximum temperature in London is anticipated to be 48°C). Note, short-term cooling due to volcanic activity was excluded from the analysis.

The 2011 report references the effect that the Urban Heat Island (UHI) effect has on increased temperatures in London, and the latest data suggests that climate change effects are likely to be exacerbated by UHI.

### High precipitation

Two H++ scenarios exist for high rainfall, the first is for increases in average winter rainfall, and the second is for heavy daily and sub-daily rainfall in winter or summer. For average winter rainfall, the H++ scenario points to an increase of 70-100% on the 1961-1990 baseline by the 2080s. This overlaps with the UKCP09 2080s high emissions scenario but is slightly higher. The H++ scenario for heavy daily and sub-daily rainfall for the same period is 60-80% increase in rainfall depth for summer or winter events. This was based on consideration of new high resolution modelling and physical processes. This increase fits within the UKCP09 distribution tails for the 2080s high emissions for the wettest day of winter variably but is higher than uplifts considered for summer.

### Low temperatures

The H++ scenarios reports describe cold snap scenarios as L-- to highlight that they are at the opposite end of the scale to the extreme heat wave H++ temperatures. In developing the L-- scenario similar data sets were used to those used for heat waves. For the L-- cold scenario for the 2020s, the UK mean winter temperature is expected to be 0.3°C, with a coldest day scenario average below freezing across the UK of approximately -7°C. For the 2080s scenario, average winter temperatures are approximately -4°C, with temperatures on the coldest day of approximately -11°C. Note, consideration of the Urban Heat Island effect was excluded from the analysis.

### Low precipitation

The H++ scenario for low rainfall shows a significant increase in 6 month duration summer drought with deficits up to 60% below the long term average from 1900-1999. There is no suggestion of significant changes in winter droughts. However, there is the possibility of longer dry periods across the UK throughout the year, with rainfall deficits of up to 20% below the long term annual average lasting several years, similar to the most severe long droughts on record. Note, these scenarios cannot be compared directly to deviations from a 1961-1990 baseline or data for smaller areas or maps with gridded data.

Both CMIP5 and UKCP09 results indicate that a reduction in long-term average summer rainfall is more probable than an increase. However, CMIP5 suggests a larger chance of an increase and a smaller risk of substantial future reductions in summer rainfall.

### Winds

The H++ scenario for windstorms, based on the analysis of CMIP5 projections, suggests a 50-80% increase in the number of days of strong winds in the UK by 2070-2100 compared to the period 1975-2005. Note, the caveat in this study is that model simulations contain biases in the position of North Atlantic storm track and systematically under represent the number of intense cyclones.

As discussed in Heathrow's 2011 CCAR, there is considerable uncertainty in projections for changes in wind speed and direction.

### Storms

Considerable uncertainty exists in the projections of future storm frequency and intensity. AR5 states that the frequency and intensity of storms in the North Atlantic have increased since the 1970s but the reasons for this are uncertain. There is low confidence on large-scale trends in storminess in the last century and there is still not enough evidence to understand whether robust trends exist in small-scale severe weather events. There is also low confidence in the near-term projections for the position and strength of the Northern hemisphere storm tracks.

### Jet stream

The AR5 Physical Science Basis report confirms that in the northern hemisphere, it is likely that circulation features have moved poleward since the 1970s. This has involved a poleward shift of storm tracks and jet streams and a contraction of the northern polar vortex. However, the AR5 report states that trends in the jet stream are uncertain.

The Extra Project[12] issued a presentation in June 2016 summarising that: climate models project that by 2100 there will be small changes to the jet stream (i.e. a northward shift and an increase in wind speeds); eastbound flight routes will experience a northward shift and be faster; and westbound flight routes will be more dispersed and slower.

### Fog

No new data has been found for projected variations in frequency or intensity of fog events due to climate change.

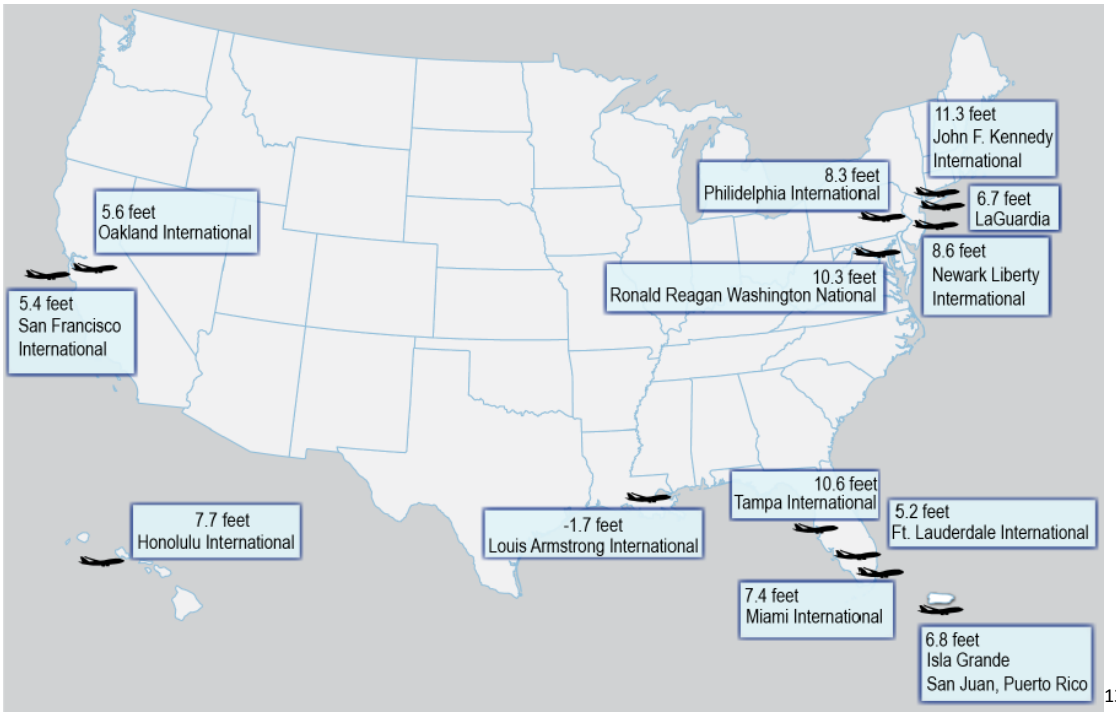
## Global climate change impacts

In addition to local effects of climate change on the UK and Heathrow Airport, climate change effects across the globe which may affect other international airports could have a severe knock-on effect for Heathrow.

The US Global Change Research Program conducts a National Climate Assessment (NCA) every four years, the most recent of which was released in May 2014. It discusses how 13 of the 47 largest airports in the US have at least one runway with an elevation within 12 feet (3.56 m) of current sea levels and therefore, within the reach of moderate to high storm surge. This is depicted in the Figure on page 17. For example, during Hurricane Sandy, in October 2012, the three major airports in New York (John F. Kennedy (JFK), Newark and La Guardia) all flooded, with La Guardia having to shut for 3 days.

The Government Office for Science published a foresight report in 2011 on the international dimensions of climate change. This report identifies how international climate change is likely to affect the UK due to its global interdependencies. The section of the report on air transportation discussed that 11% of the 9,915 major airports worldwide are located within the coastal zone. These airports will most likely be at risk from sea level rise and flooding.

12 http://www.met.reading.ac.uk/~gb902035/PDRA_Work.html [Accessed 1st July 2016]



[13]

**Heathrow's climate change risks**

Using UKCP09 climate projections, Heathrow's first Climate Change Adaptation Report in 2011 identified seven climate variables and related climate change risk categories for Heathrow. These are summarised in Table 6 below.

**Table 6: Heathrow's 2011 climate change risks**

| Climate variable | | Summary of long-term climate projection for south-east England | Level of certainty | Summary of impact on Heathrow |
|---|---|---|---|---|
| 1 | **High temperatures** | Higher temperatures in Summer and Autumn | High | Overheating |
| 2 | **High precipitation** | More rainfall / increased intensity in Winter<br>Less rainfall, but increased intensity in Spring / Summer /Autumn | High | Flooding |
| 3 | **Low temperatures / snow** | Warmer winters and less snow – but snow events still predicted | Medium | Cold weather |
| 4 | **Low precipitation** | Less rainfall in Summer | Medium | Water shortages |
| 5 | **Fog** | More fog days in Winter<br>Less foggy days in Spring /Summer / Autumn | Low | Low visibility |
| 6 | **Wind** | Changes to wind speed and direction uncertain. Increased frequency and severity of low pressure storms. | Low | Strong headwind / crosswind |
| 7 | **Storms / lightning** | Increased frequency, particularly in Autumn | Low | Lightning/storms |

[13] http://nca2014.globalchange.gov/

**Comparison of climate change science, data and information between Heathrow climate change adaptation reports**

Table 7 provides a summary of new sources of data and information published since the first Heathrow Climate Change Adaptation Report in 2011, relevant to each climate variable. Note that most of the information used in report in 2011 remains valid. Most of the new sources of data complement the information provided in the 2011 report.

**Table 7: summary of new sources of data and information**

| Climate variable | | Data and information in existing Heathrow report and risk register (2011) | New sources of data and information to potentially include in updated 2016 report and risk register (2016) | Numbers refer to climate variables above, Table 6 |
|---|---|---|---|---|
| Temperature | Low temperatures | UKCP09, UKCP09 Technical note | H++ scenario<br>UKCP09 Weather Generator 2.0 | 3 |
| | High temperatures | UKCP09 | H++ scenario<br>UKCP09 Weather Generator 2.0 | 1 |
| | Mean temperature | UKCP09 | | |
| Precipitation | Low precipitation | UKCP09 | H++ scenario<br>CMIP5<br>UKCP09 Weather Generator 2.0 | 4 |
| | High precipitation | UKCP09 | H++ scenario | 2 |
| | Mean precipitation | UKCP09 | Use of CMIP5 for summer precipitation<br>For 2080s, UKCP09 projects a decrease of 23% while the data based on CMIP5 points to a decrease 2.5% decrease. See data for 2020s and 2050s in Table 8 | |
| Jet stream | | N/A | AR5<br>The Extra Project | 7 |
| Winds | | UKCP09 Technical documentation | H++ scenario | 5 |
| Fog | | UKCP09 Additional product | N/A | 8 |
| Storms and lightning | | UKCP09 Technical note | AR5 reports | 6 |

For this 2016 update report, minor additions have been made to six of these seven climate variables to reflect new data and information summarised in the previous section. Lightning has been amended to 'storms and lightning', and the 'jet stream' has been added as a new climate variable bringing the total number of climate change risk categories to eight. These changes are summarised in table 8.

**Table 8: Climate change projections for mean climatic conditions, 2016**

| Climate variable characteristic | | | Baseline[a] | 2020s [b,c] | 2050s [b,c] | 2080s [b,d] | Sources |
|---|---|---|---|---|---|---|---|
| Temperature | Low temperature | Number of frost days (Minimum temperature equal or lower than 0 °C) | 39 | 24 | 17 | 9 | UKCP09 WG for Heathrow and H++ report |
| | | | | H++ scenarios: Coldest day ~ -7°C | | H++ scenarios: Coldest day ~ -11°C | |
| | High temperature | Heatwaves (2 days with maximum temperature higher than 29°C and minimum temperature higher than 15°C) | 0 | 1 | 2.5 | 7 | UKCP09 WG for Heathrow and H++ report |
| | | Number of hot days (Max temperature higher than 25°C) | 15 | 32 | 52 | 70 | UKCP09 WG for Heathrow and H++ report |
| | | | | H++ scenarios: Annual average summer max temps of >34°C over central and southern England Hottest days >40°C (London >48°C) possible | | | |
| | Mean temperature | Winter mean temperature (°C) | 4.4 | 5.7 (5.0 – 7.5) H++ (L- -) scenarios: Mean winter temp ~ 0.3°C | 6.6 (5.6 – 8.2) | 7.4 (6.0 – 10.1) H++ (L- -) scenarios: Mean winter temp ~ -4°C | ProCliPs (London) and H++ report |
| | | Summer mean temperature | 16.4 | 18.0 (17.0 – 19.1) | 19.2 (17.7 – 21.7) | 20.3 (18.5 – 24.5) | ProCliPs (London) |

| Climate variable characteristic | | | Baseline[a] | 2020s [b,c] | 2050s [b,c] | 2080s [b,d] | Sources |
|---|---|---|---|---|---|---|---|
| | | (°C) | | | | | |
| | | Winter mean daily minimum temperature (°C) | 1.5 | 2.9 (2.0 – 3.9) | 3.8 (2.4 – 5.9) | 4.8 (2.9 – 8.2) | ProCliPs (London) |
| | | Summer mean daily maximum temperature (°C) | 21.3 | 23.2 (21.9 – 24.7) | 24.8 (22.7 – 28.1) | 26.2 (23.4 – 32.0) | ProCliPs (London) |
| Precipitation | Low Precipitation | Dry spells (10 day+ with no precipitation) | 9 | 9<br><br>H++ scenarios: Reduction in long-term average summer rainfall more probable than an increase | 9 | 11<br><br>H++ scenarios: Increase in 6 month duration summer drought with deficits up to 60% below long term average. Longer dry periods throughout the year, with rainfall deficits of up to 20% below long term annual average | UKCP09 WG for Heathrow and H++ report |
| | High Precipitation | Median annual maximum rainfall (mm/day) | 38 | 35 | 36 | 40 | UKCP09 WG for Heathrow and H++ report |
| | | | | H++ scenarios: Heavy daily and sub-daily rainfall events = 60-80% increase in rainfall depth for summer or winter events. Threshold defined by Met Office to indicate likely flash flooding exceeded more often | | | |
| | Mean Precipitation | Winter mean precipitation (mm) | 1.75 | 1.8 (1.67 – 2.06) | 2.0 (1.77 – 2.37) | 2.09 (1.80 – 2.76) | ProCliPs (London), CMIP5 and H++ report |
| | | | | H++ scenarios: Average winter rainfall increase of 70-100% | | | |
| | | Summer mean | 1.66 | 1.54 (1.22 – 1.97) | 1.35 (0.98 – 1.82) | 1.28 (0.86 – 1.75) | ProCliPs |

| Climate variable characteristic | | | Baseline[a] | 2020s [b,c] | 2050s [b,c] | 2080s [b,d] | Sources |
|---|---|---|---|---|---|---|---|
| | | precipitation (mm) | | UKCP09: 7% decrease<br>CMIP5: 2.5% decrease | UKCP09: 18% decrease<br>CMIP5: 6% decrease | UKCP09: 23% decrease<br>CMIP5: 5% decrease | (London) |
| Fog | | Winter (number of fog days) | 5.0 | - | - | Increase of 20% | UKCP09 reports (London) |
| | | Summer (number of fog days) | 0.3 | - | - | Decrease of 67% | |
| Wind | | | - | Approximately no change in winter and small reduction in mean wind speed in summer | | | UKCP09 reports |
| Jet Stream | | | Since the 1970s poleward shift of storm tracks and jet streams | Trends in the jet stream are uncertain. Climate models project that by 2100 there will be small changes to the jet stream (i.e. a northward shift and an increase in wind speeds) | | | AR5 reports and The Extra Project |

[a] The baseline period refers to the period 1961 – 1990

[b] The climate change projections are given for the medium scenario and 50% probability level, the brackets indicate the uncertainty range from the medium emissions scenario and 10% probability level to high emissions scenario and 90% probability level when available.

[c] Data for extreme weather events for the 2020s and 2050s has been derived using the Weather Generator from UKCP09 (see more details in http://ukclimateprojections.metoffice.gov.uk/23261).

[d] The source for this information is the UKCP09 report 'An illustration of the effects of the revised Weather Generator' (available from: http://ukclimateprojections.metoffice.gov.uk/media.jsp?mediaid=87942&filetype=pdf. Last accessed 22 July 2016).

Note: Dashes indicate that information is not readily available. The definition provided for heatwaves is the one used in UKCP09 http://ukclimateprojections.metoffice.gov.uk/media.jsp?mediaid=87944&filetype=pdf

**Thresholds of climate change impacts**

The nature of airport operations, in particular airfield operations, is sensitive to extreme weather. Thresholds of climate impacts already exist in most areas that enable the application of extreme weather scenario operating procedures, as described in table 9.

**Table 9: Climate change thresholds for Heathrow airport**

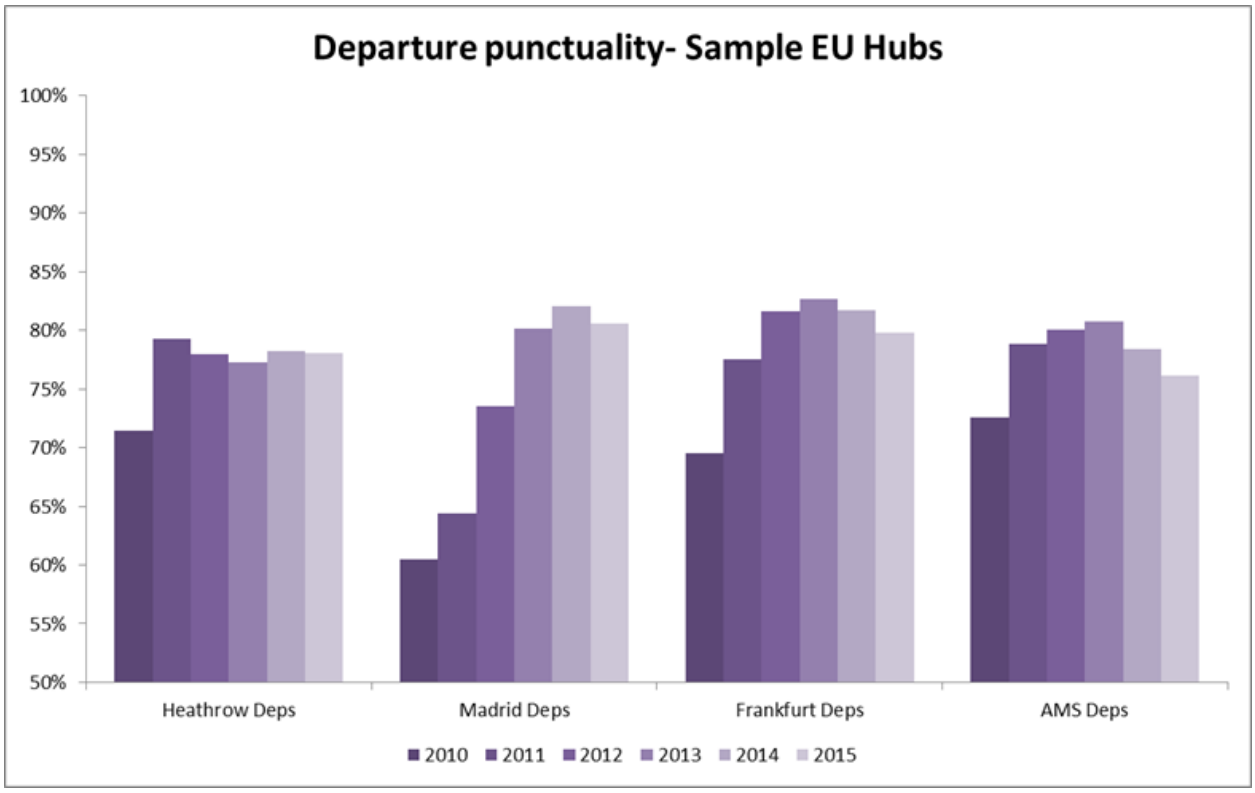
| Climate variable | Summary of impact on Heathrow | Thresholds of impacts | Operational control deployed |
|---|---|---|---|
| **Hot temperatures** | Overheating | 38 degrees threshold for flashpoint of aviation fuel | Airport fire service |
| **More rainfall** | Flooding | No specific threshold | Operational Flood Plan and Pollution Control System |
| **Low temperatures / snow** | Cold weather | Varying thresholds depending on aircraft type and flight. For runway and taxiways depends on a combination of temperature and moisture conditions | Aircraft and runway/taxiway de-icing/anti-icing |
| **Less rainfall** | Water shortages | Drought order | Compliance with drought order<br>Airside vehicle wash facilities replaced with rainwater recycling systems |
| **Fog** | Low visibility | Instrumented Runway Visual Range (IRVR) is less than 600 metres and/or the cloud ceiling is less than 200 feet | NATS: Low visibility procedures plus enhanced instrument landing system |
| **Wind** | Strong headwind/ crosswind | Strong headwinds | Demand capacity balancing by creating a plan for the day by balancing aircraft demand with airport capacity – see case study 3.<br>Time based separation – see case study 1 |
| **Lightning** | Lightning/ storms | No specific threshold | Demand capacity balancing by creating a plan for the day by balancing aircraft demand with airport capacity – see case study 3.<br>Time based separation – see case study 1 |

**Organisational vulnerability**

Heathrow measures its operational performance with a suite of performance indicators. Airfield punctuality and the number of cancellations are good overall indicators of resilience (and an effective way of measuring organisational vulnerability). Punctuality and cancellations are tracked in real-time by Heathrow's Airport Operations Centre (APOC). APOC produces a daily summary of performance, and attributes the cause of any cancellations or significant delays.

We benchmark Heathrow's punctuality against other EU hub airports and get data direct from other participating airports as part of an information exchange agreement.

The graph below highlights Heathrow's punctuality remaining relatively static while Frankfurt and Amsterdam (AMS) declined over the past two years. Heathrow's resilience efforts have helped protect us from a decline in punctuality.




## 4.2 Climate change uncertainties

In Heathrow's first Climate Change Adaptation Report, a number of the climate change projections have a low level of certainty associated with them, such as changes to fog, wind and lightning.

Heathrow's main focus areas are to build resilience to those adverse weather events that have the highest impact on our airport operation - flooding and cold / snow events. The climate conditions which lead to these events are both more likely to occur in the future, especially for the case of flood frequency and intensity. However, uncertainty remains with medium and long term projections with these climate variables also.

Heathrow maintains a watching brief on developments in climate science. Following the publication of UKCP18, Heathrow will review the relevant climate change projections and uncertainties and will review and update its Climate Change Adaptation Report and Risk Assessment. Heathrow's business planning process will factor in this review and update into relevant budgets.

## 4.3 Case studies

Heathrow has installed a number of new technologies and processes to increase resilience to weather disruption and thereby decrease organisational vulnerability. A selection of case studies is provided.

### Case Study 1: Strong winds - Time Based Separation

Introduced in May 2015, Time Based Separations (TBS) is a pioneering new system with operational methodology which separates arriving aircraft at Heathrow by time instead of distance. This cuts flight delays and reduces cancellations due to high headwinds. Supported in the Airports Commission's interim report in December 2013, the delivery of TBS comes after three years of exhaustive analysis from co-members of the Single European Sky Research ATM Research and development programme (SESAR).

During strong headwind conditions, Heathrow experiences a decrease in the landing rate when operating with Distance Based Separation (DBS), because arriving flights are spaced a specified distance apart regardless of the wind conditions. Aircraft on approach fly at the same speed in the air and so when they fly into a strong headwind that means a reduced speed over the ground. This results in increased time separation for each arrival pair. This increased time separation between arrivals, reduces the landing rate and creates a lack of stability of the runway throughput when operating near capacity.

As noted by Eurocontrol the European Network Manager, London Heathrow airport remained a delay hot spot in 2013 due to significant impact to aircraft operations under adverse weather conditions. Strong winds cause the most disruption to Heathrow flights operations, with a knock on effect to wider global operations. Heathrow currently experiences approximately 35 "strong wind" days per year.

**Objective**

To deliver new technology to facilitate TBS operations into Heathrow in order to maintain an enhanced flow rate during strong wind conditions.

**Solution**

In order for NATS (En Route) PLC ("NERL"), to provide functionality for TBS of aircraft approach, local systems needed to be upgraded. In addition, NATS required changes to the ATM engineering systems. This included all necessary training of ATCO staff and amendments to the safety case and procedures.

The overall scope of this investment covered:

- Heathrow Tower Approach Radar Display
- Servers
- Workstations
- Tower and Virtual Control Facility
- Air Traffic Control (ATC) Training
- Engineer Training
- Update to ATC Method of Operations
- Unit and System Safety Cases

**Benefits**

The specific benefits relating to TBS are:

- 4 movements per hour on strong wind days
- 50% reduction in annual delays attributable to strong winds

## Case Study 2: Improving arrivals and departures - wake vortex separations

Reducing the safe separation distance between a given aircraft pair means that not only the wake vortex generated by the leader has to be taken into consideration but also the following aircraft's resistance to it, on departure or final approach.

ICAO's existing wake vortex separation rules (based upon Heavy, Medium and Light categorisations) were implemented over 40 years ago. In some respects, they are now outdated and lead to over-separations in many instances.

European Wake Vortex Re-categorisation (RECAT-EU) is a new, much more precise categorisation of aircraft than the traditional ICAO one. It aims at safely increasing airport capacity by redefining wake turbulence categories and their associated separation minima. It subdivides wake vortex categories to make them aircraft specific and therefore more accurate.

## Case Study 3: Airfield flow management – Airport Operating Plan

Heathrow Airport is scheduled to 98% of its declared capacity. However the time at which aircraft arrive and depart the airport is not generally stable as it can be affected by global winds, Air Traffic Control (ATC) routing and outstation punctuality. Similarly airport capacity may vary if terminal, taxiway or runway throughput is reduced due to adverse weather, infrastructure limitations or one-off incidents. Capacity may also be affected by airspace issues, either in the airport vicinity or en-route.

Any fluctuations in demand from arriving or departing flights lead to unacceptable performance degradation. To manage this, Heathrow produces a plan that constantly updates to account for these uncertainties. All of this activity is known as Demand Capacity Balancing (DCB) – dynamically evolving the set schedule up to operation of the flight using the latest available information. DCB processes formulate the Airport Operating Plan (AOP) which, once agreed, is shared with wider stakeholders including airlines and the Network Manager.

To enable the airport to consider the effects of the uncertainties in more detail, a systemised capability is required to create and maintain the AOP from Day minus Ten (D-10) to on the day of operation Day minus Zero (D-0). This capability provides a robust plan for other key stakeholders within and in support of the airport operation. The active controlled trials are being consulted and planned for late 2017 into 2018. This will require wide collaboration with other global air traffic control systems and airline participation.

DCB will predict the behaviour of flights and the effects of any actions taken by the airport to change the outcomes. Predictability can be influenced by:

- Global winds
- Variations to the published schedule of aircraft
- Local weather
- Airport infrastructure availability
- Lessons learned from past performance (historical data), including:
    - Punctuality at outstations
    - Airline performance (cost index, flight speed, and response to ground delay)

This is currently in feasibility and options stage with implementation due in 2018 – 2019.

## Case Study 4: Low visibility

Improvements have been made at Heathrow to increase resilience to the impact of fog. Changes to low visibility procedures (LVPs) have been made through installing new enhanced Instrument Landing Systems (eILS). The eILS provides Heathrow with the capability to increase the number of aircraft that can land in low visibility, giving improved resilience and punctuality. To date we have done 3 of 4 runway ends with the next planned by March 2017. Once fully operational the benefits in low visibility will increase by up to 5-6 arrivals per hour during LVP.

Other improvements have been made including:

- Introducing Met Office forecasters at Heathrow
- Improved procedures for planning aircraft flow when fog is forecast
- Working collaboratively with pilots, the CAA and NATS
- Improvements to the cloud ceiling and visibility parameters that trigger the introduction of LVPs
- Improved cleaning and maintenance regime for runway lighting that improves the threshold for introducing LVPs.

## Case Study 5: Snow

As a result of snow in 2010, Heathrow has invested significant capital, £37m, and time, on improving resilience of the airport during a snow event. This includes additional equipment, new processes for weather forecasting, enhanced command and control structure supported by over 240 people on various 'on call' teams and a detailed Passenger Welfare Plan.

We continue to develop the Snow removal programme and continue to improve and introduce new aircraft de-icing capabilities. We have constructed a two position de-icing pad. This also gives us glycol recovery capability.

# 5. Heathrow's action on managing climate change adaptation risks

## 5.1 Progress with actions

Heathrow's climate change adaptation risk assessment published in 2011 alongside its Climate Change Adaptation Report identifies 34 separate risks to the business from climate change. The risk process identified three key responses to each risk:

- **Action** – Defines actions that are known and required now to mitigate identified short-term climate related risks and/or longer term risks if the solution requires action now
- **Prepare** – Defines tasks to improve understanding of the cause or solution to a significant short or medium term risk. Tasks are therefore predominantly research based.
- **Watching brief** – watching brief to be maintained in the short term on the latest climate science developments, and the situation on the ground.

### Update on risks requiring action

Five risks were identified as requiring action: four related to the increased flood risk at Heathrow, and the remaining one related to the snow/winter conditions risk. From these, five separate actions were identified. The progress against these is summarised in table 10.

**Table 10: Risks requiring action**

| Climate Impact on Heathrow | Risk ID | Risk | Summary of actions (as set out in first round report) | Progress on implementation of actions | Benefits / challenges experienced |
|---|---|---|---|---|---|
| Flooding | 12 | Changes to groundwater levels affect asset integrity and could cause subsidence and water ingress damage to buildings and surfaces | 12a. Ensure appropriate design standards are applied to new buildings to address risks from water ingress/flooding | Design standard for new buildings address risks from water ingress/flooding | Improved future resilience to flood impacts |
| | | | 12/17b. Investigate and address risks of groundwater flooding to existing critical assets | Operational Flood Plan developed to manage the impact of flooding on critical assets. | Improved resilience to flood impacts |
| | 16 | Pollution Control System (PCS), challenged during episodes of extreme weather. Increased severity of first flush effect, less seasonal distinction in PCS operation | 16/18a. Continue to liaise with the Environment Agency to develop and implement improvement options for the Pollution Control System, ensuring that the risks identified by this study are considered appropriately | PCS improvement plan developed. Funding being sought for a revised weir for the River Crane to deal with the impact of flooding and to address water quality. | Improved resilience to flood impacts |

| | | | | | |
|---|---|---|---|---|---|
| | 17 | Localised flooding if older drainage overwhelmed by heavy rainfall events | 17a. Sensitivity test airport drainage infrastructure to ensure as robust as practicable to future climate extremes. | Report produced by Atkins identifying hotspots for flooding. Operational Flood Plan developed to manage the impact of flooding on critical assets. | Improved resilience to flood impacts |
| | | | 12/17b. Investigate and address risks of flooding to existing critical assets. | As per action 12b | |
| | 18 | Integrity of balancing ponds at risk of subsidence of earth walls and/or extreme rainfall events | 16/18a. Continue to liaise with the Environment Agency to develop and implement improvement options for the Pollution Control System (PCS), ensuring that the risks identified by this study are considered appropriately | As per action 16a | |
| **Cold weather (snow)** | 30 | Increasing variability of snowfall challenges winter contingency plans, de-icing supplies and staff experience | 30a. Continue to implement the recommendations of the Heathrow Winter Resilience Enquiry and ensure that planned future contingencies consider future change | We continue to develop the Snow removal programme. Most significantly we continue to improve and introduce new aircraft de-icing capabilities. We have constructed a two position de-icing pad. This also gives us glycol recovery capability. | Improved resilience to increased snow fall |

## Update on risks requiring research

Eight risks were identified that did not need immediate action but required further understanding through research. Six related to overheating, one related to both overheating and cold weather and one related to just cold weather. Research actions were summarised into 10 preparation actions. The progress against these is summarised in Table 11.

**Table 11: Risks requiring research**

| Climate impact on Heathrow | Risk ID | Risk | Summary of research actions (as set out in first round report) | Progress on implementation of actions | Benefits / challenges experienced |
|---|---|---|---|---|---|
| Overheating | 1 | Flashpoint of aviation fuel exceeded on hot days – potential fire hazard | 1a. Research into spill clean-up options currently used at airports in warmer climates to commence to develop policies robust to air temperatures exceeding 38C. | Heathrow Aviation Fuels Operations Manager has experience of working with aviation fuel and military aircraft in very hot desert climates. Perceived risk of fuel combustion is low; therefore risk rating has been reduced. | Improved understanding of risk of aviation fuel combustion due to hot weather |
| | 2 | Increased incident of fuel venting from aircraft in warm weather | 2a. Research into options currently used at airports in warmer climates for spill reporting and clean up procedures. | Spill reporting and clean up procedures have been enhanced | Improved understanding of number and volume of spills |
| | 3 | Increased fire risk due to hotter temperatures combined with increased lightning and drought potential | 3a. Ensure that the planned changes and development of the airports fire main considers and addresses the potential for increased fire risk resulting from climate change. | We have assessed the risk of increased fire risk and consider the airport fire main to be sufficient to mitigate risk | Improved understanding of fire risk and resilience |
| | 13 | Overheating of aircraft on stands | 13a. Research robustness of PCA and FEGP (and any cooling alternatives) making sure that the design standards used are as robust as practicable against future temperature extremes. | Aircraft overheating is prevented by the use of the aircraft power unit to drive integral cooling systems. However, this increases emissions due to local burn of aviation fuel. Pre-conditioned air (PCA) offers commercial and environmental benefits if we can improve the reliability and capability of systems. Investment in Q6 is intended to improve delivery systems. | Improved resilience to overheating of aircraft on stands |
| | 14 | Heat damage to road and apron | 14a. Review and ensure continued robustness of hard | Our technical standards for airfield pavements and roads are based on | Improved resilience to damage to |

| Climate impact on Heathrow | Risk ID | Risk | Summary of research actions (as set out in first round report) | Progress on implementation of actions | Benefits / challenges experienced |
|---|---|---|---|---|---|
| | | surfaces caused by temperatures exceeding design standards (i.e. melting, cracking) | standing (road/apron/runway) asset design standards to future climate change | current industry practice and standard construction materials used within wider industry, meeting foreseeable temperature extremes. The surface condition on extreme temperature days are monitored by airside and landside operations teams to ensure safe operations. Future increases to temperature extremes will be incorporated in to our technical standards as required. | road surfaces caused by extreme temperatures |
| | 15 | Overheating of operationally-critical buildings which could impair performance of critical staff or equipment and breach regulated conditions | 15a. Review and ensure continued robustness of building design standards to future temperature change | Building systems are designed for foreseeable temperature extremes and systems can be supplemented if required. The more significant operational issue is resilience of these systems, not necessarily coinciding on a day of extreme temperature, due to the potential adverse impact in the event of failure. | Improved resilience to overheating of operationally-critical buildings |
| | | | 15b. Ensure design and development of Heathrow's long term masterplan manages risks from future climate change | We assess the risk that future climate change presents to our airport master plans and will review design options for infrastructure to consider the impacts of climate change; particularly future extreme weather | Improved future resilience to climate change |
| **Overheating / cold weather** | 19 | Increased energy demand for cooling in the | 19a. Ensure that the future changes to the airport's heat, power and cooling | Future demand is considered as part of the heating and cooling strategy. This may | Improved future resilience to increased |

| Climate impact on Heathrow | Risk ID | Risk | Summary of research actions (as set out in first round report) | Progress on implementation of actions | Benefits / challenges experienced |
|---|---|---|---|---|---|
| | | summer and for heating during winter extremes increases energy spend and emissions. High temperatures reduce performance of some plant. | generation and transmission assets are stress-tested to be as robust as practicable against future climate change projections. | trigger a change to our technical standards | energy demand |
| | | | 19b. Research spare capacity and critical thresholds for plant and transmission infrastructure performance in hot weather and potential to accommodate increased demand. | This is considered as part of our technical standard review | Improved future resilience to climate change |
| Cold weather | 29 | Fracture risk to underground infrastructure from increased winter temperature variability and freeze / thaw damage | 29a. Investigate vulnerability of underground services to climate change risks from fracture / damage and ensure appropriate adaptation changes are incorporated into future development plans where appropriate. | We survey buried services for condition. A significant risk is mechanical damage during excavations, poor installation or deterioration due to age. New services are not laid at shallow depths to avoid damage due to temperature extremes. | Increased resilience to fracture risk to underground infrastructure |

## Update on risks requiring a watching brief

21 risks were identified that did not need immediate action but required a watching brief. The progress against these is summarised in Table 12.

**Table 12: Risks requiring research**

| Climate impact on Heathrow | Risk ID | Risk | Update since 2011 | Additional action required |
|---|---|---|---|---|
| Flooding | 6 | Torrential rain creates hazardous conditions for vehicles and planes i.e. airside and landside road vehicles and planes i.e. and taxiing and | Monitor impact of torrential rain on airside and landside road vehicles and planes. | Continue to maintain a watching brief |

| | | | | |
|---|---|---|---|---|
| | | landing aircraft | | |
| **Cold weather** | 22 | Freeze / thaw damage of surfaces as winter temperatures become more variable | We survey buried services for condition. A significant risk is mechanical damage during excavations, poor installation or deterioration due to age. New services are not laid at shallow depths to avoid damage due to temperature extremes. | Increased resilience to fracture risk to underground infrastructure |
| | 25 | Wintry conditions pose health and safety risks for passengers and staff | We have plans in place to clear paths and manage slip hazards in winter to ensure the safety of staff and passenger. We provide staff with appropriate protective clothing and equipment, adequate breaks and accommodation. There has been no increase in cold related incidents. | Continue to maintain a watching brief |
| **Overheating** | 5 | Reduced lift for departing aircraft due to 'thin air' and reduced engine efficiency in very hot weather. | No perceptible change in impact on aircraft performance since 2011. | Continue to monitor through weather trend analysis and maintain watching brief |
| | 20 | Heat stress risks to staff, particularly those in highly physical roles. Additional cooling costs may result. | Newly launched wellbeing toolkit provides sun awareness briefings to manage heat impacts. Team briefings take place on hydration. There has been no increase in sun or heat related incidents. | Maintain watching brief |
| | 28 | Overheating on surface access transport from rising temperatures | Watching brief. No perceptible change in impact since 2011. | Continue to monitor and raise with public transport operators and Highway Agency |
| | 31 | Heat wave conditions result in negative impact on air quality. More difficult to comply with air quality standards | Air quality standards do not apply directly to Heathrow but to the UK government. Heathrow is working to reduce emissions of air pollutants under our control, and we continue to work with others to reduce emissions not under our control. Air quality forecasts are predicting improved air quality as future reductions in emission from diesel vehicles (airport-related and not) are anticipated.<br>Stronger and more frequent south-easterly winds blowing in pollution | Continued implementation of Heathrow's 2011-2020 Air Quality Strategy and Action Plan.<br>See Heathrow's 2015 and 2016 blueprints for reducing emissions[14]. |

[14] http://www.heathrow.com/file_source/Company/Static/PDF/Communityandenvironment/air-quality-strategy_LHR.pdf

| | | | | |
|---|---|---|---|---|
| | | | from the continent could lead to more frequent and severe pollution episodes, negatively impacting local air quality, making it more difficult to comply with air quality standards | |
| **Water shortage** | 21 | Drought conditions affect water availability and cause bore hole levels to drop. Restrictions may be posed to water intensive activities | Drought conditions imposed in 2011. We have assessed the impacts from temporary use restrictions (lowest forms of restrictions) and there is little significant impact. Primary issue is reputational, particularly cleaning activity. Responses were tested in the drought during 2011. Of particular concern is the impact on vehicle washing. We have subsequently installed recycling/harvesting vehicle washes airside where there is a safety case for vehicle cleanliness. | The future water strategy for Heathrow includes provision of harvesting and water recycling to offset the impacts of a more significant emergency drought order by recirculating Heathrow generated water supplies not reliant on the wider environment. Cuts in water consumption will reduce the demand on local water sources supporting the objectives of the local water supplier. |
| **Fog** | 7 | Seasonal changes to fog related disruption (increase in winter months, decrease for remainder of year) | No significant change to frequency of fog. However improvements to increase resilience to the impact of fog (in terms of changes to low visibility procedures or LVPs) have been made through the installation of new enhanced Instrument Landing Systems (ILS), the establishment of Met Office forecasters at Heathrow, improved procedures for planning aircraft flow when fog is forecast, and, working with pilots, the CAA and NATS, improvements to the cloud ceiling / visibility parameters that trigger the introduction of LVPs as well as an improved cleaning / maintenance regime for runway lighting that again improves the threshold for introducing LVPs. | Further improvements to improve forecasting capability are planned. Continue to monitor trend of fog frequency |
| **Lightning/ wind/ flooding** | 8 | Increased risk of schedule interruption from stormy conditions | Time based separation has been in in place since May 2015. This allows improved arrival approach separation in strong wind conditions with potential to land an extra 4 aircraft an hour.<br>Demand and capacity balancing | Monitor through weather trend analysis and maintain watching brief |

| | | | | |
|---|---|---|---|---|
| | | | (DCB) by creating a plan for the day by balancing aircraft demand (predicted arrival and departure time) with airport capacity. See case study 3.<br>Improved collaboration with airlines regarding punctuality performance improvement including BA Ops Effectiveness Programme & turn-round management. See case study 6. | |
| **Wind** | 9 | Increased longevity of wing tip vortex effect due to general becalming of surface wind speeds | Investigating feasibility of Improving arrivals and departures Wake Vortex separations as part of a European Wake Vortex Re-categorisation (RECAT-EU) | Monitor through weather trend analysis and maintain watching brief |
| | 10 | Change to prevailing wind direction affects runway utilisation and schedules. | Monitor through weather trend analysis and maintain watching brief | Continue to monitor and maintain a watching brief |
| | 23 | Increased risk of wind damage to assets, standing aircraft, vehicles and injuries to staff | Monitor and maintain watching brief | Continue to monitor and maintain a watching brief |
| **Lightning** | 11 | Disruption to airfield operations from lightning i.e. refuelling suspension, changes to flight routing. | Demand and capacity balancing (DCB) by creating a plan for the day by balancing aircraft demand (predicted arrival and departure time) with airport capacity. See case study 3.<br>Improved collaboration with airlines regarding punctuality performance improvement including BA Ops Effectiveness Programme & turn-round management See case study 6.<br>Monitor refuelling suspensions. | Monitor through weather trend analysis and maintain watching brief |
| | 24 | Impacts of lightning on control systems and electricity supply. Power cuts and voltage spikes to parts of the airport not run on UPS during electrical storms | Running on a UPS during a storm is unlikely to provide complete protection from lightning strikes. Where the risk to equipment is high (e.g. long runs of copper cable), lightning protection units are used at Heathrow. Power cuts in general are dealt with through resilience of supply based on the significance of the equipment or service. Heathrow has three separate | |

| | | | | |
|---|---|---|---|---|
| | | | intakes from the national grid, and categorises each of its supplies as A, B or C. 'C' supplies are not resilient; 'B' supplies are fully resilient with duplication of all components as a minimum; and 'A' supplies are highly resilient with many levels of redundancy. 'B' supplies are used for operational areas, 'C' supplies are used for the airfield and other safety related functions. All systems are designed in compliance with G5/4. | |
| **Indirect – bird strike** | 4 | Change in distribution of pests and wildlife species. Potential changes to bird migration patterns and bird strike risk. | We have been actively monitoring the movement of birds across the airport since 2011. Results of monitoring feed into the Heathrow Bird Strike Group. We have also been actively monitoring wildlife species on site through our well established Biodiversity Action plans. | Any changes in the distribution of birds or other wildlife species will be assessed and action taken if necessary. |
| **Indirect – pax, staff** | 26 | Offsite impacts (snow, flooding, storms etc) could impede the flow of people (pax, crew, staff) if destination airports or the UK surface transport network is affected | Communications between external stakeholders (Highways England, TfL, EA, etc.) and Heathrow Airport Operations Centre (APOC), allows for a proactive response during forecasted events.<br>Met Office forecaster on site in APOC results in improved forecasting.<br>Mitigation plans in place to deal with snow and significant rain fall events on the airport campus. | Maintain current activity and assess opportunities for improving communications and information sharing as APOC evolves. |
| **Indirect – supply chain** | 27 | Remote impacts could restrict the flow of essential supplies to the airport | Heathrow has a Responsible Procurement Policy and assesses the impact of procurement activities on our key sustainability impacts. | Consider climate change impacts during the Procurement process |
| **Indirect – network / passengers** | 32 | Changes to global distribution of disease could increase likelihood and frequency of epidemics and pandemics | Protocols in place to deal with and manage communicable diseases.<br>Regular communications between Heathrow and Public Health England regarding potential risks. Details communicated to wider community when required.<br>Plans exist for a loss of resource as a consequence of epidemic / pandemic. | Maintain current activity and assess opportunities for improving communications and information sharing as APOC evolves. |
| **Indirect – network** | 33 | Sea level rise / storm surge risks | Airline Business Development team engaged with airlines to ascertain | Maintain current activity |

| | | | | |
|---|---|---|---|---|
| | | loss of low lying destination airports i.e. Schiphol, Hong Kong (without adaptation) | potential impacts on their services to LHR.<br>Plans in place to deal with extreme weather events such as typhoons, snow, etc. | |
| **Indirect – infrastructure** | 34 | Sea level rise / storm surge risks disruption to UK infrastructure i.e. utility supplies, surface transport routes (without adaptation) | Engagement between Met Office and Environment Agency to ascertain impact to LHR | Consider climate change adaptation during the Procurement process of utility suppliers.<br>Understand interdependencies<br>Maintain involvement in the IOAF |

## 5.2 Risk review

Heathrow follows a corporate risk process, which is outlined in section 4 of the Heathrow Operational Resilience Plan[15]. In accordance with this risk process, Heathrow regularly reviews the climate change adaptation risk register to assess progress against actions, review risk ratings and identify any new risks.

The climate change adaptation risk assessment falls within the 'risks and opportunities' section of our Environmental Management System. Progress against the actions is tracked through our internal governance structures. Where climate change risks require action in the immediate to short term, these actions are actively embedded in the appropriate operational department's risk register. Risks which require a 'watching brief' approach are regularly reviewed by our Strategy department, with discussions with operational departments taking place as appropriate.

Further work is underway to ensure that Heathrow's climate change adaptation risks are embedded into other key business processes:

- our management of assets, through Heathrow's asset management system, which is certified to the international standard on asset management systems (ISO55001:2014)
- operational resilience planning, consideration of climate change adaptation risks during the operational resilience review cycle
- Procurement process

The climate change adaptation risk profile will change if Heathrow is approved to proceed with plans for a third runway. Following Government approval, the third runway design will be progressed and refined. Climate change adaptation and resilience will be included as key design principles.

## 5.3 Understanding interdependencies

We have mapped out the key interdependencies that Heathrow relies upon to operate efficiently and provide our passengers with the best airport service on the world. These can be split into those organisations that rely upon 'on the ground' transport or connections, and those that rely on connections via the air.

**'On the ground' interdependencies**

**Supplies** (including cargo)

- Road network (HGV)
- Rail

**People** (passengers & staff)

- Road (cars, bus/coach, taxi)
- Rail: London Underground / Heathrow Express / Heathrow Connect

**Utilities**

- Electricity and gas
- Water
- Aviation fuel
- Information and telecommunications

[15] 2015 Operational Resilience Plan

Heathrow relies on an extensive surface transport network to bring people and products to and from the airport. Heathrow is connected to the local road and highways network. When there is congestion on the road network, Heathrow is impacted by passengers and staff not being able to reach the airport on time. Heathrow is also connected to the London Underground and rail network (Heathrow Express and Heathrow Connect).

We are working with other transport providers to increase the routes and frequency of trains, bus and coach services[16]. This will help to increase the number of options to reach the airport.

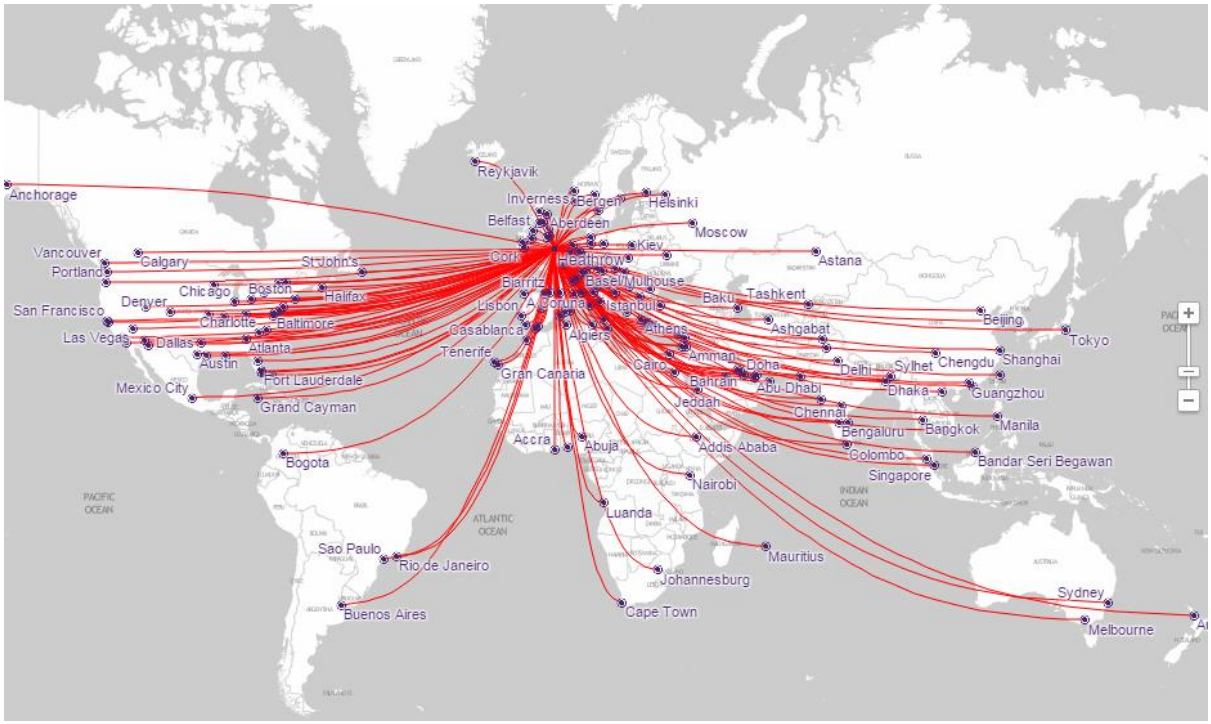
The efficient operation of Heathrow is also reliant on uninterruptable supplies of utilities to the airport. This includes electricity, gas, water, fuel, and information and telecommunications (ITC) infrastructure. Through our Responsible Procurement process we ask suppliers about their approach to resilience and that in turn they are aware of Heathrow's approach.

We also have plans to become more self-sustainable, for example we are reviewing our energy supply strategy to assess if more energy can be provided on-site, and move away from sole reliance on grid electricity.

Heathrow is the only airport member of the Infrastructure Operators Adaptation Forum, co-ordinated by the Environment Agency. Through this forum, Heathrow is involved with a working group looking at how to address interdependencies. This working group is in its early stages and Heathrow is planning to work on this area further.

16 http://www.heathrow.com/file_source/Company/Static/PDF/Communityandenvironment/Reducing_Traffic_New_Plan_for_Public_Transport.pdf

**'In the air' interdependencies**




Heathrow is the UK's only hub airport. Heathrow's passengers can access 80 different airlines and airline alliances to 183 destinations in 81 countries.

As discussed in section 2.2, Heathrow is running at 98% capacity. When there is disruption in other parts of the airspace network, due to the capacity constraints at Heathrow, there is not room in the schedule to easily accommodate changes.

Heathrow airport is directly affected by weather events immediately affecting London and the south-east of England. In addition, Heathrow is also indirectly affected by weather events in London and the south-east of England that have an impact on the arrival and departure routes of aircraft, and of passengers and staff getting to and from the airport. Arriving and departing aircraft will also be impacted by weather at the connecting airport in other parts of the UK or internationally, which can have an impact on the schedule. The case study 6 shows how we are working with our partners to improve performance during weather disruption.

**Case Study 6: Improved collaboration with airlines**

During weather disruption both the ground and air operations come under significant challenge. This is due to rolling and changes sector regulations being applied to the airspace due to safety grounds. It is very important during these situations that the ground operations try to maintain as stable as possible target off times (TOBT) so that the expected traffic demand counts can be factored into the busy and congested airspace.

A joint initiative is underway with airlines, ground handlers, ATC and the Network Operations under the Airside Operations new "Strive for Five Punctuality and efficiency improvement programme". This programme involves working together more efficiently and transparently, sharing data and targets punctuality performance improving TOBT through management of pre-departure milestones. This adds resilience and stability to the very challenging Heathrow operation. We have also launched this year, a new approach to Operational Intelligence (Performance Management).

Accurate departure times have a dual benefit, they:

- Allow all airport partners to use their assets more efficiently
- Enable better utilisation of European airspace
- Improve information to the Network, resulting in dynamic improvement of regulation slots (CTOT's).

At thirty minutes before departure we use the TOBT to create a 'virtual place' for the aircraft on the runway and provide visibility of an expected Target Start-up Approval Time (TSAT). We also use the TOBT to calculate a Target Take-Off Time (TTOT) that is communicated to the Network Manager (NMOC) in Eurocontrol. This TTOT is used in the management of European airspace.

## 5.4 Addressing barriers

Heathrow's original Climate Change Adaptation Report in 2011 identified eight categories of barriers to successful adaptation, these are detailed in Table 13. These have been reviewed and all remain valid as barriers to successful adaptation.

Heathrow recognises that the main barrier to implementing action on climate change adaptation is a lack of certainty in changes to specific climate variables (e.g. wind speed, fog). Where there is certainty in change, evidence of changing climate and there is a business case for investment, then adaptation measures are taken. The main barrier to Heathrow building resilience against future climate change is the lack of runway capacity.

**Table 13: Barriers to successful adaptation**

| Barrier | Explanation from 2011 ARP report |
|---|---|
| Scientific uncertainty | Scientific uncertainty regarding the pace and scale of climate change – particularly scientific uncertainty surrounding some variables not currently available in a probabilistic fashion i.e. prevailing wind direction. |
| Financial uncertainties and resource constraints | Heathrow, like all businesses, acts within financial constraints. The airport has to balance the need to invest in adaptation with other business investment priorities. |

| | |
|---|---|
| | Furthermore as a regulated company its return is regulated by the CAA in 5 year cycles that don't necessarily match the long term timescale challenges posed by climate change. |
| Uncertainty regarding future aviation industry developments | Uncertainty with regard to long term development trends within the aviation industry, demand projections, destination trends, aviation technology changes and future development plans at the airport in the medium and longer term can act as barriers to adaptation. |
| Space constraints | Heathrow's footprint is comparatively compact when compared to other major hub airports around the world. Space constraints on the site do limit the storage of supplies onsite and limit the ability of Heathrow to expand some infrastructure and assets which would improve adaptive capacity at the airport. |
| Runway capacity constraints | Heathrow is among the most congested airports in the world and the lack of spare capacity means that unlike many other British or European airport, Heathrow has very little room to manoeuvre when disruption occurs. |
| Permitting constraints | Heathrow's activities are constrained by numerous permitting constraints reflecting the airport's proximity to residential areas i.e. the night flight quota, Cranford Agreement, air quality and noise footprint limits. Some of these permitting constraints may affect the adaptation options available to the airport. |
| Interdependencies | As a landlord to many other organisations based at the airport, Heathrow is limited in how directly it can shape the adaptation undertaken by other organisations. Not all adaptation decisions will be taken in-house by Heathrow and the airport operator will be affected by the degree to which other bodies at the airport choose to adapt to climate change.<br>Furthermore, Heathrow relies on external, offsite third party organisations for some of its essential services i.e. fuel, staff transport, power, potable water and should climate change negatively impact these services then the adaptive capacity at Heathrow could be impaired. |
| Other legislative requirements | Heathrow's adaptation response will need to be balanced with other regulatory requirements. Primary amongst these is the need to maintain airfield and aviation safety. |

## 5.5 Monitoring and evaluating

**Business as usual monitoring**
Punctuality and cancellations are tracked in real-time by Heathrow's Airport Operations Centre (APOC). APOC produce a daily summary of performance, and attributes the cause of any cancellations or significant delays – including weather related disruption.

Heathrow plans to undertake periodic analysis of adverse weather related disruption compared to punctuality data to identify any long-term climate trends already affecting Heathrow's operations, or which might affect operations in the future.

**Reviewing incidents**

Heathrow's Operational Resilience Plan requires that a post incident review be undertaken with the relevant stakeholders following the deployment of incident mitigation plans. These reviews incorporate consideration of the incident response, the effectiveness of the plans, the identification of areas for improvement and of additional preventative measures. The findings from these reviews are then used to improve plans and responses to subsequent events. We have worked with the airport community and seen improvements in our resilience, incident avoidance and improved response to disruptive events.

Heathrow's 2015 Operational Resilience Plan sets out the following post incident review procedure:

'*10.23 In the event of mitigation plans being deployed a post incident review should take place to ensure that any learning and issues are captured and dealt with in the appropriate manner.*

*10.24 At Heathrow, these reviews entail a "hot wash-up" immediately following the exercise or event followed by a "cold wash-up" no more than six weeks after the event. The purpose of the "hot wash-up" is to capture and immediate concerns whilst the "cold wash-up" gives those involved the time to reflect on the incident and their response.*

*10.25 Heathrow endeavours to complete the reviews sooner than the timescale detailed above however a significant event or exercise involving a multi-agency response may take this long (e.g. major baggage failure). The findings of these reviews should be published and shared with the stakeholders involved.*

*10.26 The findings from these reviews are then used to improve the plans and response to subsequent events. '*

Since 2011, the following weather-related disruptive events have been reviewed as part of the Operational Resilience Plan:

| | |
|---|---|
| 16th December 2011 | Snow |
| 2nd February 2012 | Snow |
| 23rd October 2012 | Fog |
| 18th January 2013 | Snow |
| 10th February 2013 | Snow |
| 28th October 2013 | Storm Jude |
| 11th December 2013 | Fog |
| 26th August 2015 | Rain |
| 1st November 2015 | Fog |
| 28th March 2016 | Storm Katie |

Heavy rainfall event at Heathrow Airport, 26 August 2015

## 5.6 Embedding

**Embedding climate change adaptation and resilience within Heathrow**

Heathrow's environmental management system is aligned with the revised international standard on environmental management systems (ISO14001:2015). The standard requires that organisations consider climate change adaptation and resilience within their management systems.

In addition Heathrow's Environment and Energy Policy states a commitment to climate change adaptation and resilience:

***"Work with our airport partners to ensure that the airport plays its role in respecting environmental limits, and adapting to the effects of a changing climate."***

**Collaborating within the airport and aviation sector**

### Airport Operators Association

Heathrow is a member of the Airport Operators Association (AOA). The AOA is a trade association, founded in 1934, that represents the interests of UK airports and is the principal body engaging with the UK government and regulatory authorities on airport matters.

### Sustainable Aviation

Heathrow is also a member of Sustainable Aviation (SA) – a coalition of the UK's airlines, airports, manufacturers and air navigation service providers. SA is driving a long term strategy to deliver cleaner, quieter, smarter flying. SA is the first alliance of its type in the world, and reports regularly on progress in reducing aviation's environmental impact.

### Eurocontrol and Airports Council International (ACI Europe)

Eurocontrol is the European Organisation for the Safety of Air Navigation. It is an intergovernmental organisation with 41 Member States, committed to building, together with its partners, a Single European Sky that will deliver the air traffic management performance required for the twenty-first century and beyond. Eurocontrol recognises that the aviation industry must ensure the resilience of its infrastructure and the provision of safe, reliable operations and passenger services in a changing climate.

ACI EUROPE is the European region of Airports Council International, the worldwide professional association of airport operators.

Eurocontrol provides organisations with a single entry point to key resources on climate resilience, as well as a toolkit of questions and case studies to help initiate a climate risk assessment. Heathrow has been included as a case study in Eurocontrol and ACI Europe's recent Adapting Aviation to a Changing Climate summary publication[17].

[17] http://www.eurocontrol.int/sites/default/files/content/documents/official-documents/factsheets/aviation-climate-resilience-factsheet-2014.pdf

## 5.7 Climate change opportunities for Heathrow

The seven climate change related opportunities identified in Heathrow's first Climate Change Adaptation Report were based upon projected changes and trends in climate over the medium to long term. There have not been any opportunities realised which can be clearly linked to climate change since the first Climate Change Adaptation Report was published in 2011.

A short summary for each of the seven opportunities is provided in Table 15 below. However, it is not possible to link these directly to changes and trends in climate. We continue to monitor these opportunities through Heathrow's internal governance structure.

**Table 15: Climate change opportunities for Heathrow**

| |
|---|
| 1. Changes to destination choice due to negative climate change impacts overseas could increase the flow of in-tourists to the UK. Conversely this may reduce outbound tourism if more people decide to holiday in the UK which could be a negative impact for Heathrow. It is not possible to quantify the net change on the strength of current evidence. |
| 2. Disease impacts in other parts of the world and a worsening of health outcomes and thermal comfort (i.e. an increased risk of heat stress in Mediterranean countries) may reduce destination demand for many parts of the world in terms of holiday destinations, and increase demand for travel to the UK. Conversely this may reduce outbound tourism if more people decide to holiday in the UK which could be a negative impact for Heathrow. |
| 3. Loss or damage to competitor hub airports due to sea level rise or other climate change impacts could increase the volume of passengers using Heathrow. |
| 4. Warmer temperatures are likely to shorten the heating season at Heathrow, whether this reduction in energy demand for heating is likely to be outweighed by an increase in cooling demand is uncertain. |
| 5. A potential reduction in fog frequency over the average year, and a potential decrease in the likelihood of snow could lead to a reduction in weather-related disruption at Heathrow in the future. Given the future variability of the climate projected to result from climate change and the fact that snow and fog cannot be ruled out in the future, it is however, important that control measures to respond to snow or foggy conditions are maintained. |
| 6. Changes to the climate could result in a reduction of the bird strike risk at the airport if the avian population in the vicinity of the airport reduces, or the species mix changes toward smaller non-flocking species. However there is considerable uncertainty about how climate change may affect avian populations and migration routes so this opportunity should not be assumed. |
| 7. New seasonal or climatic opportunities could arise for Heathrow and its retail tenants providing that they adapt the seasonality of their retail mix and product offerings accordingly. |

## 5.8 Next Steps

We are committed to continuing to address the risks posed by climate change on our business, customers and other stakeholders. We have identified the following next steps in our approach:

- Continue to review Heathrow's climate change adaptation risk register on a regular basis, monitoring progress against actions, assessing risk status and identifying new risks posed by climate change
- Continue to review and where necessary improve our operational controls to manage the impact of the changing climate on our business resilience
- Continue to incorporate further improvements in climate change adaptation and resilience into future business plans
- Regular review of progress in climate change science and new information, updating our risk register and operational controls where necessary. In particular reviewing the UK's new set of climate change projections (UKCP18) when they are published in 2018
- Continue to play an active role in climate change adaptation forums through attendance at:
    - London Climate Change Partnership
    - Environment Agency's Infrastructure Operators Adaptation Forum
- Work with the aviation industry to share learning on climate change adaptation and resilience

## Appendix 1: Transport Resilience Review (July 2014) recommendations relevant to Heathrow, and Heathrow's response submitted on 23 October 2014

**Recommendation 9**
**With the winter's experience fresh in the should revisit their Climate Change Risk Assessments and Adaptation Plans in advance of winter 2014.mind, operators of strategic transport infrastructure**

1. Heathrow's Climate Change Adaptation Report was completed and submitted to DEFRA under the Adaptation Reporting Power in 2011.

2. We assessed climate risks in the short (to 2020) and medium to long term (2040/50). In the short term, based on current mitigation, most risks are considered low with the remainder assessed as moderate. In the medium to long term two significant risks were identified that relate to (1) the capacity of our pollution control system; and (2) fuel spill response due to higher summer temperatures.

3. We have reviewed our risk assessment in 2014 and, in the main, the findings remain current. The weather conditions from Winter 2014 have not significantly changed the assumptions and findings in the Climate Change Risk Assessment.

4. We will be providing a progress update on our Climate Change Adaptation Report to DEFRA in 2015. This will be used by DEFRA to inform the next UK Climate Change Risk Assessment due in 2017 and the National Adaptation Programme expected to be published in 2018.

**Recommendation 10**
**All transport operators should have contingency plans to cope with extreme weather events. For infrastructure operators these should extend to include their major customers, and at a minimum be developed in consultation with them. Contingency plans should be regularly rehearsed and progressively extended to take account of a wider range of extreme weather scenarios as experience develops.**

1. Heathrow Airport has developed a series of plans that could be deployed in the event of disruption based on a combination of experience of previous events, the risk assessment process and assurance that the plans are resilient by design (ease of use, reliant on roles not individuals, etc.) These plans include the following:

**Operational Safety Instructions & Emergency Orders**
Operational Safety Instructions are issued to the airport community to advise them of processes or procedures to be followed that affect the airfield or aircraft. They are identified through previous events, wash-ups and horizon scanning. They include a wide range of issues such as:

- Protocol for the Notification of Infectious Disease at Heathrow Airport
- Low Visibility Operations
- Escorting of Vehicles Airside

As part of the Airfield Licence, CAP 168, there is an obligation to produce plans called the Emergency Orders for a series of predefined emergencies. These emergencies are:

- Aircraft accident imminent

- Aircraft accident on airport
- Aircraft accident off airport
- Aircraft ground incident
- Full emergency
- Threat to aircraft or ground installation
- Renegade aircraft
- Local standby
- Act of aggression
- Evacuation of Heathrow Express or London Underground

The development of Emergency Orders involves he collaboration and participation of all agencies involved in the response to a listed incident. These agencies are:

- Air Traffic Control
- Metropolitan Police
- London Ambulance Service
- London Underground
- Airport Fire Service
- London Fire Brigade
- Airlines / Handling Agents
- Heathrow Express

**Contingency Plans**

Where a risk cannot be reduced sufficiently through preventative measures there may be a need to develop a contingency plan. A contingency plan is put in place to manage the consequences of an incident whilst ensuring that unaffected parts of the operation continue with minimal knock-on disruption.

Heathrow has a suite of contingency plans that would be deployed during disruptive events. The objective of these plans is to deal with the consequence of the disruption through common response types as opposed to seeking to remedy the cause. The consequence types are:

- Loss of Facility
- Loss of Utility
- Loss of Systems
- Loss of Resources
- Evacuation
- Congestion

The contingency plans are developed by the Operational Business Units and the Business Resilience team. Depending on the plan under development other airport stakeholders such as Airlines or Handlers will be involved in the process.

On completion, the plans are exercised by means of desk-top or live exercise play prior to being signed-off. The plans are reviewed on an annual basis or following a deployment of the plan or any significant changes within the Business Unit.

The opening of the Airport Operating Centre (APOC) in November will see the consolidation of the business-as-usual standard operating procedures and contingency plans into one location. This will allow for better monitoring during normal operations and more efficient deployment of contingency plans during disruption.

**Business Continuity Plans**

A business continuity plan is a plan developed to ensure that a proportion of the operation is delivered in the event of a significant event such as fire, flood or loss of IT / facility / infrastructure.

Heathrow has a number of business continuity plans that have been developed to address key operational incidents. Whilst contingency plans will be deployed to deal with the immediate consequence of an incident, the business continuity plans are deployed in order to maintain a level of operational performance.

These plans are:

- Loss of the Main Tunnel
- Loss of Resource
- Loss of Control Tower
- Secondary Gate Screening
- Interruption to aviation fuel supply
- Loss of IT systems
- Loss of Perimeter Roads
- Loss of Compass Centre

On completion, the plans are exercised with the relevant stakeholders prior to being published on the Heathrow intranet and shared with relevant stakeholders.

The Airside Operations team have a number of processes that can be deployed to ensure airfield operations continue during disruptive events. These processes are:

- Demand versus Capacity
- HADACAB (Heathrow ATM Demand and Capacity Balancing Group)

**Recommendation 11**
**All transport operators should ensure they have clearly agreed channels for receiving weather and flood forecasts. These should be monitored in real time during periods when extreme weather is expected.**

1. Information about the weather is critical to airport operation.

2. Heathrow now has its own on-site weather forecaster, fully integrated into our new control centre - APOC. The airport takes five-day-out probabilistic forecasts, which allows early commencement of alerts to an impending event. 24hrs out, the Heathrow snow response forecast provides hourly updates of time of onset, time of cessation, accumulation, temperature, with deterministic decision at T-8 hours. Climatic forecasts are provided giving a 3 month out forecast of climate differentials.

3. Additionally, runway surface temperature devices fitted to both runways allow actuals to be assessed against forecast information.

4. The Met Office manager provides support and information on the development of potential events, as well as participating in weather event training and drills.

**Recommendation 12 – N/A**

**Recommendation 13**
**All transport operators and authorities should develop, test and implement a dedicated passenger and user communications plan for times of transport disruption.**

**Communication during Disruptive Events**

1. Within the Heathrow Corporate Affairs Directorate there is the recognition that during a disruptive event the requirement for information from staff, stakeholders and passengers increases significantly. In this instance the principles that guide the communication process are:

- Provide reassurance to Heathrow's stakeholders.
- Provide tangible examples of what Heathrow is doing to resolve the situation.
- Ensure there is an integrated and coordinated approach between the Operations and Corporate Affairs.
- Ensure that the communications and message is relevant to the audience.

2. During such a disruptive event the communication objectives are:

- Enable passengers to make good decisions.
    - Give up to date and accurate information on flight delays and cancellations.
    - Give advice on travelling to the airport.
    - Give information on welfare / security arrangements.

- Ensure that information and messages are consistent and correctly aligned.
    - Identify and correct misinformation.
    - Identify and respond to stakeholder concerns.
    - Assist stakeholders in understanding and supporting the operational response.

- Support the Operation.
    - Give clear messages to passengers, Heathrow staff and airport community stakeholders both directly and by coordinating with 3rd parties such as Transport for London.
    - Engage with stakeholders to secure support for exceptional operational measures.

3. This involves coordination:

- Between internal teams of Heathrow Airport Limited.
- With our airport community stakeholders, including airlines, handlers, Border Force, etc.
- With third party stakeholders, including local and national government and emergency services.

4. Various forms of communication designed to ensure that all parties (internal Heathrow staff, community stakeholders and passengers) are kept informed during the disruption are deployed. This will include situational reports, conference calls, social media, email updates and press releases.

**Recommendation 14**
**Transport and network operators should:**

- **Give prominence on websites to the latest service information during periods of disruption, ensuring that marketing and promotional information is relegated to the background at these times.**

- **Use everyday language, not technical jargon to explain what is going on and causing the disruption. There is scope to research descriptions and phrases to use to test passengers' reactions during 'peacetime'.**
- **Ensure consistency of information provided through different channels and by different parties. This will involve lines being agreed and re-agreed by all the key parties involved – e.g. airports and airlines, Network Rail and the train operating companies - and communicated through the variety of channels available.**
- **Make greater use of photographs distributed by text or social media, to improve transport users' understanding of the reasons for disruption.**

1. During a disruptive event the Crisis Communication Team will activate their Incident Response Teams and have membership within the Bronze, Silver and Gold teams.

2. At the delivery level, the Crisis Communication Team is organised into four Incident Response Teams, reflecting the business-as-usual structure: Passenger; Internal and Airport Community; Policy / Political and Media.

***Communications Incident Response Teams***

| *Team* | *Role* |
|---|---|
| *Passenger* | *- Deliver accurate, clear and timely information to passengers, allowing them to make informed decisions.*<br>*- Respond with agility to social media comment, enquiry and sentiment by carefully selecting the right channels depending on the situation.*<br>*- Support the Heathrow Welfare team in delivering appropriate messages and advice to passengers.*<br>*- Advise passengers on their rights and next steps regarding claims under EC261 – if appropriate.* |
| *Internal and Airport Community* | *- Deliver accurate, clear and timely information to Heathrow employees and the airport community, including airlines and other on airport stakeholders.*<br>*- Provide relevant information so that audiences can make well-informed decisions or respond appropriately to calls for support and action.*<br>*- Support the relevant Heathrow Command & Control Commander to draft messages for dissemination to staff and stakeholders.* |
| *Policy / Political* | *- Deliver accurate, clear and timely information to key external stakeholders and shareholders.*<br>*- Facilitate site visits by key stakeholders.*<br>*- Identify areas where key stakeholders can support recovery.* |
| *Media* | *- Deliver accurate, clear and timely information to the media.*<br>*- Ensure strong alignment of messages with airport stakeholders which include airlines, handlers, Border Force and others.*<br>*- Protect the reputation of Heathrow by responding with agility to a changing news agenda and social media.*<br>*- Continually assess reporting to ensure it is accurate.*<br>*- Prepare spokespeople for interview.*<br>*- Facilitate media access where appropriate.* |

3. In some scenarios, prior to an event occurring, early identification of a risk or incident may enable advance communication of information to the Heathrow Community or passengers. This enables internal resource to be mobilised, stakeholders to make plans or decisions and inform passengers about an expected event and possible disruption (e.g.: seven days' notice in advance of industrial action).

4. Bronze and silver communication Situation Reports (Sit Reps) provide the foundation and „one source of truth" for the communications teams and contain the key messages that can be shared across all relevant audiences. The Communication Sit Reps are produced after each bronze / silver conference call. They include:

- Reinforcement of the three tenets of crisis communication – care, concern, control – and what Heathrow is doing to demonstrate these.
- Up to date information on the operational situation including what has changed since the last Sit Rep.
- The communications actions to be taken.
- The current communications line to take.

**Recommendation 15**
**In the face of an extreme weather event, or a high-confidence forecast of extreme weather, transport operators should plan for the best practicable service which they can realistically deliver, and which manages expectations, providing a high degree of certainty to passengers, other users and industry partners.**

1. If disruption is expected to occur for a prolonged period HAL may invoke Local rule 4 – Heathrow Procedures for Temporarily Reduced Capacity ("HADACAB").

2. The HADACAB processes are a well-established and tested set of procedures for agreeing reduced capacity at the airfield due to significant operational events such as snow. For less significant forecast disruption such as high winds, storms or even light snow HAL have developed a set of demand versus capacity procedures that allow the following days" operation to be managed more effectively in the passengers interest. These procedures, developed in partnership with CAA, NATS, Met Office, airlines, Aircraft Coordination Ltd and the AOC, have been in trial since October 2013 and will be formalised for winter 2014/15.

3. Heathrow will also suspend the allocation of ad-hoc slots during adverse operating conditions e.g. severe weather when it is expected that the conditions are likely to lead to significant and prolonged disruption or delay. This mechanism facilitates both the suspension of allocation of new ad-hoc availability and also it permits the withdrawal of ad-hoc slots upon reasonable notice. This measure prevents slots being recycled and provides the schedule with some flexibility to re-organise the disrupted demand.

4. HAL has upgraded the current slot booking system to enable the suspension and re-allocation of ad-hoc slots to be "switched" on and off both during office and out of hours. This has historically not been available.

5. From November 2014 the new Airport Operations Centre, APOC, will become live at Heathrow. This is a single control room facility housing all key operational functions designed to ensure improved coordination of all decision making and key resources.

**Recommendation 16**
**Transport operators should have checklists of resources which they will need as part of their recovery effort from different weather- related events, with details such as the location, owner and source(s).**

1. Heathrow Airport works to the UK standard of Integrated Emergency Management for disruptive events. In line with this standard, Heathrow and many of the airport stakeholders operate a Bronze, Silver and Gold Command structure. This structure consists of over 400 staff on call throughout the year to respond to a disruptive event at the airport.

2. This number does not include the large number staff who would support the airfield and ground transport response to a snow event.

**Recommendation 17**
**Transport operators should consider whether they have the best possible organisation of their intra-industry crisis management machinery, taking account of the benefits of working more closely with their partners. They should similarly review their participation in wider cross-sector fora, to ensure they are appropriately represented and the benefits of closer liaison between modes are secured.**

1. At each level of the command and control structure membership is made up of representatives of both Heathrow Airport and additional Airport Stakeholders. These Stakeholders include:

- AOC
- Metropolitan Police
- Handling Agents
- Airlines
- Border Force
- Subject Matter Experts

2. In the event of an activation of the command and control teams a number of these Airport Stakeholders will receive the notification alarms and then attend the appropriate location / team.

3. Within each command and control team the Lead or Commander will assign roles and responsibilities to those attending. Airport Stakeholders represent their respective agency and will offer advice / guidance / support depending on the incident or crisis that is underway.

4. The communications strategy for any incident or crisis will be discussed and agreed by the communications departments of the respective agencies. For some events the communications will be led by the Emergency Services (e.g.: major fire or security threat) with the Heathrow using this information to update Stakeholders and inform passenger.

5. The new Airport Operations Centre will incorporate a Police presence for the first time allowing a joined-up approach in day-to-day operations and ensuring that any response to an incident is coordinated from the outset.

**Recommendation 57**
**All major ports and airports should review the location and flood- protection of their power, communications and IT infrastructure in light of the winter's experience at Immingham and Gatwick.**

1. Heathrow has identified the risk from different flooding scenarios and we are finalising the Heathrow Flood Plan to manage these different flooding risks. The experience of Winter 2013/14 supports Heathrow's assessment of risk from groundwater flooding as adequate for the rise in groundwater levels experienced, and tested contingency plans.

2. We are managing the risk of flooding in a similar approach to local authorities – we identify the risks and develop a plan to manage these risks to improve our resilience.

3. Heathrow's Strategic Flood Risk assessment was completed in 2010. We have modelled on and off airport areas at risk of flooding. We have then worked with operational teams to identify critical assets and / or critical operational activities that are located in areas of high risk. We are revisiting the Strategic Flood Risk Assessment to ensure that the risk to IT and Communications critical infrastructure has been adequately identified and assessed.

4. We include resilience in the design of our critical assets. For example, our two main IT data centres provide back up to each other. Power supplies are also duplexed across the site.

5. Heathrow is developing a Surface Water Management Plan, which commenced in 2013. This is part of a £16m investment in our surface water drainage system – part of our Q6 business plan (2014-2018). The focus is on protection and improving the resilience of our critical assets.

**Recommendation 62**
**Airports should draw up contingency plans jointly with their major airlines. These should also be jointly exercised.**

See detail in response to recommendation 10.

**Recommendation 63**
**In order to provide greater certainty to travellers and operators, airports should work with their principal airlines to adjust capacity on a pre-emptive basis when there is a high degree of confidence in the forecast of extreme weather, rather than waiting for the weather to hit.**

The demand versus capacity procedures implemented during 2014, are specifically designed for this purpose. They have been enacted on a number of occasions for various low visibility, strong wind and thunder storm events. The procedures are being continually refined in conjunction with the airline community based on experience from these events.

## Appendix 2: ARUP Review of climate change science, data and information published since 2011