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Adapting European airports to a changing climate

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Abstract

Airports are often classed as nationally critical infrastructure as they facilitate both mobility and economic growth. However, due to their fixed infrastructure and vulnerability to disruptive weather, they are particularly at risk from the potential consequences of climate change, with impacts such as sea level rise, higher temperatures and greater weather extremes creating both an operational and business risk. Therefore, to protect vital infrastructure and ensure future service continuity for airport operations, it is necessary to develop resilience to such risks.

This paper expands on previous analysis from EUROCONTROL, the European Organisation for the Safety of Air Navigation, to further clarify what the expected impacts for airports might be. In particular it highlights the need for action in areas which are expected to experience both high growth in demand and significant climate change impacts. It also presents an analysis of the outcomes of a stakeholder consultation which identifies lack of awareness, information and guidance as key barriers preventing aviation organisations from taking climate adaptation. It then introduces work carried out by EUROCONTROL in collaboration with aviation sector organisations to develop awareness of those risks so as to promote action to develop resilience.

Following this, it identifies some key questions to ask when initiating a climate change risk assessment at an airport and provides examples of organisations which have already carried out risk assessments. Finally, the paper presents the outcomes of a recent workshop on Adapting Aviation to a Changing Climate which identified four key priorities for action to develop climate change resilience. It highlights identifying knowledge gaps, raising awareness and promoting collaboration as key steps in building climate change resilience for the European and global aviation sector.

Peer-review under responsibility of Road and Bridge Research Institute (IBDiM)

Keywords: Climate change; resilience; adaptation; extreme weather; sea level rise; climate risk assessment; barriers to adaptation

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1. Introduction

There has been broad scientific consensus for several years that climate change will cause impacts such as higher temperatures, sea-level rise and greater weather extremes (IPCC, 2013). However, there is now growing realization that this will require all sectors of society to take action to adapt and develop resilience to such impacts (IPCC, 2014). Within the aviation sector, there may be risks for both en-route traffic and airport operations, and airport and ANSP infrastructure (EUROCONTROL, 2013, IPCC, 2014[b]).

For en-route traffic this will potentially cause loss of capacity, increased turbulence, route extensions and delay (EUROCONTROL, 2013[a]; Burbidge, 2015; Williams and Joshi, 2013). However, due to their fixed infrastructure and vulnerability to disruptive weather, airports are particularly at risk from the potential consequences of climate change, with impacts such as sea level rise, higher temperatures and greater weather extremes creating both an operational and business risk (Burbidge, 2014[a], ACRP, 2014). Airports are often classed as nationally critical infrastructure as they facilitate both mobility and economic growth. Therefore, to protect vital infrastructure and ensure future service continuity for airport operations, it is necessary to develop resilience to such risks.

This paper expands on previous analysis from EUROCONTROL, the European Organisation for the Safety of Air Navigation, to further clarify what the expected impacts for airports might be. In particular it highlights the need for action in areas which are expected to experience both high growth in demand and significant climate change impacts. The paper then introduces work done by EUROCONTROL in collaboration with aviation sector organisations to develop awareness of those risks so as to promote action to develop resilience.

Following this, it identifies some key questions to ask when initiating a climate change risk assessment and provides case study examples from organisations which have already carried out risk assessments. Finally, the paper presents the outcomes of a recent workshop on Adapting Aviation to a Changing Climate, organised by EUROCONTROL and Manchester Metropolitan University, which identified four key priorities for action to develop climate change resilience for the European and global aviation sector.

2. Key impacts for airports

The general climate impacts which we can expect within Europe are reasonably well-established, although they will vary according to climate zone, and there remains less certainty as to how they will involve at the local scale (EEA, 2012). This translates into a range of potential risks for airports which will also vary according to geographical location and scale of operations. Several papers and reports have already set-out in detail the key impacts which airports may experience from a changing climate (c.f. Burbidge, 2014[a]; EUROCONTROL, 2013[a]; ACRP, 2012). Therefore this section will provide a brief overview of the main potential risks to consider (figure1).

2.1. Changes in precipitation

Heavy precipitation events can require increased separation distances between aircraft; this impacts airport throughput. Snowfall in new areas implies that a much greater geographical area needs to be prepared for heavy winter weather.

Current aerodrome surface drainage capacity may be insufficient to deal with more frequent and intense precipitation events, leading to increased risk of runway and taxiway flooding. Underground infrastructure such as electrical equipment and ground transport access may also be at risk of inundation (Eurocontrol, 2013[a])

Fi. 1. Climate impacts for airports.

2.2. More frequent and more intense convective weather

Summer convective weather can have an exponential effect on weather delay due to the high seasonal traffic levels. Moreover, European continental areas may experience larger, meso-scale convective systems with the potential to affect multiple hub airports in a region. This may reduce the choice of diversionary airports whilst those that are available may not have sufficient capacity for the traffic which they need to accommodate. Consequently, dynamic capacity-based flight planning may be required (Burbidge, 2014[b]).

2.3. Changes in wind patterns

Runways constructed along the locally prevailing wind direction may experience more cross-winds due to deviations from that prevailing direction, or an airport may start to experience crosswinds but have no crosswind runway (Thomas et al, 2009). This may entail the need for a change in procedures and airspace redesign which, in turn, may incur an additional environmental risk due to the redistribution of noise impact around airports.

2.4. Sea-level rise and storm surges

The impact of storm surges could result in a temporary reduction in capacity and increase in delay. In the longer term, the potential permanent loss of capacity at some locations could have implications for overall network capacity and operations.

Sea-level rise may lead to permanent inundation and capacity loss unless preventative measures, such as constructing sea defences, are taken. At some locations, ground transport links are also potentially at risk of inundation.

2.5. Increased temperatures

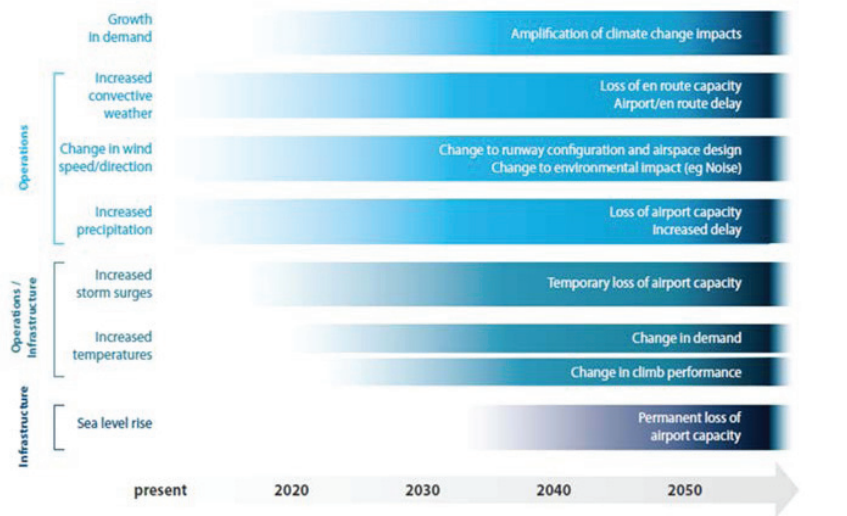
Higher temperatures may cause physical infrastructure impacts. For example, extreme summer temperatures may exceed design standards leading to heat damage to tarmac surfaces, and tarmac runways or aprons may experience difficulties due to surface melting during peak heat periods. There will also be a need for increased summer cooling of airport buildings with the attendant energy costs. Some buildings which were designed for cooler climates may not be able to maintain comfortable temperatures during very hot periods leading to overheating of equipment and health issues for staff (Thomas *et al*, 2008).

There may also be impacts for tourism demand. The Mediterranean region currently attracts around 100 million visitors from Northern Europe each year (Amelung and Moreno, 2009). Therefore, if a proportion of tourists who fly

to the Mediterranean during the summer months decide to travel to alternative destinations, there may be significant changes in infrastructure and staffing requirements at both traditional and potential new destinations. More positively, if tourists decide to visit traditional holiday destinations in the spring or autumn months instead of the customary summer season, this could ease congestion during the traditional peak season. However, whether and to what extent this is an issue is not yet well-understood.

2.6. Different impacts: different timescales

It should also be noted that impacts will be experienced over a range of timescales (figure 2). For example, in the longer-term higher summer temperatures may impact demand patterns, whilst mean-sea level rise may threaten coastal airports. However, such impacts will be experienced persistently but gradually so this allows for longer term planning which can be based on cost benefit analyses, if for example it needs to be decided whether to protect an airport from rising seas or relocate it. In the shorter-term, increased frequency and intensity of storm systems and snow events is expected to disrupt operations, leading to temporary loss of capacity and increased delays, and this require resilience measures which can be applied proactively according to the situation.



NB. This is a broad indication which does not account for regional differences nor future emissions trajectories/climate sensitivity. Timescales are based on analysis for Europe and may vary for other regions. ***Sources:*** *IPCC 2007b; Thomas et al 2008; Thomas and Drew (eds) 2010; SESAR 2012*
Analysis: *EUROCONTROL, Challenges of Growth, 2013*

Fig. 2. Timeline of expected impacts.

3. Growth in demand and climate change impacts: a double challenge

Section 2 has considered some of the key risks which climate change may pose for European airports. However, there is an additional factor which may exacerbate those risks in some locations, namely traffic growth. Although traffic growth stagnated during the global economic crisis, it is expected to resume in coming years, putting increasing pressure on operations in both emerging and established markets. However, forecasts suggest that even within the European market there will be differing rates of growth; some states with emerging markets may potentially experience up to 5-6% average annual growth (Figure 3, EUROCONTROL, 2013[b]). Moreover, some of the locations where the highest growth rates are forecast, such as South East and Central Europe, are also some of the areas where the greatest potential climate change impacts are predicted. Consequently, such states may have to cope with a rapid growth in demand whilst tackling climate change impacts such as higher temperatures or increased extreme weather. Further, as the impacts of disruptive events such as convective weather or heavy precipitation can

be exacerbated when capacity at an airport is constrained, it is essential to build resilience at locations which may have to address the double challenge of a rapid growth in traffic and significant impacts from climate change (EUROCONTROL, 2013[a]).

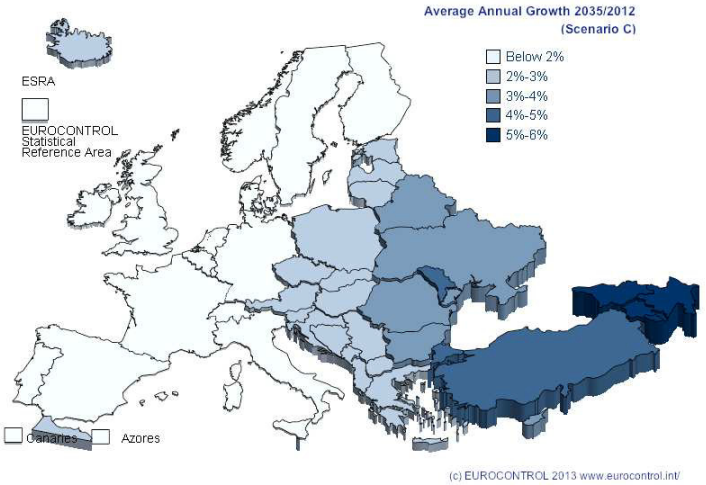


Fig. 3. Forecast annual average annual growth in European traffic 2035/2012.

4. Barriers to Adaptation?

In 2013 EUROCONTROL carried out a consultation of European aviation stakeholders as part of its Challenges of Growth 2013 work. The Challenges of Growth reports are a series of studies which aim to provide decision-makers with the best-achievable set of information to support long-term planning decisions for aviation in Europe. The purpose of the consultation was to gather stakeholder views as to whether the industry now considers adaptation actions are necessary, and what actions they are taking. The survey was sent to approximately 100 European aviation operational stakeholders. 35 valid responses were received, mainly from ANSPs and Airport Operators.

The survey identified that over 80% of respondents consider that resilience measures to adapt to climate change will be necessary now or in the future (N = 29, Figure 4b). However just under half of respondents replied that their organisation does not yet have an official position (N = 33, Figure 4a) and less than half of the organisations that responded had begun planning for adaptation to climate change (N = 25, Figure 4c).

The survey results indicated that although a significant number of organisations expect to need to take action to adapt to the potential impacts of climate change the number of organisations that have not yet begun to take action indicates that this is still an emerging issue. Given that vulnerability in one part of the network can have a knock-on impact for the network as a whole, the reasons that aviation organisations are not yet taking action warrants consideration.

Moser and Ekstrom (2010, p.22026) describe barriers to adaptation as “obstacles that can be overcome with concerted effort, creative management, change of thinking, prioritization, and related shifts in resources, land uses, institutions, etc.” Analysis of the results of the survey suggests that in this case there are two types of barrier to action identified; those that are based on a lack of information or guidance as a result of which an organisation either doesn’t know how to take appropriate action or doesn’t know if, or whether, it needs to act; and, barriers at the organisational level whereby the lack of an official position prevents action, the resources are not available for adaptation measures, or the organisation has decided it does not need to take action at this stage. However, it should be noted that such a decision may be based on lack of or misleading information and could therefore also be considered an information barrier. Figure 5 identifies the key barriers to adaptation action identified by the survey.

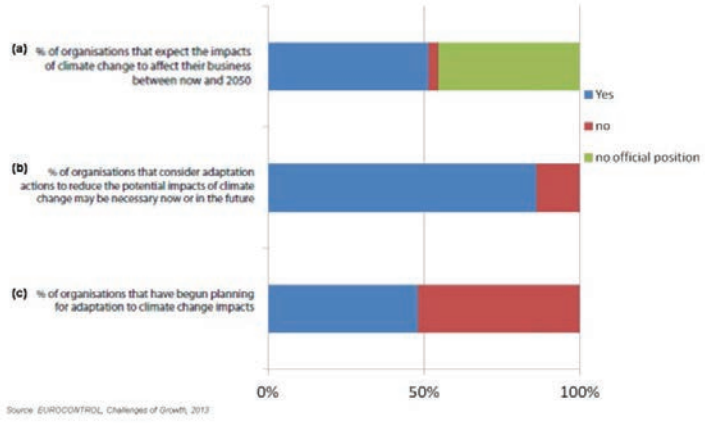


Fig. 4. Percentage of respondents who (a) expect to be impacted by climate change by 2050; (b) consider adaptation to climate change will be necessary (c) have begun adaptation planning.

Information barriers	Organisational barriers
Lack of information and guidance	Official position not established
Risk assessment not carried out	Lack of financial resources
Not aware that need to take action	Considered too early to take action*

**This may also be considered as an information barrier if the decision that it was too early were based on lack of or misleading information.*

Fig. 5. Key barriers to climate adaptation action in the European aviation sector.

Of course, no barrier exists in isolation; there are interdependencies both between the barriers identified and other unidentified factors. For example, an organisation which has not yet established an official position may not have done so due to a lack of information, or not carrying out a risk assessment may be due to a lack of financial resources. Overall, however, this preliminary analysis suggests that providing better information on the potential impacts of climate change for the aviation sector, and guidance on how to address those risks, is key to promoting climate adaptation action.

Finally, it should be kept in mind that the number of respondents was relatively small and there may also be some degree of self-selection. Nevertheless, the results can act as a starting point for identifying and addressing barriers to aviation climate adaptation action. Sections 5 and 7 will look in more detail at measures which EUROCONTROL has initiated to address these barriers.

5. A first step to increasing awareness

Having identified lack of awareness and guidance as a key barrier to adaptation for the European aviation sector, in 2014 Eurocontrol began working in collaboration with a group of 7 air transport organisations to develop some awareness material in this area. This has initially resulted in a high-level factsheet which was launched at ACI Airport Exchange in November 2014 (EUROCONTROL et al, 2014).

The factsheet starts with an overview of some of the key climate risks for aviation which, although it isn't an exhaustive list is intended as a starting point to introduce the types of risks which organisations might need to think about. It then provides a checklist of questions for beginning to assess whether climate change is a risk for your organisation. Again, this isn't an exhaustive list but rather is intended as a starting point for thinking about a risk

assessment. It then provides a set of case studies from organisations who are already taking action to adapt to climate change and gives examples of what they are doing and how they are doing it. Finally it provides a resource list with further information on both risks and impacts and more detailed advice on how to carry out a risk assessment.

One of the key objectives of the factsheet is not only to raise awareness of possible impacts but also to highlight the potential need to carry out a risk assessment. The next section will look at this in more detail.

6. Climate change risk assessment at airports

In order to establish whether and to what extent adaptation actions may be required at an airport, it is necessary to carry out a risk assessment. So how should an airport go about doing this?

6.1. Risk assessment: initial questions to ask

EUROCONTROL et al, (2014) identified an initial set of high-level questions to ask when considering initiating an airport climate risk assessment (figure 6). The purpose of these questions is twofold: firstly to facilitate an organization with identifying whether it has sufficient reason to warrant a risk assessment and, secondly, to address some of the barriers to adaptation identified in section 4 by identifying a need for organizational action so as to secure top management buy-in.

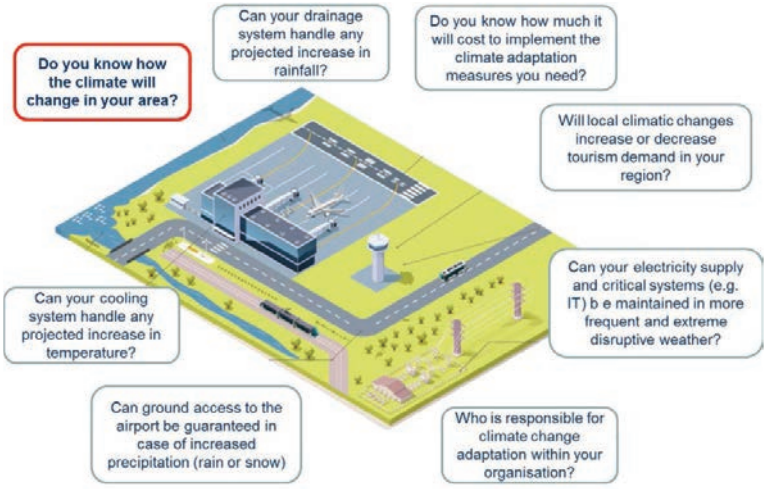


Fig. 6. Climate change risk assessment: initial questions to ask.

The first key question an organization should ask is whether it knows how the climate will change in its local area. Understanding this is fundamental as it highlights the key areas where adaptation action may be required. Following this, it needs to be identified who within the organization would have responsibility for adaptation action (noting that this could be more than one person or department).

When it comes to initiating an actual risk assessment, as Larsen (2015) points out, airports may already have risk assessment methodologies in place or there could be national guidelines that can be used. Alternatively, airports could use or adapt an existing methodology developed for climate change impact assessment by another airport. At least three proven examples are currently available from London Heathrow, the French Directorate General of Civil Aviation (DGAC) and Avinor, the Norwegian airport operator and ANSP (LHR, 2011; Larsen 2015; Oh, 2015).

Finally, once an assessment is initiated it is important to keep in mind that there may not only be infrastructure but operational and business risks to assess, and that not all risks (e.g. ground transport access or utility supply) may be entirely within the control of the airport itself.

7. Key priorities for building aviation climate resilience

As a follow-up to the 2013 consultation and Adapting Aviation factsheet, in September 2015 EUROCONTROL and Manchester Metropolitan University organised a workshop on Adapting Aviation to a Changing Climate. The workshop was attended by around 30 participants representing industry, regulators and academia and identified four consensus key priorities for action to develop climate change resilience for the European, and global, aviation sector (figure 7).

7.1. Priority 1: Understanding the problem

There are two aspects to this priority. Firstly, we need to review and frame the challenge from a holistic sectoral perspective. This entails identifying the key potential impacts for each stakeholder and the network as a whole. Following this we need to identify what knowledge of those impacts already exists and where are the knowledge gaps so that we can identify research priorities.

7.2. Priority 2: Assessing the problem

This refers to risk assessment as described in Section 6. A key factor to address here is the development of a generic impact matrix from a common baseline e.g. a 3°C temperature rise and Xm of sea-level rise. Although this would be extremely challenging to achieve, it is recognized that it is essential to ensure that adaptation actions are coordinated and effective. Ideally, compatible risk assessment methodologies should also be used to facilitate the development of comparable local and network

7.3. Priority 3: Actions to Adapt

This entails both identifying operational measures (e.g. flexible airspace system management) and infrastructure measures to build resilience to both increased disruption and changing baseline conditions. It also involves identifying win-wins and no-regrets measures (e.g. measures to address capacity issues) and trade-offs, especially where environmental improvements may introduce vulnerabilities (e.g. engines).

7.4. Priority 4: Communicate and collaborate

Ongoing communication and collaboration, both within Europe and at global level was identified as key. This may, inter alia, involve: establishing a core group or forum on adaption within Europe so as to maintain momentum and open door to greater participation; collaboration in research and information sharing; the combination and coordination of knowledge and research from other regions and sectors, and; communication: awareness-raising and assessment/dissemination of best practice both within Europe and globally.

Fig. 7. Four key priorities for adapting global aviation to a changing climate.

8. Conclusions

This paper has demonstrated that although awareness is growing of the need for European airports to take action to adapt to the potential impacts of climate change, and several organizations have already begun to take action, this is still an emerging issue with lack of information and awareness presenting a significant barrier to action. EUROCONTROL, working with other aviation organizations, has taken action to address this lack of information and awareness by producing a Climate Adaptation Factsheet and co-organizing a workshop on Adapting Aviation to a Changing Climate. This work has identified four priority areas for action, namely: better understanding the problem by further clarifying potential impacts, existing knowledge and research priorities; assessing the problem, ideally with compatible risk assessment methodologies and working from the same baseline; initiating actions to adapt both operations and infrastructure, including the identification of no-regrets measures and trade-offs, and; continuing and increasing communication and collaboration, both within Europe and at a global level.

As a sector we are making progress to address climate change risk. We have a reasonable qualitative understanding of both the potential impacts and the high-level actions which we need to take to address them. But uncertainties remain and we have made little progress in *quantifying* what climate change implies from an operational perspective. Moreover, as a vulnerability in one part of the global aviation network can impact the network as a whole, we not only need to identify and address risks to individual organizations, but to work together as a global sector to learn from each, collaborate and communicate, and build partnerships for action. Finally, it is well-recognized that pre-emptive action can be cost effective, reducing both damages and costs. Therefore we should not wait until impacts become severe, but begin to address climate risks as part of ongoing operational and infrastructure improvements. We need to address this risk as the global industry which we are, and the time to act is now.

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