RiverOak Strategic Partners

Applicant's Written Summary of Case put Orally - Need and Operation Hearing and associated appendices

TR020002/D5/ISH2

Examination Document

Project Name: Manston Airport Development Consent Order
Application Ref: TR020002
Submission Deadline: **5**
Date: 29 March 2019

MANSTON AIRPORT DEVELOPMENT CONSENT ORDER APPLICATION

DOCUMENT REFERENCE TR020002/D5/ISH2

APPLICANT'S WRITTEN SUMMARY OF ORAL SUBMISSIONS PUT AT ISSUE SPECIFIC HEARING ON NEED AND OPERATIONS

21 MARCH 2019

Laurence Suite, Building 500, Discovery Park, Sandwich, CT13 9FF

1 Introduction

1.1 This document summarises the case put by RiverOak Strategic Partners (the Applicant) at issue specific hearing 2 into the Need and Operations of the proposed Manston Airport. The hearing opened at 10.00am on 21 March 2019 at Laurence Suite, Building 500, Discovery Park, Sandwich, CT13 9FF. The agenda for the hearing was set out in the Examining Authority's (ExA) letter published on the Planning Inspectorate's website on 11 March 2019.

1.2 In what follows, the Applicant's submissions on the points raised broadly follow the items as set out in the ExA's agenda.

2 Agenda Item 4: Policy

2.1 The Applicant set out the policy context and noted its relevance for the proposed Manston Airport. The Applicant noted that the general picture on aviation policy reveals the Government's increasing recognition of the importance of air freight to the UK economy. It is fair to say that the work of the Airport Commission has primarily focused primarily on passenger capacity, however recent emerging policy shows growing recognition by the Government of the important role played by air freight.

2.2 The ExA asked the Applicant to what extent the policies noted referred to Manston Airport. The Applicant noted that given that Manston was not an operational airport at the time the adopted and emerging policies were published, the policies were not likely to and did not refer specifically to Manston Airport. The ExA queried to what extent the policies referred to other airports. The policies do refer to other airports in giving examples and case studies to illustrate the policy context. However, aside from London Heathrow, the policies do not explicitly support specific development at those other airports. Indeed, as noted by Beyond the Horizon, Making best use of existing runways (June 2018) *"The Aviation Strategy call for evidence set out that the government agrees with the Airports Commission's recommendation and was minded to be supportive of <u>all airports</u> who wish to make best use of their existing runways, including those in the South East, subject to environmental issues being addressed. The position is different for Heathrow, where the government's proposed policy on expansion is set out in the proposed Airports NPS."* (emphasis added). The Applicant considers that the government's policy emphasis on making best use of existing runways applies to the existing runway at Manston. The construction of new runways is notoriously difficult – indeed there have been no new runways constructed in the South East of England for over 60 years. Existing runways are therefore valuable assets that should be utilised rather than lost.

2.3 The Applicant notes that the Appeal Decisions for the appeals brought by the current land owners Stone Hill Park (SHP) (then called Lothian Shelf (718) Ltd) in respect of applications for the change of use of units at Manston Airport (Ref: APP/Z2260/W/15/3140995, 3140990, 3140992, 3140994) confirmed that national aviation policy applies to airports that are existing but closed.

Aviation Policy Framework 2013

2.4 The Aviation Policy Framework sets out the Government's high level objectives and policy on aviation.

2.5 It is generally recognised that Government aviation strategy has not, until recently, focused sufficiently on the air freight sector. However, there are a number of parts of this policy relevant to the proposed Manston Airport.

Importance of air freight

Paragraph 1.6:

> *"Although air freight carries a small proportion of UK trade by weight, it is particularly important for supporting export-led growth in sectors where the goods are of high value or time critical. Air freight is a key element of the supply chain in the advanced manufacturing sector in which the UK is looking to build competitive strength. Goods worth £116 billion are shipped by air between the UK and non-EU countries, representing 35% of the UK's extra-EU trade by value."*

Paragraph 1.7:

> *"The express air freight sector alone contributed £2.3 billion to UK GDP in 2010, and facilitates £11 billion of UK exports a year. Over 38,000 people are directly employed in the express industry, which supports more than 43,000 jobs in other sectors of the economy."*

Paragraph 1.8:

> *"A successful and diverse economy will drive a need for quicker air freight. Key components to keep factories working are often brought in from specialist companies in North America and the Far East. To keep production lines rolling this often has to be done at short notice. Access to such services is crucial to keeping UK manufacturing competitive in the global marketplace."*

Paragraph 1.13:

> *"The UK's aviation sector enables productivity and growth in the following ways:*
>
> - *enhanced access to markets and new business opportunities through improved connectivity;*
> - *lower transport costs and quicker deliveries. For example, transporting freight by air allows smaller inventory holdings, and the rapid transport of perishable goods leads to increased specialisation of production which results in greater efficacies. The Organisation for Economic Co-operation and Development (OECD) notes that 40% of international freight trade by value is accounted for by airlines; and*

- *facilitating inward investment and the movement of goods, people and ideas both within the UK and to and from the rest of the world thus enhancing trade and the diffusion of knowledge and innovation."*

Benefits to the economy

Paragraph 1.20:

> *"One of the Government's aims in helping the economy to grow is to encourage investment and exports as a route to a more balanced economy. Airports are in some ways cities in themselves, creating local jobs and fuelling opportunities for economic rebalancing in their wider region or area. New or more frequent international connections attract business activity, boosting the economy of the region and providing new opportunities and better access to new markets for existing businesses."*

Paragraph 1.22:

> *"Many airports act as focal points for business development and employment by providing rapid delivery of products by air and convenient access to international markets."*

Making best use of existing capacity

Paragraph 1.24:

> *"The Government wants to see the best use of existing airport capacity."*

Paragraph 1.60:

> *"In the short term, to around 2020, a key priority for Government is to continue to work with the aviation industry and other stakeholders to make better use of existing runways at all UK airports."*

Paragraph 1.109:

> *"We have set out above a strategy based on practical measures which we believe will improve the use of existing runways across the UK and ease pressure on our hub airport in the short term and into the medium and long term with the development of HS2."*

Beyond the Horizon: Next Steps towards an Aviation Strategy (April 2018)

2.6 The Executive Summary to this policy cites that one of the objectives to the Aviation Strategy is to provide a global and connected Britain including through reducing barriers to the movement of freight.

Paragraph 4.5:

> *"Whether in the bellyhold of commercial airlines or in dedicated aircraft, air freight plays a crucial role in the sector and is currently flourishing. The strategy will establish our approach to place the UK at the forefront of air freight technology and facilitation processes."*

Paragraph 4.6:

> *"Aviation plays a crucial role in our wider economy and productivity challenge."*

Paragraphs 4.26 to 4.36 include whole sections on 'Facilitating the air freight market in the UK and 'Supporting Aviation Exports':

> *"Facilitating the air freight market in the UK*
>
> *4.26 Many of the respondents to the call for evidence underlined the importance of aviation and air freight to the UK economy. As an island nation in a globalised world, aviation is critical to enable businesses to deliver services across the world and to maintain the UK's place in international supply chains. A thriving air freight sector makes the UK more attractive for multi-national companies, and more able to attract international talent and tourists.*
>
> *4.27 The industries which rely on aviation to deliver their products and services are often of high value to our economy. Aviation supports the more productive aspects of the UK economy and has directly and indirectly been a driver of innovation. As the Industrial Strategy identifies, tackling our productivity challenge is a priority for the government. The UK air freight sector is flourishing. In 2016, the volume of freight handled by UK airports grew by 5% to 2.4 million tonnes shipped. There is also significant investment underway; last year, for example, ground was broken on Segro Logistics Park East Midlands Gateway — a 700 acre facility, which will link the airport with a major new rail freight terminal as well as the M1.*
>
> *4.28 The government recognises the crucial role this sector plays in our economy, especially high end manufacturing, engineering, pharmaceuticals, retailing and the automotive sectors. For time-critical goods such as pharmaceuticals, air freight is the only method of shipping fast enough to deliver these items in the required timeframe.*
>
> *4.29 Although the volumes are comparatively small, the value of air freight per tonne is much greater than other modes of freight, due to the nature of the goods transported. In 2016 goods worth around £178 billion were shipped by air between the UK and non-EU countries. This represented over 45% of the UK's non-EU trade by value. In 2016, Heathrow handled 64% of air freight by volume and is the UK's highest value port, with East Midlands Airport and Stansted being the next largest airports for freight transport. The importance of Heathrow to the air freight market, and its potential for growth, was an important consideration for the government in supporting its proposed expansion.*
>
> *4.30 Air freight operates in several distinct markets: domestic; UK to EU/EEA; and UK to Non-EU/EEA. Dedicated fast parcel operators are dominant in the domestic market and, to a lesser extent, the UK to EU market, whereas the vast majority of long haul air freight is flown in the bellyhold of passenger aircraft. The UK and EU will continue to be important freight markets for each other after we exit the EU.*
>
> *4.31 As the Aviation Strategy is developed, the government will engage with all major airports and all major operators across the market, and the businesses that rely on them, to identify barriers and understand what government can do to reduce them. This will include what action can be taken on infrastructure and capacity building, as explored further in Chapter 6.*
>
> *4.32 The Aviation Strategy will set out our approach to working closely with industry and other government departments such as HM Revenue and Customs and HM Treasury, as well as industry organisations such as the International Air Transport Association (IATA), the British*

> *International Freight Association and the Freight Transport Association, to help ensure that our air freight sector is at the forefront of technology and the facilitation processes.*
>
> *Supporting aviation exports*
>
> *4.33 The aviation sector itself provides at least £22 billion to the UK economy each year – with around £14 billion from the air transport sector and £8 billion from the aerospace sector. This covers a vast range of industries including airlines, airports, aircraft manufacture, aircraft maintenance, ground handling, air traffic management and regulatory expertise. In addition, the success of the aviation sector in the UK creates a platform for British companies overseas in many other sectors of the economy not included in the numbers above. For example, the terminal building at Stansted Airport completed in 1991 and designed by Foster + Partners was the start of many terminal projects across the world for the architectural firm...".*

Paragraph 6.7:

> *"There hasn't been a new runway built in south-east England for over 60 years..." (*emphasis added)*.* This emphasises the importance of the need to use existing runways, particularly as Heathrow runway 3 is some way off.

2.7 Paragraphs 6.48-6.52 include a section on 'Better planning to improve resilience'. Manston will help improve the resilience of the south-eastern airport system for both passengers and freight. Uniquely, Manston's long runway allows all aircraft types to land unlike at other airports:

> *"The UK's airport and airspace capacity is constrained, and there will be no new significant airport runway capacity until 2025. The benefits of airspace modernisation are still a number of years away. The situation is particularly acute in the south-east of England where increases in capacity have been achieved through higher utilisation of existing runways and airspace.*
>
> *While this brings more choice and competition, it makes airports vulnerable to potentially disruptive events such as severe weather. For example. 48 hours of snow disruption in December 2010 cost Heathrow £20 million. British Airways estimated its lost revenue from disruption during the winter of 2010-11 as approximately £50 million. Passengers suffer most in terms of delayed or cancelled flights.*
>
> *At the UK's busiest airports delays have been increasing in recent years. Without industry working together this performance may continue to decline further as aircraft movements grow.*
>
> *In 2017 the CAA published its report 'Operating resilience of the UK's aviation infrastructure and the consumer interest', which concluded that collective cross-industry action was needed to mitigate the risks to consumers arising from events which impact upon aviation resilience. The government is working jointly with the CAA, NATS and industry representatives to consider how coordinated resilience planning can deliver on the recommendations of this study and whether there is a role for government and the CAA in overseeing future."*

Airports National Policy Statement, designated 26 June 2018

Paragraph 1.12:

> *"The Airports NPS...is an important and relevant consideration for new runway capacity and other airport infrastructure in London and the South-East of England."*

Paragraph 1.14:

> *"It sets out planning policy in relation to applications for any airport nationally significant infrastructure project in the South East of England, and its policies will be important and relevant for the examination by the Examining Authority, and decisions by the Secretary of State, in relation to such applications."*

Paragraph 1.39:

> *"...The Government has confirmed that it is supportive of airports beyond Heathrow making best use of their existing runways..."*

Paragraph 2.1:

> *"International connectivity, underpinned by strong airports and airlines, is important to the success of the UK economy. It is essential to allow domestic and foreign companies to access existing and new markets, and to help deliver trade and investment, linking us to valuable international markets and ensuring that the UK is open for business. It facilitates trade in goods and services, enables the movement of workers and tourists, and drives business innovation and investment, being particularly important for many of the fastest growing sectors of the economy."*

Paragraph 2.2:

> *"International connectivity attracts businesses to cluster round airports, and helps to improve the productivity of the wider UK economy. Large and small UK businesses rely on air travel, while our airports are the primary gateway for vital time-sensitive freight services."*

Paragraph 2.7:

> *"Air freight is also important to the UK economy. Although only a small proportion of UK trade by weight is carried by air, it is particularly important for supporting export-led growth in sectors where goods are of high value or time critical...This is especially important in the advanced manufacturing sector, where air freight is a key element of the time-critical supply chain. By 2030, advanced manufacturing industries such as pharmaceuticals or chemicals, whose components and products are predominantly moved by air, are expected to be among the top five UK export markets by their share of value. In the future, UK manufacturing competitiveness and a successful and diverse UK economy will drive the need for quicker air freight."*

Paragraph 3.14:

> *"Increasing airport capacity in the South East of England and maintaining the UK's hub status can be expected to result in both positive and negative impacts, as would be the case for any major infrastructure project. Important positive impacts are expected to include better international connectivity and providing benefits to passengers and the UK economy as a whole (for example for the freight industry)."*

Paragraph 3.23:

> *"The aviation sector can also boost the wider economy by providing more opportunities for trade through air freight. The time-sensitive air freight industry, and those industries that use air*

> *freight, benefit from greater quantity and frequency of services, especially long haul. By providing more space for cargo, lowering costs, and by the greater frequency of services, this should in turn provide a boost to trade and GDP benefits."*

Beyond the Horizon, The future of UK Aviation (June 2018)

Paragraph 1.1:

> *"The government's 2013 Aviation Policy Framework provided policy support for airports outside the South East of England to make best use of their existing airport capacity. Airports within the South East were to be considered by the newly established Airports Commission."*

Paragraph 1.2:

> *"The Airports Commission's Final Report recognised the need for an additional runway in the South East by 2030 but also noted that there would be a need for other airports to make more intensive use of their existing infrastructure."*

Paragraph 1.5:

> *"The Aviation Strategy call for evidence set out that government agrees with the Airports Commission's recommendation and was minded to be supportive of all airports who wish to make best use of their existing runways, including those in the South East, subject to environmental issues being addressed. The position is different for Heathrow, where the government's proposed policy on expansion is set out in the proposed Airports NPS."*

Paragraph 1.25:

> *"As a result of the consultation and further analysis to ensure future carbon emissions can be managed, government believes there is a case for airports making best of their existing runways across the whole of the UK. The position is different for Heathrow Airport where the government's policy on increasing capacity is set out in the proposed Airports NPS."*

Paragraph 1.29:

> *"Therefore the government is supportive of airports beyond Heathrow making best use of their existing runways..."*

Aviation 2050, published Dec 2018 (consultation closes 20 June 2019)

Paragraph 1.2:

> *"The government has been clear about the importance of aviation to the whole of the UK. Aviation creates jobs across the UK, encourages our economy to grow and connects us with the rest of the world as a dynamic trading nation. It also helps maintain international, social and family ties. This is why the government supports the growth of aviation, provided that this is done in a sustainable way and balances growth with the need to address environmental impacts.."*

Paragraph 1.3:

> *"The government has also consulted on plans to modernise our airspace. It has stated that it supports airports throughout the UK making best use of their existing runways, subject to environmental issues being addressed."*

Paragraph 1.8:

> *"Aviation forms an important part of the global supply chain, the means by which many businesses are able to operate, export and grow. An effective transport system is an important enabler of sustained economic success, with benefits for the wider economy."*

Paragraphs 1.19-21:

> *"There were record quantities of freight handled by UK airports in 2017, highlighting the growing importance of aviation to the transport of freight. Globally, air freight grew more than twice as fast as overall global trade during 2017 – the widest margin of outperformance since 2010. The changing nature of the goods and services we trade means that aviation freight is becoming increasingly significant to the economy, transporting high value, high tech products, medicines and just in time deliveries.*
>
> *This highlights the need for further capacity – delivered sustainably and in a way that benefits the whole country. The London airport system will be almost entirely full by 2030 without expansion. The Airports Commission estimated that failing to address the need for extra airport capacity could cost passengers £21-23 billion in the form of fare increases and delays, and potentially £30-45 billion to the wider economy.*
>
> *This is why the government is supportive of the development of a third runway at Heathrow Airport, which could deliver up to £74 billion worth of benefits to passengers and the wider economy. It is also supportive of airports throughout the UK making best use of their existing runways, subject to environmental issues being addressed. However, there is a need for clarity on what the future framework will be for providing additional capacity to meet demand, while managing environmental and community impacts."*

Paragraph 2.4:

> *"The goods and services that support aviation are valuable UK exports and the government wants to work with the aviation industry to remove barriers, so that UK companies who want to compete in the global market are able to do so."*

Paragraph 4.3:

> *"The government has also confirmed that it is supportive of airports beyond Heathrow making best use of their existing runways, subject to proposals being assessed in light of environmental and economic impacts."*

Paragraphs 4.45-4.50:

> *"Air freight is a major part of aviation. It connects UK exporters to new markets across the world, and benefits consumers who increasingly have access to a range of globally sourced goods which can be delivered within days of ordering. <u>Air freight facilitates trade that otherwise may not be viable, for example for goods with a short shelf life.</u>*

> *Air freight and those businesses that support it deliver over 46,000 jobs and contributes over £1.4 billion to the UK economy. The UK ships a greater proportion of its extra-EU exports by air than most other European economies. [Note – reference at footnote 99 is to the Steer Report: Airlines UK (2018): Assessment of the value of air freight services to the UK economy which is included as appendix ND1.13 to the Applicant's response to the ExA's First Written Questions REP3-187].*
>
> *The three main airports for handling air freight in the UK are Heathrow, East Midlands and Stansted. Collectively they account for around 85% of the total amount of freight handled at UK airports. The benefits of air freight to the UK, however, are not restricted solely to the areas around those airports. It has a catalytic effect on the UK economy – for example, it has been estimated that 8.6% of the gross value added (GVA) of the Welsh economy is dependent on air freight, despite Wales having no major air freight traffic at its airports.*
>
> *The government recognises the importance of night flights to the air freight industry particularly for the express freight market which allows UK consumers to receive products from around the world in ever shorter timescales. For example, around 50% of freight at East Midlands Airport arrives before 7.00am. Industry can support growth within existing night noise limits by using quieter and more environmentally friendly cargo aircraft and the government encourages their early adoption wherever possible.*
>
> *The government supports continued growth of the air freight sector particularly making best use of existing capacity at airports, to continue to facilitate global trade for UK businesses and consumers. It has already taken action by supporting the Northwest Runway scheme at Heathrow, which has been estimated to nearly double the capacity for freight at the airport to 3 million tonnes per year.*
>
> *Since the call for evidence, the government has worked with the industry to examine the potential barriers to the air freight industry and how it can help reduce them. This work will continue; the government is committed to removing or reducing any unnecessary barriers to air freight and the global trade that it supports, including in non-aviation areas of policy.*
>
> *One area where the government is already working to remove barriers to trade is in supporting increased digitisation of the air freight sector...."* (Emphasis added)

Paragraph 4.63:

> *"The aviation industry is already leading the way in using innovative methods to train, recruit and retain a resilient labour force..."*

National Planning Policy Framework

Paragraph 104(e):

> *"Planning policies should...provide for large scale facilities [Footnote 42 notes that this includes airports] and the infrastructure and wider development required to support their operation expansion and contribution to the wider economy."*

Paragraph 104(f):

"*Planning policies should... maintaining a national network of general aviation airfields, and their need to adapt and change over time – taking into account their economic value in serving business, leisure, training and emergency* service *needs, and the Government's General Aviation Strategy."*

3 Agenda Item 5: Forecasts and Freight Types / Patterns

3.1 As suggested at the hearing, the Applicant has provided projected average freight loads that were used in the Azimuth report at Appendix 1.

3.2 The basis of the Applicant's calculation of the aircraft that will be flown is in the Azimuth report and is broken down by aircraft type.

3.3 The Applicant noted that there is no standard methodology for forecasting demand for air freight: neither the government nor any other public body produce a model.

3.4 There are broadly 3 approaches to forecasting demand for air freight:

3.5 Top down approach (as undertaken by Northpoint Aviation):

3.5.1 involves looking at both capacity and demand at a national or regional level and identifying any shortfall between available capacity and demand. The outcome of that assessment is the unmet need. It provides an overarching view of the potential scale of the capacity gap but does not explain what form of freight that is or which carriers would be used.

3.6 Bottom up approach (as undertaken by Azimuth Associates):

3.6.1 involves trying to identify factors that drive the demand for freight capacity – that may be growth sectors in the market such as E-Commerce; capture of trucked overspill; specific types of cargo that are not successfully or efficiently handled elsewhere (e.g. temperature controlled goods); growing economies. Those factors identify potential growth in demand for freight and potential markets.

3.6.2 That information is then coupled with the offer that is proposed at Manston – which includes unconstrained, state of the art freight, digitalised freight handling facilities - speciality handling (for race horses); refrigerated storage facilities; flexible warehousing (eg to accommodate outsized freight) and security clearance.

3.6.3 The bottom up approach is more commercially focused in that it identifies the types of freight likely to be attracted to Manston and the types of carriers that are likely to use it.

3.7 The third method is to extrapolate past trends and project them forward. For example, York Aviation appear to have looked at the past relationship between GDP and growth in freight traffic and assumed that the relationship will remain constant into the future. The Applicant considers this to be a wholly unsuitable approach, not least given the difference between the airport operation as it was in the past, and the new proposal currently before the ExA.

3.8 The Applicant explained that the previous operations at Manston suffered from lack of investment. The absence of modern infrastructure at the airport made it unattractive to investors. British Airways was in discussions with Infratil to operate from Manston but ultimately would not move because they themselves would have had to invest in the airport to be stationed there and they lacked confidence in the airport given the owner's own lack of investment. The Applicant has a strategy which envisages a transformational approach; this cannot be compared to what previous owners did before. The Applicant has the opportunity to create a brand new, modern, automated and digitalised airport which is effectively 5 year's ahead of its time because it will be designed to serve cargo markets in their new emerging form, and none of the other airports in the UK have this.

3.9 The Applicant notes that Louise Congdon of York Aviation is quoted as saying, in her written evidence to the London Ashford Airport Planning inquiry in February 2011: *"That Manston has not thrived says nothing about its future as it is likely to be more dependent upon spill from the London airports that have not yet reached their capacity, although projected to do so by 2020"* (para 5.3.45).

3.10 The Applicant has provided the 2018 academic study regarding Qantas, which shows the difference in freight and passenger routes at Sections 2.2 and 4.7 in particular, at Appendix 2.

3.11 The Applicant questioned SHP's unsubstantiated assertion that the cost of flying cargo on freighters was four times more expensive than flying in bellyhold, emphasising the difficulty of securing appropriate data from which to draw any such conclusions. The Applicant believes the margins are materially lower and depend on airports used, the markets being served, seasonality, and for some kinds of less time critical freight, comparative rates for shipping by sea. The Applicant is undertaking further research and will provide the ExA with this at a later deadline.

3.12 The Applicant did not agree with SHP's claim that dedicated freighters were only serving "niche" and limited markets that could not be accommodated as bellyhold. It pointed out that in competitor European airports, Amsterdam, Paris and Frankfurt between 40 and 60% of total freight volumes were carried by freighter aircraft (see the Steer Report paragraph 3.24, Appendix ND1.13 to the Applicant's response to the ExA's First Written Questions).

3.13 The Applicant explained that the dominance of bellyhold in the UK and the prevalence of trucking goods produced in or destined for the UK to European airports was a result of capacity constraints rather than market preference. This is apparent from the disparity in freight volumes carried on dedicated freighters between the UK on the one hand and both in Europe and globally on the other.

3.14 Goods that could be flown from the UK, to the benefit of the UK economy, are instead trucked across the channel to European airports. The Applicant rejected SHP's suggestion that this was simply a result of market preference. It pointed to the York Aviation Report of 2015 (Appendix ND.1.7 of the Applicant's Appendices to answer to written questions REP3-187) and the Steer Report of October 2018 (Appendix ND.1.13 to our 1WQ Responses at REP3-187) to support its position.

3.15 The York Aviation Report of 2015 was commissioned by Freight Trade Association and TfL and was used to inform their response to the Airports Commission. The report is still available on the TfL website and TfL have made it clear that they stand by it. It explains that air freight is a significant driver for UK economy. Damaging its ability to function effectively could have serious implications for UK economy (page 4). The report explains that speed is a key feature for a number of goods (machinery parts, aircraft parts, perishables etc) and that express freight, with the most time-critical activities, is the fastest growing segment of the market (pages 9 and 15). If demand cannot be met in the London system, freight will need to be trucked elsewhere, resulting in longer transit times or earlier final pick-up times. For some parts of the market this could represent a critical loss of utility with significant impact on operations (page 15). Trucking leads to delay and to additional costs which are likely to be passed on to the users of air freight services (page 4).

3.16 The York Aviation 2015 report found that even with a third runway at Heathrow, by 2050 some 1.2 million tonnes of freight would have to be diverted elsewhere because of a lack of capacity (page 19), even before account is taken of the burgeoning ecommerce sector. It anticipated that a significant proportion of excess demand would be trucked overseas. The York Aviation Gravity Model (page 23) showed that 71% of excess freight was likely be trucked to Europe and flown from European airports: 71% of the anticipated 1.2m tonnes of excess demand equates to 852,000 tonnes of freight being trucked to European airports. That is goods destined for or produced in the UK being flown into or out of European airports and trucked across the channel: a market that could be served by UK airports. The Applicant's forecasts assume that by Year 20, Manston will handle 340,000t of freight. That is entirely reasonable.

3.17 The York Aviation 2015 report notes that even with a third runway at Heathrow, by 2050 the additional trucking costs arising from unmet need would equate to £23.5 million per annum. The increase in costs associated with additional trucking and loss of utility to users will affect the level of air freight demand in and around London which, in turn, will impact on economic activity as productivity is reduced through impairment of trade and/or companies relocating to places with better connectivity (York Aviation, page 27).

3.18 The Steer Report of October 2018 has informed, and is cited in the recent Aviation 2050 Green Paper. It explains that freight is often flown to continental Europe, particularly from Asia, as there is often more available air freight capacity than to UK airports, partly due to the lack of slots for freighter aircraft at Heathrow. This represents an inefficiency from the perspective of the UK economy (paragraph 2.24). It reports that several stakeholders noted that capacity constraints are a significant hindrance to the operation of air freight – one stated that it has caused volume growth to fall behind other European countries and another stated it is one of the main reasons why so much air freight is flown to mainland Europe and trucked to the UK – in turn causing more road and port congestion (paragraph 2.34). The Steer Report includes (on page 10) a case study of a particular business. It explains that the importer only flies 20% or its total imports directly to the UK, with the remaining 80% flown to mainland Europe and trucked to the UK. The reason such a high proportion of its goods are flown to the UK via Europe is because the UK's air freight capacity is not sufficient to service the required import volumes. The main problem the importer cited with UK air freight capacity was the quality of the infrastructure. The importer said that it avoids using UK airports because they are too congested and therefore not efficient; air freight infrastructure has not been upgraded in line with increased traffic which causes delays that can be avoided at continental airports. Indeed, "Several stakeholders commented that the quality of the UK's air freight infrastructure is a major issue, with freight facilities at UK airports often being decades old and having suffered from continued under-investment" (paragraph 2.34).

3.19 The Applicant explained that the cargo industry is fundamentally changing. It needs an innovative response which cannot be accommodated at other SE airports because of the constraints they are under. A complementary facility tailored to the demands of freighters is required in the same way that similar facilities have begun to emerge in Europe and North America. If the UK does not keep up, there is a real danger it will lose market share to the detriment of the wider economy.

3.20 The offer at Manston will provide something that has not been done in this country before. It will provide a state of the art facility which offers unconstrained capacity and that is digitilised to handle the latest data requirements that the industry is currently developing. The offer at Manston will be extremely attractive to the market.

3.21 The Applicant pointed to the example of Rockford International Airport in the US. Rockford grew the freight tonnage it handled by 16% in 2016; 50% by 2017 and a further 55% by 2018, due mainly to the presence of an e-commerce integrator-type operation. Rockford Airport is some 75 miles Northwest of Chicago – a comparable distance to that from Manston to London. Additionally, the Applicant referred to Liege in Belgium which grew 21.5% between 2017-18 and is likely to see further substantive growth with the arrival of Cainaio to drive new integrator growth. Liege is 60 miles from Brussels and therefore its geographical advantage is similar to East Kent and London. Further examples of dedicated freighter lead airports are Hamilton in Ontario (55 miles from Downton Toronto) and Allentown in Pennsylvania, which is 60 miles from Philadelphia and a major Amazon Air east coast base.

3.22 The Applicant explained that the e-commerce integrators it plans to attract would be different to old integrators and not reliant on night-time flights. The businesses targeted by Manston would include the new e-commerce integrator-type carriers such as Amazon Air, who now operates 50 aircraft with further expansion planned. The Applicant stated that it is likely that Amazon, or another e-commerce integrator, will want to expand into the European market, particularly as Chinese based e-commerce operations are already beginning to do so. The Applicant explained that the flights from Manston would be primarily for Business-to-Consumer (B2C) operations rather than Business-to-Business (B2B) as is the case with traditional integrators. This involves the aircraft delivering stock to fulfilment centres which are kept topped through proper stock management, negating the need for night-flights as the e-commerce integrator would only need to top up the stock at the fulfilment centre, which could be done across the day.

4 Agenda Item 6 - Existing and future capacity and constraints in the South East and wider UK Airports

4.1 The Applicant explained that as aircraft types change, the capacity for bellyhold may not necessarily increase.

4.2 Most airlines, particularly Low Cost Carriers who generally do not carry freight, focus on passenger markets, and view freight merely as useful additional income. The Applicant explained that if the destinations preferred by passengers do not align with the location of freight markets, then this would slow down the delivery of freight and make the use of dedicated freighters with greater routing flexibility more attractive.

4.3 The Applicant highlighted the key capacity constraints at Gatwick, East Midlands, and Amsterdam. It was then explained that East Midlands and Doncaster would serve markets in the centre of the UK, but Manston will be focussing on freight in the South East of the UK. As suggested at the hearing, the Applicant has provided a note setting out analysis of Doncaster freight growth at Appendix 3.

4.4 The Applicant recognised that there was likely to be growth in the volume of freight handled at East Midlands airport. East Midlands currently handles 350,000 tonnes per annum but has long-term ambitions to handle 1 million tonnes by 2035 - 40. The Northpoint Report acknowledged that growth aspiration and found that even if East Midlands achieved or indeed exceeded its goal of 1mt, there would still be unmet demand of at least 500,000mt of freight based on anticipated growth rates. Manston would capture some of that demand.

4.5 The Applicant described Stansted Airport as approaching capacity. The Applicant explained that there was a correlation between increased slot utilisation and delays, and stated that, due to operational issues it becomes increasingly difficult to attract an airline when an airport suffers from delayed departure. The Applicant has provided an analysis of the Stansted cargo position (current and projections for dedicated freight) at Appendix 4 and a UK CAA runway resilience study at Appendix 5 to support this – the ExA is referred in particular to the graphs at pages 100-104.

4.6 As requested by the ExA, the Applicant has provided a note explaining its business model (Appendix F.1.5 to the Applicant’s Appendices to Answers to FWQs REP3-187) at Appendix 6.

5 Agenda Item 7 - Locational factors

5.1 The Applicant explained Figure 4 on page 28 of the Azimuth report (APP-085), which shows businesses served by integrators at East Midlands Airport. As is apparent from the map, East Midlands Airport serves a wide catchment area. The map shows that London is a big market for those integrators flying into East Midlands Airport, and that there are a lot of deliveries being made by road via the two main motorway corridors.

5.2 Manston Airport is ideally located to serve the South East market. It is on the Isle of Thanet in East Kent, 17 miles from the Port of Dover, 65 miles from Central London and 60 miles from the Port of Tilbury.

5.3 The Applicant explained that the road network around Manston Airport meant that if there were significant issues with the motorways that it was possible to deliver via a series of cross routes between the M2/A299 and M20 corridors, starting with the A256 to Dover and Folkestone, the A28 via Canterbury and Ashford, the A249 and the A229 if the M2 was closed. The Applicant noted that the level of traffic on these networks is for the most part substantially less than the M1, M25 and other radial and circular routes in London.

5.4 The Applicant stated that the Lower Thames Crossing would allow easier access to the M11/A14 corridor, and consequently allow for quicker and more reliable times to the biomedical industry and technology companies in Cambridge, the M11 Growth Corridor and prospectively to the planned Varsity Corridor. The Applicant noted that its Transport Assessment had not assumed that the Lower Thames Crossing would be implemented.

6 Agenda Item 8 - Operations – Runway Usage

6.1 The Applicant explained the conclusion of the Osprey report.

6.2 The conclusions on runway preference were built solely on meteorological data, which included the wind direction, wind speed and precipitation. The Applicant stated that winds were primarily from the west over the UK. Sometimes the UK experienced wind from the east, but often at low velocities, with exceptions like the 'beast from the east' occurring rarely. Normally when the wind blows from the west, the aircraft would depart towards the west and land from the east at Manston. If there are winds from the east, the opposite would normally occur. The Applicant looked at historical wind data for the airport, and the ability to operate with slight tail wind conditions, which is now possible when the tailwind factor is low. The Applicant stated that a preferred runway option, departing to, and arriving from, the west would operate when there are less than 5 transport movements an hour during light easterly wind conditions.

6.3 The Applicant explained that this runway preference was not factored into the Environmental Statement, which was based on the worst case scenario.

6.4 The Applicant also explained that steeper glide paths could be used but the gains in altitudes were only 10s of feet without much benefit to underlying populations and therefore such a strategy was not being pursued.

7 Agenda Item 9 - Operations – Scale and Capacity

7.1 The Applicant explained how it came to determine the scale of the necessary infrastructure included within its application. The Applicant explained that the 83,000 figure was provided as a theoretical maximum capacity, but that practically speaking the airport was unlikely to achieve that figure as it would rely on all aircraft arriving and departing at the most efficient time, the airport being used 18 hours a day with 2-2.5 hour stand time with all 19 stands being used, and without any holding or delays. That is not how airports operate in practice.

7.2 The Applicant explained that the 17,000 figure assumes ground time and stand efficiency (bunching factor of 3). The Applicant explained that many stands will be unused for periods of time however there will be peaks where all 19 stands are used. The Applicant has assumed stand time of 3 hours for visiting aircraft. That is a reasonable assumption. Based aircraft will be on stand much longer. It is important that the capacity provided is such that the airport presents an attractive offering. Capacity constraints result in delays which cause additional costs to the airlines and discourage them from using an airport.

7.3 As suggested at the hearing, the Applicant has provided its underlying calculation used to determine the required amount of airside warehouse space and the required number of aircraft stands (Appendix 11 to the Applicant's Summary of Oral Submissions made at the Compulsory Acquisition Hearing).

7.4 The Applicant has also provided a note about land to be used for airport 'associated' uses – this can be found at Appendix 7. The Applicant is undertaking further research to provide detailed analysis of the extent to which these uses are prominent at dedicated freight airports, as opposed to small and medium sized airports that have freight operations in the UK which are not directly comparable.

8 Agenda Item 10 - Operations – Aerodrome Certificate

8.1 The Applicant explained that they anticipate it would take 2 years for the certification process to be completed. The Applicant stated that it would be an iterative process, and although the formal process had not started, a team was ready to begin immediately. The Applicant explained that the CAA would not allow the Applicant to enter the formal process until the DCO is granted, as the CAA require certainty before commencing the certification process. The same procedure will be followed by Heathrow.

8.2 The Applicant acknowledged that there was inevitably some risk involved in securing the relevant certification from the CAA. The outcome of that process could not be guaranteed. However, there are opportunities to address any issues in the iterative process and the CAA would provide guidance throughout.

8.3 The Applicant considers that the risk is minimal. It has assembled an expert team to advise it, including individuals who have previously worked for the CAA, who cannot see any reason why the Applicant would be unable to secure the Aerodrome Certificate particularly as Manston was previously operational.

9 Agenda Item 11 - Operations – Airspace Change Process

9.1 The Applicant has engaged with the CAA regarding the timing of the aerodrome certificate application. The respective roles of the airspace change process and the DCO process in scrutinising the safety, operational and environmental aspects of any proposed airspace and instrument flight procedures was discussed at length at the CAA/PINS Process Workshop held on 12 June 17. It was recognised that, due to the respective timescales, the airspace change process would have to commence before the DCO process was complete and that it would have to be run in a parallel and complimentary manner. There is equally a need to initiate the airspace change at this stage so that it can be taken into account as part of the UK Future Airspace Strategy Implementation (South) (FASI(S)) programme which is currently seeking to redesign the airspace requirements of 16 airports in the southeast of England.

9.2 A draft Statement of Need, which initiates the airspace change process was submitted to the CAA ahead of the meeting with CAA staff on 18 October 2018. It was discussed as part of the meeting and a finalised version subsequently submitted to the CAA on 6 November 2018.

9.3 The Applicant is currently awaiting the allocation of a CAA Case Officer and date for an Assessment Meeting before proceeding further. It is expected that the Assessment Meeting will take place in late summer this year (2019).

9.4 The Applicant believes, from experience and knowledge, that it would be 2 years before approval is obtained and explained that no airport had yet completed this process, and Heathrow was at stage 2, CAP1616.

10 Agenda Item 12: Operations – Public Safety Zones

10.1 The Applicant agreed to further consider the issues raised by the ExA as regards Public Safety Zones (PSZs). PSZs are areas of land at the ends of runways established at the busiest airports in the UK, within which certain planning restrictions apply. Guidance does not set an Air Transport Movement (ATM) limit above which a PSZ should be introduced, but generally if ATMs exceed 1,500 per month (18,000 per year) and are expected to exceed 2,500 per month (30,000 per year), then one is likely to need to be introduced.

10.2 The Applicant's forecast is for 26,468 ATMs by year 20 and 5,840 general aviation movements (which are not technically ATMs but still affect the decision to create PSZs), and the Noise Mitigation Plan contains a cap of 26,468 ATMs and 38,000 general aviation movements. It is therefore possible that PSZs may need to be introduced towards year 20.

10.3 The Applicant has considered PSZs at other airports and has provided a drawing showing what it believes the 1 in 10,000 PSZs at Manston Airport would look like in the event that the criteria for requiring PSZs is met (Appendix 8).

10.4 There is no occupied development within this 1 in 10,000 individual risk contour at Manston, within which properties would have had to be vacated. Local planning authorities are expected to put in place policies restricting development within the 1 in 100,000 individual risk contour in their local plans to ensure that the population living and working in the zone does not increase. The Applicant will consider the environmental effects of introducing PSZs and report to the ExA at the next deadline.

11 Agenda Item 13: Operations – Safeguarding

11.1 The Applicant explained that whilst impact of wind turbines on aviation was historically an issue, technology has now advanced enough to safeguard against this. The Applicant explained that a radar system would be used that had mitigating features to control the effect of wind turbines on the air traffic surveillance system. That and appropriate placement of radar on the airport should safeguard against this issue. A SoCG had been agreed between the Applicant and the promoter of the Thanet Offshore Windfarm Extension project (REP3-177), and a corresponding SoCG between the parties for that DCO application (REP1-027 of its examination library).

12 Agenda Item 17 – Any other Relevant Business

12.1 SHP argued at the Compulsory Acquisition Hearing that its housing proposals represented a viable alternative to the Applicant's proposed use of the site, and that the public interests of its scheme should be taken into account in determining whether there is a compelling case in the public interest to justify the compulsory acquisition of land. SHP noted that its own viability assessment was available for consideration. The Applicant noted that the viability assessment cited by SHP for its project is not in fact in the public domain and invited SHP to submit it to the examination. The Applicant awaits SHP's response as to whether it can be provided.

APPENDIX 1: Azimuth Forecast Average Loads

Azimuth Forecast Average Loads

1. The Azimuth Report details the calculation used to forecast inbound and outbound tonnage. Volume III at paragraph 3.2.2 explains how tonnage was calculated from the forecast number of aircraft movements. Tonnage figures were calculated from the maximum payload for each aircraft type multiplied by 65% for the main route (either import or export).

2. The assumptions used for the secondary (return) route are detailed in paragraph 3.2.3 of this report. For dedicated freight airlines to and from the US, an assumption of 80% import/20% export was used. For dedicated freight airlines to and from Africa, 100% import and a 5% return load was assumed from Year 3, rising to 10% in Years 5 and 6, with an additional 5% increase added every two years. The African market showed 24.8% growth in FTKs in 2017 (IATA, 2017).

3. E-commerce integrator aircraft types were assumed to be Code D initially swapping to Code E as volumes build. Feeder aircraft are modelled as Code C. For e-commerce integrator movements, tonnage was calculated as 100% outbound (being 65% of maximum payload) with a return (import) calculation of 20% included in Years 2 and 3, rising by an additional 5% every two years. Integrator feeders were assumed to carry 100% inbound traffic with 10% return loads added to Year 5, 15% to Year 9, and 20% thereafter.

4. Average loads, calculated simply by dividing tonnes by ATMs, half the total for inbound and half for outbound, shows around 10 tonnes inbound and 13 tonnes outbound. This figure takes account of the lower capacity of the feeder aircraft Feeder flights are non-based aircraft and are forecast to carry a small secondary leg (return flight) tonnage.

5. Types of aircraft for charter airlines are modelled as Cat E and Cat C. The average load computes at around 25 tonnes inbound and 33 tonnes outbound in Year 1. Due to the increase in smaller aircraft in the forecast by Year 10, the average load reduces to 19 tonnes.

6. Scheduled and combination carriers are modelled as Cat C and Cat E. Average loads work out at 24 tonnes inbound and 36 tonnes outbound in Year 1. By Year 10, average loads are 32 tonnes inbound and 34 tonnes outbound. This average is across both Cat C and Cat E aircraft.

7. Other types of service were calculated dependent on market information obtained. Some movements, such as military and humanitarian and medevac were expected to carry outbound only.

APPENDIX 2: The Role of Freighter Aircraft in a Full-Service Network Airline Air Freight Services: The Case of Qantas Freight

Czech Technical University in Prague
Faculty of Transportation Sciences
Department of Air Transport

Magazine of Aviation Development
6(4):28-51, 2018, ISSN: 1805-7578
DOI: 10.14311/MAD.2018.04.05

The Role of Freighter Aircraft in a Full-Service Network Airline Air Freight Services: The Case of Qantas Freight

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Abstract

The dedicated all-cargo aircraft market is vital to the global economy. Freighter aircraft now carry around 56 per cent of world air cargo traffic. Using an in-depth case study research design, this study examined the Qantas Freight Boeing B747-400 and B767-300 freighter aircraft route network design during the 2017/2018 Northern Winter Flight schedule period, which was in effect from the 29th October 2017 to March 24th, 2018. The qualitative data were examined by document analysis. The study found that Qantas Freight deploy their leased B747-400 freighter aircraft on a route network that originates in Sydney and incorporates key markets in Thailand and China with major markets in the United States. The Boeing B767-300 freighter aircraft operated 5 services per week on a Sydney/Auckland/Christchurch/Sydney routing as a well as a weekly Sydney/Hong Kong/Sydney service. The Boeing B747-400 freighter services could generate 114,755,020 available freight tonne kilometres (AFTKs) over the schedule period. The Boeing B767-300 freighter aircraft could generate 46,974,1440 AFTKs. The Qantas Freight route network and freighter fleet is underpinned by Australia's liberalized freighter aircraft policy, the "Open Skies" agreement between Australia and China – which permits the onward carriage of cargo traffic across the trans-Pacific – and the liberalized "open skies" agreement with New Zealand.

Keywords

air freight; air services agreement; airline route networks; case study; freighter aircraft; Qantas Freight

1. Introduction

The air transportation of goods/freight for commercial purposes plays a significant role in the global economy. Air freight is defined as "anything carried in an aircraft except for mail or luggage carried under a passenger ticket and baggage check but including baggage shipped under an airway bill or shipment record". [1] Passenger baggage is associated with the carriage of passengers and is included as part of the individual passenger's air fare. [2] Passenger baggage is therefore not a part of the air cargo service. In the world air freight industry, air freight capacity is provided by combination passenger airlines, that is, airlines that carry passengers on the main deck and air cargo in their passenger aircraft lower lobe belly-holds and by dedicated all-cargo carriers as well as the integrators, for example, FedEx and United Parcel Service (UPS). [3] All-cargo services are operated by dedicated freighter aircraft with all the available capacity dedicated to air cargo transportation. The dedicated all-cargo market is vital to the aviation industry, and to the global economy. [4] A freighter aircraft is an aircraft that has been expressly designed or which has been converted to transport air cargo, express, and so forth, rather than passengers. [5] Boeing [6] estimates that currently around 56 per cent of global air cargo revenue ton kilometres (RTKs) is carried in dedicated freighter aircraft, and forecasts that this volume of traffic will more than double in the next 20 years.

In 1949-50, there was only a very small amount of Australia's international trade that was transported by the international air freight mode. During this infancy period of Australia's air freight industry, four airlines, British Commonwealth Airlines, Qantas Empire Airways Ltd, British Overseas Airways Corporation, and Tasman Empire Airways transported Australia's international air freight. The primary air freight destinations were in the South Pacific Islands, Hong Kong, London, Tokyo and Vancouver. [7] From these very humble beginnings, Australia's international air freight mode has now developed into an integral part of Australia's economy. Since the early 1990s, the Australian Government has increasingly embraced a more liberalized international air freight policy that has aimed to encourage the development of air freight as a market in its right and to ensure that air freight capacity is available to satisfy the opportunities for Australian firms in international markets. This policy was reaffirmed in the Australian Government's 2009 White Paper – Flight Path to the Future. [8] This liberalized air services policy has provided Qantas Freight, the air freight division of Qantas Airways, Australia's major flag carrier, with the opportunity to operate dedicated freighter services to key air freight markets using a fleet of two Boeing B747-400F and one Boeing B767-300F freighter aircraft.

The aim of this paper is to examine the Qantas Freight freighter aircraft route network architecture and to quantify the total available freight tonne kilometres (AFTKs) that these services produced during the 2017/2018 Northern Winter flight schedule period. The Northern Winter flight schedule period commenced on the 29th October 2017 and concluded on the 24th March 2018. A second aim is to quantify the flight stage lengths of the freighter services operated by Qantas Freight during the flight schedule period. A further aim is to examine the regulatory framework that underpins the ability of Qantas Freight to operate its desired Boeing B747-400 and Boeing B767-300 freighter aircraft services. A final aim of the paper is to examine the difference in the Qantas international passenger route network vis-à-vis the Qantas Freight freighter route networks.

The remainder of the paper is organized as follows. Section 2 sets the contextual setting of the study and presents a review of the extant literature on the research topic. The role of freighter aircraft in airline networks, the international aviation regulatory framework and the key operational characteristics of the Boeing B747-400F and the Boeing B767-300F are examined in this section. Section 3 describes the research method that underpinned the study. The case study is presented in Section 4. Section 5 presents the study's findings and conclusions.

2. Background

2.1 Air freight market liberalization

Air transport has had a long history of economic regulation. [9] Much of the recent focus in the global air transport industry has been on the liberalization of the passenger market, but the regulatory structure has also been applied to air freight activities. [10, 11] This is especially so in the case of combination carriers' belly-hold operations. The arrangement, in which passengers are carried on the aircraft's main deck, and cargo is carried below in the lower lobe "belly-hold" compartments, is referred to as a combination aircraft. [2]

International air transport operates within the framework of the 1944 Chicago Convention on International Civil Aviation and has been traditionally administered by a complex network of multilateral government air services agreements (ASA's) and International Air Transport Association (IATA) rules. The 1919 Paris Convention on the Regulation of Air Navigation established each state's complete and exclusive sovereignty over the airspace above its territory. [14, 15] The 1944 Chicago Convention on International Civil Aviation later reinforced this framework through codifying the rights and responsibilities of air service providers into a set of rules known as the Freedoms of the Air (Table 1) [16]. The 1944 Chicago Convention established multilateral agreements in some areas, mainly concerning an airline's right to overfly and make technical stops in a foreign country, but not in areas of commercial rights. Commercial air rights were left to bilateral air services agreements to be negotiated between individual countries. [17]

Following the 1946 Bermuda Agreement – between the United Kingdom and the United States – the Freedoms of the Air were operationalized globally in multiple reciprocal bilateral air services agreements between states (and supported by detailed Memoranda of Understanding). [16] In 1946, the very first bilateral air services agreement was signed between the United States and the United Kingdom and is known as Bermuda 1. The Bermuda 1 agreement set strict limitations regarding (1) ex post facto capacity, (2) designation of airlines, (3) air traffic rights in terms of which routes are to be served by the designated airlines, and (4) double approval of tariffs by both Governments. [18]

It is important to note that the International Civil Aviation Organization (ICAO) refers to all freedoms beyond the Fifth Freedom as "so-called" freedoms. The reason being that only

Table 1. The freedoms of the air [12, 13]

Freedom	Definition
1st	The right of the airline of State A to fly across the territory of State B without landing
2nd	The right of the airline of State A to land in the territory of State B for non-traffic purposes (that is, a technical stop)
3rd	The right of the airline of State A to put down passengers or freight originating in its home territory in the territory of State B
4th	The right of the airline of State A to take on, in the territory of State B, passengers or freight destined for State A
5th	The right of the airline of State A to operate beyond State B and to take on and put down passengers, cargo and mail travelling between State B and State C (that is, carriage of third country traffic, not originating or terminating in the home country of the airline
6th	The ability of the airline of State A to carry traffic between State B and State C via its home territory with nor requirement to include on such operation any point in the territory of the recipient State
7th	The right of airline of State A to transport traffic between State B and State C, with no requirement to operate via a point in its home territory (that is, the service need not connect to or be an extension of any service to/from the home State of the airline
8th	The right of the airline of State A to transport local domestic (often referred to as cabotage) traffic between two points in the territory of State B, on a service which originates or terminates in State A
9th	The right or privilege of transporting cabotage traffic of the granting State on a service performed entirely within the territory of the granting State

the first five freedoms have been officially recognized by way of international treaties arising from the Convention. [19]

Bilateral air services agreements (ASAs) are negotiated on the principle of reciprocity, and equal and fair exchange of air services traffic rights between countries very different in size and with airlines of varying sizes. Scheduled airline services and capacity between nations is therefore determined through a legal framework of bilateral negotiations of ASA's. [20] Bilateral ASA's vary in form, but in general, these agreements establish a country's market access (entitlement of capacity), airline designation, capacity (the level of flight frequencies, the authorized routings, and whether dedicated freight services would be permitted). These agreements can also determine tariffs, the types of aircraft that can be used, and what airports can be utilized by airlines for their services. [21] Bilateral air services agreements normally cover the carriage of both passengers and air freight by air, including both passenger and all-cargo flights. [11]

A critical issue arises once an air services agreement is agreed between two states: the designation of airlines. In addition to the nationality clause that defines the qualitative criteria an airline must fulfill to be designated, every ASA also generally contains a quantitative regulation on the total number of airlines that a country can designate. A country may be permitted to nominate just one airline (single designation) or several airlines (multiple designation). [12] For example, Australia has moved to a multiple designation policy. [22, 23]

Air traffic rights for the transportation of air freight and postal mail can be exercised both on passenger and all-cargo (freighter) flights. Those related to passenger services, which also carry air freight in the aircraft's lower deck belly holds, are dependent upon the carriage of passengers and the negotiations between the two governments is principally concerned with factors that are governed by the passenger market. [11] These air services agreements have been liberalized over the past 2 to 3 decades, particularly with the regard to the designation of the national carrier permitted to provide services, ranging from single to multiple airline designation. [11, 24]

The number of third and fourth freedom routes has also been liberalized, with the addition of some fifth freedom rights. Some airlines have also been able to expand their hub operations and the volume of traffic carried by combining two sets of third/fourth freedoms to carry sixth freedom traffic. Examples of this include Singapore Airlines, Etihad Airways and Emirates. Operating wide-body passenger aircraft they have been able to carry substantial amounts of air freight on these routes, primarily from Australasia to Europe. [11]

Air freight traffic rights are typically granted under the same Air Services Agreement (ASA) as passengers, and hence, have benefited from the gradual liberalization of air rights that was evident for passengers. [11]. Furthermore, in recent years, all-cargo services traffic rights have become increasingly liberalized. An intermediate traffic stop provides the airline with the possibility of earning additional revenue, which may often be the difference between the profit and loss on the overall freighter flight operation. [25] These agreements are often more liberal than their passenger counterparts, as they provide less of a threat to national or flag carriers that are reliant upon passengers. [11]

2.2 Features of air freight services

The primary reason for liberalizing air freight services is that air freight has features that are quite distinct from air passenger services. Human air travelers prefer flying directly to their destination whenever possible. [26] Should a transfer be required, then passengers prefer the shortest possible waiting time at the hub airport. Passengers also prefer a comfortable and attractive airport environment to make their travel experience as productive and enjoyable as possible. [27] Air freight, being inanimate, have no such feelings and air freight shippers often have little preference regarding the routes that their consignment travels provided time windows are satisfied. Indeed, whether the consignment travels direct, or is routed through one or more hub airports, is of lesser consequence than for passengers. Nonetheless, the transportation of air freight is sensitive to other factors, such as whether a change of aircraft is required, whether aircraft containers or pallets are required to be broken down and rebuilt, and the cost of transshipment handling. [26]

In addition, patterns of international air freight traffic are clearly different from those of passenger transport. In general, passengers tend to travel to their destination, then return to their point of origin, thereby providing passenger airlines roughly even per-seat load factors across their network system. [25]

However, the air freight mode is an important part of the world merchandise trade regime [28], and so is highly directional. World air cargo traffic is concentrated on several key trade flows between regional centres of production and consumption. This concentration is especially pronounced in air freight than for airline passenger flows which are more diffuse in nature. [29] The most significant international air freight flows are in the northern hemisphere between North America, Europe, and Asia. The United States, the world's largest economy, has a large air cargo (both domestic and international markets) with trade to Asia, Europe and South America. In the Asia/Pacific region, the major markets are China (including Hong Kong), Japan, Korea, Singapore and Taiwan. Air-freighted exports from Asia comprise consumer electronic items, textiles and clothing that are destined to key "western" markets. [30]

Unlike passengers, air freight is normally just one-way [31]. This results in geographically unbalanced transportation patterns in terms of the structure and volume of the air freight shipped. [32] In addition, air freight flows are "unidirectional" in nature. [33, 34] This is because air freight tends to move from manufacturing to distribution centres or from production to the point of consumption. [27, 35] Moreover, in international import/export trade, in terms of air freight consignments shipped between two countries, the trade volume can vary substantially so that one of the destinations is more in demand than the other.[36] Thus, considerable imbalances in air freight flows on routes can occur, which rigid ASAs may be ill-equipped to deal with.[37] On major world air freight routes, it is quite common to find that the volumes of traffic shipped in the densest direction is almost double the volume of the return direction [24]. This is because the inbound/outbound imbalance is essentially influenced by import/export trade imbalances between countries/regions. [26]

Whilst combination airlines flights are confined to the requirements of passengers, freighters are routed and scheduled based on shipper requirements. [38, 39] Therefore, all-freight carriers sometimes design their route networks with "big-circle" or convoluted routes, whilst passenger airlines typically operate east to west or north and south along the same linear route linking two cities. [26] However, the 'directionality problem' in air freight flows can often make it difficult for freighter operators to fill their aircraft profitably across their international route networks. The opportunity to make an intermediate stop in a freighter network opens the possibility for the airline of earning additional revenue, which may often mean the difference between profit and loss on the overall routing. Hence, freighter aircraft operators require the aircraft routing and load-building flexibility provided by fifth, sixth and seventh-freedom rights in air services agreements (ASAs) [25].

2.3 Combination airline passenger and freighter airline aircraft route networks

Line-haul operators transport air cargo on an airport-to-airport basis and typically rely on international air freight forwarders to deal directly with shippers. Line haul operators embody both scheduled and unscheduled all-cargo undertakings transporting only cargo in dedicated freighter aircraft for example, dedicated all-cargo airlines provide relatively high reliability and have the capability to move large volumes of air cargoes over long distances. For the combination airlines, air cargo operations are primarily long-haul, with large volumes of cargo being interlined onto shorter haul feeder services. [40] Some combination airlines operate freighter aircraft as well their passenger services. [39, 41, 42]

Although not quite half of the world air cargo is still carried in the belly holds of passenger aircraft there are some inherent limitations with belly-hold air freight. [11, 43] On passenger flights, passengers and their baggage have a higher boarding priority than air freight [44]. If unfavorable wind conditions on a long-haul flight necessitate a reduction in the available payload, air freight is likely to bear the brunt of that payload reduction. Offloading of cargo is a major complaint of major shippers because it causes considerable problems with their supply chains. [43]

Furthermore, airline passenger services are timed for the convenience of passengers. For air cargo shippers, flights departing in the late evening and night tend to be the most compatible with their daily production schedules. [43] Accordingly, most all-cargo airlines schedule their services to operate to and from their hubs overnight to meet shippers' requirements for overnight deliveries. [45] As shippers' expectations regarding the speed, reliability and timeliness of air transport has grown, so too has the attraction for the operations of dedicated freighter aircraft. The larger capacities of dedicated freighter aircraft are also an increasingly important advantage as major companies seek to ship large consignments, often at short notice. [43]

As freighter fleets have expanded, the ability of airlines to schedule higher frequencies services has further strengthened the attraction for freighter operations. Higher freighter frequencies are critical as they permit manufacturers to more tightly time larger consignments to fit in neatly meshed production networks. [43]

Airlines operating freighter aircraft often confront scheduling difficulties due to the directional imbalance in air cargo flows. Dedicated freighter aircraft may be fully laden when travelling eastbound from Asia to the United States, or westbound to Europe, but then fly back to Asia with much smaller cargo loads. Consequently, due to these demand/supply imbalances, airlines are required to construct special routing freighter aircraft patterns – for instance, clockwise circular routes around the Pacific or intensive hub-and-spoke operations. [26]

Inter-continental freighter routes are designed to link up the major centres of world trade. Such networks consist of long-haul flights to and from the airlines major hub airport, where long-haul shipments are often broken down and uplifted on subsequent flights to their final destinations. The major types of freighter aircraft operated on long-haul intercontinental routes are the Boeing B777-200LRF, B747-400F B747-8F and MD11 aircraft. Regional freighter routes are designed to link up the airline's major hub airport with important centres of regional trade. Air cargo is sourced from these markets and transported back to the airline's hub airport for loading onto to the airline's long-haul inter-continental services. [46]

3. Research Method

3.1 Research Approach

A qualitative research approach was used in this study. The study of the role of freighter aircraft in a full-service network carrier's (FSNC) air freight operations is still an emergent area of study. Thus, the most appropriate research method for such an emerging area is a qualitative method. [47] A case study approach was used in this study as this allows for the exploration of complex phenomena. [48, 49] Furthermore, a case study permits researchers to expand and build theories rather than perform statistical analysis to test a certain hypothesis. [50]

3.2 Document Collection

Qualitative data was also gathered from Qantas Airways, Qantas Freight and relevant Government web sites, air transport and airport industry-related magazines, and press articles. An exhaustive source of the air transport and cargo industry-related magazines – Air Transport World, Air Cargo World, Airline Business, Flight International, and Journal of Commerce was also conducted. These industry publications were accessed in the Proquest ABI/INFORM and EBSCO Information Sources databases. Table 2 shows the publications used in the study and the time-period for which the key word search was conducted. A search of the SCOPUS and Google Scholar databases was also undertaken. The key words used in the database searches were "Qantas Freight", "Qantas Freight freighter services", "Australia/China air services agreement", "Australia/New Zealand air services agreement". The website for Payload Asia, another key air freight industry publication, was also used in the study.

The study therefore used secondary data analysis to investigate the research problem. The three principles of data collection suggested by Yin [49] were followed in this study. These included the use of multiple sources of case evidence, the creation of a database on the subject, and the establishment of a chain of evidence.

3.3 Document Analysis

The empirical data collected for the case studies was examined using document analysis. Document analysis is often used in case studies and focuses on the information and data from formal documents and company records. [51, 52] According to Beaudry and Miller [53], qualitative document analysis "describes and interprets written materials that are produced by actors and are not solicited by the researcher". The documents collected for the study were examined according to four criteria: authenticity, credibility, representativeness and meaning. [54, 55, 56]

Prior to undertaking the formal analysis of the documents gathered in the study, the context in which the documents were created was determined and the authenticity of the documents was assessed. [57] Authenticity involves an assessment of the collected documents for their soundness and authorship. Scott and Marshall [55] note that 'soundness refers to whether the document is complete and whether it is an original and sound copy. Authorship relates to such issues as collective or institutional authorship. As previously noted, in this study the primary source of the case study documents was from the Qantas Freight 2017/2018 Northern Winter Flight Schedule, Qantas Airways and Qantas Freight websites, Qantas Airways press releases, and case study-related articles from the leading air transport and air cargo industry-related publications. Also, as previously noted, these publications included Air Cargo World, Air Transport World, Airline Business, Flight International, and Journal of Commerce. The documents gathered in the study were available in the public domain or from the Proquest/ABI Inform and EBSCO Host databases.

Authenticity addresses whether the document is original, are not of questionable origin, and that they have not been subsequently altered in any way. If a document has been found to be transformed, through textual editing, marginalia,

Table 2. Publication, time-period, and database sources used in the study

Publication	Time Period	Database
Air Cargo World	2004-2018	EBSCO Host
Air Transport World	2004-2018	Proquest ABI/INFORM
Airline Business	2004-2018	Proquest ABI/INFORM
Flight International	2004-2018	Proquest ABI/INFORM
Journal of Commerce	2004-2018	Proquest ABI/INFORM

or any other means, then the researcher is required to clearly identify those alterations. Once it has been determined by the researcher that the document is "genuine and of unquestionable origin," then the material can be considered "valid" as an artefact. [58] The documents gathered for the present study were all found to be genuine and there was no evidence of any changes being made to documents that were collected for the study.

Whilst any form of qualitative data may be original and genuine, that is, authentic, it is possible that the content may still be distorted in some manner. Thus, a second criterion in appraising materials is determining their credibility and identifying whether the document's information is both honest and accurate. [58] Hence, credibility refers to the extent to which a document is sincere and not distorted and is free from error and evasion. In assessing this criterion, it is necessary for the researcher to determine whether the document can be regarded as a credible, worthwhile piece of evidence and, also in some instances, whether it is accurate. [59] The documents gathered for the present study were all found to be free of error. The accuracy of all the gathered documents were checked to ensure that they were credible pieces of evidence, and thus, could be used in the study.

A third criterion, representativeness, refers to the "general problem of assessing the typicality or otherwise of the evidence" [59] collected for the study. A document's representativeness may become distorted over time. This is because with the passing of time the survival rate of certain materials becomes greater as the items may have been viewed as less valuable. Accordingly, the document(s) may have been stored away, rarely viewed following their point of origination, and hence, preserved. Furthermore, some important documents do not survive because their great significance caused them to become well used and worn. Consequently, they may be discarded while on the other hand less important documents survive because they attract so little use. [58] In this study, the Qantas Freight Northern Winter 2017/2018 flight schedule, Qantas Airways press releases and annual reports were available in the public domain. The news-items on Qantas Freight were stored in the Proquest ABI/INFORM or EBSCOhost databases, thus, the documents had been preserved. Consequently, the issue of a document being well used and worn did not arise in this study.

A final criterion—meaning—refers to the degree to which the evidence is clear and comprehensible to the researcher(s) [58, 59] and concerns the assessment of the actual documents gathered for the study. [59] The fourth criterion, meaning, is a most important matter and occurs at two levels. The first is the literal understanding of a document, by which is meant its physical readability, the language used and whether it can be read, as well as the date of the document. [59, 60]

The study's qualitative document analysis process was undertaken in six phases as presented in Table 3.

The documents gathered for the study covered the period 2004 to 2018, that is, the documents covered the period from the inception of the dedicated international freighter operations by Qantas Freight through to the present time of the study.

All the gathered documents were downloaded into a case study database. [49, 62] The documents collected for the study were all in English. Each document was carefully read and key themes, such as, "Qantas Freight", "Qantas freighter aircraft", "Qantas freighter services", "Australia/China air services agreement", "Australia/New Zealand air services agreement", and "airline freighter route network" were coded and recorded. This study followed the recommendation of van Schoor [63], to "avoid bias, documents of different sources were analyzed". Triangulation is used to add discipline to a study in both qualitative and quantitative research. One of the principal reasons for triangulation is the recognition that bias can be introduced if only one way of obtaining and interpreting data is used in the study. Triangulation is also used in qualitative research as a procedure to ensure stronger accuracy, employ cross-referencing, or demonstrate the verification of the data. This study used data triangulation with the documents being collected from various sources. This approach helped verify the themes that were detected in the documents gathered in the study. [62, 64]

4. Results

4.1 A Brief Overview of Qantas Freight

Qantas Freight is Australia's largest air freight services provider. Qantas Freight, the air freight division of Qantas Airways, markets the available freight capacity on Qantas and Jetstar Airways passenger aircraft. It also operates a fleet of 14 dedicated freighters. These aircraft are used to supplement the Qantas and Jetstar Airways belly-hold capacity on key domestic and international routes. [65]

In addition to being Australia's major air freight carrier, Qantas Freight is also Australia's largest airfreight cargo terminal operator. Qantas Freight operates a network of 22 air cargo terminals. These air cargo terminals provide ground

Table 3. The study's document analysis process [61]

Phase of the Study	Activity/Task Undertaken
Phase 1	This phase involved planning the types and required documentation and their availability.
Phase 2	The data collection involved gathering the documents and developing and implementing a scheme for the document management;
Phase 3	Documents were reviewed to assess their authenticity, credibility and to identify any potential bias
Phase 4	The content of the collected documents was interrogated, and the key themes and issues were identified
Phase 5	This phase involved the reflection and refinement to identify any difficulties associated with the documents, reviewing sources, as well as exploring the documents content
Phase 6	The analysis of the data was completed in this final phase of the study

handling to the Qantas Group and other client airlines. [65]. Figure 1 shows Qantas Freight's annual inbound and outbound enplaned air cargo tonnages for the period 2004 to 2016.

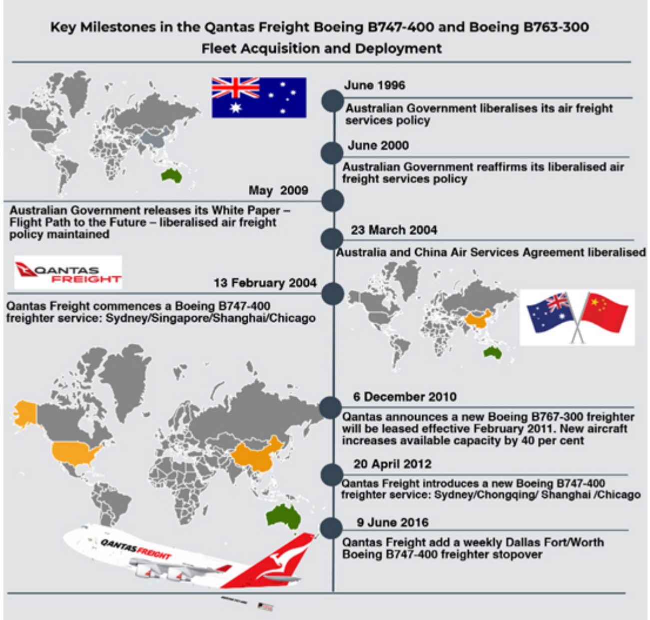
Figure 1. Qantas Freight annual inbound and outbound air freight tonnage: 2004-2016. Note: Data includes both Jetstar Airways and Qantas Airways. Source: data derived from [66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78]

Qantas Freight operates in all the international markets where the Qantas Group flies and, as previously noted, operates dedicated freighter aircraft through Asia to the Americas, and to New Zealand. In addition to the international freight services, Qantas Freight also serves over 80 domestic Australian destinations, utilizing Qantas Group passenger aircraft lower-deck belly hold capacity and the capacity provided by a fleet of dedicated freighters.

Qantas Freight's principal customers are firms seeking efficient and reliable domestic and international air freight transport and cargo and ground handling services. Qantas Freight's 'Q-GO' product range offers customers a comprehensive range of air freight services. These services include airport-to-airport air linehaul and ground handling services (including customs clearance), which are supported by related courier and road feeder trucking services. [65]

Qantas Freight have defined and implemented strategies to optimize their revenue and satisfy customer requirements. The Qantas Freight strategy aims to provide excellence in freight services, the leveraging of an integrated freight network and customer relationships, capitalize on air freight growth opportunities in the Asia/Pacific region and provide the lowest cost and best service through operational excellence. The Qantas Freight strategy also aims to leverage the company's position in China and to utilize favourable air services rights to optimize freight traffic, and to continually respond to the evolving air freight market dynamics, for instance, shifting manufacturing trends. [79]

Figure 2 shows the key milestones in the Qantas Freight Boeing B747-400F and B767-300F freighter aircraft acquisition and deployment. These are discussed in greater detail in the following sections of the case study.



June 1996
Australian Government liberalises its air freight services policy

June 2000
Australian Government reaffirms its liberalised air freight services policy

May 2009
Australian Government releases its White Paper – Flight Path to the Future – liberalised air freight policy maintained

23 March 2004
Australia and China Air Services Agreement liberalised

13 February 2004
Qantas Freight commences a Boeing B747-400 freighter service: Sydney/Singapore/Shanghai/Chicago

6 December 2010
Qantas announces a new Boeing B767-300 freighter will be leased effective February 2011. New aircraft increases available capacity by 40 per cent

20 April 2012
Qantas Freight introduces a new Boeing B747-400 freighter service: Sydney/Chongqing/ Shanghai /Chicago

9 June 2016
Qantas Freight add a weekly Dallas Fort/Worth Boeing B747-400 freighter stopover

Figure 2. The key milestones in Qantas Freight Boeing B747-400F and B767-300F freighter aircraft acquisition and deployment

4.2 Australia's International Air Freight Policy

Prior to examining Qantas Freight's deployment of their Boeing B747-400 and B767-300 freighter aircraft and their freighter route network design, it is important to note Australia's international air freight policy, as this has a major impact on the route network design and Qantas Freight commercial operations. International trade in goods and services was significantly liberalized by Australia in the 1980s.[80] Commencing in the early 1990s, Australia moved further towards liberalized provisions, with the removal of restrictions on equity investments between international and domestic airlines, together with multiple designations, enabling more integration between these services. [81] Since the early 1990s, Australia has signed many free trade agreements (FTA) [82] and has ten currently in force with New Zealand, Singapore, Thailand, United States, Chile, Association of South East Asian Nations (ASEAN) (with New Zealand), Japan, Korea, Malaysia and China. [83] Currently, Australia generally favors an open free trade system. [80] At the time of the present study, Australia was engaged in nine FTA negotiations:

- Australia-Gulf Cooperation Council (GCC) FTA;
- Australia-India Comprehensive Economic Cooperation Agreement;
- Environmental Goods Negotiations;
- Indonesia-Australia Comprehensive Economic Partnership Agreement;
- Pacific Alliance Free Trade Agreement;
- Peru-Australia Free Trade Agreement;
- Regional Comprehensive Economic Partnership;
- Trade in Services Agreement; and
- Australia-Hong Kong Free Trade Agreement. [82]

Australia has air services agreements/arrangements with 101 countries/economies. Airlines operating international air services to and from Australia do so within capacity entitlements contained in air services arrangements. The air services arrangements ratified by Australia are usually comprised of a treaty level Air Services Agreement (ASA) supplemented by arrangements of less than treaty status between aeronautical authorities, such as Memorandums of Understanding (MOU) and/or exchanges of letters. It is an Australian Government policy to publish all treaty-level agreements. [84]

The role of Australia's Commonwealth Government in determining the economic regulation of Australia's international air freight industry is limited to negotiating dedicated air freight capacity in ASA's. The Australian Government negotiates through its bilateral ASA's whether dedicated freight services will be permitted and/or whether a conversion mechanism that authorizes airlines to exchange passenger rights for dedicated freight services can be applied. Essentially this is the limit of the Government's involvement in determining dedicated air freight capacity. Notwithstanding, the Government has indirect influence on the level of capacity through the passenger capacity ASA's, as the majority of Australia's international air freight is transported in the belly holds of scheduled passenger aircraft. [85]

The Australian Government has increasingly embraced a more liberalized air policy framework. In June 1996, the Australian Government implemented a liberalized air freight arrangements policy which aimed to encourage the development of air freight as a discrete market, rather than have it treated as a by-product arising from the supply of passenger services. [86]

In June 1999, the Australian Government further announced that international airlines would be granted unrestricted access (with no limits on capacity) to all airports except for Brisbane, Melbourne, Perth and Sydney – although dedicated freighter services would be allowed access to all airports. [82]

In 2000, the Government released its "International Air Services Policy Statement". The key areas of this policy statement included:

- The liberalization of air services arrangements;
- The liberalization of the ownership requirements of Australian airlines;
- The allocation of capacity available under Australian air services arrangements;
- Liberalizing international aviation multilaterally; and
- The development of air cargo as a discrete market, rather than have it treated as a by-product of passenger services. [86]

The key air freight related objective of this policy was to ensure that air freight capacity would be available to satisfy the opportunities for Australian exporters and importers in international markets. To achieve this objective, the Government defined and implemented three important strategies:

- Australia will continue to include "open skies" dedicated air freight arrangements in the country's air services arrangements where bilateral partners are willing.
- In all other cases, offer significant dedicated air freight capacity under each air services arrangement.
- Seek to negotiate a more liberal universal framework for dedicated air freight services in the World Trade Organization (WTO). [86]

In addition, the Australian Government has stated its intention to pursue multilateral liberalization of charter services in the WTO. [86] Since that announcement, the Government has negotiated ASA's that authorize designated airlines to determine the type of aircraft; frequencies, capacity and routing according to the market demand. [85]

In 2006, following a formal review of its international air services policy, the Government once again reaffirmed its commitment to developing Australia's international air freight market by seeking unlimited access for freighter aircraft from Australian markets to and beyond foreign markets.[87] Thus, the Australian Government negotiates ASA's with its key bilateral partners to ensure that dedicated air freight capacity is not used in ASA's at the expense of passenger capacity. [85] In 2009, the Australian Government's White Paper – Flight Path to the Future – reaffirmed the government's policy on liberalizing Australia's international air freight industry "recognising the benefits to the Australian economy of pursuing a liberal market for dedicated cargo services, the Government will continue to seek the removal of limits on all cargo capacity in our bilateral agreements and in multilateral forums". [8]

4.3 Qantas Freight Boeing B747-400 Freighter Aircraft Deployment and Route Network Design

As previously noted, an objective of Australia's international air freight policy has been to develop international air freight market by seeking unlimited access for freighter aircraft from Australian markets to and beyond foreign markets. Qantas Freight, the air freight division of Qantas Airways, Australia's major flag carrier has been able to take advantage of this policy. Following the conclusion of an "open skies" or liberalized agreement between Australia and China in 2004 [88], that allowed Australian airlines fifth freedom, or beyond rights from China, on the 13th February 2004 Qantas Freight introduced a twice weekly dedicated freighter service that operated on a Sydney/Singapore/Shanghai/Chicago routing before returning to Australia. On the 20th April 2012, Qantas Freight commenced a new weekly dedicated Boeing B747-400F freighter service (Flight number QF7583) direct from Sydney to Chongqing's Jiangbai International Airport. The aircraft continued to Chicago via Shanghai before returning to Sydney under flight number QF7552.89 This strategy has proved successful for Qantas who now carries around 5 per cent of the air freight traffic between China and the United States. [89]

Qantas Freight operated four weekly freighter routes linking Australia with China and the USA and returning to Sydney, Australia during the 2017/2018 Northern Winter flight schedule period. Qantas has wet-leased two Boeing B747-400 freighter aircraft from USA-based Atlas Air for use on trans-Pacific routes linking Australia with Asia and the United States. [90] On June 9, 2016, Qantas Freight added a new stop at Dallas Fort/Worth Airport. [91]

During the 2017/2018 northern winter flight schedule, Qantas Freight scheduled a Boeing B747-400 freighter aircraft each Monday on a Sydney to Chongqing, Pudong International Airport (Shanghai), Anchorage and Chicago's O'Hare International Airport flight routing (Figure 3). The outbound flight number from Sydney is QF7521 and the return flight from O'Hare International Airport, to Dallas Fort Worth, Los Angeles, and Honolulu to Sydney is QF7558 (Figure 3). [92]

Figure 3. Flight routing for the Qantas Freight QF7521 and 7558 Boeing 747-400 freighter services.

Legend: ANC=Anchorage, CKG=Chongqing, DFW=Dallas Fort/Worth, HNL=Honolulu, LAX=Los Angeles International Airport, ORD=O'Hare International Airport (Chicago), PVG=Pudong International Airport (Shanghai), SYD=Sydney

Table 4 shows the total available freight tonne kilometres (AFTKs) that could have been potentially generated on the QF7521 service. According to Qantas Freight (2018), the Boeing B747-400 freighter aircraft has an available payload of 110 tonnes. Due to the flight longer stage lengths, the largest source of AFTKs will be on the Sydney to Chongqing and Pudong International Airport to Anchorage sectors. The number of AFTKs on the Chongqing to Pudong International Airport are 161,040 AFTKs (Table 4); these are lowest AFTKs on this service due to the short flight stage-length. There will be a total of 503,910 AFTKs on the Anchorage to O'Hare International Airport sector. The total FTKs generated over these flight sectors is 2.358 million (Table 4).

Table 5 shows the total available freight tonne kilometres (AFTKs) that that could have been potentially generated on the QF7558 service. The most AFTKs on this service would be generated on the Honolulu to Sydney sector (896,940 AFTKs), due to the long stage length (Table 5). The US domestic legs, that is, between O'Hare International Airport and Dallas Fort/Worth have a quite short stage length, and thus, the AFTKs produced are quite low when compared to the Los Angeles to Honolulu (452,540 AFTKs) and the Honolulu to Sydney (896,940 AFTKs) sectors. The total AFTKs that could have been potentially produced on these services is 1.710 million AFTKs (Table 5). The AFTKs generated on the QF7558 are lower than for the QF7521 service, due to the shorter flight stage lengths on these services.

Following the return of the Boeing B747-400 freighter aircraft from the United States on Friday evening Sydney time (QF7558), the aircraft was scheduled to be unloaded and then subsequently reloaded in preparation for the QF7589 service departing on Saturday. During the 2017/2018 Northern Winter flight schedule [93], this service was scheduled to operate direct from Sydney to Shanghai's Pudong International Airport, then onwards to Anchorage before terminating at New York's John F. Kennedy International Airport (Figure 4). The return flight QF7554 operated on a John F. Kennedy International

Table 4. Available freight tonne kilometres (AFTKs) generated by flight segment on the QF7521 service

Flight Number	Sector	Distance (km)^6	AFTKs
QF7521	SYD^5/CKG^2	8,462	930, 820
QF7521	CKG^2/PVG^3	1,464	161,040
QF7521	PVG^3/ANC^1	6,934	762,740
QF7521	ANC^1/ORD^4	4,581	503,910
Total		21,441	2,358,510

Legend: ANC=Anchorage Airport, 2 CKG=Chongqing Airport, 3 PVG=Pudong International Airport (Shanghai), 4 ORD=O'Hare International Airport (Chicago), 5 SYD=Sydney, 6 Source: flight distance. [94]

Table 5. Available freight tonne kilometres (AFTKs) generated by flight segment on the QF7558 service

Flight Number	Sector	Distance (km)^6	AFTKs
QF7558	ORD^4/DFW^1	1,291	142,010
QF7558	DFW^1/LAX^3	1,988	218,680
QF7558	LAX/HNL^2	4,114	452,540
QF7558	HNL^2/SYD^5	8,154	896,910
Total		15,547	1,710,170

Legend: 1 DFW=Dallas Fort/Worth Airport, 2 HNL-Honolulu, 3 LAX=Los Angeles International Airport, 4 ORD=O'Hare International Airport (Chicago), 5 SYD=Sydney, 6 Source: flight distance [94]

Airport (New York), O'Hare International Airport (Chicago), Honolulu, Sydney routing (Figure 4).

Figure 4. Flight routing for the Qantas Freight QF7589 and 7554 Boeing 747-400 freighter services.

Legend: ANC=Anchorage, HNL=Honolulu International Airport, JFK= John F. Kennedy International Airport (New York), ORD=O'Hare International Airport (Chicago), PVG=Pudong International Airport (Shanghai), SYD=Sydney

Table 6 shows the available AFTKs that that could have been potentially generated on the QF7589 services during the 2017/2018 Northern Winter flight schedule period. The Sydney to Pudong International Airport sector would generate the largest number of AFTKs (862,180 AFTKs), due to it being the long flight stage length. The Pudong International Airport to Anchorage flight sector is the second longest at 6,934km, and a total of 762,740 AFTKs could be generated (Table 6). This is followed by the Anchorage to John F. Kennedy International Airport sector, which could produce 599,390 AFTKs (Table 6). The total AFTKs for these services is 2.22 million (Table 5).

Table 7 shows the total available freight tonne kilometres (AFTKs) that that could have been potentially generated on the QF7554 service. The most AFTKs on this service would be generated on the Honolulu to Sydney sector (896,940 AFTKs), due to the long stage length of this sector (Table 7). The second largest source of AFTKs is on the O'Hare International Airport to Honolulu sector (751,190 AFTKs) (Table 6). The US domestic leg between New York's John F. Kennedy International Airport and O'Hare International Airport is quite short at 1,192km. The total AFTKs potentially produced over this sector is 131,120 AFTKs. The total AFTKs produced on these services is 1.779 million AFTKs (Table 7). The AFTKs generated on the QF7554 are lower than for the QF7589 service, due to the shorter flight stage lengths on this service.

As noted earlier, Qantas Freight leases two Boeing B747-400 freighter aircraft from Atlas Air. During the 2017/2018 Northern Winter flight schedule period the second Boeing B747-400 freight was deployed on two weekly rotations from Australia through Asia and across the Pacific to the USA. Qantas Flight Number 7581 was scheduled to operate each Monday on a Sydney, Bangkok, Pudong International Airport, Anchorage, John F. Kennedy Airport (New York) routing (Figure 5). The return flight QF7552 operates on a John F. Kennedy International Airport (New York), O'Hare International Airport (Chicago), Honolulu, Sydney routing (Figure 5).

Table 8 presents the available freight tonne kilometres (AFTKs) on the QF 7581 service for the 2017/2018 Northern Winter flight schedule period. The outbound sector from Sydney to Bangkok could have potentially generated 825,330 AFTKs. The distance between Bangkok and Pudong International is 2,894 kilometres, and thus, the total AFTKs produced on this leg of the flight could have been 318, 340 AFTKs. As

Table 6. Available freight tonne kilometres (AFTKs) generated by flight segment on the QF7589 service

Flight Number	Sector	Distance (km)[6]	AFTKs
QF7558	ORD[4]/DFW[1]	1,291	142,010
QF7558	DFW[1]/LAX[3]	1,988	218,680
QF7558	LAX/HNL[2]	4,114	452,540
QF7558	HNL[2]/SYD[5]	8,154	896,910
Total		15,547	1,710,170

Legend: 1 ANC=Anchorage, 2 PVG=Pudong International Airport (Shanghai), 3 JFK=John F. Kennedy International Airport, 4 SYD=Sydney, 5 Source: flight distance. [93]

Table 7. Available freight tonne kilometres (AFTKs) generated by flight segment on the QF7554 service

Flight Number	Sector	Distance (km)[6]	AFTKs
QF7558	ORD[4]/DFW[1]	1,291	142,010
QF7558	DFW[1]/LAX[3]	1,988	218,680
QF7558	LAX/HNL[2]	4,114	452,540
QF7558	HNL[2]/SYD[5]	8,154	896,910
Total		15,547	1,710,170

Legend: 1HNL=Honolulu International Airport, 2 JFK=John F. Kennedy International Airport, 3 ORD=O'Hare International Airport (Chicago), 4 SYD=Sydney, 5 Source: flight distance. [93]

Figure 5. Flight Routing for the Qantas Freight QF7581 and 7550 Boeing 747-400 Freighter Services.

Legend: ANC=Anchorage, BKK=Bangkok, HNL=Honolulu International Airport, JFK= John F. Kennedy International Airport (New York), ORD=O'Hare International Airport (Chicago), PVG=Pudong International Airport (Shanghai), SYD=Sydney.

previously noted, fifth freedom air services rights are the right of the airline of State A to operate beyond State B and to take on and put down cargo (and mail) travelling between State B and State C. [12, 13] Should Qantas Freight have decided to uplift air freight traffic between Bangkok and Pudong International Airport to the United States on the QF7581, then it would be exercising its fifth freedom rights from Thailand. The flight sectors between Pudong International Airport and Anchorage and Anchorage and New York's John F. Kennedy Airport will generate 762,740 and 599,390 AFTKs, respectively. Both sectors have quite long stage lengths, and hence, the AFTKs production reflects these distances. The total AFTKs that could have been potentially produced on each QF7581 service during the 2017/2018 Northern Winter Flight Schedule period was 2,505,800 AFTKs (Table 8).

During the 2017/2018 Northern Winter flight schedule period, the weekly QF7550 could have been potentially been able to produce a total of 1.77 million AFTKs (Table 9). The return flight to Sydney from New York's John F. Kennedy Airport includes two long stage lengths, that is, the O'Hare International Airport to Honolulu and the Honolulu to Sydney sectors. These two sectors could have potentially produced 751,190 and 896,940 AFTKs, respectively. Due to the short stage length between John F. Kennedy Airport and O'Hare International Airports, the number of AFTKs (131,120 AFTKs) is much lower than for the two other sectors, due to the shorter flight stage length (Table 9).

During the 2017/2018 Northern Winter flight schedule period, Qantas Freight deployed its second leased Boeing B747-400 freighter on a Sydney, Chongqing, Pudong International Airport, Anchorage, O'Hare International Airport routing. The return flight includes a stopover in Auckland, New Zealand as part of the routing: O'Hare International Airport, Los Angeles, Honolulu, Auckland, Sydney (Figure 6).

The longest stage length on the QF7557 service is between Sydney and Chongqing, and consequently, this sector could have potentially produced the highest number of AFTKs (930,820 AFTKs). The flight stage lengths between Pudong International Airport and Anchorage and Anchorage and O'Hare International Airport are also quite long, and the AFTKs generated on these two sectors are 762,740 AFTKs and 503,910 AFTKs, respectively (Table 10). The smallest number of AFTKs on the weekly QF7557 service was on the short domestic leg in China between Chongqing and Pudong International Airports. Due to the short stage length distance of 1,464km, a total of 161,040 AFTKs could have been potentially generated over this sector. During the 2017/2018

Table 8. Available freight tonne kilometres (AFTKs) generated by flight segment on the QF7581 service

Flight Number	Sector	Distance (km)[6]	AFTKs
QF7581	SYD[5]/BKK[2]	7,503	825,330
QF7581	BKK[2]/PVG[4]	2,894	318,340
QF7581	PVG[4]/ANC[1]	6,934	762,740
QF7581	ANC[1]/JFK[3]	5,449	599,390
Total		22,780	2,505,800

Legend: 1ANC=Anchorage, 2BKK= Bangkok, 3JFK=John F. Kennedy International Airport, 4PVG=Pudong International Airport (Shanghai), 5SYD=Sydney, 6Source: flight distance. [93]

Table 9. Available freight tonne kilometres (AFTKs) generated by flight segment on the QF7550 service

Flight Number	Sector	Distance (km)[5]	AFTKs
QF7554	JFK[2]/ORD[3]	1,192	131,120
QF7554	ORD/HNL[1]	6,830	751,190
QF7554	HNL/SYD[4]	8,154	896,940
Total		16,176	1,779,250

Legend: 1 HNL=Honolulu International Airport, 2 JFK=John F. Kennedy International Airport, 3 ORD=O'Hare International Airport (Chicago), 4 SYD=Sydney, 5 Source: flight distance. [93]

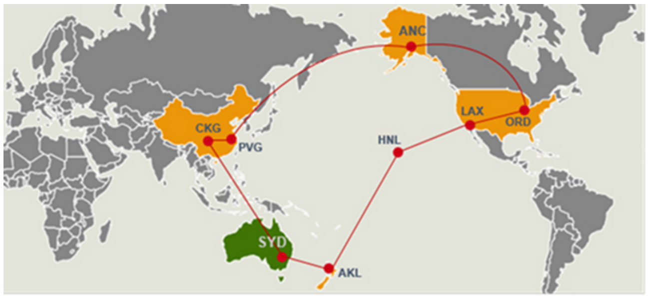


Figure 6. Flight routing for the Qantas Freight QF7557 and 7552 Boeing 747-400 freighter Services

Legend: AKL-Auckland, ANC=Anchorage, CKG= Chongqing, HNL=Honolulu International Airport, ORD=O'Hare International Airport, PVG=Pudong International Airport (Shanghai), SYD=Sydney.

Northern Winter flight schedule period, the total AFTKs generated on the weekly QF7557 service would have been 2.35 million AFTKs (Table 10).

During the 2017/2018 Northern Winter flights schedule period, Qantas Freight included a stop-over in Auckland on the return leg of the QF7552 flight to Sydney. This provided Qantas Freight with the ability to source Auckland destined cargo traffic in the United States and carry it to New Zealand, should it have decided to do so. In such a case, Qantas Freight would be using fifth freedom rights. The longest stage length on the QF7552 service was between Honolulu and Auckland (7,063km) (Table 11). The total AFTKs potentially produced over this sector is the highest at 776,930AFTKs. This is followed in significance by the Los Angeles to Honolulu sector with 452,540 AFTKs. The domestic service between O'Hare International Airport and Los Angeles offers 308,770 AFTKs. The Auckland to Sydney service has quite a short stage length of 2,165 kilometres. Due to the short stage length, a total of 238, 040 AFTKs could have been generated over this sector (Table 11).

4.4 Qantas Freight Boeing B767-300 Freighter Aircraft Deployment and Route Network Design

4.4.1 Qantas Freight Boeing B767-300 Trans-Tasman Freighter Network

On December 6, 2010, Qantas Airways announced that it would be increasing its Trans-Tasman by 40 per cent through the lease and deployment of a Boeing B767-300F freighter aircraft on the route. The aircraft will be operated for Qantas Freight by Express Freighters Australia (EFA). Express Freighters Australia (EFA) are the Qantas Group's freighter management company. EFA holds its own Air Operators Certificate and the group's freighter aircraft on behalf of Qantas Freight. The new Boeing B763-300F freighter aircraft entered service in February 2011. 95 During the 2017/2018 Northern Winter flight schedule period, Qantas Freight were operating the aircraft in the Trans-Tasman and Sydney to Hong Kong air cargo markets (Figure 7).

Before examining the deployment of the Qantas Freight Boeing B767-300 freighter aircraft in the Trans-Tasman market and quantifying the AFTKs that these services could have produced, it is important to note the regulatory framework covering this market, as this affects the route network design and the services provided by the actors competing in this market. Air services between Australia and New Zealand were initially regulated by an air services agreement (ASA) signed in 1961 [22, 94], and the subsequent Memoranda of Understanding (MOU). The arrangements were originally very restrictive. Air New Zealand and Qantas Airways were the only two designated airlines and the governments of both countries had to

Table 10. Available freight tonne kilometres (AFTKs) generated by flight segment on the QF7557 service

Flight Number	Sector	Distance (km)[6]	AFTKs
QF7557	SYD[5]/CKG[2]	8,462	930, 820
QF7557	CKG[2]/PVG[3]	1,464	161,040
QF7557	PVG[3]/ANC[1]	6,934	762,740
QF7557	ANC[1]/ORD[4]	4,581	503,910
Total		21,441	2,358,510

Legend: 1 ANC=Anchorage, 2 CKG= Chongqing, 3 PVG=Pudong International Airport (Shanghai), 4 ORD=O'Hare International Airport (Chicago), 5 SYD=Sydney, 6 Source: flight distance. [93]

Table 11. Available freight tonne kilometres (AFTKs) generated by flight segment on the QF7552 service

Flight Number	Sector	Distance (km)[6]	AFTKs
QF7552	ORD[4]/LAX[3]	2,807	308,770
QF7552	LAX[3]/HNL[2]	4,114	452,540
QF7552	HNL[2]/AKL[1]	7,063	776,930
QF7552	AKL[1]/SYD[5]	2,164	238,040
Total		16,148	1,776,280

Legend: 1 AKL=Auckland, 2 HNL=Honolulu, 3 LAX= Los Angeles International Airport, 4 ORD=O'Hare International Airport (Chicago), 5 SYD=Sydney, 6 Source: flight distance. [93]

agree on air fares, flight frequencies and capacity. Some of these restrictive features were relaxed during the 1980s. [95] Since the Australia–New Zealand Closer Economic Relations Trade Agreement (known as the CER Agreement) entered effect in 1983, the Australian and New Zealand economies have become increasingly integrated. In 1988, when the CER Trade in Services Protocol was concluded, however, Australia chose to exclude international and domestic air services from its application; the only air services exclusion by New Zealand was international airlines flying cabotage. Consequently, liberalization of air services across the Tasman continued to be dealt with by a bilateral air services agreement and related understandings (for example, the 1989 understanding agreed to multiple designation for freight with no capacity constraint). [96]

In 1992, Australia and New Zealand concluded a Memorandum of Understanding (MOU). This agreement lifted capacity restrictions across the Tasman Sea, introduced multiple designation and a double disapproval tariff regime. [81, 96] The ratification of the MOU opened the Trans-Tasman air travel market to Australasian airlines other than Air New Zealand and Qantas and provided a phased introduction (with a limit up to 12 Boeing 747s per week) of an all-points exchange so that by November 1st, 1994, all Australasian airlines could operate to, from or between and designated international airport in either country. [97] The MOU also contained a commitment by both States to consult on the subsequent full exchange of beyond rights and cabotage rights, the ownership and control of designated airlines, and the possibility of forming a joint bloc for negotiating international traffic rights. [81] Airlines were permitted to set their own air fares and flight frequencies. [98] In addition, by November 1, 1994, there was multiple designation for passenger and air cargo services with no limit on the number of cities that an airline(s) could serve. The joint air services agreement was due to take effect on November 1, 1984. In October 1994, Australia withdrew its commitment. [95, 96, 99]

In 1996, Australia and New Zealand ratified the "Single Aviation Market" (SAM) arrangements, which was incorporated into the CER Protocol. The arrangements permitted a "SAM carrier" to operate without restrictions trans-Tasman and domestic services in either State. Unlimited beyond rights were excluded from the agreement, and which were subsequently governed by the bilateral air services (ASA) agreements and the 1992 MOU. In 2000, Australia and New Zealand ratified an "open skies" agreement, which was officially signed in 2002. [96] This agreement liberalized air traffic between the two States and opened the Trans-Tasman market to other airlines from other countries, thus raising the connectivity of both countries with foreign markets [100]. Effective from November 2006, any airline with 50 per cent or more Australian and/or New Zealand ownership was permitted to operate services freely between the two countries or within them, subject only to border restrictions.

During the 2017/2018 Northern Winter Flight Schedule period, Qantas Freight deployed their leased Boeing B767-300 freighter aircraft on five Sydney/Auckland/Christchurch/Sydney services per week (Figure 7). The five Boeing B767-300 freighter services per week from Sydney to Auckland could have potentially generated 606,200 AFTKs. The return flights from Christchurch (QF7524/QF7528) could have potentially produced 596,400 AFTKs (Table 12). The very short sector between Auckland and Christchurch (745km) could have potentially generated 208,600 AFTKs (Table 12). On a weekly basis, these services could have potentially produced a com-

Figure 7. Flight routing for the Qantas Freight Boeing B767-300 freighter services

Legend: AKL=Auckland, CHC=Christchurch, HKG=Hong Kong, SYD=Sydney.

bined total of 1.41 million AFTKs, during the 2017/2018 Northern Winter flight schedule period (Table 12).

4.4.2 Qantas Freight Boeing B767-300 Hong Kong Route Network Design

Under the terms of the air services agreement (ASA) ratified between the Australian and Hong Kong governments only one all-cargo services between Sydney, Melbourne, Brisbane and Perth and Hong Kong is permitted per week. [84] During the 2017/2018 Northern Winter flight schedule period, Qantas Freight scheduled a once weekly Boeing B767-300 freighter service from Sydney to Hong Kong and return. The QF7531 service from Sydney to Hong Kong could have potentially generated 412,832 AFTKs, whilst the return flight (QF7532) from Hong Kong to Sydney could have produced the same amount of AFTKs (412,832 AFTKs). The total weekly available freight tonne kilometres (AFTKs) that potentially could have been produced on these services was 825,664 AFTKs (Table 13).

4.5 Qantas Freight Freighter Fleet Available Freight Tonne Kilometres (AFTKs) Production in the 2017/2018 Northern Winter Flight Schedule Period

Figure 8 presents the distribution of the available total weekly available freight tonne kilometres (AFTKs) for the four Boeing B747-400 freighter services that operated from Australia to Asia, China, Trans-Pacific, the USA and return during the 2017/2018 Northern Winter flight schedule period. The figure also shows the percentage of AFTKs by flight sector. The largest number of AFTKs that could have been potentially produced by the Qantas Freight Boeing B747-400 freighter fleet during this flight schedule period are on the Pudong International Airport to Anchorage sector 64,070,160 AFTKs (19 per cent of the total AFTKs produced). The total available AFTKs on the Honolulu to Sydney leg is 56,507,220 AFTKs (16.7 per cent of the total FTKs produced). The third busiest route, as measured by AFTKs, is the Sydney to Chongqing sector, where the total AFTKs amount to 39,094,440 AFTKs (11.5 percent of the total AFTKs performed). The lowest numbers of AFTKs are on the O'Hare International Airport to Dallas Fort/Worth (1.3 per cent of the total AFTKs performed), Dallas Fort/Worth to Los Angeles (1.3 per cent of the total AFTKs performed) and the Auckland to Sydney (1.4 per cent of the total AFTKs performed) sectors (Figure 8).

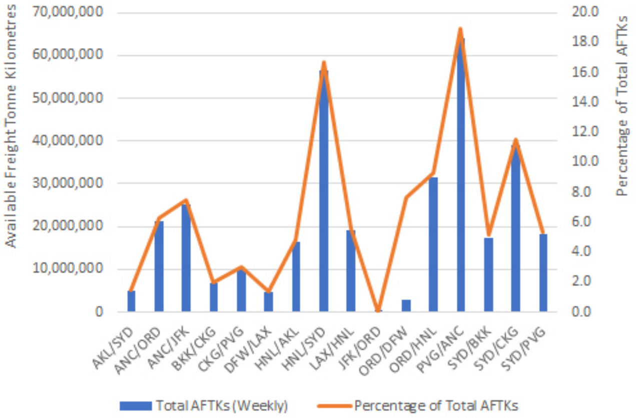


Figure 8. The distribution of the Boeing B747-400 freighter aircraft available freight tonne kilometres (AFTKs) and the percentage of total weekly AFTKs by flight sector during the 2017/2018 northern winter flight schedule period

Figure 9 shows that on the Boeing B767-300 freighter aircraft deployment on the Trans-Tasman that the Sydney to Auckland sector could have potentially generated slightly more AFTKs than for the Christchurch to Sydney sector. This is because of the slightly longer stage length of the Sydney to Auckland segment. Due to the short stage distance between Auckland and Christchurch, the total potential AFTKs would have been 208,600 AFTKs (14.7 per cent of the total AFTKs performed) versus 606,200 AFTKs (43 per cent of the total AFTKs performed) and 596,400 AFTKs (42.3 per cent of the total AFTKs performed) for the Sydney to Auckland and Christchurch to Sydney sectors. Figure 9 also presents the total weekly AFTKs that could have potentially been produced on the Qantas Freight Trans-Tasman and the Sydney, Hong Kong, Sydney Boeing B767-300 freighter aircraft services. The largest share of the Qantas Freight Boeing B767-300 freighter fleet AFTKs during the 2017/2018 Northern Winter

Table 12. Available freight tonne kilometres (AFTKs) generated by flight segment on the Qantas Freight Boeing B767-300 Trans-Tasman freighter services

Flight	Sector	Frequency4	Distance (km)^5	Km/week	AFTKs
QF7523	SYD^3/AKL^1	M,Tu, W, Th	2,165	8,660	484,960
QF7524	AKL/CHC^2	Tu, W, Th, F	745	2,980	166,880
QF7524	CHC/SYD	Tu, W, Th, F	2,130	8,520	477,120
QF7527	SYD/AKL	Sa	2,165	2,165	121,240
QF7528	AKL/CHC	Su	745	745	41,720
QF7528	CHC/SYD	Su	2,130	2,130	119,280
Total			16,790	25,200	1,411,200

Legend: 1AKL=Auckland, 2 CHC=Christchurch, 3 SYD=Sydney, 4 Frequencies, M=Monday, Tu=Tuesday, W=Wednesday, Th=Thursday, F=Friday, Sa=Saturday, Su=Sunday, 5 Source: flight distance [93]

Table 13. Available freight tonne kilometres (AFTKs) generated by flight segment on the Qantas Freight Boeing B767-300 Sydney/Hong Kong/ Sydney freighter services

Flight Number	Sector	Frequency3	Distance (km)^4	AFTKs
QF7531	SYD^2/HKG^1	Su	7,372	412,832
QF7532	HKG^1/SYD^2	Su	7,372	412,832
Total			14,744	825,664

Legend: 1HKG=Hong Kong, 2 SYD=Sydney, 3 Frequencies, Su=Sunday, 4 Source: flight distance. [93]

flight schedule period could have been produced on the Trans-Tasman services (29,635,200 AFTKs) (63 per cent of the total AFTKs produced). The weekly Boeing B767-300 freighter service from Sydney to Hong Kong and return could generate 17,338,944 AFTKs (37 per cent of the total weekly AFTKs produced).

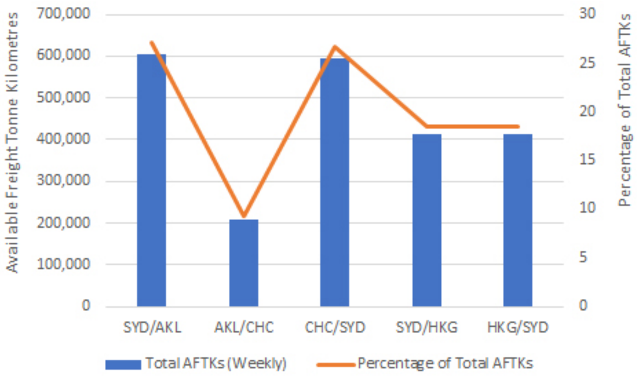


Figure 9. The distribution of the Boeing B767-300 freighter aircraft available freight tonne kilometres (AFTKs) and the percentage of total weekly AFTKs by flight sector during the 2017/2018 northern winter flight schedule period

4.6 Qantas Freight Freighter Fleet Flight Stage Lengths During the 2017/2018 Northern Winter Flight Schedule Period

According to Wensveen [5], the "overall flight stage length is the average distance covered per aircraft hop in revenue service, from takeoff to landing, including both passenger/cargo and all-cargo aircraft". In the global airline industry, there are various categories of flight stage lengths. 57 Length of haul or transportation of freight is divided into short-haul (up to 1,500km), medium haul (1,500 to 3,500km), and long haul (more than 3,500km). [101]

The Atlas Air freighter fleet includes the Boeing B747-400F and the Boeing B747-400ERF aircraft models. The maximum range of the Atlas Air Boeing B747-400 freighter aircraft is 7,170 kilometres. [102] The maximum range of the Boeing B747-400ERF freighter aircraft is 9, 220 kilometres for the General Electric CF6-80C2-B5F powered aircraft and 9,230 kilometres for the Pratt and Whitney PW4062 powered aircraft. [103]

Figure 10 presents the flight stage lengths for the city pairs that were served by the Qantas Freight Boeing 747 freighter services during the 2017/2018 Northern winter flight schedule period. As can be observed in Figure 10, Qantas freight operate their freighter aircraft on several short-haul routes in the USA – Dallas Fort Worth to Los Angeles (1,099km), John F. Kennedy Airport (New York) to Chicago's O'Hare International Airport (1,192km) and from O'Hare International Airport to Dallas Fort Worth Airport (1,291kms). The Chongqing to Shanghai Pudong International Airport at 1,464 kilometres, and thus, falls into the short haul category.

Qantas Freight operates three medium haul flight stage length sectors. The weekly Boeing B747-400 freighter service on the Auckland to Sydney sector has a flight stage length of 2,165 kilometres. The O'Hare International Airport to Los Angeles International Airport sector has a flight stage length of 2,807 kilometres. The Boeing B747-400 freighter service from Bangkok to Shanghai (Pudong International Airport) has a flight stage length of 2,894 kilometres, and thus, these services fall into the medium haul category (Figure 11).

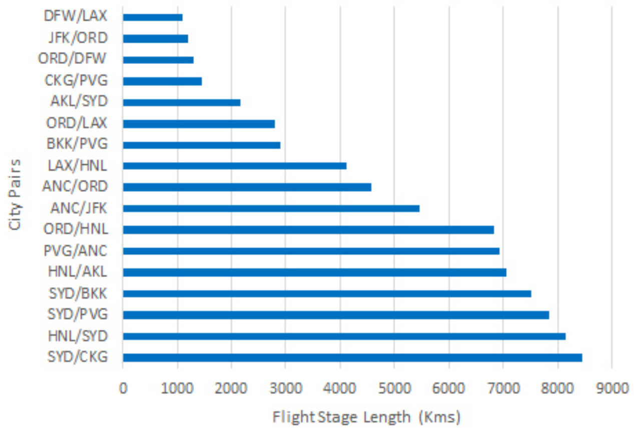


Figure 10. Qantas Freight Boeing B747-400 freighter flight stage lengths

Legend: AKL=Auckland, ANC=Anchorage, BKK=Bangkok, CKG-Chongqing, DFW=Dallas Fort/Worth, HNL=Honolulu, JFK=John. F. Kennedy Airport (New York), LAX-Los Angeles International Airport, ORD=O'Hare International Airport (Chicago), PVG=Pudong International Airport (Shanghai), SYD=Sydney

As can be observed in Figure 10, Qantas Freight operated their fleet of Boeing B747-400 freighter aircraft in the 2017/2018 Northern Winter flight schedule on 10 long-haul sectors. The flight stage lengths between Los Angeles and Honolulu, from Anchorage to O'Hare International Airport, are 4,114 and 4,581 kilometres, respectively. The Anchorage to John F Kennedy Airport in New York has a flight stage length of 5,449 kilometres. The non-stop service from Chicago's O'Hare International to Honolulu International Airport is 6,830 kilometres in length. The Pudong International Airport (Shanghai) to Anchorage, Alaska service is slightly longer at 6.934 kilometres. The non-stop flight distance from Pudong International Airport to O'Hare International Airport and to John F Kennedy International Airport are 11,358 and 11, 897 kilometres, respectively, and are thus, greater than the range offered by the Boeing B747-400F or Boeing B747-400ERF. Thus, the en-route stop in Anchorage, Alaska enables Qantas Freight to optimize the air freight uplift on these two sectors as the Boeing B747-400F or Boeing B747-400ERF offers a meaningful payload on these sectors.

The weekly service on the Honolulu to Auckland sector has a flight stage length of 7,063 kilometres. The flight stage lengths on the services from Sydney to Bangkok and Sydney to Pudong International Airport are 7,503 and 7, 838 kilometres in length, and thus, fall into the long-haul category. The two longest Boeing B747 freighter services operated by Qantas Freight during the 2017/2018 Northern Winter flight schedule were the Honolulu to Sydney and Sydney to Chongqing services at 8,154 and 8,462 kilometres, respectively (Figure 10).

Figure 11 shows the city pair flight stage lengths of the Qantas Freight Boeing B767-300 freighter aircraft during the 2017/2018 Northern Winter flight schedule. As can be seen in Figure 12, the Boeing B767-300 freighter services are operated on a mix of short, medium and long-haul sectors. The shortest flight stage length is between Auckland and Christchurch, New Zealand's two largest air freight markets, at just 745 kilometres. The Sydney to Auckland and Christchurch to Sydney services are 2,130 kilometres and 2,165 kilometres in length, respectively, and hence, fall into the medium range category. The weekly Boeing B767-300 freighter service from Sydney to Hong Kong and return is 7,372 kilometres in length and is therefore categorized as a long-haul service (Figure 11).

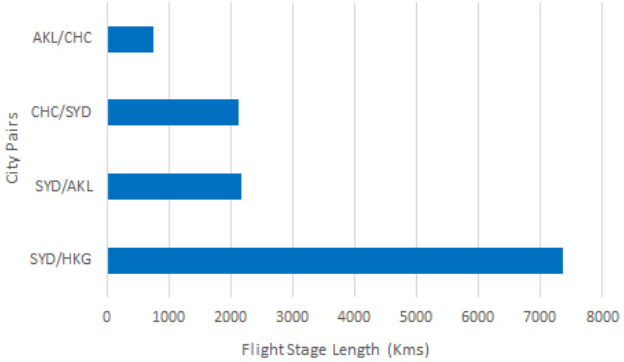


Figure 11. Qantas Freight Boeing B767-300 freighter flight stage lengths

Legend: AKL=Auckland, CHC=Christchurch, HKG=Hong Kong, SYD=Sydney

Figure 12 shows the relationship between flight stage length and the AFTKs produced by the Qantas Freight Boeing B747-400 freighter aircraft. As can be seen in the figure, the longer the flight stage length the greater the number of AFTKs produced. Conversely, the shorter the flight stage length, the small the number of AFTKs. As previously noted, the greatest number of AFTKs are produced on the Qantas Freight service from Sydney to Chongqing (the longest flight sector), whilst the smallest number of AFTKs are produced on the Dallas Fort Worth to Los Angeles sector (Figure 12).

Figure 13 shows the relationship between flight stage length and the AFTKs produced by the Qantas Freight Boeing B767-300 freighter aircraft. The long-haul services over the Sydney/Hong Kong/Sydney flight routing produce the greatest number of AFTKs as these are the longest sectors operated by this aircraft type. The smallest number of AFTKs are on the relatively short Auckland to Christchurch sector (Figure 13).

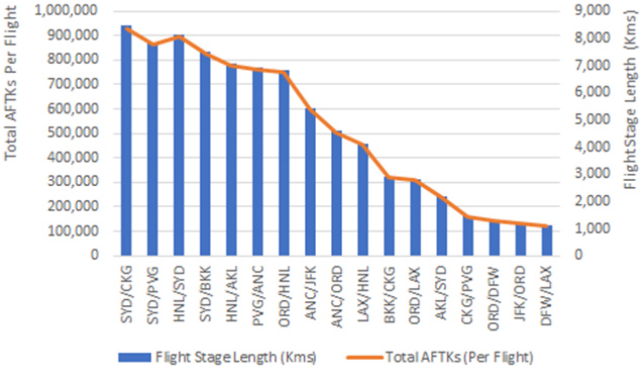


Figure 12. The relationship between flight stage length and AFTKs produced on the Qantas Freight Boeing B747-400 freighter services

Legend: AKL=Auckland, ANC=Anchorage, BKK=Bangkok, CHC=Christchurch, CKG=Chongqing, DFW=Dallas Fort Worth, HKG=Hong Kong, HNL=Honolulu International Airport, JFK=John F. Kennedy International Airport (New York), LAX=Los Angeles International Airport, ORD=O'Hare International Airport, PVG=Pudong International Airport (Shanghai), SYD=Sydney

4.7 A Comparison of the Qantas Airways International Passenger and Qantas Freight Boeing B747-400 and Boeing B767-300 Freighter Route Network Designs

An airlines network design is the most important attribute of its product offering [104] as it is the primary driver for generating an airline's revenues and costs. Network design is also a source of competitive strength or weakness for an airline. [105] In addition to its route network, a further principal benefit to an airline from operating freighter aircraft is that these services can be scheduled and attuned to the requirements of its customers. [106] Figure 13 presents the Qantas Freight Boeing B747-400 and Boeing B767-300 freighter aircraft route network. The route network has been very carefully designed to satisfy shippers' air freight requirements. Qantas Freight has been able to use the Australia/China "open skies" liberalized air service agreement (ASA) to operate a dedicated freighter route network that connects China with the major United States air cargo markets of O'Hare International Airport, John F. Kennedy International Airport, Dallas Fort/Worth and Los Angeles International Airport. This strategy has proven most successful for Qantas Freight, who have captured around 5 per cent share of the air-freight market between China and the US - the world's two biggest economies.[89] In addition, Qantas Freight has been able to take advantage of fifth freedom rights on its service linking Los Angeles with Sydney via Honolulu and Auckland – these rights give the carrier the ability to carry US-origin cargo destined for New Zealand, should it decide to do so. Airlines operating freighter aircraft have the option of an enroute technical stop, though this can result in additional costs. [107] Anchorage often serves as a midway point on trans-pacific services. [11] As can be observed in Figure 14, all the Qantas Freight Boeing B747-400 freighter services from China to the United States make a stop in Anchorage, Alaska.

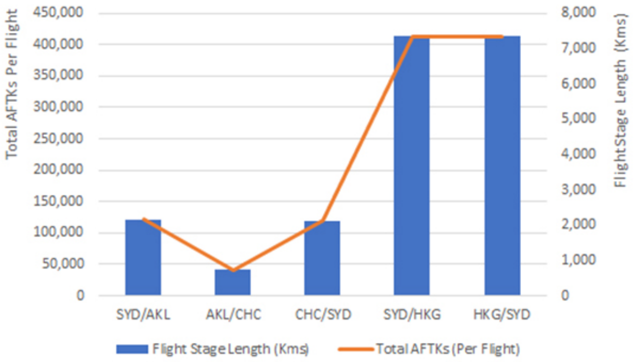


Figure 13. The relationship between flight stage length and AFTKs produced on the Qantas Freight Boeing B767-300 freighter services

Figure 14. Qantas Freight Boeing B747-400 and Boeing B767-300 freighter aircraft route network: 2017/2018 northern winter flight schedule period

Legend: AKL=Auckland, ANC=Anchorage, BKK=Bangkok, CHC=Christchurch, CKG-Chongqing, DFW=Dallas Fort/Worth, HKG=Hong Kong, HNL=Honolulu, JFK=John. F. Kennedy Airport (New York), LAX-Los Angeles International Airport, ORD=O'Hare International Airport (Chicago), PVG=Pudong International Airport (Shanghai), SYD=Sydney

Figure 15 shows the Qantas international passenger and freighter route networks. As can be seen in the figure, the Qantas international passenger route is very dense in nature and links key Australian gateway cities with cities in the Asia, Europe, Middle East, South Africa, South Pacific, and the United States. In contrast, as noted in the case study, the Qantas freighter network is very concentrated focusing on important global air cargo markets: Thailand, China, Hong Kong, New Zealand the USA. Also, a further difference between the Qantas international passenger network and the Qantas Freighter network, is that Qantas Freight serves Chicago in the United States and Chongqing in China. At the time of the study, Qantas Airways did not operate passenger services to either of these cities. In addition, it can be observed in Figure 15, that the Qantas freighter services supplement the air cargo capacity offered on the Qantas international passenger services in the Auckland and Christchurch to Sydney, Dallas Fort Worth to Sydney, Sydney/Hong Kong/Sydney, and the Los Angeles and Honolulu to Sydney city pairs or origin-and-destination markets (O & Ds).

It is important to note that combination airlines passenger flights, particularly those operated by wide-bodied aircraft, such as the Airbus A380-800, A350-900XWB or the Boeing B777-300ER and 787-8/-9 aircraft, can now offer a significant air freight payload for the transportation of air freight shipments. [107] For a large full-service network carrier (FSNC), like Qantas Airways, these aircraft have the advantage of frequent services to many destinations. [11, 24] There are, however, two principal disadvantages with combination airlines: the timing of the flights is geared around passenger requirements, although on long-haul intercontinental flights they may also suit freight shippers. Second, as noted earlier, the lower deck belly holds on passenger aircraft are restricted in the size of the freight consignments that can be carried and may not be able to accommodate larger shipments, whether due to space availability or the size of the aircraft door. [11] Also, some passenger destinations are not major air freight markets, and therefore, will not attract much air freight. [11, 108] A further problem with the air freight product based only on the use of lower deck passenger service belly hold capacity is that it often fails to take into consideration air freight shippers' requirement for dedicated air freight space. [108] Air freight generally peaks strongly at night, following production during the working day, and at the end of the working week. [39] There is also often a very pronounced lull in demand for air freight space on Sundays and Mondays. Some combination airlines belly hold capacity will be provided at times of the day or week when there are relatively small volumes of air freight being shipped. At other times, though, there may be a critical shortage of air freight capacity, this is especially so on a Friday evening. [108] In contrast, airlines operating dedicated freighter aircraft enjoy some important advantages: flight schedules can be optimized to meet shipper requirements, freighter aircraft offer greater payload and air freight space, distinct types of dangerous goods and large dimensional cargoes can be carried on freighter aircraft, and freighter services offer reliability and predictability. [109] The Qantas freighter network has been customized to satisfy air freight shippers requirements with the flights timed to optimize air cargo traffic flows. The Qantas freighter services also enable Qantas Freight to carry large, dimensional freight that may be too large to be carried in the lower-lobe passenger aircraft belly-holds of the Qantas Airways passenger services.

The principal differences between the Qantas Airways international passenger route network and the Qantas Freight are summarized in Table 14.

5. Conclusion

This paper has examined, for the first time, the Qantas Freight 2017/2018 Northern Winter flight schedule freighter route network. Despite the increasing trend in the operation of freighter aircraft in the global air freight industry, there has been very limited research undertaken on such initiatives. Thus, this study adds some valuable insights to the literature. The study was underpinned by a case study research framework that followed the recommendations of Yin (2017). Qantas is a full-service network carrier (FSNC) that has strategically deployed a fleet of two Boeing B747-400 and one Boeing B767-300 freighter aircraft in key air cargo markets. The aircraft are leased and operated on its behalf by Express Freighters Australia, a subsidiary of the Qantas Group, The Boeing B747-400 fleet is deployed on several different routes that link Australia with Asia/China and across the trans-Pacific to the United States.

- Route 1: Sydney/Chongqing/Pudong International Airport (Shanghai)/Anchorage/O'Hare International Airport (Chicago)/ Dallas Fort Worth/Los Angeles/Honolulu/Sydney
- Route 2: Sydney/ Pudong International Airport (Shanghai)/Anchorage/John F Kennedy International Airport (New York)/ O'Hare International Airport/Honolulu/Sydney
- Route 3: Sydney/Bangkok/ Pudong International Airport/ Anchorage/O'Hare International Airport/ Honolulu/Sydney
- Route 4: Sydney/Chongqing/Pudong International Airport /Anchorage/O'Hare International Airport/Honolulu/Auckland/Syd

The Boeing B767-300 freighter aircraft operated five services per week on a Sydney/Auckland/ Christchurch/Sydney routing as a weekly Sydney/Hong Kong/Sydney service. During the 2017/2018 Northern Winter Flight Schedule period (from 29 October 2017 to 24 March 2018), the Boeing B747-400 services could have potentially generated 114,755,020 AFTKs. The Pudong to Anchorage sector could have generated the most AFTKs (64, 070,160 AFTKs). This represents 19 per cent of the AFTKs performed by the Boeing B747-400 freighter aircraft during the 2017/2018 Northern Winter flight schedule period. The Boeing B767-300 freighter services could have potentially produced 46,974,144 AFTKs during 2017/2018 Northern Winter flight schedule period. The Trans-Tasman services could have accounted for 63 per cent of these AFTKs, with the balance being produced on the weekly Sydney/Hong Kong/Sydney services. The case study revealed that there are distinct differences in the Qantas Airways international passenger and the Qantas Freighter route networks. The Qantas Airways international passenger route has been carefully designed to link key Australian gateway cities with destinations located throughout Asia, the Middle East, South Africa, South Pacific, United States and London in the United Kingdom. In contrast, the Qantas Freighter route network has been designed to serve key air freight markets

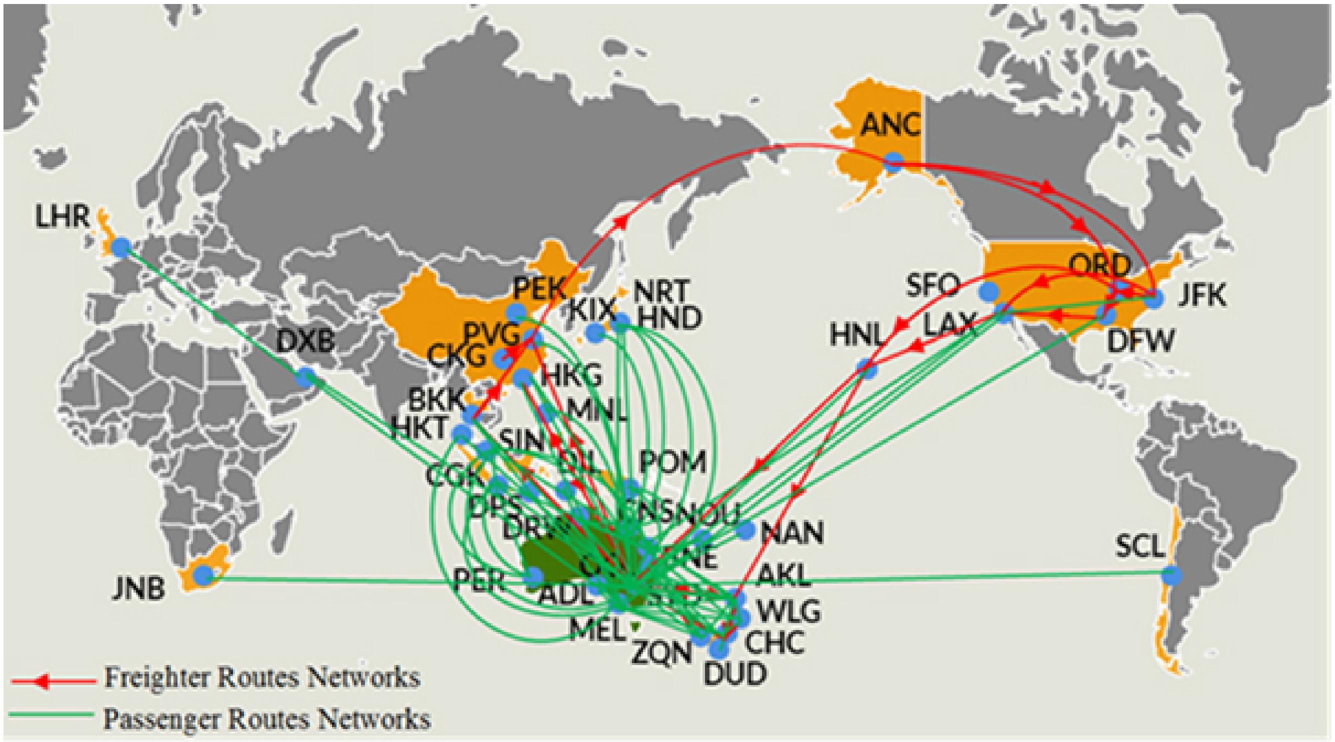


Figure 15. Qantas International passenger and dedicated freighter route networks: 2017/2018 northern winter flight schedule period

Legend: ADL = Adelaide Airport, ANC=Anchorage, AKL = Auckland Airport, BKK=Bangkok, BNE = Brisbane Airport, CHC = Christchurch International Airport, CKG = Chongqing Jiangbei International Airport, CGK = Soekarno–Hatta International Airport (Jakarta), CNS = Cairns Airport, DFW = Dallas/Fort Worth International Airport, DIL = Presidente Nicolau Lobato International Airport (Díli, Timor-Leste), DPS = Ngurah Rai International Airport (Denpasar), DRW = Darwin International Airport, DXB = Dubai International Airport, DUD = Dunedin Airport, HKG=Hong Kong, HND = Haneda Airport, HNL = Daniel K. Inouye International Airport (Honolulu), HKT = Phuket International Airport, JFK = John. F. Kennedy Airport (New York), JNB = O. R. Tambo International Airport (Johannesburg), KIX = Kansai International Airport, LAX-Los Angeles International Airport, LHR = Heathrow Airport, MEL = Melbourne Airport, MNL = Ninoy Aquino International Airport, NAN = Nadi International Airport (Fiji), NOU = La Tontouta International Airport (New Caledonia), NRT = Narita Airport, OOL = Gold Coast Airport, ORD=O'Hare International Airport (Chicago), PEK = Beijing Capital International Airport, POM = Jacksons International Airport (Papua New Guinea), PVG = Shanghai Pudong International Airport, SCL = Santiago International Airport, SFO = San Francisco International Airport, SIN = Singapore Changi Airport, SYD=Sydney, WLG = Wellington International Airport, ZQN = Queenstown Airport

in Australia, China, New Zealand and the USA. The Qantas Freight freighter network serves several cities that are not serviced by the Qantas Airways passenger services. These cities are Chongqing in China and Chicago in the USA. Importantly, the Qantas Freight freighter networks supplement the Qantas Airways passenger services from Auckland and Christchurch to Sydney, Dallas Fort Worth to Sydney, Sydney/Hong Kong/Sydney passenger services and the passenger services from Los Angeles and Honolulu to Sydney. The Qantas Freight freighter services are routed and scheduled to optimize air freight shippers' requirements. These services also enable the carriage of over-sized and certain types of dangerous goods that could not be carried on passenger services. The regulatory framework has played a key role in underpinning the Qantas Freight Boeing B747-400 and Boeing B767-300 freighter network. Australia has a fully liberalized freighter aircraft aviation policy. Australia and China have also ratified an 'open skies' or liberalized air services agreement (ASA), which enables Australian-based airlines to carry air freight from China across the trans-Pacific to the United States of America. Qantas Freight has also been able to take advantage of liberal air service arrangements that permit it to carry air freight traffic between the United States and Auckland, New Zealand. Australia and New Zealand also have an "open skies" air services agreement, which grants airlines based in either country, with full access to the Trans-Tasman aviation market. In conclusion, the study has shown that the Qantas Freight freighter network and services act as an important revenue stream for the Qantas Group and form a key part of the carrier's overall route network. A limitation of

Table 14. Key differences between the Qantas Airways international passenger route network and the Qantas Freight freighter route network

	Qantas Airways	Qantas Freight
Route network market segments	Global route network focusing on key premium and leisure air travel markets	Concentrated: focusing on key trade lanes
Route network design	Hub-and-spoke1. For example, Sydney is a key hub linking domestic and international services	Point-to-point linking key air freight markets
Aircraft fleet	Heterogenous – Airbus A330, Airbus A380, Boeing B737, Boeing 747-400	Boeing B767-300 and Boeing B747-400 dedicated freighter aircraft
Traffic directionality	Typically, round trip	Typically, uni-directional
Air freight capacity	Lower lobe belly-hold on the Qantas Airways passenger services	Main deck and lower deck on the Boeing B747-400 and Boeing B767-300 freighter aircraft

Note: Qantas Airways operates an Airbus A380 passenger service from Sydney to Dallas Fort/Worth (and return) on a hub-to-hub basis linking the Qantas passenger hub in Sydney with its fellow oneworld alliance partner American Airlines key hub at Dallas Fort/Worth Airport.

the current study was that the actual freight tonne kilometres (FTKs) or enplaned tonnages carried on the Qantas Freight freighter services was not available in the public domain at the time of the study. Thus, it was not possible to quantify the actual volumes of air cargo traffic transported on these services. The available freight tonne kilometer (AFTKs) provides an indicative idea of the available payload protentional on a flight sector. Should the actual FTK data become available then a future study could investigate the traffic flows and quantify the actual load factors of dedicated freighter services operated on the various Qantas Freight freighter aircraft routes.

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APPENDIX 3: Analysis of Doncaster freight growth

Doncaster Sheffield Airport

1. Stone Hill Park suggested at the Issue Specific Hearing on Need and Operations that freight volumes at Doncaster Sheffield Airport had declined in 2018 as against 2017. As noted by the Applicant at the hearing, this statement gave a misleading impression.

2. The table below drawn from CAA data[1] shows that to be true, but also misleading as between 2011-16 tonnages handled increased by a factor of 45 times and the equivalent figure for 2017 was only marginally less than that. In other words, Doncaster has experienced significant growth in freight traffic since the beginning of the decade and is seeking to establish itself as a dedicated freight airport for non-integrator traffic serving the north of England.

Year	Belly (T)	Freighter (T)	Total (T)	Freight ATMs	Ave Tonnes/ATM
2018	75	7032	7107	147	47.8
2017	7	8650	8657	340	25.4
2016	17	9324	9341	688	13.6
2015	5	3196	3201	111	28.8
2014	8	850	858	20	42.5
2013	120	235	355	11	21.4
2012	5	271	276	9	30.1
2011	9	93	102	5	18.6
2010	20	197	217	12	16.4
2009	3	341	344	16	21.3

Chris Cain
Northpoint Aviation
28 March 2019

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[1] The source is CAA annual statistics – which are publically available via the CAA's website: https://www.caa.co.uk/Data-and-analysis/UK-aviation-market/Airports/Datasets/UK-airport-data/

APPENDIX 4: Stansted Freight Demand-Capacity Analysis

STANSTED: FREIGHT DEMAND-CAPACITY ANALYSIS

Introduction

1. This note is presented to clarify trends in freight activity at Stansted Airport over the last 20 years, explain why the airport is entering a period of capacity constraint for freight that will get progressively worse as time goes by, and considers what the potential implications are for the sector at the airport.

2. Table 1 summarises freight tonnages at Stansted Airport on both passenger and freighter aircraft since 2000. The source is CAA annual statistics – which are publically available via the CAA's website: https://www.caa.co.uk/Data-and-analysis/UK-aviation-market/Airports/Datasets/UK-airport-data/

Table 1: Stansted Freight Activity Since 2000

Year	Freight (T) Bellyhold	Freight (T) Freighter	Total Freight (T)	% Bellyhold
2018	0	226,128	226,128	0.0
2017	0	236,892	236,892	0.0
2016	197	223,006	223,203	0.1
2015	790	207,207	207,997	0.4
2014	1,185	203,540	204,725	0.6
2013	4,579	207,373	211,952	2.2
2012	4,269	209,891	214,160	2.0
2011	5,401	197,192	202,593	2.7
2010	1,911	200,328	202,239	0.9
2009	1,818	180,922	182,740	1.0
2008	1,434	196,304	197,738	0.7
2007	1,486	212,261	213,747	0.7
2006	1,948	222,364	224,312	0.9
2005	1,347	235,698	237,045	0.6
2004	1,382	224,390	225,772	0.6
2003	1,428	197,137	198,565	0.7
2002	2,546	181,903	184,449	1.4
2001	1,981	163,679	165,660	1.2
2000	2,802	165,502	168,304	1.7

Source: CAA Data

3. Table 1 highlights some important factual points:

   3.1 Air cargo carried on freighters has always been the dominant form of freight at Stansted and is likely to remain so for the foreseeable future.

   3.2 Bellyhold freight 'maxed out' at 5,400 tonnes and 2.7% of total freight carryings in 2007; since 2013 there has been a rapid decline in bellyhold freight handled until in

2017 and 2018 Stansted is recorded as handling no bellyhold freight at all (and none was recorded in the first two months of 2019).

3.3 Emirates began a long-haul service from Dubai using a B777 (a bellyhold freight friendly aircraft) in June 2018 – this far it has carried no freight. Nor apparently have other inter-continental passenger services.

3.4 Thus, while the 2015 Sustainable Development Plan talks of attracting 60,000 of bellyhold freight on the back of inter-continental services, and there are already existing services to New York, Boston and Toronto and Emirates which have been flying since June 2018 in a freight friendly B777, no bellyhold freight has been carried to or from Stansted in the last 2.5 years.

3.5 The largest volumes recorded are just over 235,000 tonnes in 2005 and 2017, with a modest decline in-between in 2018.

3.6 If we look at Table 2 below, we also see cargo air transport movements (ATMs) declining, average tonnages increasing to levels above the long run average and total ATMs at over 70% of the airport's long term cap.

Table 2: Freighter Activity at Stansted.

Year	Tonnes	Cargo ATMs	Tonnes/ATM	Pax ATM	Pax	% of 43.5mppa cap	Pax/ATM	Total ATMs	% of 264K ATM CAP
2018	226,128	9,478	23.86	175,599	27,996,116	64.36	159.4	185,077	70.10
2017	236,892	10,126	23.39	162,027	25,904,450	59.55	159.9	172,153	65.21
2016	223,006	11,246	19.83	152,649	24,320,071	55.91	159.3	163,895	62.08
2015	207,207	9,793	21.16	144,522	22,519,178	51.77	155.8	154,315	58.45
2014	203,540	9,425	21.60	133,805	19,965,093	45.90	149.2	143,230	54.25
2013	207,373	9,790	21.18	122,135	17,852,393	41.04	146.2	131,925	49.97
2012	209,891	9,992	21.01	121,375	17,472,699	40.17	146.2	131,367	49.76
2011	197,192	9,759	20.21	127,140	18,052,843	41.50	142.0	136,899	51.86
2010	200,328	9,970	20.09	133,223	18,573,592	42.70	139.4	143,193	54.24
2009	180,992	10,071	17.97	145,914	19,949,689	45.86	136.7	155,985	59.09
2008	196,304	10,574	18.56	166,711	22,360,364	51.40	134.1	177,285	67.15
2007	202,261	10,345	19.55	181,177	23,759,250	54.62	131.1	191,522	72.55

Source: CAA Data

4. What we see happening at Stansted, is therefore very different from the picture painted by York Aviation for Stone Hill Park at the Issue Specific Hearing on Need and Operations. There is physical space for freight operations to grow at Stansted (for now at least) – and the airport development plan indicates how this can be achieved[1]; some additional stands may even have been constructed. However, despite all that, there is no evidence of bellyhold growth currently happening despite the emergence of long-haul carriers serving traditional freight routes. The picture in relation to freighter growth is one of stasis or decline too.

5. In our view, the overriding consideration driving this is because passenger aircraft are being given priority during peak and shoulder periods so that they can complete 3 or 4 rotations per day; consequently, they are not readily available at the times when freighters would like to use them, and consequently those slots are mainly being allocated to short haul low cost operators who are uninterested in carrying freight.

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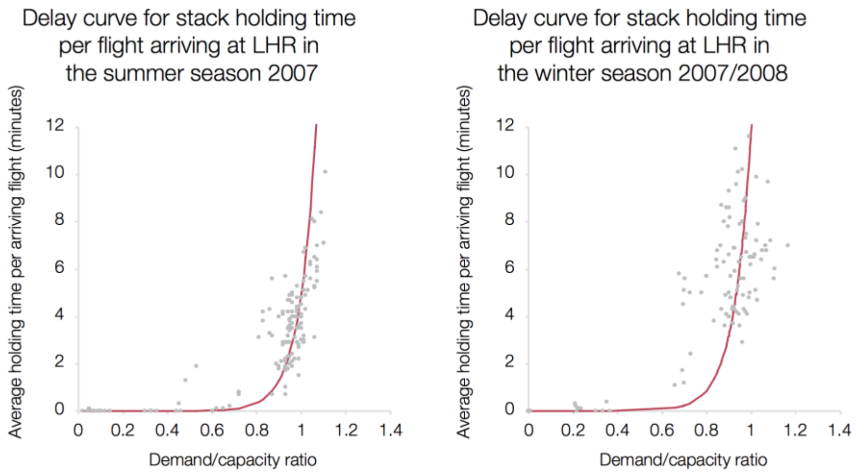
[1] Page 35: Stansted Airport Sustainable Development Plan (2015)

6. Lack of volume growth, reductions in freighter numbers (cargo ATMs are lower than in every year since 2000 and the short-term trend is one of significant decline), increased average tonnes/ATM and the emphasis of current marketing on the bellyhold opportunity, all point to constraints beginning to bite on future freighter growth at Stansted. At current rates of pax atm/growth (see Table 2) the airport will reach 200,000 ATMs, equivalent to 75% of runway movement capacity, in 2020. As the charts below[2], which are taken from the 2008 CAA South East Runway Resilience Study, demonstrate this is a key metric, because beyond 75% of utilisation (the demand/capacity ration on the x-axis of the charts) delays begin to rise exponentially until by 85% it becomes difficult to attract new users, unless you are at the world's most valuable hubs like Heathrow. It is certainly not going to be a propitious environment to attract new freighter activity.

Figure 4: Relationship between demand to capacity ratios and average stack holding time at Heathrow



Source: UK CAA Runway Resilience Study (2008)

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[2] Airports Commission: Economic Impact of Delays (Nov 2014)

Future Plans

7. In the Planning Statement[3] supporting its application for planning approval for 43.5mppa, Manchester Airport Group (MAG) explained that the extant planning condition from 2008 below would be varied to allow up to 264,000 movements for any purpose:

   "ATM1: [Subject to ATM2 below], from the date that the terminal extension hereby permitted within Site "A" opens for public use, there shall be at Stansted Airport a limit on the number of occasions on which aircraft may take-off or land at Stansted Airport of 264,000 ATMs (Air Transport Movements) during any twelve-calendar month period, of which no more than 243,500 shall be PATMs (Passenger Air Transport Movements) and no more than 20,500 shall be CATMs (Cargo Air Transport Movements)."

8. At 264,000 ATMs the comparative figure to get to the planned passenger throughput of 43.5mppa would be 165/atm; but with the restrictions on passenger aircraft at 243,500 as in ATM1, then the average pax/atm to reach 43.5mppa is 178.5. This latter figure is well above the current figures for Heathrow and Gatwick at 166 and 162 respectively.

9. Based on the planning statement MAG have submitted they suggest that the number of passengers per aircraft movement is forecast to have risen to 170 (CAGR 0.5%) due to a number of factors:

   - airlines upgrading to aircraft with additional seats, including easyJet phasing out A319s (156 seats) in favour of A320s (186 seats) and A321s (235 seats), and Ryanair's transition to the B737MAX 200 (197 seats) from the B737-800 (189 seats);
   - the introduction of long-haul services at Stansted with some airlines using larger wide-body aircraft types such as the Boeing 787 and the larger Boeing 777 (to be used by Emirates from June 2018); and
   - a small increase in the average load factor over the forecast period from 87% to 88%.

10. As a result, passenger volumes at Stansted are expected to grow more quickly (CAGR 4.9%) than passenger aircraft movements (CAGR 4.3%), which are forecast to increase from 152,000 in 2016 to just over 253,000 movements by 2028. Since this excludes freight movements (currently at 9,500), it would effectively mean the movement planning cap would have been met by 2030. In reality, the rate of slot take-up will probably slow down as they become scarcer and less attractively timed, but certainly by 2035 Stansted is likely to be full and possibly earlier, and the best-case scenario for freight movement by then is one of stasis with the current day. However, it is also possible that the greater value generated per movement by passenger aircraft vs freight aircraft, could even see the number of movements shrink. Hence, even assuming there is some growth in bellyhold freight carryings we see little reason to believe

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[3] Planning Statement submitted by Stansted in support of its planning application to increase its passenger throughput to 43.5m (Feb 2018)

Stansted will be carrying more freight by 2030 than it is today, and possibly significantly less, especially if uncongested modern facilities were available at Manston.

Conclusions

11. The forgoing is likely to be the primary commercial reason why Stansted may wish to limit freight growth in favour of passenger growth, and the 75% threshold shown in the London Heathrow graphs above is the point at which the opportunity costs of not doing so really start to bite. This is because at that level of capacity utilisation, slot shortages become increasingly important and if freight operators are allocated slots, they will need to use 80% of the slots they are allocated across a season or risk losing them. If they meet this threshold, they will be deemed to have established grandfather rights, preventing passenger aircraft accessing them at a later date.

12. MAG is likely to have recognised that it will reach this critical tipping point by 2020. Hence while publicly they may continue to market Stansted as open for new freight business, privately and commercially, they may in reality be increasingly resolved to discourage more ad hoc freighter movements (FEDEX are consistent/regular business), with the resulting traffic going to East Midlands or probably cross-channel.

13. So our assessment is that freight activity at Stansted may have already probably ‘topped out’, and that is without any impact from night noise constraints biting sooner.

14. Hence any suggestion that Stansted is unconstrained and is therefore there that there is plenty of long term capacity at Stansted to meet future freight tonnage or movement volumes is extremely unlikely to be true.

Chris Cain
Northpoint Aviation
28 March 2019

APPENDIX 5: UK CAA runway resilience study

SH&E
an ICF International Company

UK CAA RUNWAY RESILIENCE STUDY – FINAL REPORT

Prepared for:

UK CAA

Prepared by:

HELIOS

XPX Consulting and SH&E Limited

December 2008

SH&E Limited. Company Registered in England & Wales. Registered Number: 3131624
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TABLE OF CONTENTS

1 EXECUTIVE SUMMARY

INTRODUCTION

1.1 The Department for Transport (DfT) has requested advice from the CAA, under Section 16(1) of the Civil Aviation Act in three areas to aid its understanding and evaluation of the end-to-end journey experience for air passengers to support policy development. These areas are[1]:

- the through-airport passenger experience
- early review of the passenger experience in Heathrow Terminal 5
- runway resilience.

1.2 Other areas that affect the overall resilience of the airport, including the availability and quality of the critical terminal infrastructure as well as the quality of the services delivered, are addressed in the regulatory regime for the designated airports through service quality standards, quality of service monitoring (QSM) and a system of rebates. These do not, however, cover the resilience of the runways themselves. Clearly, the airport has to be viewed as a single system and any gains made through regulatory initiatives could be negated through poor runway performance as the runway effectively delivers the passengers to and from the terminals.

1.3 The CAA has, therefore commissioned a study on runway resilience to investigate, in cooperation with the airlines and the airports, lessons learned from current runway operations at Heathrow and Gatwick airports. This document, prepared for the Economic Regulation Group (ERG) of the Civil Aviation Authority (CAA), by Helios, XPX and SH&E, is the final report of that study.

OPERATIONAL OVERVIEW

1.4 All departures from an airport are funnelled from their stands, via the taxiway system to take-off along a runway before dispersing along their departure air routes, usually standard instrument departures (SIDs). The situation is reversed for arrivals which are funnelled from their arrival air routes, often standard terminal arrival routes (STARs) to land on the runway and then dispersed via taxiways to their stands. The runway, therefore, represents a pinch point in the air traffic network. When demand is high it is a scarce resource

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[1] Letter from the Secretary of State for Transport to the Chairman of the CAA, dated 20 November 2007

utilisation of which must be managed carefully and optimised. This is the situation at both Heathrow and Gatwick airports.

1.5 As with all systems where demand is approaching capacity, queues to use the runway can build up. For arriving aircraft, the first mechanism used to manage these queues at Heathrow and Gatwick is the airborne holding stack. Generally, in holding stacks aircraft fly in a spiral racetrack pattern, entering at the top, descending through several levels and exiting at the bottom. Stacks are used to moderate the demand for the runway, as a buffer to allow air traffic controllers to sequence aircraft to optimise the throughput of the runway whilst maintaining separation between aircraft to ensure that the following aircraft is not affected by the preceding aircraft's wake vortex. This separation varies depending on the sequence of aircraft (heavy-heavy, heavy-light, light-heavy, etc). In simple terms the separation for a lighter aircraft following a heavier aircraft must be greater than if the sequence were the other way round. In this report, this process is called **stack holding** and the time that each aircraft spends in the stack is termed the **stack holding time**. Heathrow can use up to four stacks and Gatwick two.

1.6 Heathrow generally operates its two runways in segregated mode, meaning that one runway is used solely for arrivals and the other for departures. Thus to maximise throughput, arrivals are spaced as closely together as possible. Gatwick, as a single runway airport, uses its runway for both arrivals and departures. Arrivals and departures can be interspersed or bunched. The pressure for arrivals in this situation is less than for the single mode arrivals runway meaning that the separation between arriving aircraft is necessarily larger than the minimum imposed by wake vortex considerations to allow for a departure or bunch of departures to be slotted between successive arrivals or bunches of arrivals.

1.7 The holding stacks themselves have a limited capacity and two techniques can be used at Heathrow to deal with situations where the stack capacity looks as though it will be exceeded by the number of planned arrivals or when average stack holding time will become greater than twenty minutes:

- in certain circumstances, a procedure know as TEAM (Tactically Enhanced Arrivals Measures) can be applied temporarily to boost arrivals capacity by allowing a proportion of the arriving aircraft to use the departure runway. Typically, this is applied to match the early morning peak of demand, or when predicted delays within the next two hours are becoming excessive and reach defined trigger points. This does not, however, raise the capacity to that expected from a full mixed mode operation. TEAM is most valuable in mitigating short-term arrivals peaks.

- if the constraint is expected to be persistent, aircraft that plan to arrive during the period of congestion are held upstream on the ground at their departure airport until the downstream capacity constraint is alleviated. This technique of air traffic flow management (ATFM) is generally restricted to aircraft departing from a point in Europe and is administered centrally by the Eurocontrol Central Flow Management Unit (CFMU). In this report, the process of holding aircraft at their departure airport is called **ATFM regulation** or **restriction**. The ATFM regulation imposes an **ATFM delay** on the affected aircraft by imposing a calculated take-off time (CTOT) on the flight to ensure its passage to its destination is not impeded by capacity constraints along the way. The ATFM delay is the difference between the CTOT and the take off time estimated in the aircraft's flight plan.

1.8 As Gatwick's runway operates for both arrivals and departures, it cannot apply TEAM but its traffic can be moderated by ATFM regulation.

1.9 It is important to draw a distinction between mixed mode operations and TEAM because:

- TEAM allows a small proportion of arrivals to use the departure runway for a limited amount of time. Mixed mode would be a continuous operation over a more extended period.
- TEAM does not allow for departures to use the arrivals runway whereas mixed mode would utilise both runways for both arrivals and departures.
- approaches on the two runways during periods when TEAM is applied interact with each other and are dependent whereas full mixed mode would use support systems and associated procedures and practices required to enable independent parallel approach operations.
- if there is high demand for departures, TEAM will have a negative effect on departure queues as it allocates a proportion of the departure capacity to arrivals whereas mixed mode allows sharing of the capacity of both runways for both arrivals and departures.

1.10 The departure flow is moderated by managing the queue to optimise the throughput of the departure runway. Departures are sequenced by managing the time that the aircraft is pushed back and by managing its passage from its stand to the runway after it has pushed back to provide the optimum sequence of aircraft at the departure runway. In this report, this process is termed **ground holding** and the period that the aircraft spends in this process is called the **ground holding time**.

1.11 The ground holding process is further complicated because it needs to take account of:

- potential capacity constraints down the aircraft’s flight path which might be manifested as ATFM regulations that cause the aircraft to be held at Heathrow or Gatwick
- short-term sequencing of aircraft departing the London terminal area through standard instrument departure (SID) routes shared between Heathrow, Gatwick, Stansted, Luton and London City airports. This sequencing, that takes into account all traffic departing London, not just Heathrow and Gatwick, is managed through the application of minimum departure intervals (MDIs) whereby short holding delays are imposed on the affected aircraft by local air traffic control.

1.12 The operational analysis undertaken in this report focuses on the three main areas impacted by the runway:

- stack holding for arrivals
- upstream ATFM regulation due to the capacity of the arrivals airport
- ground holding for departures.

1.13 In each case, section 4 describes the current situation and section 5 assesses the impact several potential future scenarios.

1.14 The root causes of the current runway performance and potential improvement opportunities are explored in section 8.

CURRENT SITUATION AT HEATHROW AND GATWICK

Capacity

1.15 The capacity of both Heathrow and Gatwick airports is determined through the scheduling process (see part 3 of this report for a full description). The scheduling process results in a scheduling limit (the maximum number of movements per hour and effectively the planned capacity of the runways) on a hourly basis for departures, arrivals and total movements based on estimates of the capacity of various elements of the airport, including the runways, terminal buildings, stands and so on, balanced against acceptable stack and ground holding times. This scheduling process is performed for summer and winter seasons separately and, hence, it is expected that there will be a different relationship between demand, delay and capacity for summer and winter. The summer season runs from the end of March to the end of October (approximately 7 months), corresponding to British Summer Time (BST) whereas the winter season runs from the end of October to the end of March (approximately 5 months) corresponding to Greenwich Mean Time (GMT). For this reason and the fact that the weather usually varies from summer to winter, the two seasons have been analysed separately.

1.16 Analysis based on the two most recent complete scheduling seasons, namely summer 2007 and winter 2007/2008 for Heathrow and Gatwick indicates that the operational demand levels for the runways were such that:

- there was little difference in demand at Heathrow between summer and winter and from month-to-month within the seasons. Across each season, on average, the airport is consistently operating at an actual flow rate of approximately between 97 to 98% of its runway capacity, as defined by the scheduling limit, with peak utilisation reaching 98.5% at times. The underlying rate of cancellations is around 2% indicating that overall the demand for the runways is 100% of capacity.
- runway demand at Gatwick is much lower than at Heathrow. Gatwick's runway demand, accounting for the underlying cancellation rate, is highest in the peak part of the summer season (roughly May to September), with average utilisation levels, compared to the scheduling limits, at around 95% and up to 99% in July and August. In the winter the seasonal average runway demand is around 88%.

Holding in stacks

1.17 At Heathrow, the time spent holding in stacks was approximately 565000 minutes in total for the summer season and 602000 minutes in total for the winter season. The holding patterns are broken down as:

- summer: an average hold per inbound flight of around 7 minutes in the peak periods and 3½ minutes in the off peak periods. The average stack holding time per inbound flight is around 4 minutes over the summer season. Peak (95th percentile) stack holding reaches approximately 15 minutes at times during the summer season
- winter: an average hold per inbound flight of around 7 minutes in the peak periods and 6 minutes in the off peak periods. The average stack holding time per inbound flight is around 6 minutes over the winter season. Peak (95th percentile) stack holding times reach 18 to 19 minutes at times during the winter season.

1.18 Tactically Enhanced Arrivals Measures (TEAM) is applied virtually every day around 06:00 to 07:00 local time to manage the early morning peak. In addition, it is applied on other occasions to manage traffic as appropriate when it appears that stack holding times will become excessive.

1.19 At Gatwick, summer stack holding is, at a total of approximately 28,000 minutes, around a factor of three times greater than the delay attributable to ATFM restrictions but, at a total of approximately 44,000 minutes in total, around the same magnitude as ATFM restrictions in winter. Average stack hold per flight is considerably lower than that experienced at Heathrow and is broken down as follows:

- summer: in the early morning peak, the average hold per flight is around 3½ minutes and is around 1 minute per flight the rest of the time. The overall average stack holding time per inbound flight is around 0.4 minutes
- winter: in the winter morning peak the average stack hold per flight is around 3 minutes per flight and is less than 1 minute per flight the rest of the time. The overall average stack holding time per inbound flight is around 0.9 minutes

ATFM restrictions

1.20 Upstream at the origin airport, arrivals at Heathrow and Gatwick from within Europe and some other places may be subject to air traffic flow management (ATFM) restrictions imposed as regulations by the Eurocontrol Central Flow Management Unit (CFMU) at the request of the London Flow Management Position (FMP), based at Swanwick. The purpose of these restrictions is to balance demand with available capacity throughout the air traffic management (ATM) network. If a regulation applies, a flight is held on the ground at its origin airport until a time that the CFMU system has calculated that it can be handled within the capacity limits declared along the entire route of flight. These regulations may be applied because of capacity constraints at the destination airport or because of capacity restrictions en route. In the case of Heathrow just over half of the inbound ATFM restrictions are due to Heathrow itself and approximately one quarter of the arriving flights that have delays of greater than 15 minutes are caused by a Heathrow restriction. It is important to stress that, particularly in the early morning arrivals peak, a high proportion of the arriving traffic, especially at Heathrow, originates outside of Europe and is, therefore, not subject to ATFM restrictions. The whole of the demand during this period is, therefore, moderated by restricting only part of the traffic.

1.21 Examination of data collected from the CFMU that describes airport ATFM restrictions at Heathrow and Gatwick indicate that;

- capacity restrictions of varying severity are applied virtually every day at Heathrow in both summer and winter seasons, although the restrictions applied during the summer are usually less severe than those applied during the winter
- Gatwick is subject to many fewer restrictions than Heathrow

1.22 The overall performance of the two airports during 2007 was as follows:

- Heathrow: during the summer season there were approximately 390000 minutes of ATFM delay imposed due to Heathrow airport ATFM regulations . During the winter season this rose to approximately 625000 minutes despite the fact that the winter season (5 months) is shorter than the summer season (7 months). These totals equate to approximate average airport ATFM delays of:
  - 6 minutes on average per inbound flight[2] during the peak times in the summer season with an average over the season of around 3 minutes per flight. Peak airport ATFM delays, quantified by the 95th percentile, reached around 25 minutes at Heathrow in the summer
  - up to 8 minutes on average per inbound flight during the peak times during the winter season. The average over the season was around 6 minutes per inbound flight. Peak (95th percentile) airport ATFM delays in the winter were around 40 to 45 minutes
- Gatwick: during the summer season there were approximately 28000 minutes of ATFM delay imposed due to Gatwick airport ATFM regulations whereas there were approximately 53,000 minutes of ATFM delay during the winter season. The average airport ATFM delay per inbound flight attributed to Gatwick never exceeded 1 minute in either the summer or winter seasons. The peak (95th percentile) Airport ATFM delays only occur at Gatwick during peak periods.

Heathrow ATFM performance compared to other hubs:

1.23 To account for scale effects the best parameter to compare the ATFM performance of different airports is the average airport-related ATFM delay per flight. Such comparison must be treated with some caution as different airports may allocate and report associated delays in different ways and have different infrastructure and associated operations – Charles de Gaulle has theoretical capacity of around twice that of Heathrow, Amsterdam’s capacity is around 75% higher than Heathrow’s and Frankfurt has comparable capacity to Heathrow. This simple comparison indicates that:

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[2] The average is performed over every inbound flight including those from outside of the CFMU area. The ATFM per delay per delayed flight is therefore much higher than the overall average

- in summer, except in the early morning peak (where Charles de Gaulle is the worst performer, despite having the highest capacity) Heathrow’s ATFM performance is worse than Amsterdam, Frankfurt and Paris Charles de Gaulle
- in winter Heathrow and Frankfurt perform much worse than Paris Charles de Gaulle in terms of average airport ATFM delays (there is no data available for Amsterdam with which to make a comparison).

1.24 Weather is the biggest single cause of airport ATFM restriction at Heathrow, Gatwick and the other major European hub airports and, unsurprisingly, the proportion of weather related restrictions increases in the winter season compared to the summer season. Comparison of Heathrow’s robustness against poor weather has been gauged by comparing the ratio of weather regulated capacity to peak capacity for the major European hubs using data available from the Eurocontrol Performance Review Commission. The results of this analysis indicate that:

- in the most extreme cases experienced in 2004 (which is the latest year for which the data is available), Heathrow outperformed the other three main hubs, Amsterdam, Frankfurt and Paris Charles de Gaulle
- averaged over 2004, Heathrow performance was more robust than Amsterdam and Paris Charles de Gaulle but was slightly outperformed by Frankfurt.

Knock-on effects

1.25 Airport ATFM restrictions imposed at the destination airport have a knock-on effect upstream throughout the network as they cause congestion at departure airports as aircraft must be held on the ground. Similarly, they might be expected to have knock-on effects downstream as inbound punctuality will have an impact on the reliability of the airlines ability to provide connecting services beyond the destination airport – specifically Heathrow.

1.26 In the case of the upstream, origin airports, the effect of ATFM restrictions is limited to those within the CFMU system: UK domestic, European and a few others. This is due to the limitation of the mandate of the CFMU to impose flow restrictions, when so required, on aircraft that originate within its area of responsibility, which in broad terms encompasses Europe to the west of the Ural Mountains and the immediately adjacent flight information regions (FIRs). Effectively, therefore, aircraft inbound to Heathrow from domestic and European destinations are disproportionately affected by ATFM as they are the only flights that can be restricted to manage demand – long haul flights are generally unaffected.

1.27 Examination of the airport ATFM restrictions imposed on arrivals from domestic and European origins show that the average delay per flight in the early morning peak (when a large proportion of flights are long haul and unaffected by ATFM) is around 8 to 12 minutes per flight whereas the equivalent delays in the evening peak are approximately 6 to 8 minutes per flight. Airport ATFM delays during the off peak period are of the order of 2 to 4 minutes. The patterns of delays from a sample of specific origin airports - the major European hubs and main domestic origins - show a similar pattern. Heathrow appears to be causing significant knock-on disruption during its peak periods.

Relation between AFTM delays and arrival punctuality

1.28 Correlating the airport ATFM delay with on time arrival punctuality performance (OTAP) on a flight by flight basis shows that:

- for airport ATFM delays of longer than approximately 30 minutes there is a direct 1-to-1 relationship between punctuality and the ATFM delay
- for shorter airport ATFM delays the very many other potential sources of delay mask any correlation that might exist.

Ground holding by ATC

1.29 Ground holding is a complex situation where runway effects are intermingled with factors other than the runway that affect the aircraft's take-off time and hence ground holding. These factors include ATFM restrictions, imposed by the CFMU in the form of a calculated take-off time (CTOT); the application of minimum departure intervals (MDIs) imposed tactically by London flow management position (FMP) to manage congestion in terminal manoeuvring area (TMA) and en-route airspace; and the requirement for air traffic controllers (ATCOs) to apply standard departure separations.

1.30 Ground holding times have been derived for both Heathrow and Gatwick using data available from the electronic flight processing system (EFPS) which allows the taxi time from stand to departure runway to be calculated. The excess taxi time beyond the unimpeded taxi time[3] is defined as the ground holding time.

1.31 Ground holding times at Heathrow are similar for both summer and winter and are typically around 10 to 12 minutes per departure during most of the day but are reduced to around 6 minutes per departure in the early morning. At Heathrow the average ground holding time per flight is:

- just over 9 minutes per departure in the summer season

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[3] Note – variable taxi times are available for most stand-runway combinations for Heathrow from work performed by Eurocontrol. Variable taxi times have been calculated for Gatwick assuming the same statistical definition as applied at Heathrow

- just under 9 minutes per departure in the winter season.

1.32 Peak ground holding times, as defined by the 95th percentile, are around 20 to 22 minutes across the day for both summer and winter seasons.

1.33 In contrast to both stack holding and airport ATFM delays, ground holding is of the same order of magnitude at Gatwick as it is at Heathrow. The average ground holding time per flight is around 10 minutes in the early morning, that is between 05:00 and 08:00 local time. At this time there is high demand for both arrivals and departures. Subsequently, the average ground holding time per flight reduces gradually throughout the day to a value of around 4 minutes per flight in the late evening.

1.34 At Gatwick, the average ground holding time per flight is:

- just over 8 minutes per departure in the summer season
- just under 8 minutes per departure in the winter season.

1.35 At Gatwick, peak (95th percentile) ground holding times are around 18 minutes in the early morning, gradually reducing to around 12 minutes by the late evening.

1.36 The large mismatch between average ground holding times and average stack holding times at Gatwick (a ratio of up to 20 for the summer averages), when compared to those for Heathrow (a ratio of 2.25 for the summer averages) suggests that arrivals are prioritised, i.e. held less, than departures on the shared Gatwick runway.

1.37 The final dimension of holding on the ground is the delay between the pilot requesting start-up and that request being approved. Here there is little difference between the summer and winter seasons. The average time difference is around 4.5 minutes at Heathrow and 2.2 minutes at Gatwick.

Summary of holding and delays

1.38 The following table summarises the various types of holding and ATFM delays at Heathrow and Gatwick over the last two complete seasons.

Exhibit 1-1: Summary of different delay types at Heathrow and Gatwick

		Heathrow				Gatwick			
		Stack	ATFM	Ground	Pre-start-up	Stack	ATFM	Ground	Pre-start-up
Summer	Total (000s mins)	565	389	1404	537	93	28	603	167
	Average (mins)	5.3	2.8	10.0	4.6	1.2	0.4	7.8	2.2
	95th %ile	10-15	15-25	14-22	19	0	0	12-18	12
Winter	Total (000s mins)	602	625	942	409	44	53	381	108
	Average (mins)	6.0	5.3	9.2	4.4	0.8	1.0	6.9	2.2
	95th %ile	15-20	35-45	14-22	18	0	0-12	12-18	12

Major disruptions

1.39 During the periods April 2007 to March 2008, Heathrow suffered 13 days when arrivals capacity was restricted to less than 90% of the norm averaged across the operating day. The main cause of these restrictions was the weather and in addition there was the BA038 accident.

1.40 Collectively, in addition to the associated ATFM delays, these 13 days resulted in approximately 2000 cancelled flights. There were, of course, additional days when large numbers of flights were cancelled for a cause other than runway restrictions. Over the period Heathrow suffered 8 days when over 10% of flights were cancelled. In total there were 47 more days when the flow of both or either of arrivals and departures was severely restricted to less than 90% of the norm or there were more than 20 cancellations. Heathrow appears to suffer around 8 to 13 days per year when operations are disastrously disrupted and a further 47 to 52 days when there is significant but recoverable disruption.

1.41 Examination of runway utilisation figures indicates that NATS uses TEAM to the maximum extent possible to provide the maximum capacity to minimise the impact of disruption and to facilitate recovery afterwards. The use of TEAM is enabled by the drop of demand for the use of the departure runway as a knock-on effect from delayed and cancelled arrivals.

1.42 In contrast, Gatwick suffered no days (despite similar weather) where the capacity was restricted to below 90% (or indeed, 95%) of the monthly average flow. Levels of cancellation were also much lower at Gatwick. Over the period, Gatwick did not suffer a single day when 10% or more of flights were cancelled. Gatwick's resilience is due to: 1) the spare buffer capacity that it has to absorb disruptions by, for example, having the freedom to accommodate delayed flights into spare slots; and 2) the natural robustness that its runway operations bring against wind and low visibility conditions primarily because of the reduced pressure and increased flexibility to sequence arriving and departing aircraft compared to heavily utilised segregated mode runways.

POSSIBLE FUTURE SCENARIOS AT HEATHROW

Normal operations

1.43 The impact of a number of scenarios on stack holding, airport ATFM delays and ground holding of potential future developments at Heathrow has been investigated. These scenarios, which are linked to potential future developments reported in part 4, are summarised in the following table.

Exhibit 1-2 Scenarios Investigated

	Sensitivity testing	Additional TEAM	Mixed mode	Theoretical reduction in demand
Additional flights added	1) Flight added in each hour separately, no capacity added			
Number of flights reduced	2) Flight removed from each hour separately, capacity held at current levels			7) 5% of flights removed each hour across the day, current capacity
Capacity added, current movement levels retained		3) application of TEAM extended across the delay peaks, demand held at current levels	4) maximum capacity mixed mode, giving 15% capacity increase 5) TWASS[4] mixed mode with amended SID[5] structure, giving 10% capacity increase 6) TWASS mixed mode with current SID structure, giving 5% capacity increase	

1.44 The objective of the scenario analysis was to test the impact on runway resilience alone in terms of operational and economic factors as one element of the policy-making process. It is well understood that many additional impact assessments, not least environmental – noise and emissions – would have to be performed should these scenarios be developed further as proposals in any way. It should also be noted that none of the scenarios, with the exception of scenario 1, add any demand and even scenario 1 adds only 1 flight per day. The scenarios are based on the current ground infrastructure and operations and primarily focused

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[4] TWASS - TWin Arrival Streams maintaining Standard Separation

[5] SID- Standard Instrument Departure

on the addition of capacity with demand held at current levels or, indeed, reduced. The impact of ongoing and potential future developments is assessed, and correlated to these scenarios in Part 4 of this document. Finally, the scenarios, with the exception of scenario 4, are based on the current traffic mix and compared to the current situation. The analysis gives a measure, therefore, of the each scenario's impact against a stable baseline. Scenario 4 is based on a 2015 traffic mix, based on a best estimate by NATS and BAA of what this is likely to be.

1.45 The impact of each scenario on airport ATFM delays, stack holding and ground holding was tested using a statistical model that describes the relationship between holding times/ATFM delays, demand and capacity. In each case the familiar exponential or power law relationship, expected from queuing theory, was derived. For most scenarios, the model was derived and validated using operational data covering the summer season 2007 and the winter season 2007/2008. The validation shows that the model predicts total airport ATFM delays to an accuracy of better than 30%. This discrepancy between the model and the actual observations for ATFM delays is caused by the broad spread of ATFM delays around the exponential relationship, reflecting, presumably, the influence of the many other factors present in the complex ATFM situation. However, the accuracy is adequate to determine the directional impact of the various scenarios in airport ATFM delays.

1.46 The statistical models predict total both stack and ground holding times to an accuracy of better than 10%. This accuracy is more than sufficient to assess the impact of the scenarios.

1.47 For the full capacity mixed mode scenario the holding time/ATFM delay, demand, capacity relationship was derived and validated using the results of the NATS HERMES simulation tool as no operational data exists. The statistical approach gives a total stack holding time that agrees with the HERMES output to around 10% which again is very adequate to assess the impact of the scenarios.

1.48 The results of the analysis of each of the scenarios in terms of the change in total ATFM delays stack holding times and ground holding times are given in the following table.

Exhibit 1-3 Impact on holding times at Heathrow by scenario

	ATFM delays (000s minutes)		Stack holding (000s minutes)		Ground holding (000s minutes)	
Scenario	**Summer**	**Winter**	**Summer**	**Winter**	**Summer**	**Winter**
Model baseline (excludes severely disrupted days which are treated separately)	352	396	565	602	1404	942
Change due to each scenario						
Additional flight (worst case)	+29	+42	+93	+21	+24	+3
Flight removed (best case)	-12	-12	-19	-17	-10	-3
Additional TEAM	-85	-92	-185	-159	193	39
TWASS MM, current SIDs (+5%) capacity, current movement limits	-109	-122	-261	-264	-181	-46
TWASS MM, enhanced SIDS (+10%) capacity, , current movement limits	-159	-241	-382	-373	-327	-86
Full capacity MM +15% capacity, , current movement limits	-196	-265	-486	-548	-1214	-730
5% fewer flights per hour	-129	-166	-264	-284	-255	-95

Source: Helios Analysis

1.49 The same data normalised to the number of flights operating in each season is presented in the following table.

Exhibit 1-4 Impact expressed as average minutes per flight

	ATFM delays (minutes per flight)		Stack holding (minutes per flight)		Ground holding (minutes per flight)	
Scenario	**Summer**	**Winter**	**Summer**	**Winter**	**Summer**	**Winter**
Baseline (excludes severely disrupted days which are treated separately)	2.49	3.98	4.00	6.05	10.02	9.20
Change due to each scenario						
Additional flight (worst case)	+0.20	+0.42	+0.66	+0.21	+0.17	+0.03
Flight removed (best case)	-0.09	-0.12	-0.13	-0.17	-0.07	-0.03
Additional TEAM	-0.60	-0.92	-1.31	-1.60	1.38	0.39
TWASS MM, current SIDs (+5%) capacity, current movement limits	-0.77	-1.23	-1.85	-2.65	-1.28	-0.46
TWASS MM, enhanced SIDS (+10%) capacity, , current movement limits	-1.13	-2.42	-2.71	-3.75	-2.32	-0.86
Full capacity MM +15% capacity, , current movement limits	-1.39	-2.66	-3.44	-5.50	-8.60	-7.33
5% fewer flights per hour	-0.96	-1.75	-1.97	-3.00	-1.90	-1.00

Source: Helios Analysis

1.50 The qualitative impact of the scenarios can be summarised as:

- in terms of sensitivity, adding a flight, especially at an inappropriate time has significantly more negative impact than removing a flight, that is the addition or subtraction of flights is asymmetric. The increase in delays and holding time caused by adding a single flight can be very large indeed and in the worst case approaches the total holding time experienced at Gatwick
- additional TEAM can deliver benefits in terms of reduced airport ATFM delays and stack holding times for arrivals but there is an associated cost in increased ground holding especially if TEAM is applied at times when

the demand for departures is high. When TEAM is extended across the morning peak and applied consistently during the evening peak, the losses due to increases in departure holding are around half of the gains from reductions in ATFM delays and stack holding

- in terms of the pure operational benefit of reducing holding times, discounting economic effects, the scenarios in order of increasing preference would be: i) TWASS mixed mode, current SIDs adding 5% capacity; ii) TWASS mixed mode, with enhanced SIDS adding 10%; iii) full capacity mixed mode. The illustrative scenario of reducing demand by 5% indicates the degree to which the balance has tipped in favour of enabling flights in preference to resilience.

MAJOR DISRUPTIONS

1.51 At Heathrow, disruption associated with the runway is principally caused by reduction in the runway flow rate because of either low visibility conditions or adverse wind conditions. As Heathrow operates in segregated mode, the spacing between arriving aircraft must be minimised to maximise the flow rate. Both adverse wind conditions and low visibility cause the spacing between (principally) arriving aircraft to be extended beyond the minimum separation applied on normal operating days.

1.52 Analysis of two case studies, one based on 23 December 2007 when severe disruption due to fog persisted throughout the day (a disaster day) and one based on 5 November 2007 where there was disruption in the early morning peak, again due to fog, that cleared by around 09:00 shows that:

- the application of TEAM on both disaster and recoverable days brings benefits to the situation compared to that in which TEAM is not applied. Without TEAM on disaster days, the shortfall in arrivals would have been up to around 40% greater than that achieved and around 50% greater than that achieved on the recoverable day. TEAM does not allow recovery on the disaster days though
- reducing or capping demand facilitates recovery by both reducing the impact of the disruption when it occurs and by ensuring that there is spare capacity available after resumption of normal operations
- it is not possible to recover from the disaster days that occur on between 8 and 13 days per year. However, use of mixed mode operations on these days would ease the situation and could result in a reduction in shortfall of flights (and cancellations depending on particular airline policy) by around 40%. This benefit arises from the natural robustness of mixed mode operations against the requirement to impose increased separation

for arriving aircraft in adverse wind and visibility conditions. Simple addition of capacity would not ease the situation on disaster days in segregated mode operations as the operational capacity is already reduced well below that available on normal days

- use of mixed mode on recoverable days at Heathrow would likely allow full recovery similar to that achieved at Gatwick on similar types of day. There is a dual benefit on the recoverable day in that mixed mode reduces the impact of the disruption (wind or fog) as well as speeding up the recovery by providing additional capacity.

ECONOMIC RESULTS

1.53 Stack and ground holding and airport ATFM delays have an economic impact, primarily on airlines and their passengers, and also an impact on the environment. Stack and ground holding result in extra flying or extended taxi times which use additional fuel so generating CO2 and damaging the environment. To compensate for time spent holding, airlines plan their schedules around an expectation that aircraft will be queuing on a daily basis to take-off or land. This incurs additional cost for the airlines as they need to operate with more crews and aircraft.

1.54 Because holding times and airport ATFM delays vary with weather conditions and traffic intensity, despite the extended sector times reflected in airlines' schedules, runway related holding and delay also has an impact on departure and arrival punctuality. Around 20% of passenger delay minutes at Heathrow are directly attributed to runway congestion; with rotational delays the figure will be higher.

1.55 The scope of this study focusses on the airlines and airports, their passengers and the environment, and excludes wider economic effects such as employment and the contribution of flying to the UK economy. The study has not looked in detail at the competitiveness of Heathrow compared to other European hubs, and how changing levels of Heathrow performance would change traffic patterns. In assessing the net benefits we have adopted the DfT's methodology used in their 2007 paper, "UK Air Passenger Demand and CO2", and which is detailed in Appendix H of that report.

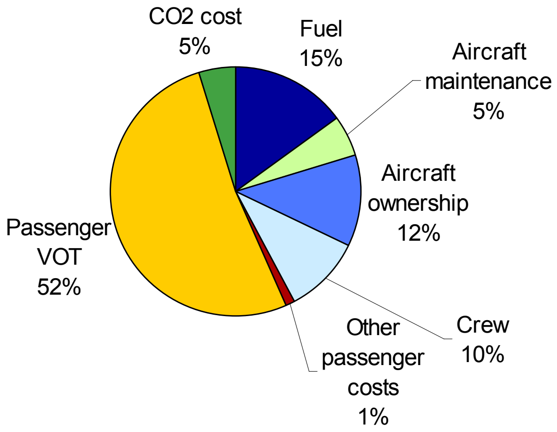
1.56 From discussions with the BAA we have concluded that at least at the margin, changes in aircraft holding times have no measurable cost or benefit to the airport operator so the impact on them is not considered. However, the economic benefits from incremental passengers are considered in line with the

DfT approach referred to above which recognises the additional profit they bring to airports.

Current Situation

1.57 The total cost of stack and ground holding, and airport ATFM delays based on analysis of the summer 2007 and winter 2007/2008 seasons for Heathrow is around £433 M. This is broken down as follows:

Exhibit 1-5 Costs of Holding in Summer 2007 and Winter 2007/2008



Source: SH&E Analysis

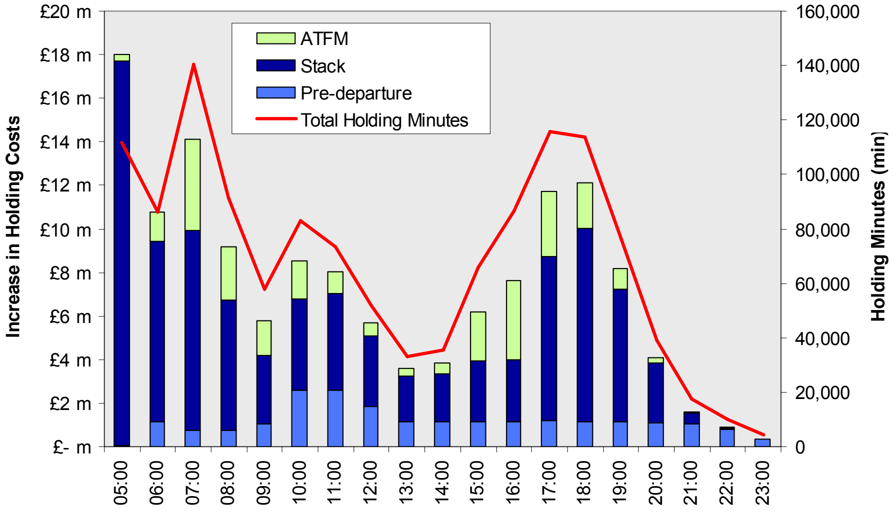
1.58 To these costs should also be added a further £3 million to £5 million share of the standby resources (aircraft, crew and ground staff) that airlines allocate to improve resilience to arrival and departure delays when they occur: a 20% share of these delays are related to runway congestion.

Changing the balance of demand and capacity

1.59 The impact of adding extra flights at Heathrow would be to increase holding times, airport ATFM delays and costs associated with runway congestion. These costs would be incurred by all airlines operating around the time of the additional flights, not just by the extra flight itself. These costs need to be considered against the benefits of the extra flights which largely accrue to the airlines and airports, their passengers and their passengers' employers.

1.60 Looking first at the increased holding costs which include airline costs, the value of passengers' time and the cost of the carbon emissions, we can see that the impact varies considerably with the time of day.

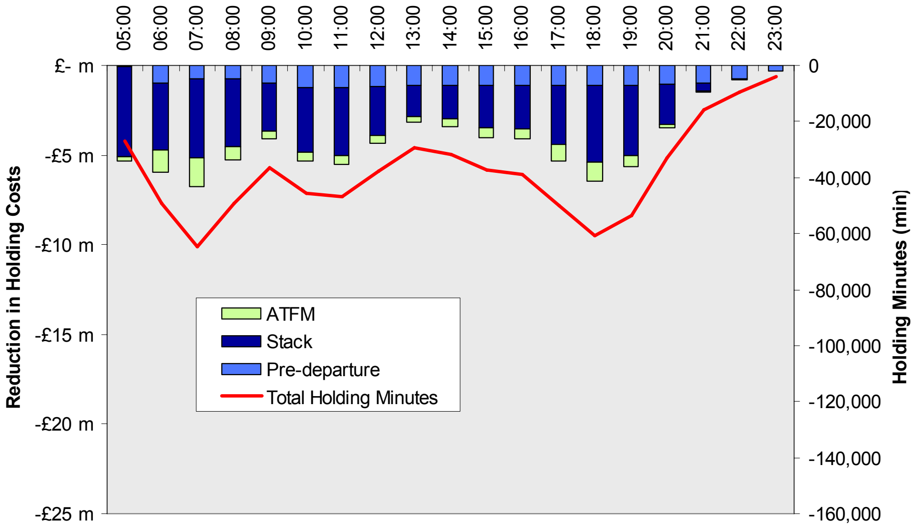
Exhibit 1-6 Effect of Adding Extra Flights on Holding Costs (assuming one arriving and one departing flight is added in any hour)



Source: SH&E Analysis

1.61 Exhibit 1-6 shows the increased costs are highest for the stack holding and particularly in the early morning arrivals peak when there is a high proportion of wide-bodied aircraft. There is another peak in the evening. The potential from reducing the demand by removing a flight in each hour has a lower and opposite impact, as shown below in Exhibit 1-7. The costs are proportional to the total holding minutes which are more sensitive to increased demand than reduced demand.

Exhibit 1-7: Reduction in Holding Costs when flights are removed is lower



Source: SH&E Analysis

1.62 The increase in holding costs from an extra daily flight pair, averaged across the day is £7.5 million a year (in 2007 costs). The decrease if a flight pair is removed is -£4.3 million.

1.63 The benefits of the extra flight are made up of several elements

- The benefits new passengers gain from the additional flights (Generated User Benefits)
- The value of time saved by existing passengers who benefit from more convenient schedules (Existing User Benefits)
- Additional profits airports make from additional passengers (Producer Benefits)
- Increased Air Passenger Duty (APD Revenue)

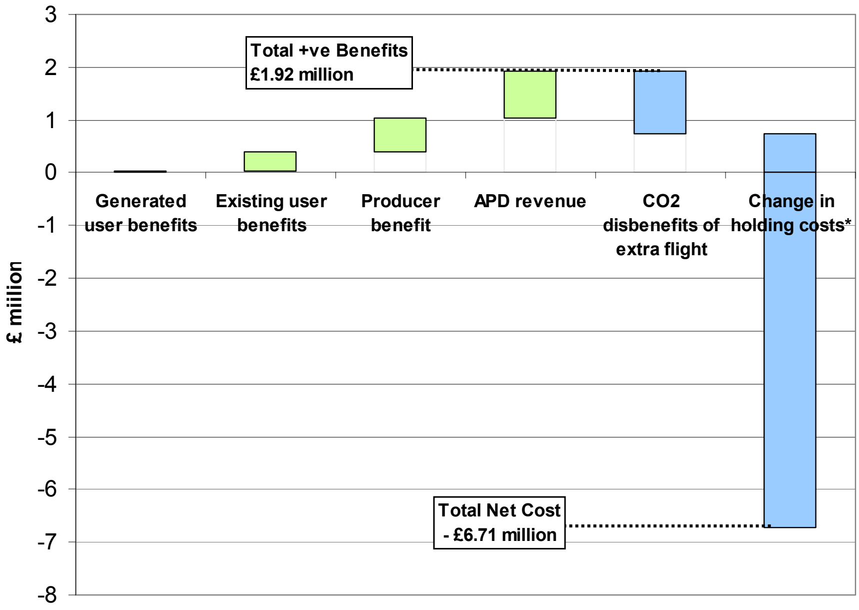
Less the offsetting incurred costs

- The environmental costs of extra flights
- The increased costs of holding, as summarised in Exhibit 1-6 above.

While the actual benefits from any additional flights may vary by time of day and also depend on the flight destination, the aircraft size and so on, the methodology of benefit estimation works at a more aggregate level and does not allow that level of differentiation.

1.64 The total average annual benefit from adding an extra flight is £0.74 million. This gives a net result per flight pair added of a loss of -£6.71 million when the increased holding costs are considered. The elements that make this up are shown in the following Exhibit 1-8.

Exhibit 1-8: The average net loss from adding a daily pair of flights at LHR



Source: SH&E Analysis

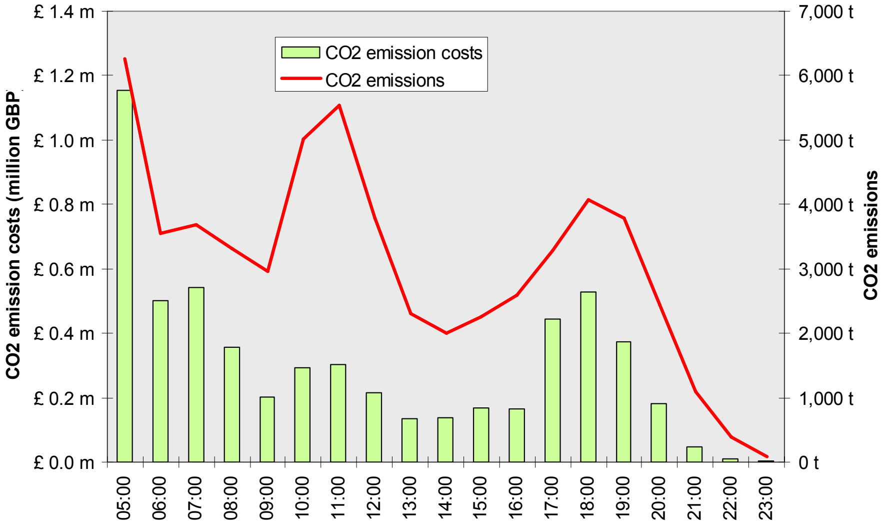
1.65 The main conclusion from this analysis is that the benefits of additional flights are, on average, heavily outweighed by increased holding costs from the resulting worsened congestion at Heathrow.

1.66 A similar picture was found when the scenario of reduced flying was analysed. In this case the magnitude of the improvement in net benefit was less - £3.52 million per flight pair compared to £6.71 million when flights are added. This difference reflects the increasingly damaging effect of adding demand to a system which is very close to its capacity.

1.67 The main environmental impacts for holding are from additional flying in the stack which burns fuel and increases emissions of C02 and NOx. The costs of carbon emissions in the stack and from additional flights include a 1.9 escalation factor for Radiative Forcing as recommended by the DfT: this reflects the additional environmental harm caused by CO2 released at altitude.

1.68 The annualised emission of CO2 and the costs of emission would increase as shown below. The average increased holding cost of carbon is around £0.3 million a year; this is in addition to annual cost of carbon for the additional flight itself of £1.2M.

Exhibit 1-9. CO2 Effect of Adding Extra Flights



Source: SH&E Analysis

Allocating more airline resources to reduce holding delay impacts

1.69 When holding delays increase airlines in theory can choose whether to plan on the increased sector times this implies, or ignore it and accept worse on-time punctuality. In simple terms this is a trade off between expenditure, lower levels of delivered customer service, and some associated costs from compensation, lost baggage and mis-connecting passengers.

1.70 A simple analysis shows that in terms of easily measurable costs it is more expensive for airlines to increase their scheduled sector times than it is to pay for the costs of worse on-time performance by a factor of ten-to-one. The fact that they do not pursue a "lowest cost" policy suggests that they put a high value on customer service and passengers' time.

ROOT CAUSE ANALYSIS

1.71 The are four main strands of root cause issues:

- Pressure on the Capacity Declaration procedures to create additional capacity – but with a process which does not have, nor is asked to have, a full set of planning parameters, metrics, and targets to make it sufficiently operationally realistic. An example is in-bound pre-departure ATFM delays which, although often caused by factors beyond the airport's control, happen on a daily basis - it would therefore seem prudent to have a collective stakeholder response in addition to the schedule buffering introduced by airlines (using their own internal assumptions). The process also lacks any real power to drive any difficult changes – particularly reductions in capacity/demand. This is exacerbated by the current lack of economic trade-off metrics.

- Pressure on tactical ATC management to correct the imbalances created by weaknesses in the plan, airline adherence to plan and factors outside their control. Over time, tactical reserve positions have been eroded and effectively incorporated into the assumed operation e.g. TEAM in the early morning. Small but measurable increases in demand and adverse trends in aircraft mix are adding to the problems and potentially further weakening resilience.
- Bunching of runway demand, caused in part by peaks within the schedule but also by airline processes and performance which do not consistently deliver aircraft on plan (although again recognising network factors which may be beyond their control).
- Gaps in the governance structure and processes which result in limited incentives and sanctions around adherence to plan and responses to endemic issues. While there are many planning and performance committees and improvement initiatives, there are few system-wide key performance indicators (KPIs) – resulting in gaps e.g. again relating to the ATFM delay problem described above and, until recent community effort, a fully co-ordinated response to days of serious disruption. This can be exacerbated by funding debates where benefits and costs accumulate in different organisations.

1.72 It should be stressed that the airport and its community of airline users have a set of planning, governance and performance review structures which are fully compliant with EU slot regulations, safety and DfT regulations, and IATA scheduling guidelines, and which are highly respected in the aviation industry. However, the problems of congestion, environment and disruption specific to Heathrow appear now to demand a new and higher order of targeting, planning and managing at the airport. We have assumed for the purposes of this study that the legislative and regulatory frameworks mentioned above will remain in place as the context for Heathrow operational planning, albeit that some of the parameters affecting demand and/or capacity may be modified.

CONCLUSIONS

Operational aspects

1.73 Heathrow’s runways are currently operating at or very near their capacity giving very limited buffer against the normal perturbations in the air traffic network or to cope with or recover from disruptions to operations. The very high utilisation at Heathrow is also reflected in its low robustness to and limited ability to recover from major disruption when compared to Gatwick.

1.74 This fragility appears to be exacerbated by the use of the runways in segregated mode with the minimum spacing between arriving aircraft when compared to the additional, buffer spacing that naturally occurs when runways are shared for both arrivals and departures.

1.75 As a consequence of operating very near to capacity, Heathrow’s current performance is significantly worse than that at Gatwick in terms of stack holding and airport ATFM delays. The performance of the two airports is comparable for ground holding for departures. Gatwick’s poor performance in ground holding, relative to stack holding and ATFM delays, is probably due to priority being given to arrivals for access to the runway.

1.76 In addition, Heathrow’s performance in terms of airport ATFM delays is worse than two of its main European hub competitors (Amsterdam Schiphol and Paris Charles de Gaulle with the caveat that both of these airports have considerably greater runway infrastructure than is available at Heathrow) and on a par with Frankfurt. Heathrow does, however, show better resilience against adverse weather conditions than both Amsterdam Schiphol and Paris Charles de Gaulle.

1.77 Heathrow’s own ATFM delays, stack and ground holding can be very sensitive to the addition of even a single flight at an inappropriate time and can increase very significantly. This is because at times the runway is operating at its very limits of capacity and small increases in demand can therefore cause large increases in delay which propagate through to subsequent hours until a fire-break is reached where sufficient spare capacity is available to stop the knock-on effects. However, the sensitivity to the removal of a single flight at a given time is much lower than for the addition of a flight at the same time as the holding time reduces more slowly as demand reduces than it increases when demand increases because (1) the relationship between queue length and demand is exponential meaning that increases result in a much greater relative change than decreases. Furthermore, the knock-on effect of reducing demand is much less than the knock-on effect of increasing demand. There is more to lose in terms of increased delays by adding a flight than there is to gain by removing a flight.

1.78 In terms of improving performance, various scenarios could be considered for increasing capacity whilst holding demand at its current levels. These options include the extension of TEAM and implementation of various manifestations of mixed mode. Although TEAM brings operational benefits in terms of reduced airport ATFM delays and stack holding, it can also have a negative effect on ground holding for departures if it applied when departure demand is high.

1.79 Clearly the greater the capacity delivered by mixed mode operations, the greater the benefit in terms of reduced airport ATFM delays, stack and ground holding as well as improved scope for recovery from disruptions. Mixed mode runway operation can also ameliorate the impact of persistent major disruptions but it will not completely overcome the effect of the disruption.

Costs and benefits of changing the balance between demand and capacity

1.80 The current level of runway utilisation at Heathrow is beyond the economic balance point throughout the day and throughout the year. Adding more flights without any change in capacity or the way existing demand is managed will have an economically adverse effect.

1.81 Should it be possible to reduce the number of flights the savings in reduced holding costs would still outweigh the benefits lost from those flights at the current balance of demand and capacity.

1.82 Airlines' policy of fully reflecting increased holding times in their scheduled sector times is beneficial to passengers even though it appears to be a more expensive option for the airlines. The apparent anomaly can be explained by the implied high value airlines must put on the competitive value of punctuality, which is consistent with previous studies and figures quoted by individual airlines consulted during this project.

Root causes

1.83 Clearly, there are no simple solutions to the root cause issues at Heathrow – different levels of mixed mode have been modelled in the main exercise (and in other studies) and operationally it has the advantage of potentially allowing increased demand and/or restoring tactical capacity (and increased arrival separations) to improve resilience.

1.84 Short of mixed mode, or alongside it, there are a number of options which could be developed – some of which are already on the continuous improvement agenda and some of which could be addressed through a co-ordinated effort if the relevant targets, objectives and amended governance structures could be agreed. Examples include:

- Changes to the shape of the schedule and incorporation of more extensive and realistic planning parameters to smooth patterns of capacity and demand. Subject to technical feasibility and further detailed modelling (beyond the scope of this study), holds should be reduced by levelling flows over the day. It is possible that technical constraints associated with such a move could lead to a marginal reduction in capacity – which may carry economic penalties to airlines as a result of losing some commercially valuable slots in the peaks.

- Targeted reductions in capacity to induce a reduction in demand. Some modelling has been reported in the main report on general reductions – in practice there would be a range of options, the most valuable in terms of operational performance concentrating on "firebreaks" – short gaps or reductions in the airport's daily schedule - to relieve the impact of the peaks. The resultant loss in aircraft traffic movements would be off-set, in terms of passengers, through demand shifting to other services either side of the change in the schedule (leading to higher load factor and/or reinforcing trends to larger aircraft).

- Resilience and operational control improvements to help restore tactical resilience. These measures are unlikely to allow increases in demand but would assist resilience and facilitate punctuality improvement. Examples include:

  - Improved control and process discipline from implementation of wider Collaborative Decision Making – this is in development at Heathrow.

  - Time-based separation – this would be a significant development requiring substantial work on the safety case for moving from current distance-based separation.

  - Extended application of TEAM – there are detailed options which are more specific than those modelled in the main project. This may require Government policy approval, given the noise implications, depending on the level of change required to the guidelines.

- A fuller package of targets, planning parameters and KPIs within a strengthened governance structure could tighten control of the operation and introduce more sanctions and incentives. Steps might include changes to the "first come, first served" procedures, new measurement points in the processes and trade-off decision support.

- Achieving change of this kind would also tighten the distribution curves to improve predictability - other drivers of poor punctuality at the airport could then be addressed with greater confidence and less interaction with runway performance.

1.85 These approaches address the identified root causes, but in terms of measured impact, most would be reflected in specific elements of performance (e.g. ATFM holds or cancellations) - rather than the fundamentals of the relationship between capacity and demand which was the focus of the main study. Therefore, rather than talk about overall improvement, it is necessary either to construct a package of changes or to specify more granular targets (e.g. reduced number of disrupted days) and to prioritise relevant initiatives.

1.86 In any event, a more holistic view of targets and governance is likely to be required to balance the historic pressures to increase the level of demand with acceptable operational integrity.

Part I:
INTRODUCTION

2 INTRODUCTION

OPERATIONAL OVERVIEW

2.1 All departures from an airport are funnelled from their stands, via the taxiway system to take-off along a runway before dispersing along their departure air routes, usually standard instrument departures (SIDs). The situation is reversed for arrivals which are funnelled from their arrival air routes, often standard terminal arrival routes (STARs) to land on the runway and then dispersed via taxiways to their stands. The runway, therefore, represents a pinch point in the air traffic network and, as such, when demand is high, is a scarce resource whose utilisation must be managed carefully and optimised. This is the situation at both Heathrow and Gatwick airports.

2.2 As with all systems where demand is approaching capacity, queues to use the runway can build up. For arriving aircraft, the first mechanism used to manage these queues at Heathrow and Gatwick is the airborne holding stack. Generally in holding stacks, aircraft fly in a spiral racetrack pattern, entering at the top, descending through several levels and exiting at the bottom. Stacks are used to moderate the demand for the runway, as a buffer to allow air traffic controllers to sequence aircraft to optimise the throughput of the runway whilst maintaining separation between aircraft to ensure that the following aircraft is not affected by the preceding aircraft's wake vortex. This separation varies depending on the sequence of aircraft (heavy-heavy, heavy-light, light-heavy, etc). In simple terms the separation for a lighter aircraft following a heavier aircraft must be greater than if the sequence were the other way round. In this report, this process is called **stack holding** and the time that each aircraft spends in the stack is termed the **stack holding time**. Heathrow can use up to four stacks and Gatwick two.

2.3 Heathrow generally operates its runways in segregated mode, meaning that one runway is used solely for arrivals and the other for departures. Thus to maximise throughput, arrivals are spaced as closely together as possible. Gatwick, as a single runway airport, operates its runway in mixed mode, that is the same runway is used for arrivals and departures. In this case, arrivals and departures are often interspersed meaning that the separation between arriving aircraft is necessarily larger than the minimum imposed by wake vortex considerations to allow for a departure to be slotted between successive arrivals.

2.4 The holding stacks themselves have a limited capacity and two techniques can be used at Heathrow to deal with situations where the stack capacity looks as though it will be exceeded by the number of planned arrivals or average stack holding time will become greater than twenty minutes:

- if the constraint is caused by a short-term peak in demand, that is it is expected to be persist for less than around an hour, air traffic control applies a procedure know as TEAM (Tactically Enhanced Arrivals Measures). TEAM temporarily boosts arrivals capacity by allowing a proportion of the arriving aircraft to use the departure runway. This does not, however, raise the capacity to that expected from a full mixed mode operation because, for example, it does not allow full, independent use of the runways and only addresses arrivals. Its use is restricted to times when holding time in the stacks is predicted to become excessive
- if the constraint is expected to be persistent, aircraft that plan to arrive during the period of congestion are held upstream on the ground at their departure airport until the downstream capacity constraint is alleviated. This technique, called air traffic flow management (ATFM), is generally restricted to aircraft departing from a point in Europe and is administered centrally by the Eurocontrol Central Flow Management Unit (CFMU). In this report, the process of holding aircraft at their departure airport is called **ATFM regulation** or **restriction**. The ATFM regulation imposes an **ATFM delay** on the affected aircraft.

2.5 As Gatwick's runway operates for both arrivals and departures, it cannot apply TEAM but its traffic can be moderated by ATFM regulation.

2.6 The departure flow is moderated by managing the queue to optimise the throughput of the departure runway. Departures are sequenced by managing the time that the aircraft is pushed back and by managing its passage from its stand to the runway after it has pushed back to provide the optimum sequence of aircraft at the departure runway. In this report, this process is termed **ground holding** and the period that the aircraft spends in this process is called the **ground holding time**.

2.7 The ground holding process is further complicated because it needs to take account of:

- potential capacity constraints down the aircraft's flight path which might be manifested as ATFM regulations that cause the aircraft to be held at Heathrow or Gatwick
- short-term sequencing of aircraft departing the London terminal area through standard instrument departure (SID) routes shared between Heathrow, Gatwick, Stansted, Luton and London City airports. This sequencing, that takes into account all traffic departing London, not just

Heathrow and Gatwick, is managed through the application of minimum departure intervals (MDIs) whereby short holding delays are imposed on the affected aircraft by local air traffic control.

2.8 The operational analysis undertaken in this report focuses on the three main areas impacted by the runway:

- stack holding for arrivals
- upstream ATFM regulation due to the capacity of the arrivals airport
- ground holding for departures.

2.9 In each case, In Part 2 of the report, section 4 describes the current situation, section 5 assesses the impact of several potential future scenarios from the operational perspective. Part 3 of the report assesses the economic impact of both the current situation and potential future scenarios.

2.10 The root causes of the current runway performance and potential improvement opportunities have been explored by XPX Consulting and are reported in Part 4 of this document.

2.11 Part 5 of the report introduces work that was done additional to the original remit of the study to help understand how best to balance resilience and additional flights in the situation that additional capacity might be made available.

BACKGROUND TO THE STUDY

2.12 In November 2007 the Department for Transport (DfT) published a report "*Improving the air passenger experience*" with particular focus on Heathrow airport. This report considers all elements of the passenger's end-to-end journey, including:

- getting to and from the airport
- getting through the airport, including check-in, security screening, transit through the terminal, embarkation, immigration, baggage handling and reclaim, and customs
- take-off and landing, including push-back, taxiing, and disembarkation
- flying to and from the desired destination/origin.

2.13 The Department for Transport (DfT) has requested advice from the CAA, under Section 16(1) of the Civil Aviation Act in three areas to aid its understanding and evaluation of the end-to-end journey experience for air passengers to support policy development. These areas are[6]:

- the through-airport passenger experience
- early review of the passenger experience in Heathrow Terminal 5
- runway resilience.

2.14 Other areas that affect the overall resilience of the airport, including the availability and quality of the critical terminal infrastructure as well as the quality of the services delivered, are addressed in the regulatory regime for the designated airports through service quality standards, quality of service monitoring (QSM) and a system of rebates. These do not, however, cover the resilience of the runways themselves. Clearly, the airport has to be viewed as a single system and any gains made through regulatory initiatives could be negated through poor runway performance as the runway effectively delivers the passengers to and from the terminals.

2.15 The CAA has therefore commissioned a study on runway resilience to investigate, in cooperation with the airlines and the airports, lessons learned from current runway operations at Heathrow and Gatwick airports.

2.16 In simple terms, the study objectives are to make an assessment of the relative values (cost and benefits), to all stakeholders including the environment, of using capacity to: either enable additional flights; or to provide higher quality of service in terms of reduced delays, improved predictability and better recovery from significant operational disruption events. Effectively, the eventual trade-off will be to balance demand and quality of service.

2.17 Further to the evaluation of this trade-off, opportunities for achieving performance improvement, through the better planning and operation of the runway, slots and associated ATC resources, have been investigated in parallel.

2.18 This document, prepared for the Economic Regulation Group (ERG) of the Civil Aviation Authority (CAA), by Helios, SH&E and XPX Consulting, is the final report of that study.

2.19 Best use has been made of existing operational and modelling data. Gaps identified in the available data have been supplemented by focused modelling and analysis as necessary. Data gathered for the study includes National Air Traffic Services (NATS) operational records, Eurocontrol Central Flow Management Unit (CFMU) data, and simulation data produced by NATS under the

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[6] Letter from the Secretary of State for Transport to the Chairman of the CAA, dated 20 November 2007

commission of BAA as part of the recent Heathrow consultation, data held by Airport Coordination Limited (ACL) and the BAA airport super-logs required to support the regulation of quality of service standards at Heathrow and Gatwick airports.

2.20 This has been supplemented by detailed discussions with airlines which have provided specific data to help complete and calibrate the overall results, and support the economic evaluation.

2.21 During the course of the study we have benefited from the contribution of the main stakeholders, particularly the airlines, airports and NATS as the air navigation services provider, both through provision of a deeper understanding of the technical and economic aspects and also by providing access to the relevant data.

2.22 The Terms of Reference for the study are contained in Appendix A.

3

MEASURING DELAYS AND RUNWAY PERFORMANCE, DEFINITIONS

INTRODUCTION

3.1 This study is concerned with assessing the resilience of runway operations at Heathrow and Gatwick airports and to learn lessons from current operations. Runway resilience, from its dictionary definition (*the abilities to withstand or recover quickly from difficult conditions*), is interpreted as having two main components:

- **Withstanding:** how robust are current runway operations against normal day-to-day perturbations to the operating environment?
- **Recovering:** how well can current runway operations recover from large-scale disruptions to the current operating environment?

3.2 Loss of resilience in runway operations manifests itself in holding, delays and cancellations.

OPTIMISING THE USE OF AVAILABLE CAPACITY USING HOLDING

3.3 Management of runway operations is set up to optimise the utilisation of runways as a scarce and critical resource at both Heathrow and Gatwick. This is achieved through the use of three sets of queue:

- airborne holding or stacking for arrivals where air traffic control (ATC) manages the inbound queue and sequences aircraft to maximise runway throughput by establishing a buffer in the air – stacks – in the London terminal area
- air traffic flow management (ATFM) regulation and associated delays for arrivals, which is administered by the Central Flow Management Unit (CFMU) and holds inbound flights on the ground at the departure airport by slot regulation. ATFM regulations, imposed by the CFMU, and hence ATFM-related delays, occur when traffic demand exceeds ATM capacity en-route (en-route ATFM delay) or at departure/arrival airports (airport ATFM delay). ATFM regulation may be imposed because of over delivery of aircraft from the network or a structural lack of capacity due to technical failures, industrial action, staff shortages or adverse weather. This project is concerned only with ATFM regulations due to the imbalance of demand and capacity at Heathrow and Gatwick as arrival

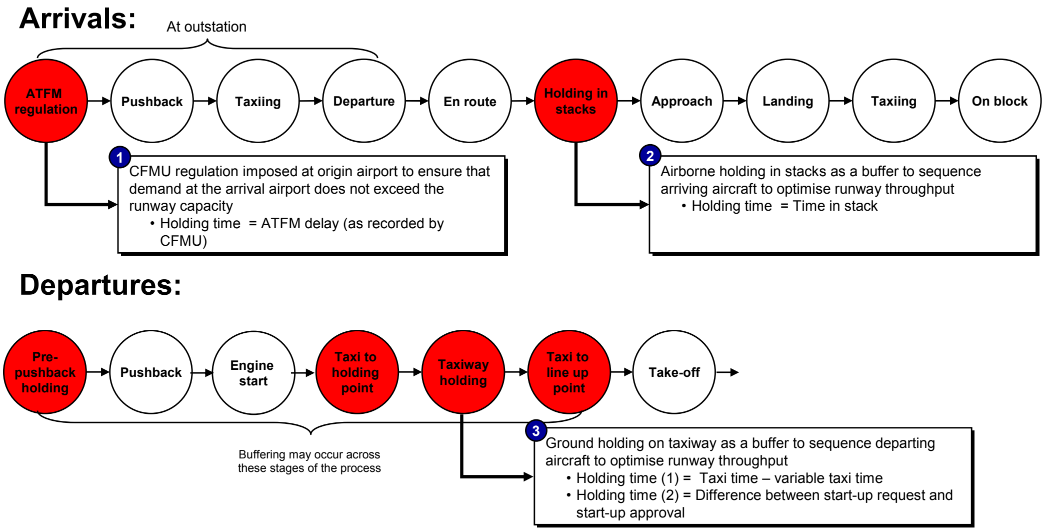
airports. Arrivals at Heathrow and Gatwick from origins within the CFMU system, which in broad terms encompasses Europe to the west of the Ural mountains and the immediately adjacent FIRs, and some other places may be subject to air traffic flow management (ATFM) restrictions imposed as regulations by the CFMU at the request of the London Flow Management Position (FMP), based at Swanwick. The purpose of these restrictions is to balance demand with available capacity throughout the air traffic management (ATM) network. If a regulation applies, a flight is held on the ground at its origin airport until a time that the CFMU system has calculated that it will be contained within the capacity limits declared along the route of flight

- ground holding for departures to manage the outbound queue and sequence aircraft, within the constraint of CFMU regulations and minimum departure intervals (MDIs), to maximise runway throughput by using the aircraft taxiing from the stand to the runway as a buffer. This may be achieved by managing the aircraft's progression from stand to departure runway after it has pushed back as well as managing the time that approval for start-up is granted.

3.4 The outcome of each of these three queue management techniques is often termed "a delay" although it is important to be aware that they might or might not impact on punctuality depending on other circumstances, including the amount of buffer built into airline schedules. The total delay comprises these three elements and other components, including en route delays, delays due to airline processes and rotational or knock-on delays. Each element of the total delay, however, has an impact on the passenger's perception of the quality of the service being delivered.

3.5 In terms of the end-to-end processes for arrivals and departures, the elements investigated in this study are highlighted in Exhibit 3-1 , together with definitions of the delays that are measured.

Exhibit 3-1: Discrete elements of the arrivals and departures processes being investigated



1 CFMU regulation imposed at origin airport to ensure that demand at the arrival airport does not exceed the runway capacity

- Holding time = ATFM delay (as recorded by CFMU)

2 Airborne holding in stacks as a buffer to sequence arriving aircraft to optimise runway throughput

- Holding time = Time in stack

3 Ground holding on taxiway as a buffer to sequence departing aircraft to optimise runway throughput

- Holding time (1) = Taxi time – variable taxi time
- Holding time (2) = Difference between start-up request and start-up approval

DEFINITIONS AND DATA SOURCES

3.6 The operational analysis part of the project has determined the relationship between delay[7], demand and capacity using statistical techniques based on a sample of data describing individual arrivals and departures to/from Heathrow and Gatwick over a 12 month period from 1 April 2007 to 31 March 2008 spanning the last two complete airline scheduling seasons, that is summer 2007 and winter 2007/2008.

3.7 The following definitions have been used:

- **demand** is defined as the number of aircraft wishing to use the runway within a given hour prior to holding (ATFM, stacking or ground holding) restrictions being applied. The demand profiles:
  - reflect actual observations and are not simply based on the schedule
  - are derived before ATFM regulations are applied to manage the demand for the runway.
- **capacity** is defined as the number of aircraft that the runway can throughput within a given hour for a given level of delay in normal operations
- **holding** and **holding time** is used to describe the time spent waiting on the ground or in the stack.
- **delays** occurs when demand approaches or exceeds capacity:

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[7] Here the term “delay” is taken to mean ATFM delay, stack holding time or ground holding time

  - when the schedule, modified by network fluctuations, exceeds the normal operating capacity of the runway
  - when capacity is reduced below its normal value by some event, such as weather.

3.8 Note that delays are also used to mean flights that arrive or depart later than their scheduled time. It should be clear from the context within the report which delay is referred to.

3.9 Historical operational data have been used as the basis of the analysis. The main sources of these data were:

- NATS, describing:
  - the use of stacks by arrivals at Heathrow and Gatwick. This data has been derived from the UK Flight Database
  - ground holding for departures from Heathrow, derived from the NATS electronic flight processing system (EFPS)
  - the output of the HERMES model used, *inter alia*, to investigate the potential of mixed mode operations at Heathrow as part of the recent consultation process
- the Eurocontrol Central Flow Management Unit, providing a complete catalogue of arrivals and departures at Heathrow and Gatwick including ATFM delays caused by regulations at those airports (note similar data was collected for Amsterdam, Frankfurt and Paris Charles de Gaulle airports to enable comparison of ATFM performance)
- airlines, describing particular operators' stack holding, ground holding and on time arrival punctuality performance as well as runway utilisation
- Airport Coordination Limited (ACL) providing information on disruption to operations and the causes of those disruptions.

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Part II:
OPERATIONAL ANALYSIS

4 CURRENT SITUATION AT LHR AND LGW

INTRODUCTION

Overview of runway operations

4.1 Heathrow operates with two parallel runways (27L/09R & 27R/09L) oriented east-west with a lateral separation of 4640ft. Heathrow operates in segregated mode with one runway for arrivals and one runway for departures. In segregated mode the runways operate independently. The preferred runway direction is Westerly (27L and 27R). Easterly operations are employed when the tail wind approaching the runway threshold exceeds 10kts. In order to meet noise restrictions, for easterly operations the northern runway (09L) is always used for arrivals and the southern runway (09R) is always used for departures as the Cranford Agreement prohibits easterly departures from the northern runway (09L). For westerly operations runway alternation is employed where the runways change over at 15:00 and where the active duty runway in the morning period (06:00 to 15:00) and in the evening period (15:00 to 23:30) changes on a rotational basis.

4.2 Gatwick is a single runway airport (08/26) and as such the runway operates both arrivals and departures interspersed or in bunches depending on the prevailing traffic situation.

4.3 As with all systems where demand is approaching capacity, queues to use the runway can build up. For arriving aircraft, the first mechanism used to manage these queues at Heathrow and Gatwick is the airborne holding stack. This approach enables air traffic controllers (ATCOs) to sequence aircraft in the optimum manner to maximise the flow rate – the penalty being that the pool of available aircraft must be held in order for the sequence to be optimised.

4.4 Generally, aircraft in holding stacks fly in a spiral racetrack pattern, entering at the top, descending through several levels and exiting at the bottom. Stacks are used to moderate the demand for the runway, as a buffer to allow air traffic controllers to sequence aircraft to optimise the throughput of the runway whilst maintaining separation between aircraft to ensure that the following aircraft is not affected by the preceding aircraft’s wake vortex. This separation varies depending on the sequence of aircraft (heavy-heavy, heavy-light, light-heavy, etc). In simple terms, the separation for a lighter aircraft following a heavier aircraft must be greater than if the sequence were the other way round. In this report, this process is called **stack holding** and the time that each aircraft spends in the stack is termed the **stack holding time**. Heathrow can use up to four stacks and Gatwick two. The current agreed average stack holding time is set at ten minutes through an agreement between the airlines, airports and NATS.

4.5 There are number of uncontrollable (from the perspective of air traffic control) factors that impact on the holding time:

- Aircraft mix: As described above is necessary for air traffic controllers to maintain wake vortex separations which vary depending on the sequence of aircraft. The mixture of aircraft in the mix influences the efficiency with which this spacing can be optimised
- Airline schedules: Holding times will vary according to the schedules of the airlines operating to the airport. Holding is likely to increase where, for example, there is concentration of demand at a specific time. Smoothing of schedules is a technique that could bring benefits in terms of reduced holding times
- Wind conditions: variability in wind conditions can impact on the separation of aircraft on approach and, when adverse conditions are experienced and separations are greater than normal, runway throughput is decreased and holding times are expected to increase.

4.6 The holding stacks themselves have a limited capacity and two techniques can be used at Heathrow to deal with situations where the stack capacity looks as though it will be exceeded by the number of planned arrivals or average stack holding time will become greater than twenty minutes:

- in certain circumstances, a procedure know as TEAM (Tactically Enhanced Arrivals Measures) can be applied temporarily to boost arrivals capacity by allowing a proportion of the arriving aircraft to use the departure runway. Typically, this is applied to match the early morning peak of demand, or when predicted delays within the next two hours are becoming excessive and reach defined trigger points. This does not, however, raise the capacity to that expected from a full mixed mode operation. TEAM is most valuable in mitigating short-term arrivals peaks.
- if the constraint is expected to be persistent, aircraft that plan to arrive during the period of congestion are held upstream on the ground at their departure airport until the downstream capacity constraint is alleviated. This technique is called air traffic flow management (ATFM), is generally restricted to aircraft departing from a point in Europe (it does not, therefore, apply to long haul aircraft from intercontinental origins) and is administered centrally by the Eurocontrol Central Flow Management Unit (CFMU). In this report, the process of holding aircraft

at their departure airport is called **ATFM regulation** or **restriction**. The ATFM regulation imposes an **ATFM delay** on the affected aircraft by imposing a calculated take-off time (CTOT) on the flight to ensure its passage to its destination is not impeded by capacity constraints along the way. The ATFM delay is the difference between the CTOT and the take off time estimated in the aircraft's flight plan.

4.7 As Gatwick's runway operates for both arrivals and departures, it cannot apply TEAM but its traffic can be moderated by ATFM regulation.

4.8 It is important to draw a distinction between mixed mode operations and TEAM because:

- TEAM allows a small proportion of arrivals to use the departure runway for a limited amount of time. It is likely that mixed mode would be a continuous operation over a more extended period although it could also be applied for limited periods
- approaches on the two runways during periods when TEAM is applied interact with each other and are dependent whereas full mixed mode would use support systems and associated procedures and practices required to enable independent parallel approach operations
- TEAM does not allow for departures to use the arrivals runway whereas mixed mode would utilise both runways for both arrivals and departures
- if there is high demand for departures, TEAM will have a negative effect on departure queues as it allocates a proportion of the departure capacity to arrivals whereas mixed mode allows sharing of the capacity of both runways for both arrivals and departures.

4.9 The departure flow is moderated by managing the queue to optimise the throughput of the departure runway. Departures are sequenced by managing the time that the aircraft is pushed back and by managing its passage from its stand to the runway after it has pushed back to provide the optimum sequence of aircraft at the departure runway. In this report, this process is termed **ground holding** and the period that the aircraft spends in this process is called the **ground holding time**.

4.10 The ground holding process is further complicated because it needs to take account of:

- potential capacity constraints down the outbound aircraft's flight path which might be manifested as ATFM regulations that cause the aircraft to be held at Heathrow or Gatwick

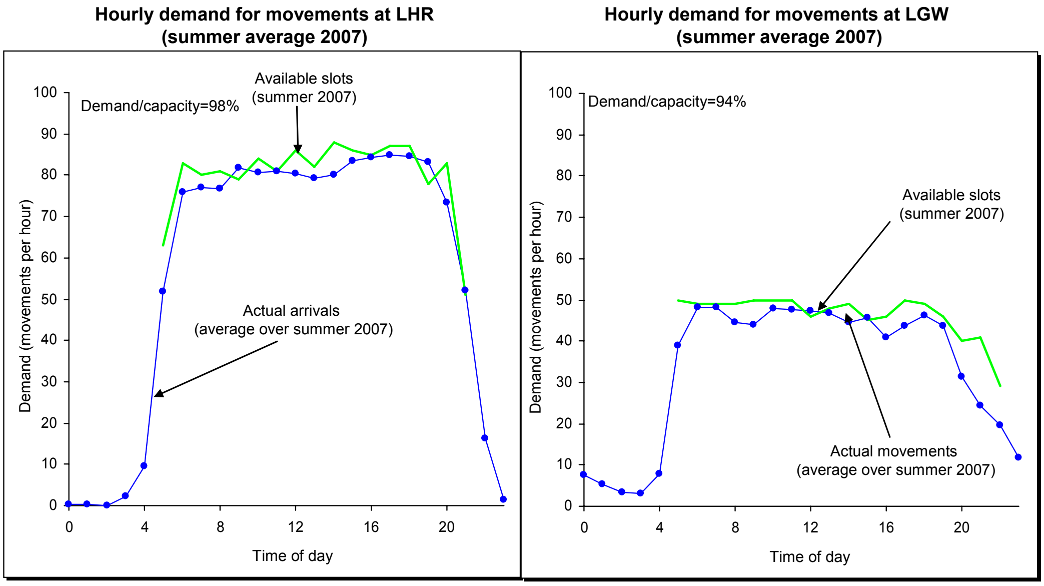
- short-term sequencing of aircraft departing the London terminal area through standard instrument departure (SID) routes shared between Heathrow, Gatwick, Stansted, Luton and London City airports. This sequencing, that takes into account all traffic departing London, not just Heathrow and Gatwick, is managed through the application of minimum departure intervals (MDIs) whereby short holding delays are imposed on the affected aircraft by local air traffic control.

Average traffic levels

4.11 The capacity of both Heathrow and Gatwick airports is determined through the scheduling process (see Part 4 of this report for a full description). The scheduling process results in a scheduling limit (the maximum number of movements per hour and effectively the planned capacity of the runways) on a hourly basis for departures, arrivals and total movements based on estimates of the capacity of various elements of the airport, including the runways, terminal buildings, stands and so on, balanced against acceptable stack and ground holding times. This scheduling process is performed for summer and winter seasons separately and, hence, it is expected that there will be a different relationship between demand, delay and capacity for summer and winter. The summer season runs from the end of March to the end of October (approximately 7 months), corresponding to British Summer Time (BST) whereas the winter season runs from the end of October to the end of March (approximately 5 months) corresponding to Greenwich Mean Time (GMT). For this reason and the fact that the weather usually varies from summer to winter, the two seasons have been analysed separately.

4.12 Heathrow is one of the world’s busiest international airports and, along with Amsterdam, Frankfurt and Paris Charles de Gaulle, is one of Europe’s four main hubs, serving intercontinental, European and domestic destinations. Gatwick is cited as the busiest single runway airport in the world. To set the context of current operations and the analysis of possible future scenarios, it is important to understand the level of demand for air traffic movements at Heathrow and Gatwick relative to the capacity of the airports. Exhibit 4-1 and Exhibit 4-2 show the actual runway capacity utilisation at Heathrow and Gatwick in the last two complete summer and winter seasons.

Exhibit 4-1: Comparison of actual utilisation and available slots at Heathrow and Gatwick in the summer season 2007

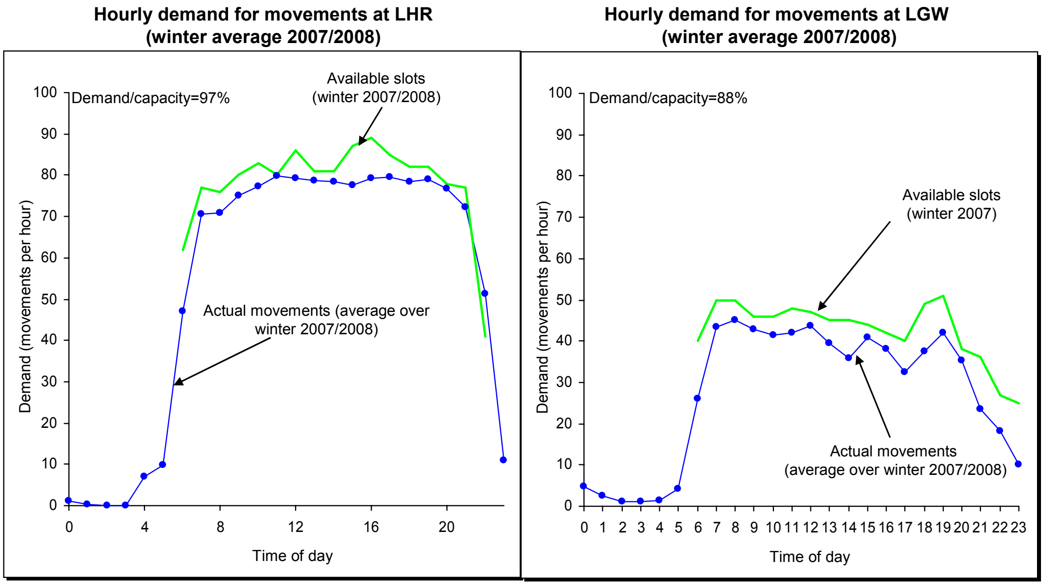


Source: ACL, CFMU

The exhibits show that:

- on average, in both summer and winter, Heathrow operates at around 97 to 98% of the available runway capacity, as defined by the number of slots made available through the scheduling process. There are peaks in specific weeks when utilisation reaches around 98.5%. There is an underlying rate of around 2% operational cancellations during both summer and winter indicating that the demand for the runway is 100% of its capacity
- similarly, on average Gatwick operates at around 94% of its available runway capacity in summer and around 88% of available capacity in winter. In August, Gatwick's demand for arrivals and departures together is 100% of the combined capacity although when taken individually the demand for arrivals and departures is around 94%. This situation occurs because the total capacity of the airport is lower than the sum of the capacity for arrivals and departures. Gatwick has a cancellation rate of between 1 and 2% indicating average demand levels compared to capacity of around 95% in summer and 89% in winter.

Exhibit 4-2: Comparison of the actual utilisation and available slots at Heathrow and Gatwick in the winter season 2007/2008


Hourly demand for movements at LHR (winter average 2007/2008)

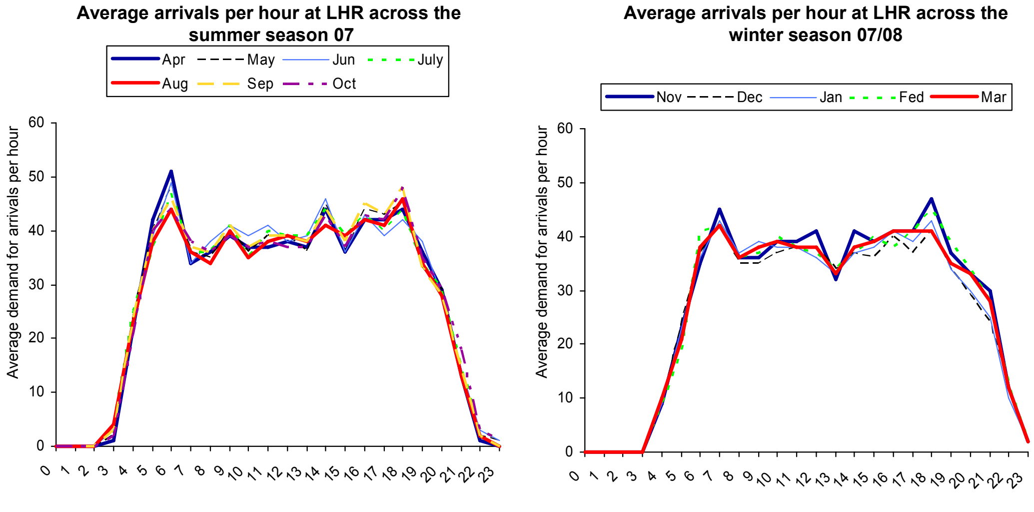
Hourly demand for movements at LGW (winter average 2007/2008)

Source: ACL, CFMU

Seasonal and monthly variation

4.13 Exhibit 4-3 compares the average daily arrivals at Heathrow each day of the week across the summer 2007 and winter 2007/2008 seasons. The figure confirms that traffic is slightly higher during the summer season but only shows slight variation from month to month within each season.

Exhibit 4-3: Comparison of the monthly variation in arrivals demand at Heathrow in the summer and winter seasons 2007 and 2007/2008

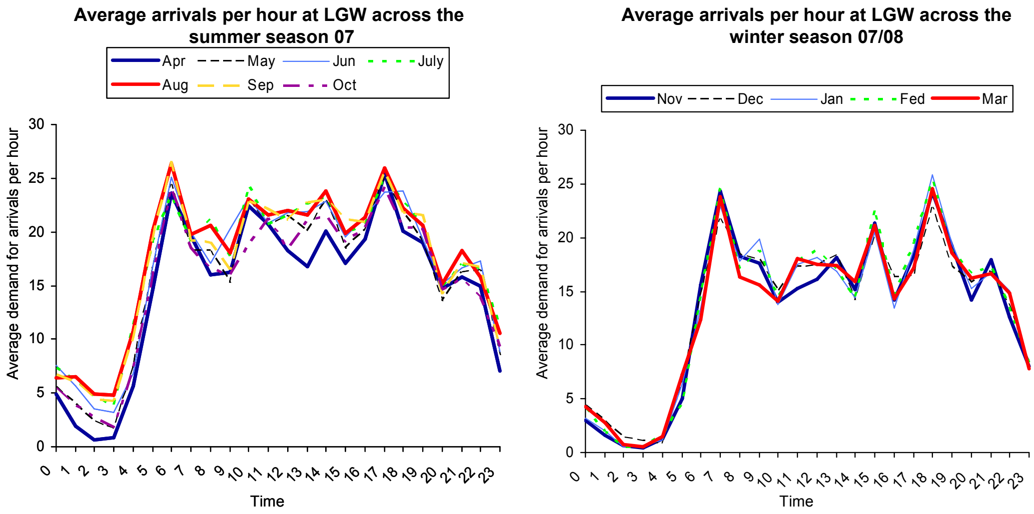

Average arrivals per hour at LHR across the summer season 07

Average arrivals per hour at LHR across the winter season 07/08

Source: CFMU

4.14 In contrast, and in addition to showing very different levels of demand in summer and winter, Gatwick shows in-season variation across the summer with July, August and September being considerably busier than April, May and October, as illustrated in the Exhibit 4-4and Exhibit 4-5 below.

Exhibit 4-4: Comparison of the monthly variation in arrivals demand at Gatwick in the summer and winter seasons 2007 and 2007/2008



Source: CFMU

Exhibit 4-5: Capacity utilisation for arrivals and departures at Gatwick during the summer months

Month						
April	May	June	July	August	September	October
85%	91%	96%	99%	100%	99%	91%

4.15 In summary, Heathrow operates at extremely high levels of runway utilisation throughout the year and across the day with a very limited buffer to ensure reliability/sustainability in operations or to recover from disruption. On the other hand, except in the peak summer months, Gatwick has spare buffer capacity.

The remainder of this section reports on the operational performance of the runways of both Heathrow and Gatwick over the last two full seasons in terms of:

- holding in the stacks to enable optimal sequencing or arrivals
- air traffic flow management (ATFM) restrictions and associated delays due to the airports causing the most penalising regulation for their arrivals
- tactical, non-ATFM holding on the ground to enable optimal sequencing of departures.

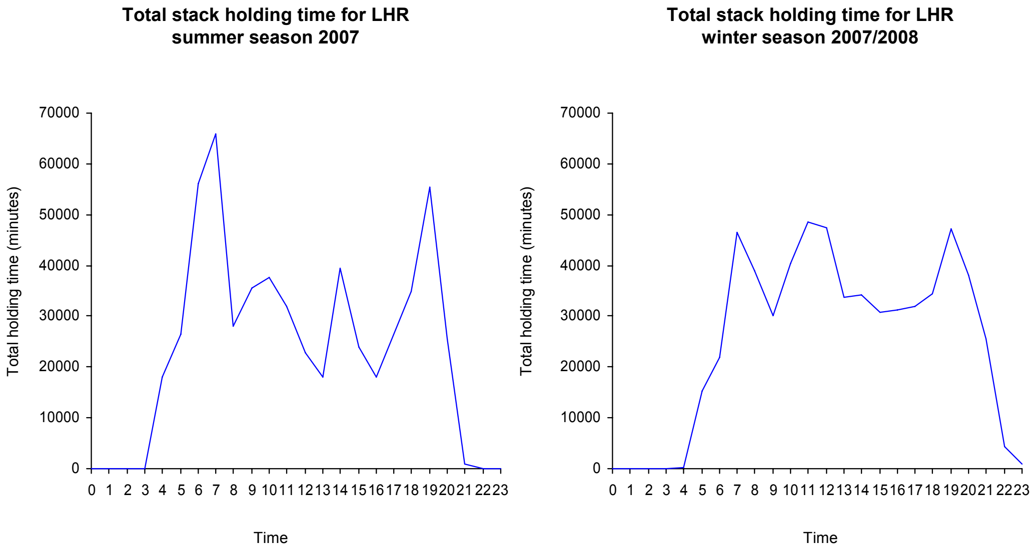
HOLDING IN THE STACKS FOR ARRIVALS

Magnitude of stack holding at Heathrow

Total holding time

4.16 Exhibit 4-6 shows the total stack holding time distributed by time of day for Heathrow for the last two complete seasons. The total stack holding time over the summer season 2007 (seven months) was approximately 565000 minutes whereas the total holding time over the winter season (five months) was approximately 602000 minutes.

Exhibit 4-6: Total stack holding time at Heathrow in the summer and winter seasons 2007 and 2007/2008



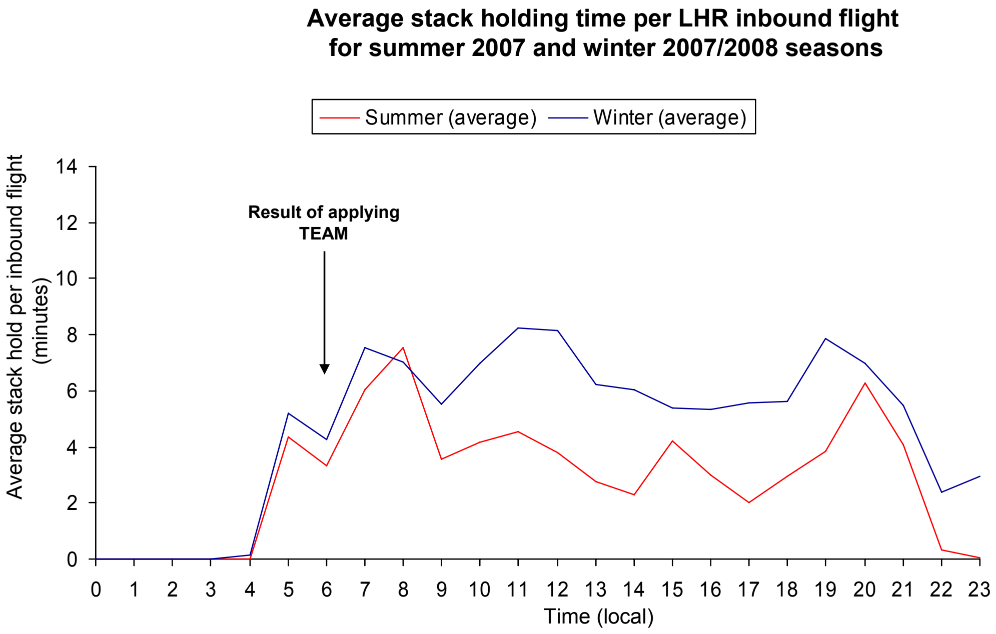
Source: Airline data, Helios analysis

Average holding times

Exhibit 4-7 shows the average stack holding time per inbound flight (that is all flights, not just those that are held in the stacks) at Heathrow for the summer and winter seasons. The average hold in winter is generally greater than that in summer except in the early morning peak where both holds are similar. In both cases, the average holding times across the day are well below the 10 minute average limit agreed between NATS, the airport and the airlines (noting that this limit does not include a contribution from ATFM holding).

There is a reduction in the average holding time during the hour starting 06:00 local time. This drop in holding time corresponds to the time in which tactically enhanced arrivals measures (TEAM) are applied virtually every day in both seasons. TEAM is applied at other times during the day but not consistently or at the same level as in the 06:00 hour.

Exhibit 4-7: Average stack holding time per inbound flight at Heathrow in the summer and winter seasons 2007 and 2007/2008



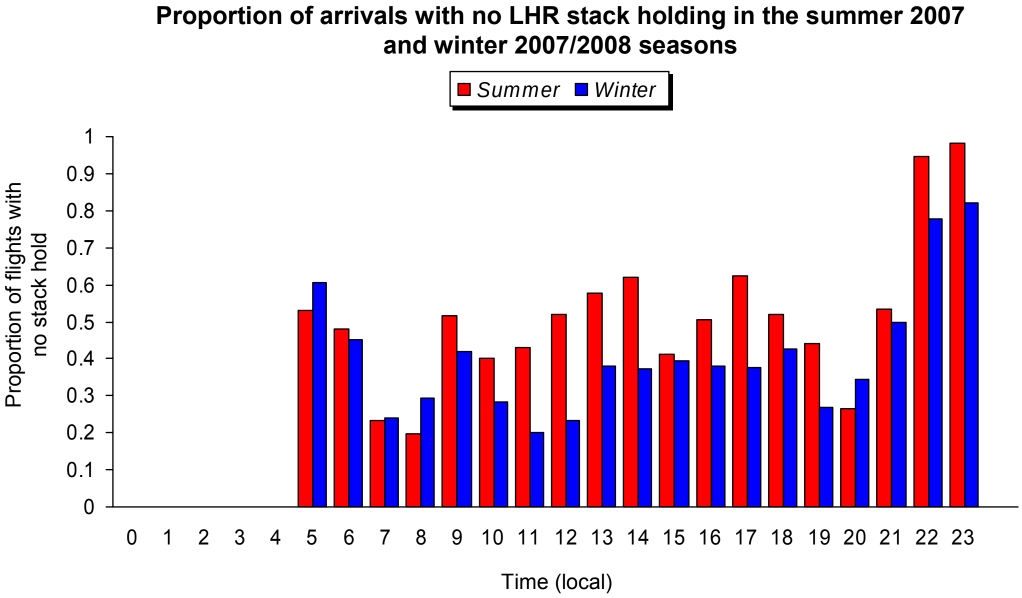
Source: Airline data, Helios analysis

Range of holding times

4.17 Stack holding at Heathrow is described by a set of statistical distributions, which is presented in full in Appendix D. The average holding times, described above, form one part of the description of those distributions. The following paragraphs highlight two other important elements of the distribution: the probability that a flight will be held and the peak holding times described by the 95th percentile of the distribution.

4.18 Exhibit 4-8 shows the proportion of aircraft arriving at Heathrow that were not subject to holding in the stacks during the summer 2007 and winter 2007/2008 seasons. A significant proportion of arrivals are held in stacks with around 80% being held in the early morning in both summer and winter and also during the middle of the day in winter. Only in the late evening does the proportion of aircraft being stacked fall significantly below 50%.

Exhibit 4-8: Proportion of inbound aircraft not subject to stacking at Heathrow in the summer and winter seasons 2007 and 2007/2008

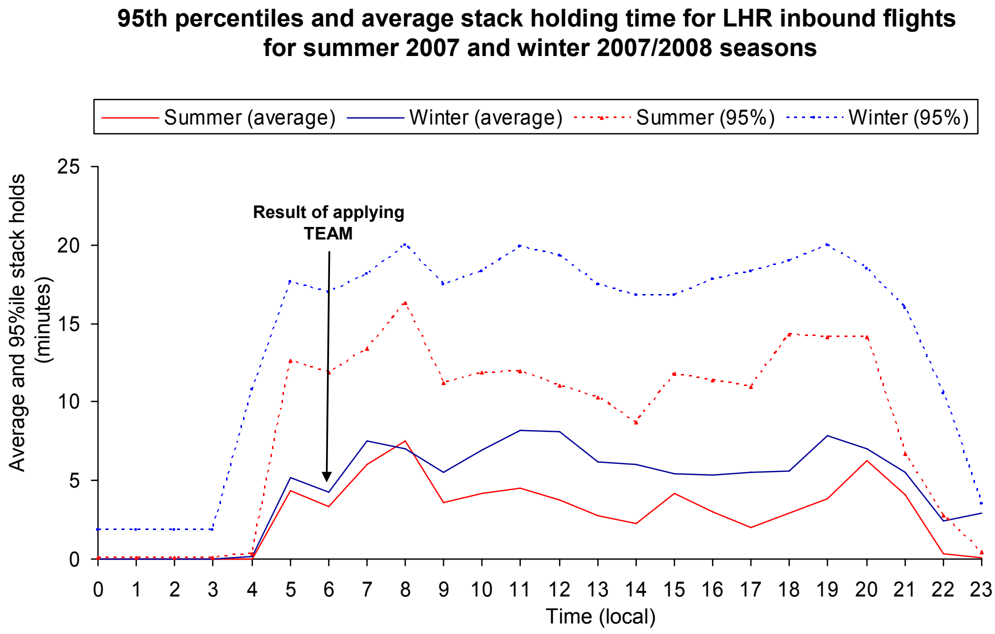


Source: NATS, Helios analysis

4.19 Exhibit 4-9 illustrates the peak holding times that might be expected in the Heathrow stacks using the 95th percentile of the holding distributions as an indicator of the peak. The shape of the 95th percentile curve generally follows that of the average holding time per flight but at a factor of between 2 and 3 greater being around 10 to 15 minutes in summer and 15 to 20 minutes in winter.

4.20 The impact of the application of TEAM at 06:00 local time can clearly be seen in the 95th percentile curves as well as the average holding times.

Exhibit 4-9: Average and peak stack holding times for arrivals at Heathrow over the last two seasons

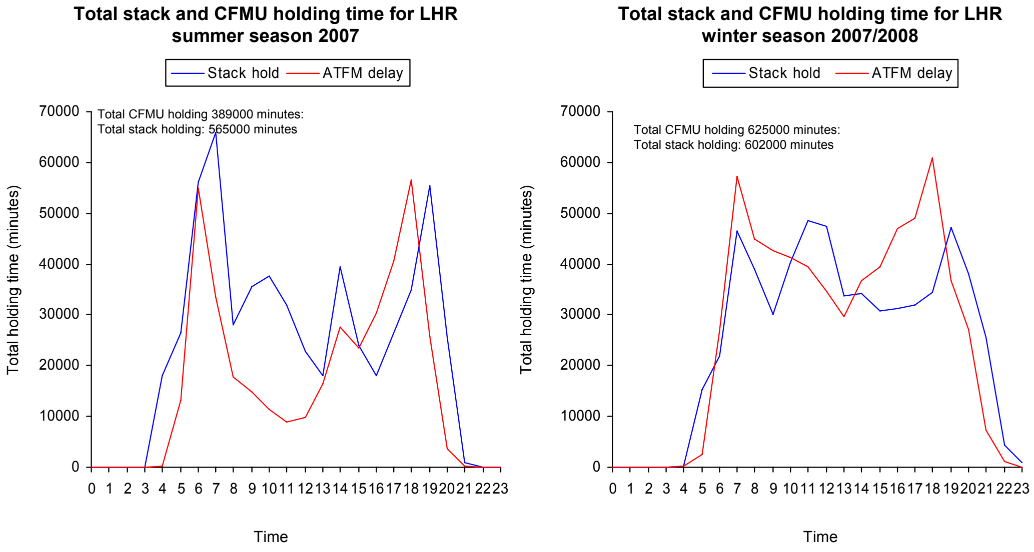


Source: NATS, Airline data, Helios analysis

Comparison of stack holding times and ATFM delays

4.21 Exhibit 4-10 compares the total stack holding times and the total airport ATFM delays (see the next section for a description of ATFM delays) at Heathrow both in terms of magnitude and distribution throughout the day.

Exhibit 4-10: Comparison of total airport ATFM delays and total stack holding times for arrivals at Heathrow over the last two seasons



Source: CFMU, NATS, Airline data, Helios analysis

The magnitude of ATFM delays and stack holding times are similar in both summer and winter seasons:

- in summer the total Heathrow generated airport ATFM delay is approximately 389000 minutes whereas the total stack holding time is approximately 565000 minutes
- in winter the total Heathrow generated airport ATFM delay is approximately 625000 minutes whereas the stack holding time is approximately 602000 minutes.

4.22 The main morning peaks in the curves are also of the same magnitude and occur at roughly the same time of day for both ATFM and stacks and correspond to periods where there is highest demand for arrivals, around 40 to 42 arrivals per hour and a high proportion of this demand is from outside Europe and cannot be moderated by ATFM (see 4.27 for an explanation). Between the peaks, when the demand for arrivals is around 38 to 40 per hour, there is an indication that the ATFM delays and stack holding are in anti-phase: that is as ATFM delays increase, stack holding decreases and vice versa. This is apparent between 08:00 and 13:00 in the summer and, to a lesser degree, between 15:00 and 18:00 in the winter and indicates that ATFM is being used to moderate stack holding.

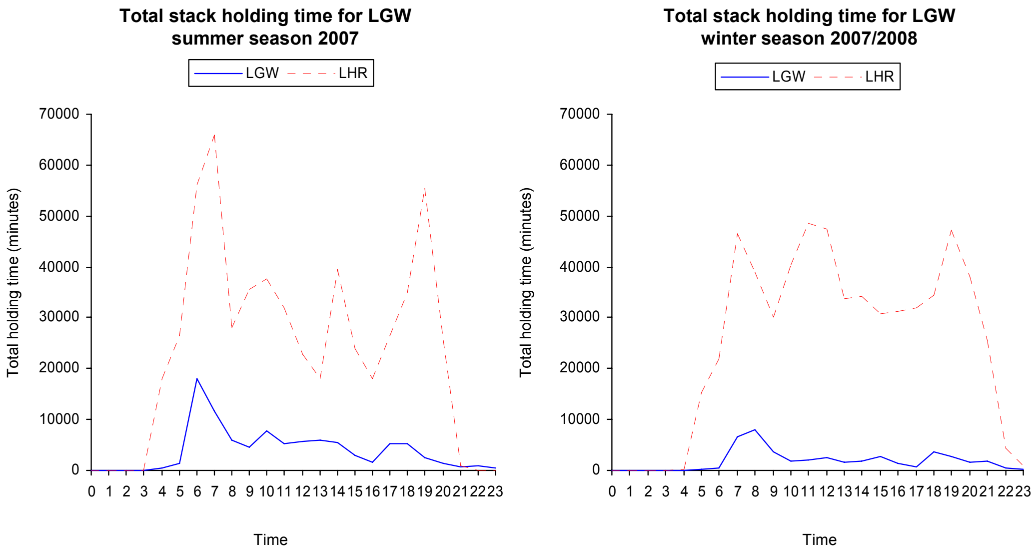
4.23 The wide variation in holding time and airport ATFM delays for relatively small fluctuations in demand, of around 3 per hour, emphasises the how near its absolute capacity the system is operating and illustrates its sensitivity to small increases in demand.

Magnitude of stack holding at Gatwick

Total holding time

4.24 The total holding in stacks at Gatwick was approximately 93000 minutes in the 2007 summer season (approximately 16% of that at Heathrow) and 44000 minutes in the 2007/2008 winter season (approximately 7% of that at Heathrow. The distribution of Gatwick's stack holding across the day is shown in Exhibit 4-11 where a comparison is also made with Heathrow for reference.

Exhibit 4-11: Total stack holding time at Gatwick in the summer and winter seasons 2007 and 2007/2008 with equivalent curves for Heathrow shown for comparison

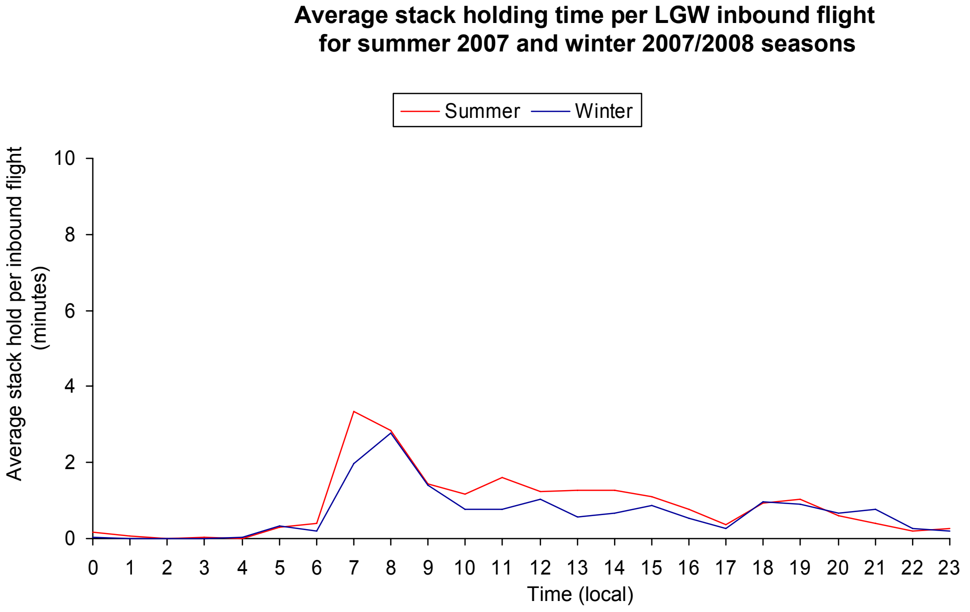


Source: Airline data, Helios analysis

Average holding times

4.25 Exhibit 4-12 shows the average stack holding times for Gatwick for the last two complete seasons using the same scale as the equivalent chart for Heathrow. There is little structure to the average hold throughout the day except in the early morning where there is a peak of 2 to 3 minutes in both seasons. This compares with the equivalent peak of 6 to 8 minutes experienced at Heathrow.

Exhibit 4-12: Average stack holding time per inbound flight at Gatwick in the summer and winter seasons 2007 and 2007/2008

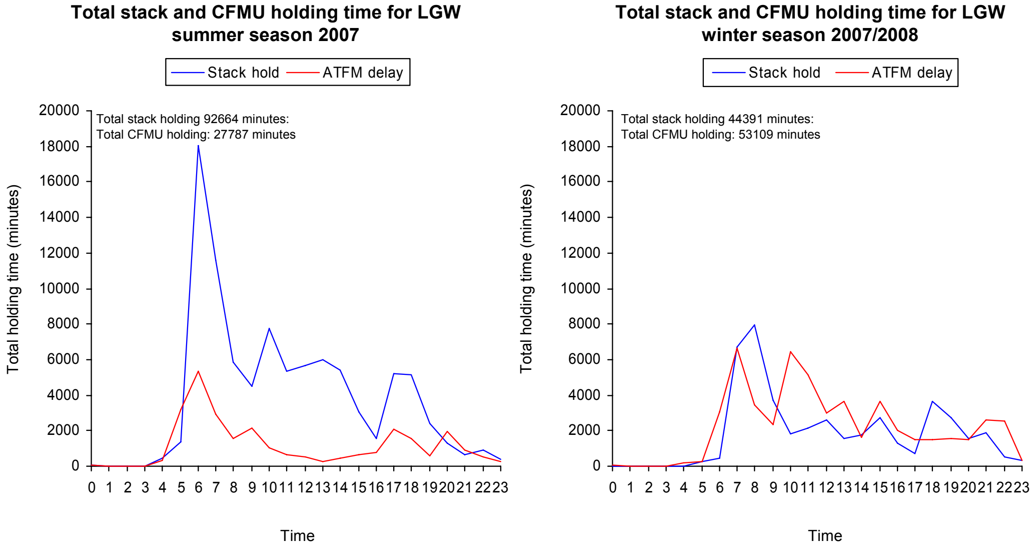


Source: Airline data, Helios analysis

Comparison of stack holding times and ATFM delays

4.26 Exhibit 4-13 compares stack holding and airport ATFM delays at Gatwick. In summer 2007, stack holding was around a factor of 3 greater than Gatwick generated airport ATFM delays (93000 minutes compared to 27000 minutes respectively) whereas the two sets of delays were roughly similar in winter (44000 minutes compared to 53000 minutes). There is little to suggest any correlation between the two sets of delays.

Exhibit 4-13: Comparison of total ATFM delays and total stack holding times for arrivals at Heathrow over the last two seasons



Source: CFMU, Airline data, Helios analysis

AIR TRAFFIC FLOW MANAGEMENT RESTRICTIONS FOR ARRIVALS

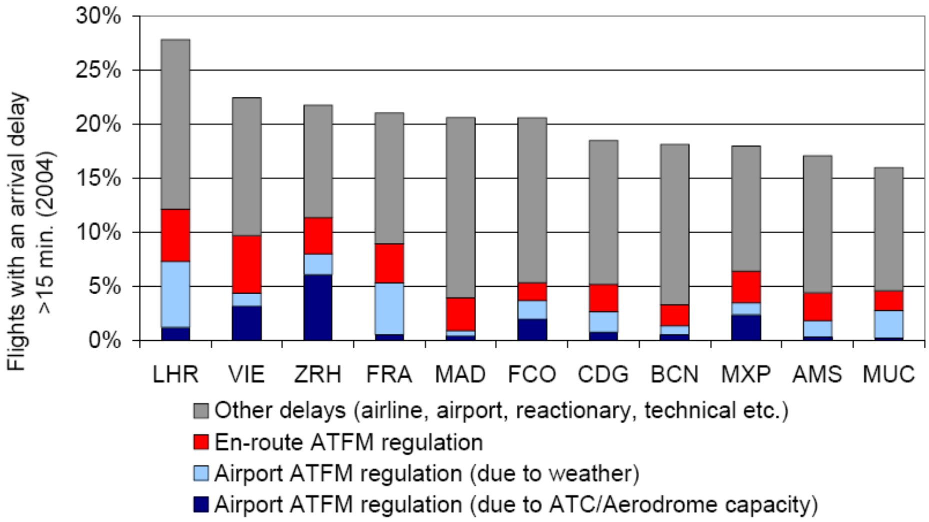
Introduction

4.27 Airport ATFM restrictions are imposed when the capacity of the destination airport is exceeded by the predicted demand in the same way that they are applied to the other parts of the ATM network. Arrivals at Heathrow and Gatwick from origins within Europe and some other places are subject to these ATFM restrictions imposed as regulations by the Eurocontrol Central Flow Management Unit (CFMU) at the request of the London Flow Management Position (FMP), based at Swanwick. This situation may occur:

- when demand is higher than expected, for example, due to bunching of traffic caused by fluctuations elsewhere in the network
- when capacity is reduced below the norm, with a variety of causes including the weather, problems with air traffic control staffing or equipment and infrastructure.

4.28 Airport ATFM restrictions cause a significant fraction (typically 25% to 35%) of the total delays experienced in the system, as illustrated in Exhibit 4-14 taken from the Eurocontrol Performance Review Commission.

Exhibit 4-14: Causes of delays at some major European airports



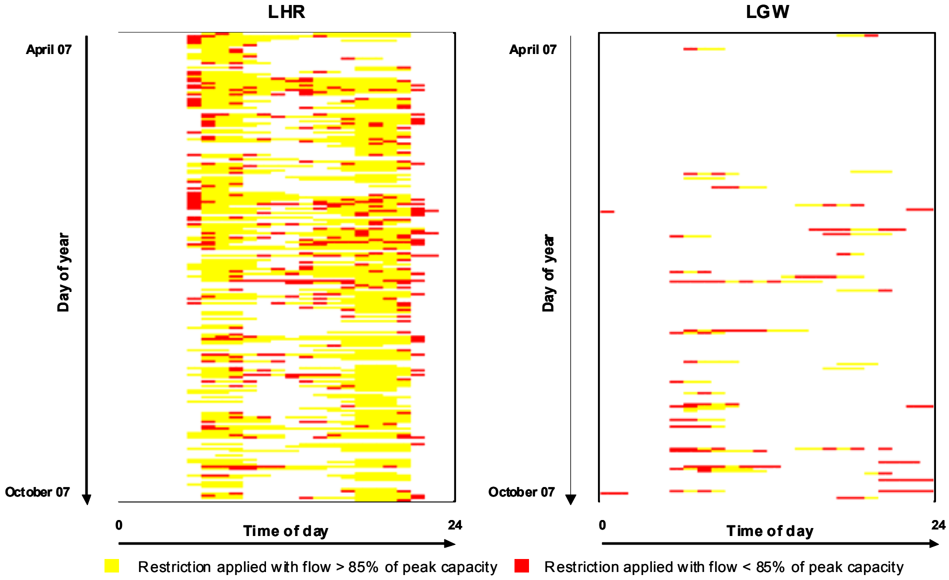
Source: Eurocontrol Performance Review Commission "Report on punctuality drivers at major European airports", May 2005

Frequency and severity of ATFM restrictions

4.29 Exhibit 4-15 and Exhibit 4-16 show the frequency and severity with which ATFM restrictions were applied at Heathrow and Gatwick over the past two complete seasons. The charts are shaded on a hourly basis indicating when:

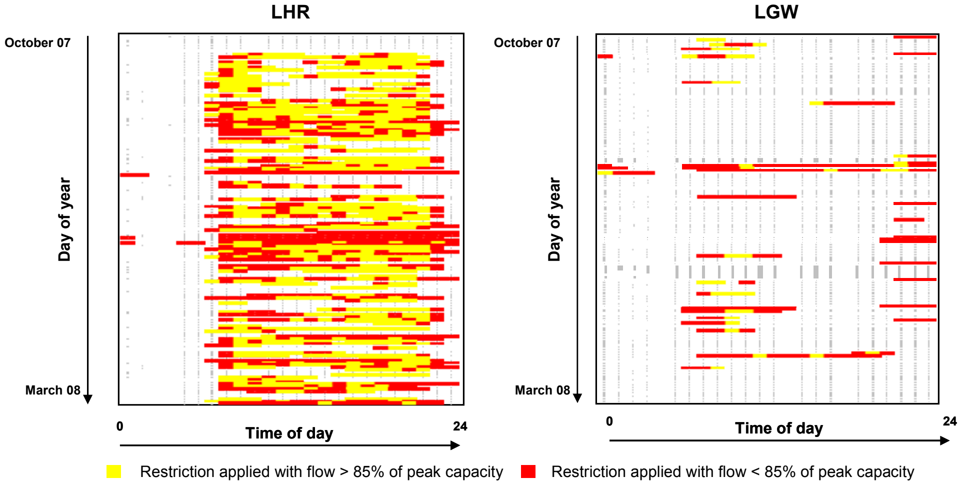
- no restriction was applied (unshaded)
- when a relatively mild restriction was applied (highlighted in yellow) where mild is understood to mean that the restriction allows traffic flows of above 85% of the normal hourly capacity. This corresponds to a flow rate of around 38 arrivals per hour at Heathrow which is understood to be the cut-off point that normal operations become unsustainable
- where the severe restriction was applied (highlighted in red) where the traffic flows were restricted to less than 85% of the normal capacity.

Exhibit 4-15: Comparison of the application of ATFM restrictions at Heathrow and Gatwick during the 2007 summer season



Source: CFMU, Helios analysis

Exhibit 4-16: Comparison of the application of ATFM restrictions at Heathrow and Gatwick during the 2007/2008 winter season



Source: CFMU, Helios analysis

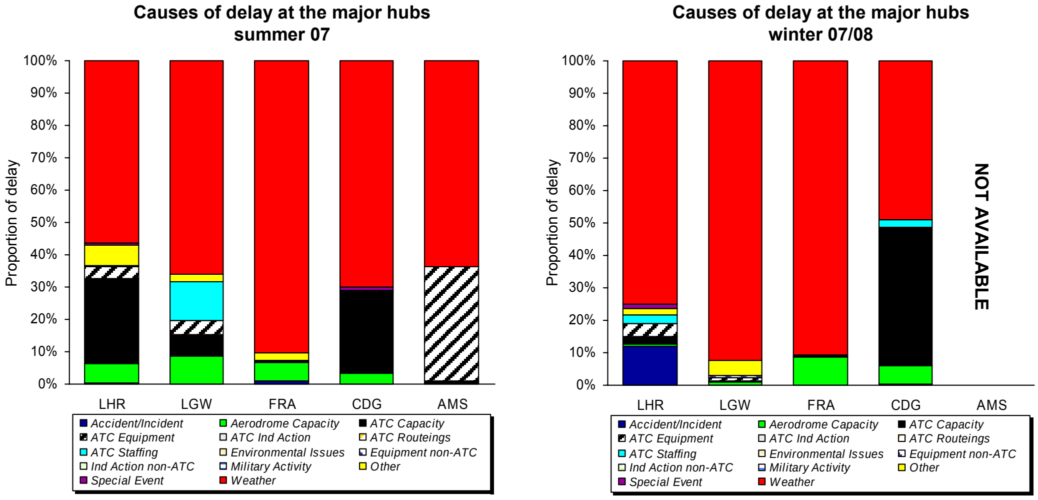
4.30 Exhibit 4-15 and Exhibit 4-16 show that ATFM restrictions were applied on most days at Heathrow during both seasons. Application of ATFM restrictions at Gatwick was much less frequent than at Heathrow, presumably due to the availability of a greater buffer between demand and capacity. The exhibits also show that:

- the majority of the restrictions applied at Heathrow during the summer season were relatively mild whereas the majority of the restrictions applied in the winter were severe
- the ratio of severe to mild restrictions applied at Gatwick is much higher than at Heathrow.

Causes of Airport ATFM restrictions

4.31 When an ATFM restriction is imposed, the air navigation service provider (ANSP) that applies the restriction allocates a code to describe the cause of the restriction. Exhibit 4-17 presents data describing the main causes of and their proportion of the overall ATFM delay for Heathrow, Gatwick and the other main European hubs, with the exception of Amsterdam Schiphol for which data is not available for the 2007/2008 winter season.

Exhibit 4-17: Proportion of ATFM delay attributed by cause for the major European hubs



Source: CFMU, Helios analysis

4.32 Exhibit 4-17 shows that:

- weather is the predominant cause of ATFM related delay at all of the airports which, unsurprisingly, is more severe in winter than in summer
- the airport’s ATC capacity (as allocated to the airport by the ANSP) is the second most significant contributor to ATFM related delay at Heathrow in the summer and at Paris Charles de Gaulle in both summer and winter
- the airport’s ATC staffing (again as allocated by the ANSP) is the second most significant cause of ATFM related delay at Gatwick
- the airport’s ATC equipment (as allocated by the ANSP) and aerodrome capacity make contributions to ATFM related delay in summer but less so in winter (presumably due to the increased influence of weather)
- the performance of Heathrow in winter 2007/2008 is masked by the consequences of the BA 038 accident.

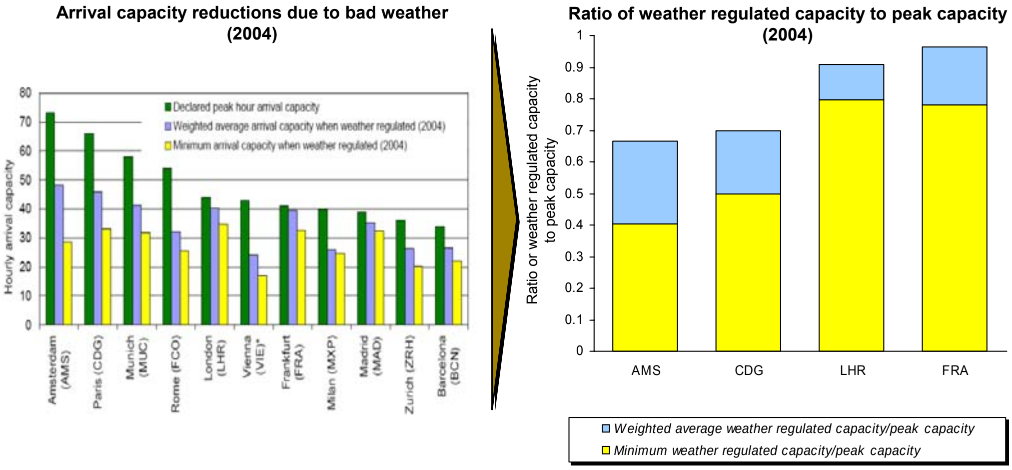
Resilience against weather effects

4.33 Given that the weather is the most significant cause of ATFM related delay, the Eurocontrol Performance Review Commission undertook an analysis of the resilience of major European airports to the impacts of bad weather. In addition to this work, it is possible to define supplementary indicators of resilience to weather as:

- the ratio of the average weather reduced capacity to the peak capacity
- the ratio of the minimum weather reduced capacity to the peak capacity.

4.34 These indicators are shown for the main European hubs in Exhibit 4-18 using 2004 data, which is the latest available.

Exhibit 4-18: Resilience of the main European hubs against weather-related ATFM restrictions



Source: Eurocontrol Performance Review Commission “Report on punctuality drivers at major European airports”, May 2005, Helios analysis

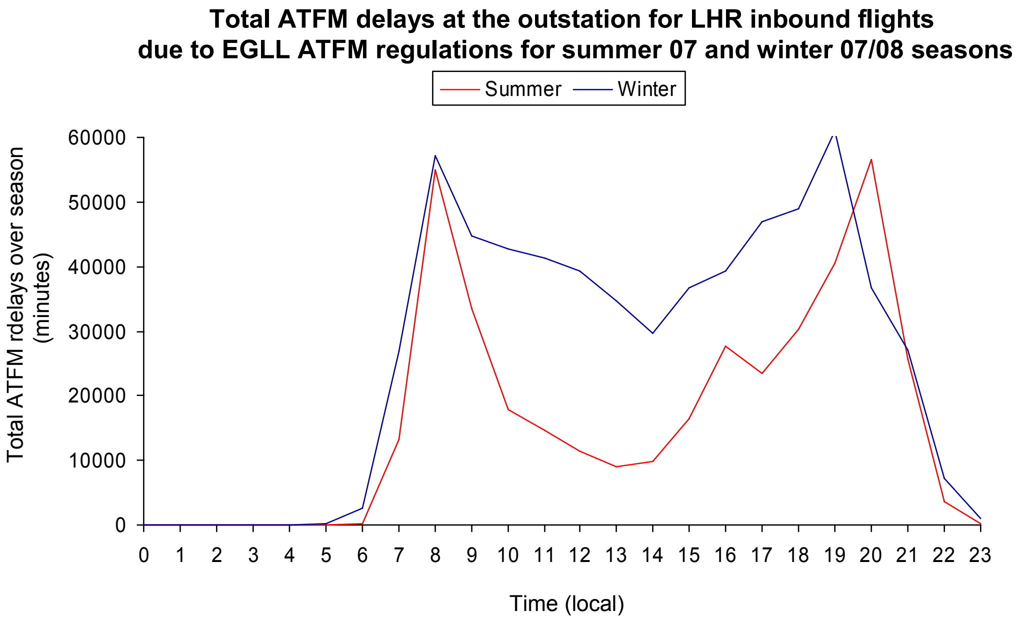
4.35 Exhibit 4-18 shows that in the case of severe weather restrictions, Heathrow shows the highest resilience of the four main European hubs; however on average Frankfurt shows greater weather resilience than Heathrow.

Magnitude of Airport ATFM delays at Heathrow

Total delays

4.36 The airport ATFM delays due to Heathrow causing the most penalising ATFM regulation to inbound flights are significant. During the summer season 2007 (7 months), Heathrow was the cause of 389000 minutes of ATFM delay on the ground at the outstation airport. In the 2007/2008 winter season (5 months), Heathrow caused approximately 625000 minutes of ATFM delay. The distribution of these delays across the airport’s operating day is shown in Exhibit 4-19.

Exhibit 4-19: Total ATFM delays due to Heathrow regulations over the last two complete seasons

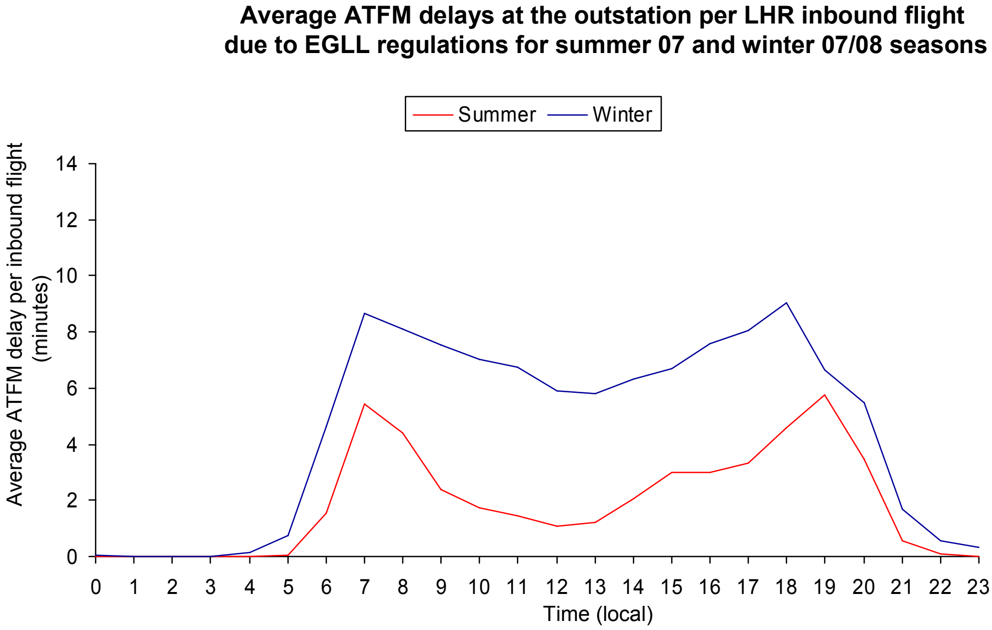


Source: CFMU, Helios analysis

Average ATFM delays

4.37 As the seasons are different lengths and airports have different levels of traffic, the average ATFM delay per flight is an important indicator that can be used to compare and contrast performance. However, when interpreting the results of such comparisons it is important to remember that only flights that originate within the CFMU area (essentially Europe) are subject to ATFM regulations so that ATFM delays are not distributed equitably across all arrivals (see discussion below). The average Heathrow ATFM delay per flight for the summer and winter seasons is illustrated in Exhibit 4-20. The time refers to the hour that the aircraft would have arrived at Heathrow in an unconstrained situation, that is before any ATFM restriction had been applied.

Exhibit 4-20: Average ATFM delay per inbound flight due to Heathrow ATFM regulations over the last two complete seasons



Average ATFM delays at the outstation per LHR inbound flight due to EGLL regulations for summer 07 and winter 07/08 seasons

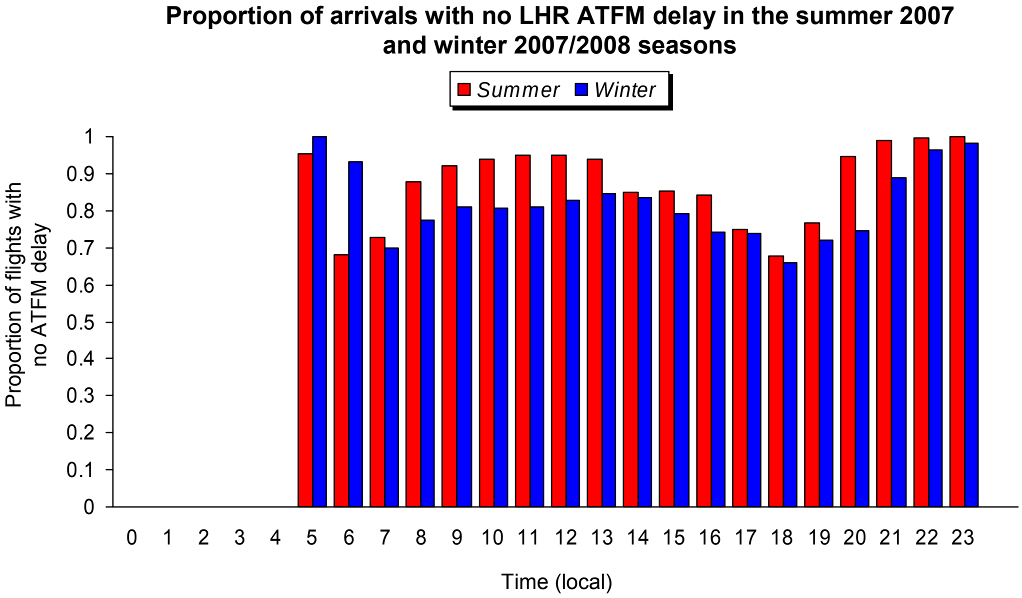
Source: CFMU, Helios analysis

4.38 Exhibit 4-20 shows that at the peaks (corresponding approximately to the peaks in demand – see Exhibit 4-1 and Exhibit 4-2), the average ATFM delay per flight is around 5½ minutes in summer and around 9 minutes in the winter season. In summer, the average ATFM restriction is reduced to a minimum of around 2 minutes per flight in summer but the reduction is less, remaining above 6 minutes (greater than the summer peak) throughout the day.

Range of ATFM delays

4.39 The previous section highlights the average ATFM delay per flight derived from the statistical distributions of ATFM delays. The full set of statistical distribution functions is provided in Appendix D. Flights to the airport experience a range of ATFM delays ranging from zero through to a maximum. Exhibit 4-21 shows the proportion of inbound flights to Heathrow that do not suffer any Heathrow generated airport ATFM delay (note that this includes inter-continental flights that by default are not within the CFMU system and cannot be subject to ATFM regulations).

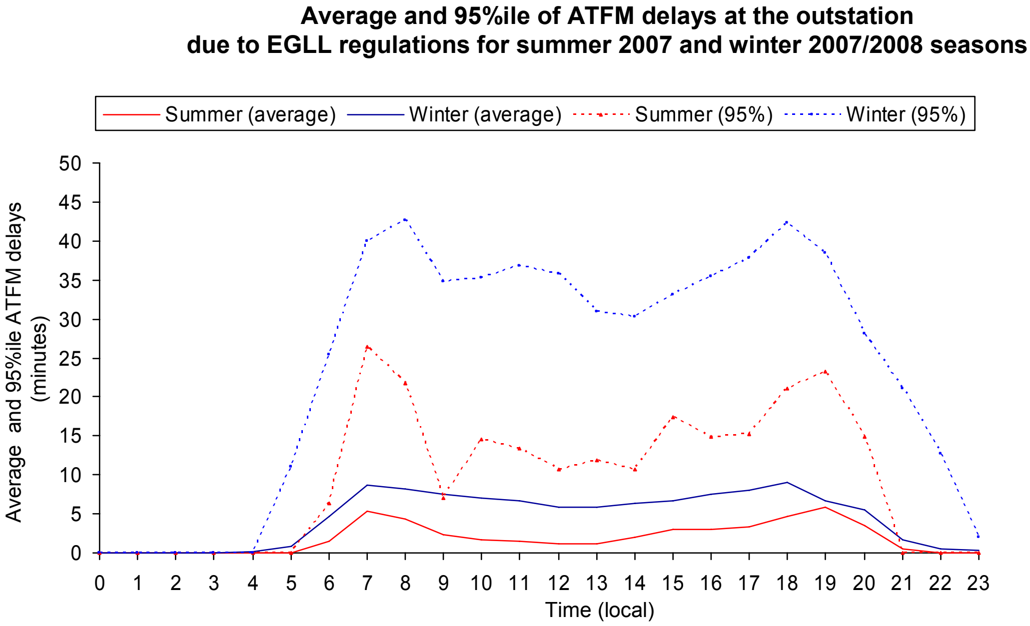
Exhibit 4-21: Proportion of flights arriving at Heathrow that have not been subject to a Heathrow related ATFM regulation



Source: CFMU, Helios analysis

4.40 At the other end of the scale, the 95th percentile of the ATFM delay (considering all flights, delayed or not) is a measure of the peak ATFM delay that might reasonably be expected. The 95th percentiles of Heathrow's ATFM delays for summer and winter are shown in Exhibit 4-22.

Exhibit 4-22: Peak and average airport ATFM delays due to Heathrow ATFM regulations over the last two complete seasons



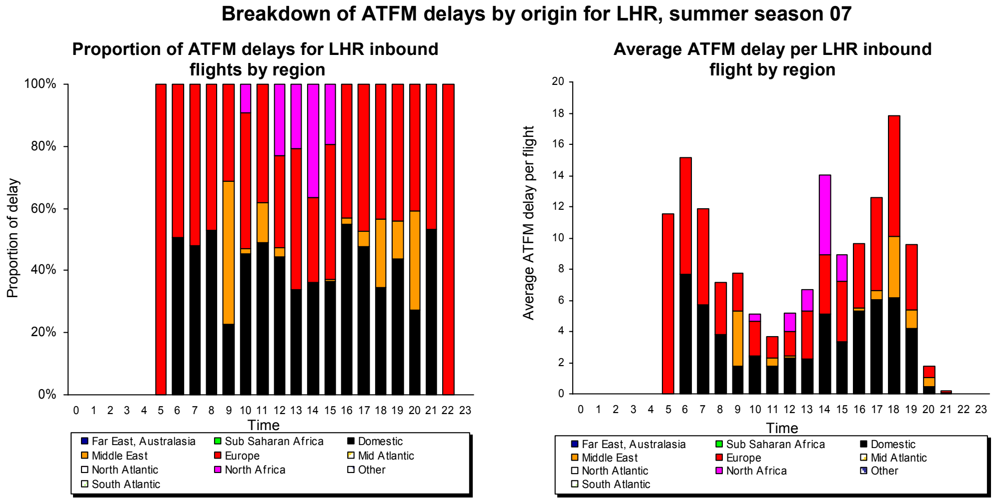
Source: CFMU, Helios analysis

4.41 Exhibit 4-22 shows that in summer Heathrow's peak airport ATFM delays were in the range 20 to 25 minutes whereas in the off-peak period, the peak airport ATFM delays were reduced to around 15 minutes. In the winter season, Heathrow’s peak airport ATFM delays were between 40 and 45 minutes and the peak off-peak airport ATFM delays were around 35 minutes.

Distribution of Heathrow’s ATFM delays by origin

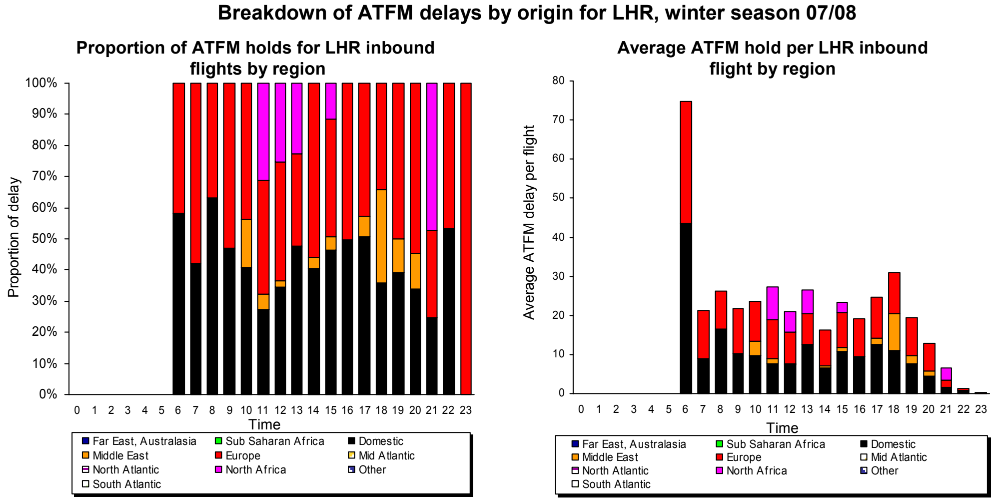
4.42 As introduced above, ATFM restrictions are only applied to aircraft that originate from within the CFMU area which comprises Europe and a few other origins including the Middle East and some parts of Africa. Exhibit 4-23 and Exhibit 4-24 show how Heathrow’s arrivals ATFM delays are distributed around the regions from which its inbound flight originate.

Exhibit 4-23: Breakdown of Heathrow’s ATFM delays by origin of the inbound flight for the summer season 2007



Source: CFMU, Helios analysis

Exhibit 4-24: Breakdown of Heathrow’s ATFM delays by origin of the inbound flight for the winter season 2007/2008



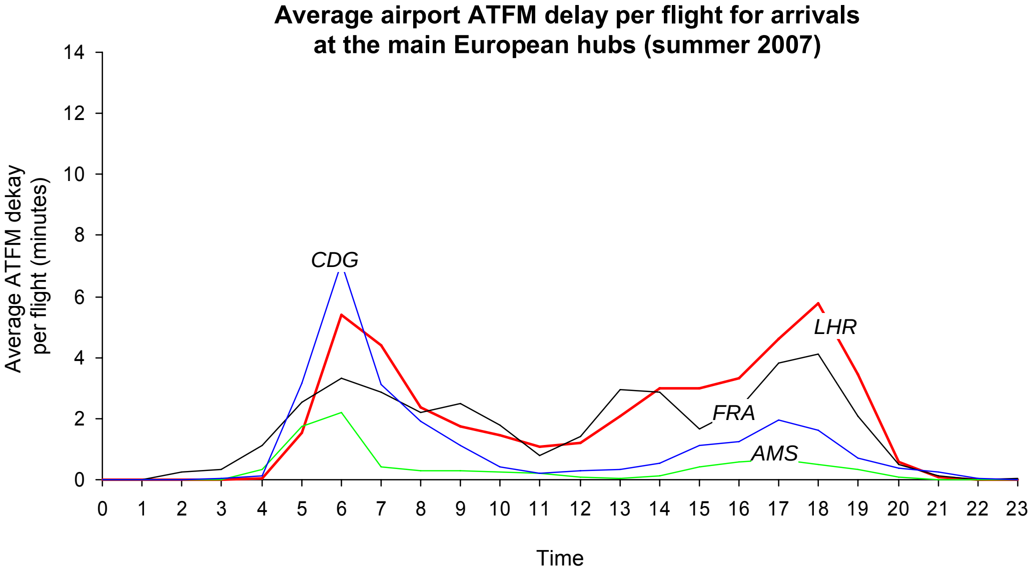
Source: CFMU, Helios analysis

4.43 The charts show, as expected, that flights from European and domestic origins suffer the bulk of the ATFM delays but with some ATFM restrictions imposed on flights from the Middle East and North Africa from the middle of the day onwards. The overall proportion of the airport ATFM delays incurred by flights from Europe is greater than that incurred by flights from domestic origins but this is due to the greater number of inbound flights from continental Europe than from the UK. The average airport ATFM delay per flight from domestic and European origins is broadly similar. Finally, the large peak in airport ATFM delays for flights scheduled to arrive in the 06:00 to 07:00 hour in the winter season is presumably due to large demand at the airport at that time from intercontinental flights.

Performance compared to other hubs

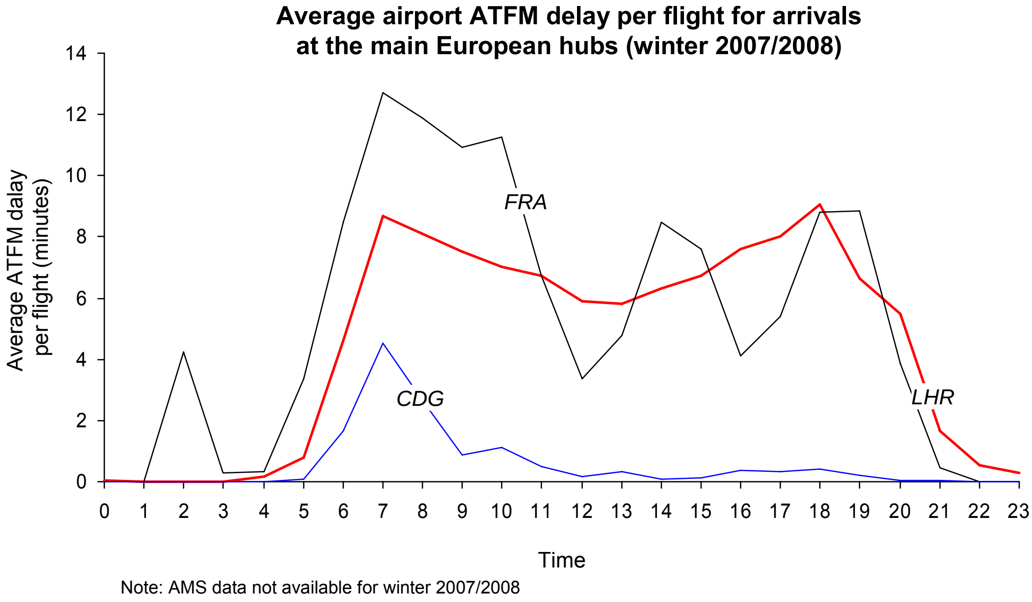
4.44 In comparison with the other main European hubs, Heathrow's ATFM performance is similar to that at Frankfurt, slightly worse than that at Paris Charles de Gaulle (except in the early morning peak in summer) and considerably worse that that at Amsterdam. Exhibit 4-25 and Exhibit 4-26 illustrate this performance in terms of the average ATFM delay per inbound flight attributed to the arrival airport. Note that data for Amsterdam in the winter season were not available for the analysis.

Exhibit 4-25: Comparison of Heathrow's ATFM performance with the other main European hubs for the summer season 2007



Source: CFMU, Helios analysis

Exhibit 4-26: Comparison of Heathrow's ATFM performance with the other main European hubs for the winter season 2007/2008



Source: CFMU, Helios analysis

4.45 The ATFM performance of the hub airports will be driven by, amongst other things, the availability of runway infrastructure. In this respect, Heathrow is rather poorly served in comparison to its competitors:

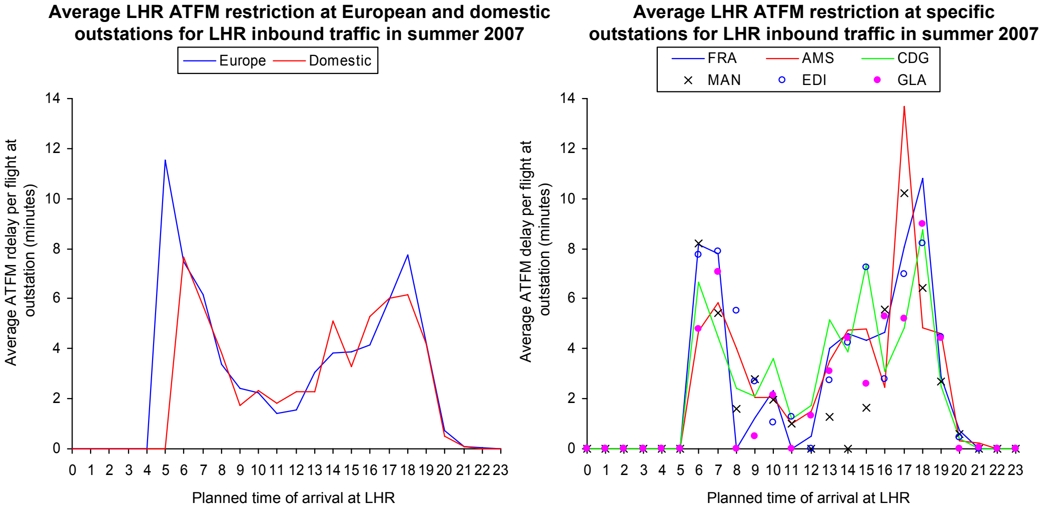
- Paris Charles de Gaulle (CDG) has four parallel runways that can be operated as two pairs of independent runways giving, in practice, around 1.5 times the capacity available at Heathrow
- Amsterdam Schiphol has multiple runways, five of which can be used for commercial air transport operations. However, because of noise and other restrictions, Schiphol is only allowed to operate three runways simultaneously: two for arrivals and one for departures in arrivals peaks and vice versa in departure peaks. With its traffic mix and operational restrictions, the capacity of the airport is approximately 70:35 with the higher figure alternating for arrivals or departures depending on the peak. Schiphol's peak capacity for arrivals is therefore around 75% higher than Heathrow's
- Frankfurt has three runways but only operates two simultaneously in semi-independent mixed mode configuration with a normal capacity similar to that at Heathrow.

4.46 The availability of buffer capacity, i.e. spare slots available to cope with disruptions, (available at Amsterdam and Paris CDG but not at Heathrow and Frankfurt) is likely to be one of the main drivers of the differences in ATFM performance between the hubs.

Heathrow's knock-on effects through the network

4.47 ATFM delays are executed as ground holding, usually on stand, at the origin airport. Airport ATFM restrictions due to the destination airport, therefore, can cause congestion at the origin airport. Exhibit 4-27 shows average Heathrow initiated ATFM delays per Heathrow arrival for all domestic and European origins as well as a few of Heathrow's main domestic and European origin airports.

Exhibit 4-27: ATFM delays at origin airports due to Heathrow ATFM restrictions



Note: only regular flights are included in the analysis

Source: CFMU, Helios analysis

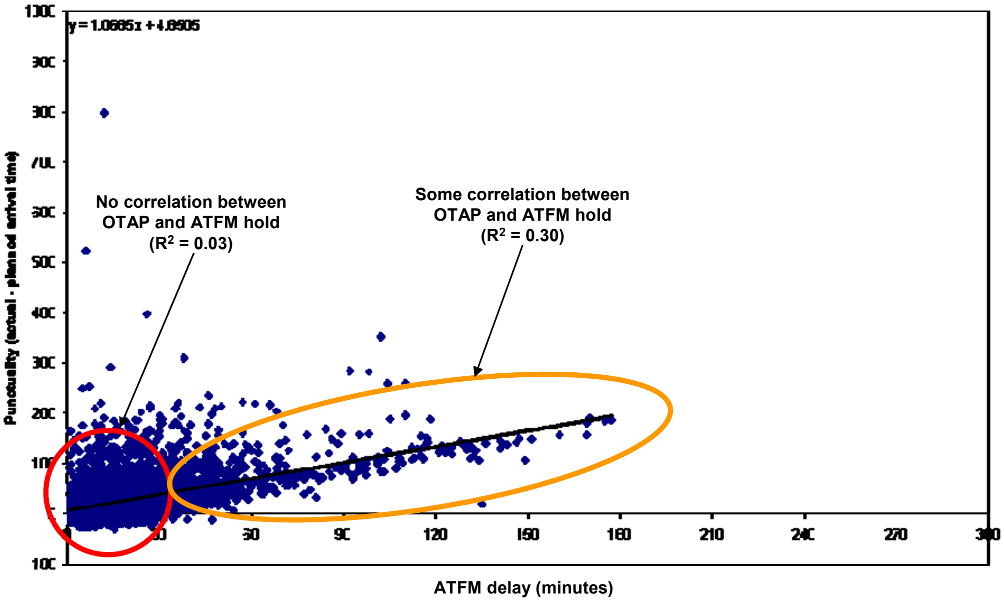
4.48 The ATFM delays at the origin airports are fairly evenly distributed (with the possible exception of arrivals from Amsterdam scheduled for arrival at around 17:00 universal time coordinated (UTC)) showing that the CFMU process is reasonably equitable. The consequences of these airport ATFM delays, especially in peak hours are:

- a large number of short haul inbound flights are delayed by the order of 10 to 12 minutes with a 95th percentile of 20 to 25 minutes (see exhibit 4-14) meaning that a buffer of this scale needs to be built into the schedule for connections at Heathrow. This might be expected to increase minimum connect times (MCTs) significantly depending on how airlines/alliance build uncertainty into their schedules
- the same large number of aircraft are held on the ground at their origin airports. For each airport with a relatively thick route to Heathrow this is likely to amount to three aircraft delayed simultaneously by the same amount of time.

The relationship between ATFM delays and punctuality

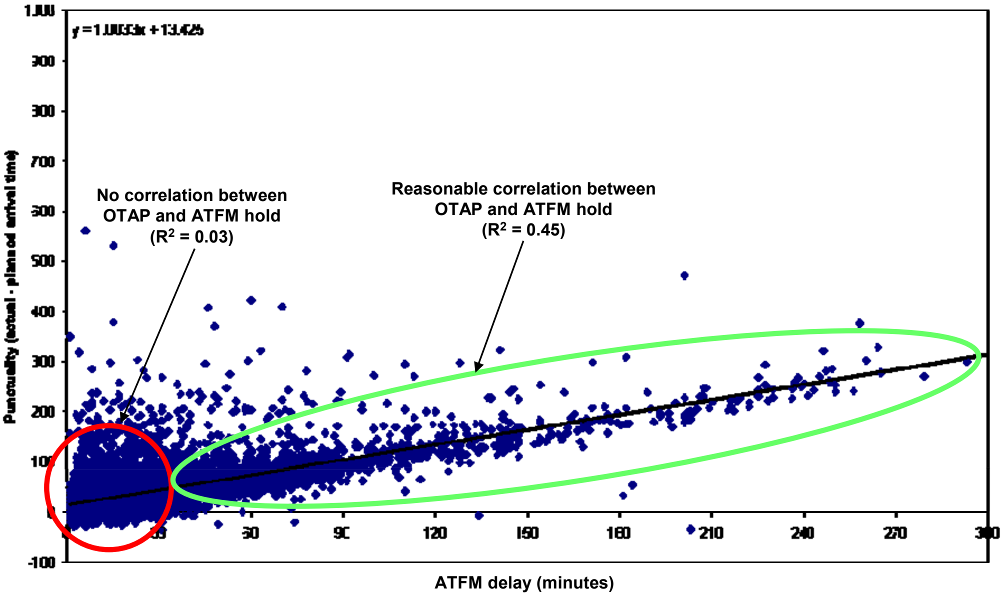
4.49 The imposition of an ATFM regulation does not necessarily mean that the regulated flight will necessarily arrive late compared to its timetable or schedule because there are buffers built into schedules and there are also many other potential causes of delay in addition to ATFM. Exhibit 4-28 and Exhibit 4-29 show the correlation between on time arrival performance (OTAP) and ATFM restrictions on a flight-by-flight basis for both the summer and winter seasons at Heathrow.

Exhibit 4-28: Correlation between ATFM delays and on time arrival performance at Heathrow, summer season 2007



Source: CFMU, airline data, Helios analysis

Exhibit 4-29: Correlation between ATFM delays and on time arrival performance at Heathrow, winter season 2007/2008



Source: CFMU, airline data, Helios analysis

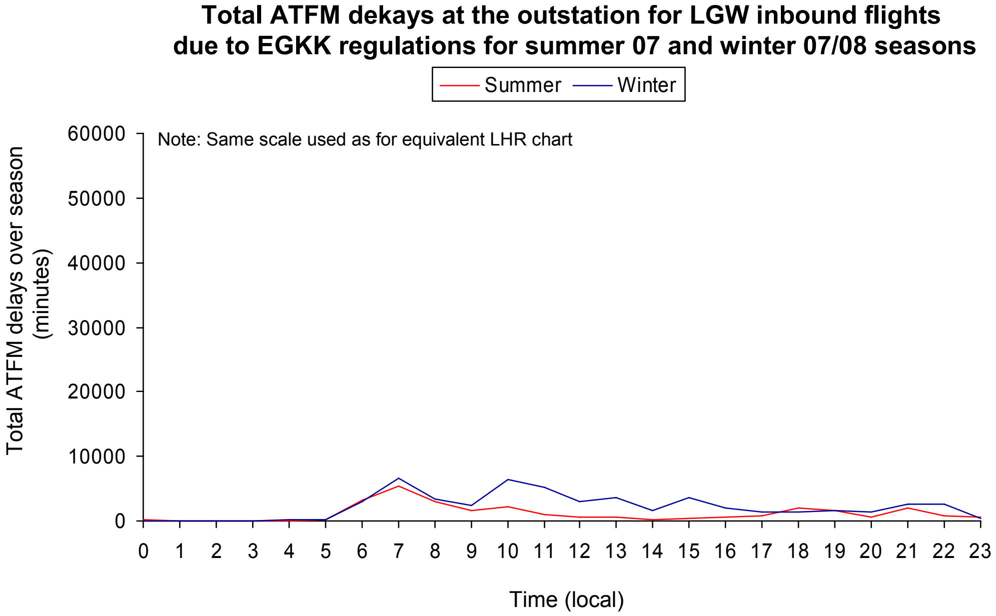
4.50 The scatter on the points in Exhibit 4-28 and Exhibit 4-29 gives a good indication of the multiple causes of delay. Only for reasonably large airport ATFM delays (>30 minutes) is there reasonable correlation between the airport ATFM delay and punctuality performance. Where this correlation exists, there is a direct one-to-one relationship between airport ATFM delays and punctuality. At shorter ATFM delays any correlation is masked by the contribution of other delay causes, which may also include ATFM restrictions arising from sources other than the airport.

Magnitude of airport ATFM delays at Gatwick

Total airport ATFM delays

4.51 Total airport ATFM delays due to Gatwick are an order of magnitude lower than they are for Heathrow, as shown in Exhibit 4-30. During the summer season 2007 (7 months), Gatwick was the cause of 28,000 minutes of ATFM delay on the ground at the outstation airport. In the 2007/2008 winter season (5 months), Gatwick caused approximately 53,000 minutes of ATFM delay. These lower levels of airport ATFM delay are to be expected given both the lower traffic levels and the much lower frequency that ATFM regulations are applied at Gatwick than they are at Heathrow (see Exhibit 4-15 and Exhibit 4-16).

Exhibit 4-30: Total airport ATFM delays due to Gatwick ATFM regulations over the last two complete seasons

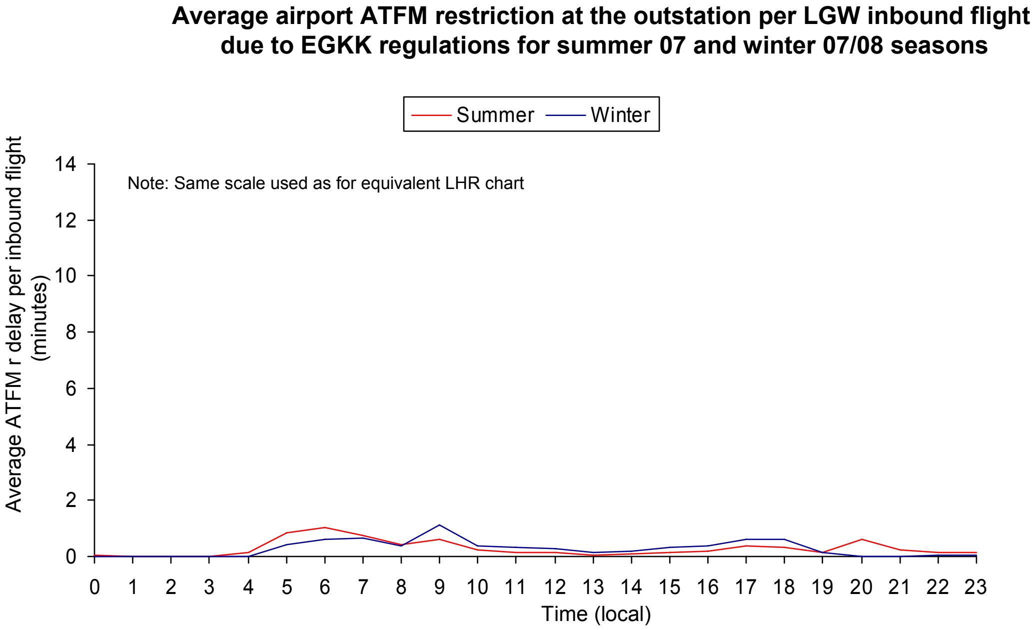


Source: CFMU, Helios analysis

Average airport ATFM delays

4.52 Taking into account lower traffic levels at Gatwick, the average ATFM delay per inbound flight is still much lower at Gatwick than at Heathrow as shown in Exhibit 4-31.

Exhibit 4-31: Average airport ATFM delay per inbound flight due to Gatwick ATFM regulations over the last two complete seasons

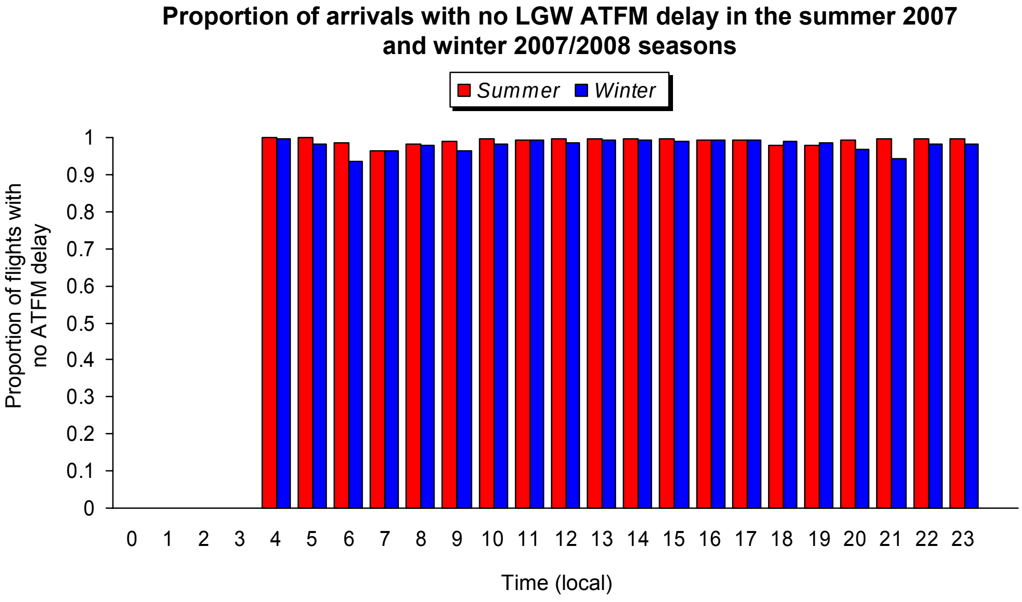


Source: CFMU, Helios analysis

Range of ATFM delays

4.53 The statistical distributions of Gatwick's ATFM delays show that the vast majority of flights to Gatwick suffer no Gatwick-related ATFM delay as shown in Exhibit 4-32.

Exhibit 4-32: Proportion of flights arriving at Gatwick that have not been subject to a Gatwick related ATFM regulation



Source: CFMU, Helios analysis

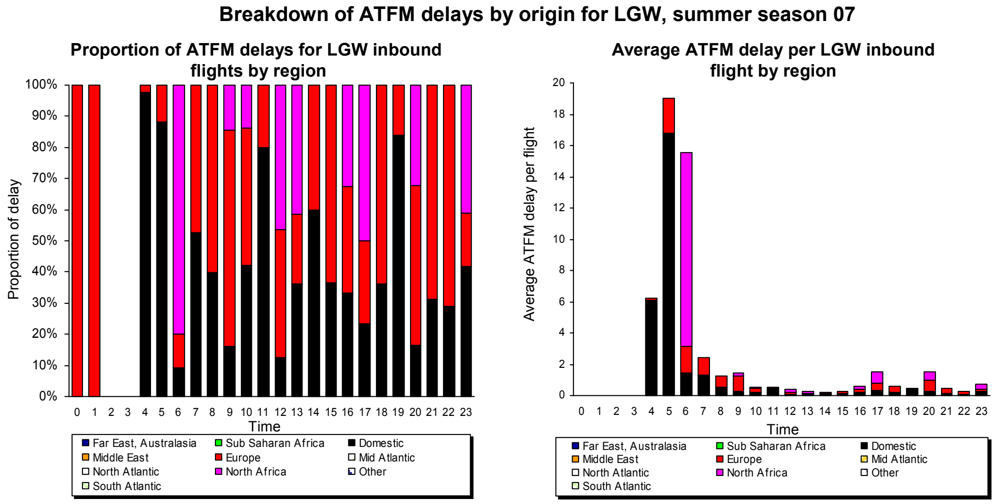
4.54 At all times except for the 06:00 to 07:00 and 21:00 to 22:00 hours during the winter season more than 95% of Gatwick's inbound flights are undelayed. The 95th percentile of Gatwick's ATFM restrictions is, therefore, zero, with the exception of:

- winter 06:00 to 07:00, where the 95th percentile ATFM delay is approximately 12 minutes
- winter 21:00 to 22:00, where the 95th percentile ATFM delay is approximately 6 minutes.

Distribution of Gatwick's airport ATFM delays by origin

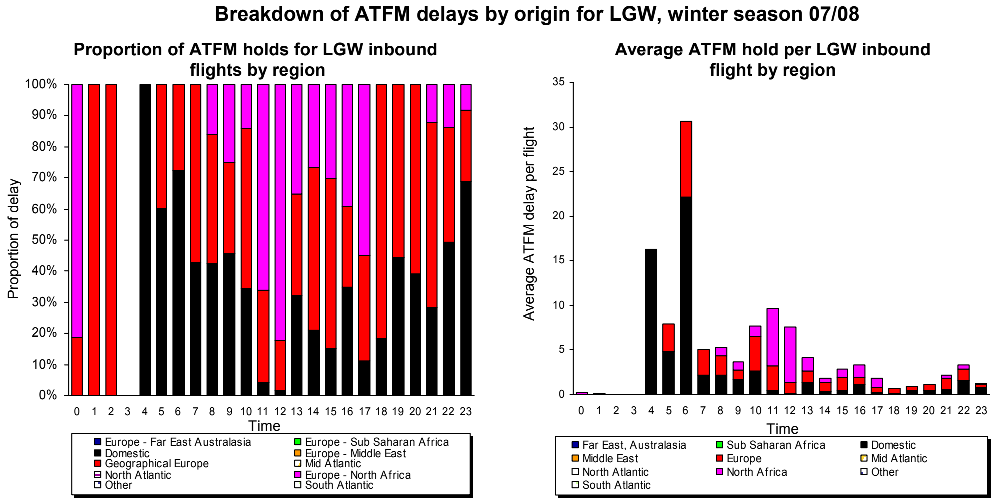
4.55 Exhibit 4-33 and Exhibit 4-34 show the distribution of Gatwick ATFM delays by region of origin of the flight both as a proportion of the ATFM delays and as the average ATFM delay per flight for both summer and winter seasons.

Exhibit 4-33: Breakdown of Gatwick’s inbound airport ATFM delays by origin of the inbound flight for the summer season 2007



Source: CFMU, Helios analysis

Exhibit 4-34: Breakdown of Gatwick’s inbound airport ATFM delays by origin of the inbound flight for the winter season 2007/2008



Source: CFMU, Helios analysis

4.56 As expected the highest proportion of airport ATFM delays inbound to Gatwick are borne by flights from domestic and European origins. However, in contrast to Heathrow where these ATFM delays are evenly distributed, those at Gatwick are borne to a much greater degree by domestic traffic in the morning peak both summer and winter. The early morning peak is the only time that ATFM delays are significant in the summer. In the winter, other than in the early morning, there is quite a high proportion of traffic from North Africa that suffers Gatwick airport ATFM delays.

GROUND HOLDING FOR DEPARTURES

Introduction

4.57 Ground holding is a more complex situation to analyse than either airport ATFM delays or stack holding. Whereas the latter two processes are concerned with optimising demand for the runway to the available capacity, ground holding must take into account issues other than the runway. These issues include the need to impose minimum departure intervals (MDIs) to account for capacity restrictions on standard instrument departure (SID) routes, the need to account for ATFM restrictions placed on departing flights and their need to meet their calculated take-off time (CTOT) issued by the CFMU as well as the need to take account of taxiway restrictions and congestion. Furthermore, holding in the stacks and ATFM delays are well-defined and bounded whereas the air traffic controller can manage a ground hold in a number of ways, including holding the aircraft on the stand, managing the taxi speed, holding the aircraft at some point on the taxiway, etc. For these reasons the approach to the analysis of ground holding is focussed on and defined as the difference in the actual overall taxi time from a particular stand to a particular runway to the ideal time as defined by the so-called variable taxi time (VTT) defined as the unimpeded taxi time from stand to runway.

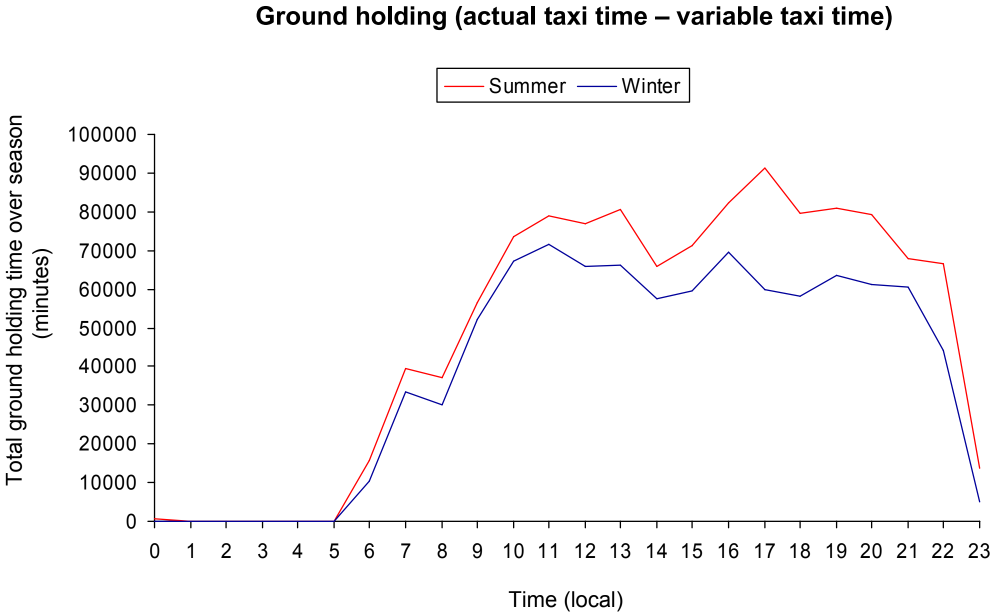
Heathrow

Overall results

4.58 Exhibit 4-35 shows the total ground holding time (actual taxi time minus the variable taxi time) over the last two complete seasons at Heathrow. In the summer season the total holding time was approximately 1404000 minutes whereas the figure for the summer season was approximately 942000 minutes. These figures are of a similar magnitude to the total stack holding and ATFM delays for arrivals combined.

4.59 Other than the factor accounting for the different length of the two seasons there appears to be little difference in the total ground holding times from summer to winter.

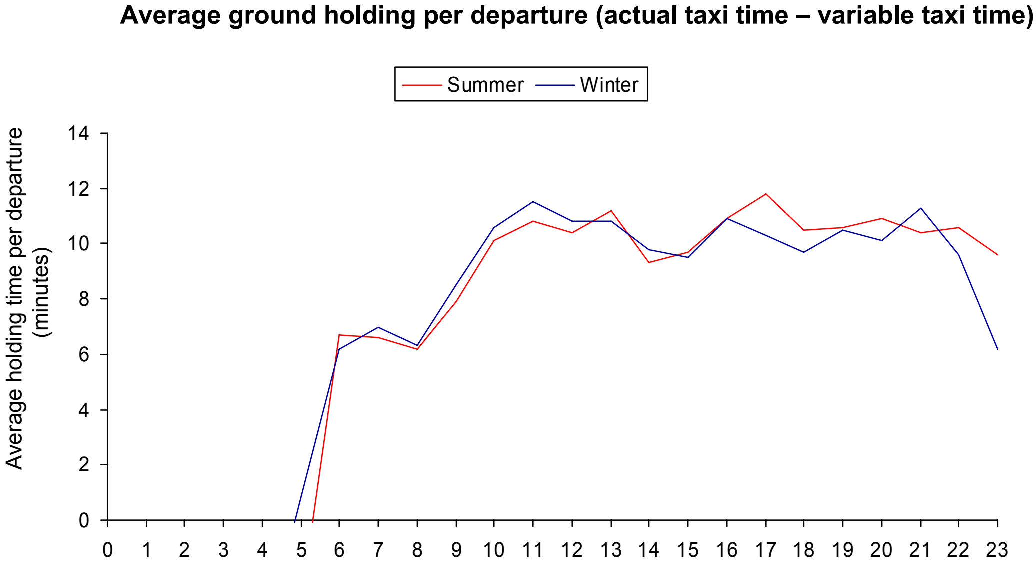
Exhibit 4-35: Total ground holding times for departures from Heathrow over the last two seasons



Source: NATS, Eurocontrol, Helios analysis

Exhibit 4-36 shows the average ground hold per departure from Heathrow over the last two seasons.

Exhibit 4-36: Average ground hold per departure from Heathrow over the last two seasons

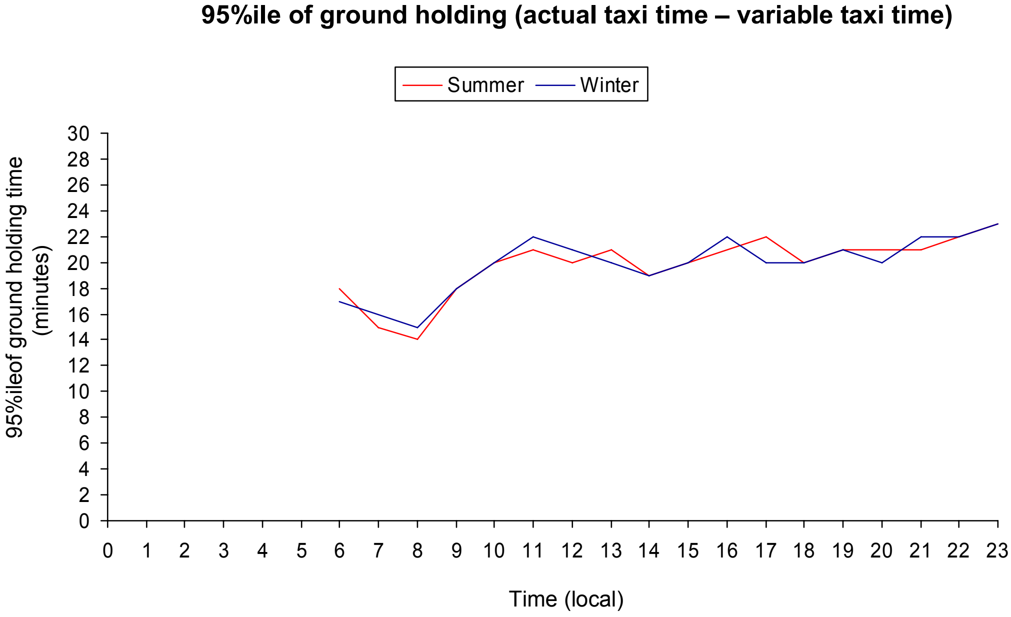


Source: NATS, Eurocontrol, Helios analysis

4.60 There is very little difference between the two curves shown in Exhibit 4-35 and Exhibit 4-36 indicating that the different conditions experienced in summer and winter have little effect on ground holding. For much of the day, the ground holding time lies between around 10 and 12 minutes per departure except for the early morning, where the departure rate is lower than during the rest of the day, when it is around 6 minutes per departure.

4.61 There is also very little difference between the 95th percentiles, a measure of the peak ground holding times, in the summer and winter seasons as shown in Exhibit 4-37. As with the average ground holding times, there is little variation in the 95th percentiles across the day except during the early morning where the range is between 14 to 18 minutes as compared to 20 to 22 minutes for the rest of the day. The higher ratio of 95th percentile to average early in the day (~3) compared to the rest of the day (~2) indicates that there is greater variability in ground holding during the morning.

Exhibit 4-37: 95th percentiles of the ground holding times observed at Heathrow in the last two complete seasons

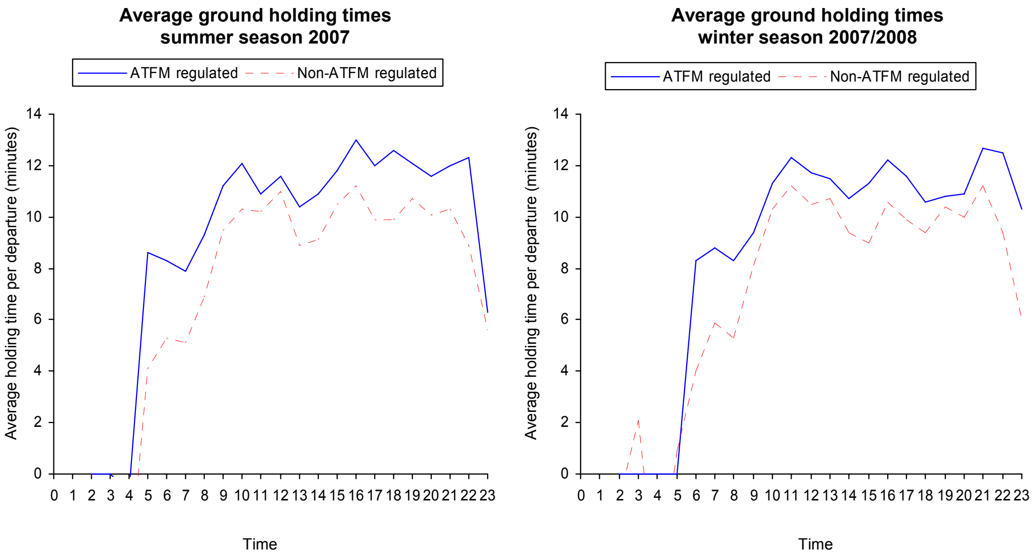


Source: NATS, Eurocontrol, Helios analysis

The impact of ATFM restrictions

4.62 When a departure is subject to an ATFM regulation, it is assigned a CTOT by the CFMU and must depart within a 15 minute window (-5 to +10 minutes) of the CTOT. Much of the ATFM delay is likely to be taken on-stand but some of the delay may be absorbed during taxiing. It is instructive to compare, therefore, the ground holding times for flights not subject to ATFM regulation with those flights that are regulated. This comparison is made in Exhibit 4-38 which shows that flights that are subject to ATFM regulations on average have longer taxi times than unregulated flights. This may indicate that the controller absorbs part of the ATFM delay in the taxi time.

Exhibit 4-38: Comparison of ground holding at Heathrow for flights with and without ATFM regulations



Source: NATS, Eurocontrol, Helios analysis

Pre-start-up holding

4.63 In addition to holding during the taxiing process as described above, an additional mechanism that can be used to hold aircraft on the ground is delaying the ATC approval to start. This is manifested in a delay between the pilot's requested start-up time and the start-up time approved by the air traffic controller.

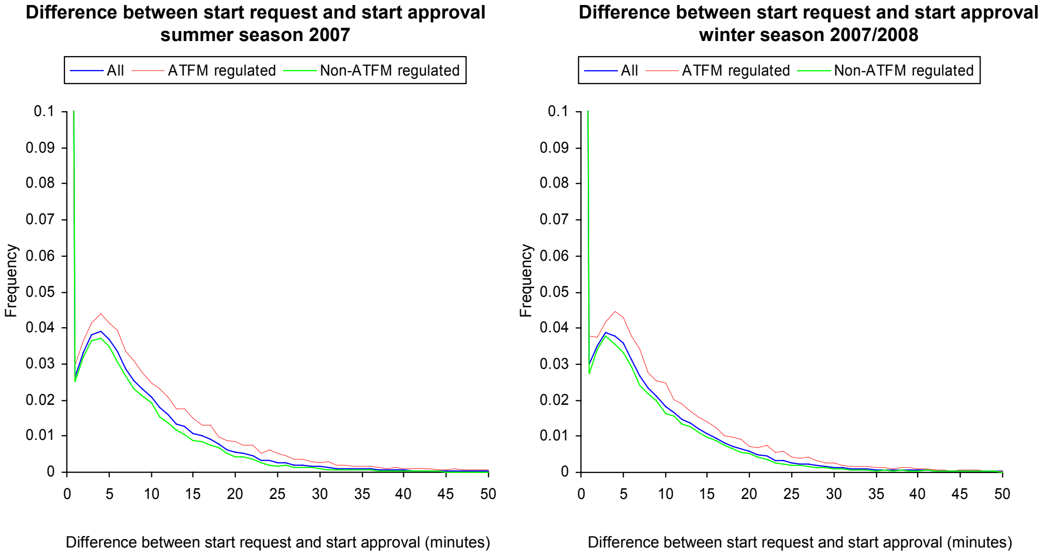
4.64 The distribution of this type of holding time at Heathrow is shown in Exhibit 4-39 for all flights, for flights subject to ATFM regulations and for flights that were not subject to ATFM regulations.

4.65 The key parameters of the distributions are summarised in Exhibit 4-40 and the following observations can be made:

- there is very little difference between the summer and winter seasons
- just over half of all departures are granted start-up approval with no delay with this figure dropping to just over 40% for ATFM regulated flights and rising to around 60% for non-ATFM regulated flights
- there is little qualitative difference between the distributions for aircraft that are subject to ATFM regulation and those that are not but the average difference rises from around 3.7 minutes for non-ATFM regulated flights to 6 to 7 minutes for ATFM regulated flights
- the 95th percentile of the difference between start-up request and start-up approval is approximately 17 minutes for non-ATFM regulated flights and 25 minutes for ATFM regulated flights.

4.66 The lower performance of the ATFM-regulated flights compared to the non-ATFM-regulated flights is probably due to the pilot calling for start-up at the very start or shortly before the CTOT period[8] in anticipation of an early a start as possible. The controller will moderate the actual start-up to sequence the departing traffic more easily and hence, premature calls for start are likely to experience longer delays. Assuming that the pilot generally calls for start-up at the earliest time, taking taxiing into consideration, that would mean departure at the beginning of the CTOT window, then a delay in around 15 minutes for start-up approval would imperil that window being met. Exhibit 4-39 indicates that this is expected to occur for around 12 to 14% of departures.

Exhibit 4-39: Time lag between start-up request and start-up approval for flights departing Heathrow for the last two complete seasons



Source: NATS, Helios analysis

Exhibit 4-40: Key parameters of the distribution of time lags between start-up request and start-up approval for flights departing Heathrow

	Parameter	Total sample	ATFM regulated flights	Non-ATFM regulated flights
Summer season 2007	Proportion of flights that are not held	54%	41%	60%
	Average hold per flight	4.6 mins	7.0mins	3.6 mins
	95%ile of hold	19 mins	26 mins	16 mins
Winter season 2007/2008	Proportion of flights that are not held	55%	44%	59%
	Average hold per flight	4.4mins	6.1 mins	3.8 mins
	95%ile of hold	18 mins	24 mins	17 mins

Source: NATS, Helios analysis

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[8] For ATFM regulated traffic, departures are allowed within a 15 minute time window of 5 minutes before 10 minutes after the CTOT

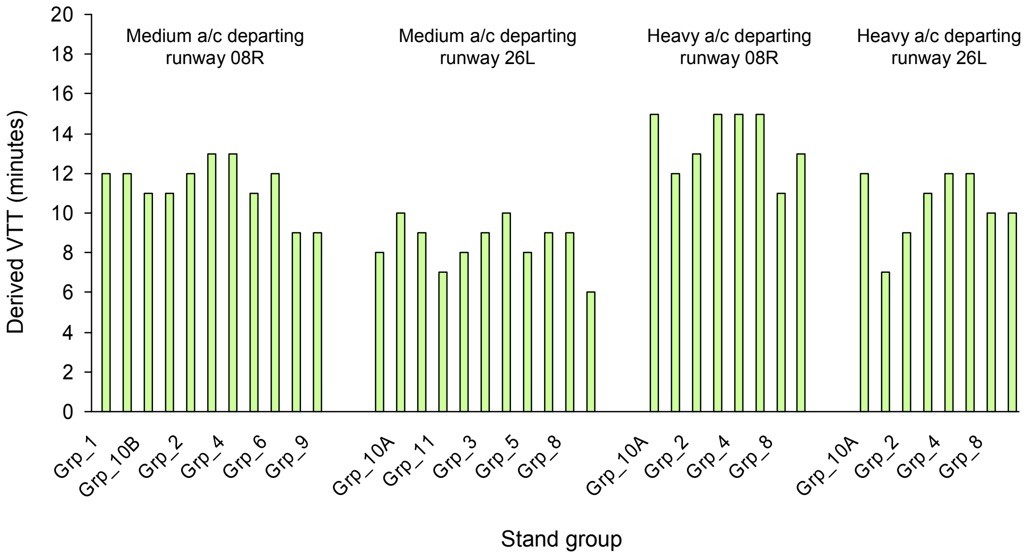
Gatwick

Derivation of variable taxi times

Variable (unimpeded) taxi times are not available for Gatwick so it was necessary to undertake an analysis to estimate the VTT for the various stand-runway configurations. This analysis was based on the observation that the VTTs for stand-runway combinations at Heathrow are consistently the 2nd percentile of the taxi time distribution for each combination. Based on the assumptions that there is unlikely to be a significant difference between Heathrow and Gatwick, the same criterion was applied to Gatwick enabling the VTTs to be estimated.

The results are shown in the following figure classified by stand group and departure runway for medium and heavy aircraft.

Exhibit 4-41: Derived VTTs used in the analysis of ground holding at Gatwick



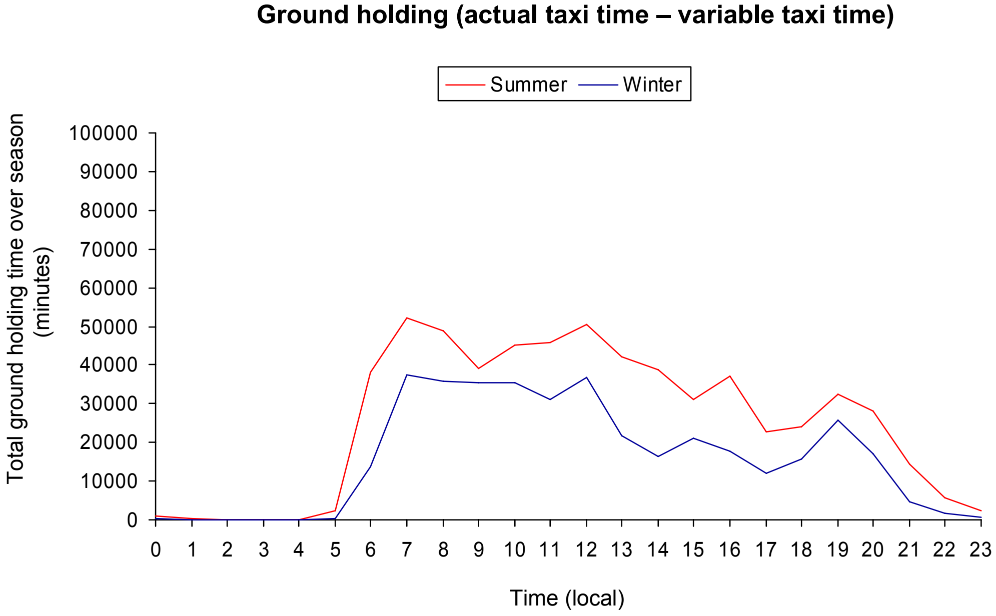
Source: NATS, Helios analysis

Overall results

4.67 Exhibit 4-42 shows the total ground holding time over the last two complete seasons at Gatwick. In the summer season the total holding time was approximately 603000 minutes whereas the figure for the summer season was approximately 381000 minutes. These figures are the same order of magnitude, allowing for differences in traffic volume, as those calculated for Heathrow and are an order of magnitude greater than the equivalent ATFM delays and stack holding times for arrivals.

4.68 Other than the factor accounting for the different length of the two seasons there appears to be little difference in the total ground holding times from summer to winter.

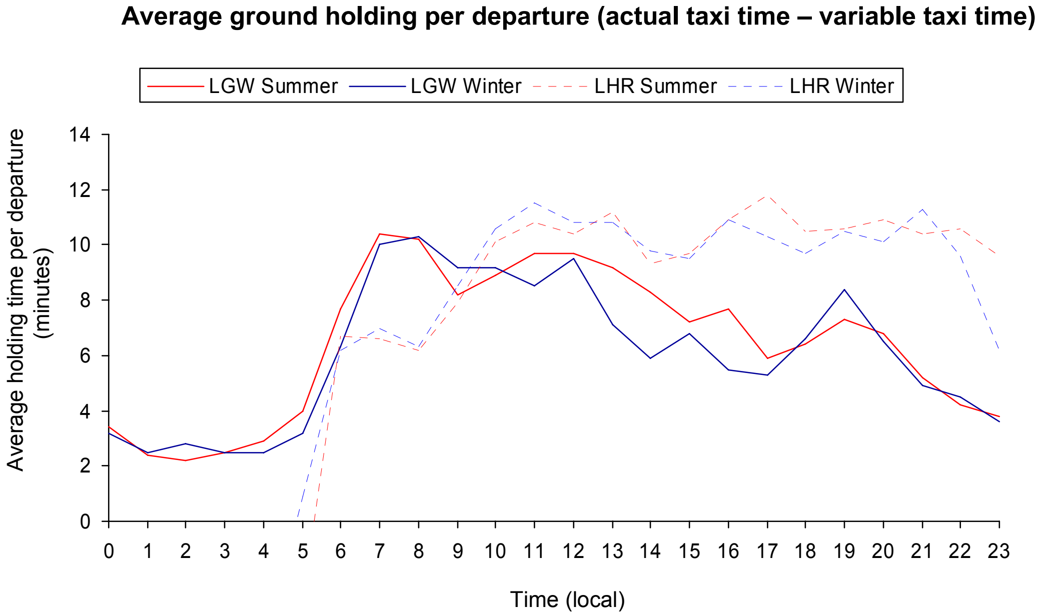
Exhibit 4-42: Total ground holding times for departures from Gatwick over the last two seasons



Source: NATS, Helios analysis

The following exhibit shows the average ground holding time per flight for departures from Gatwick.The equivalent data are also shown for Heathrow. In contrast to stack holding times and ATFM delays, whose averages are much greater for Heathrow and Gatwick, in this case the two sets of average are similar. In fact, in the early morning, average ground holding at Gatwick is worse than at Heathrow although the situation reverses as the day progresses.

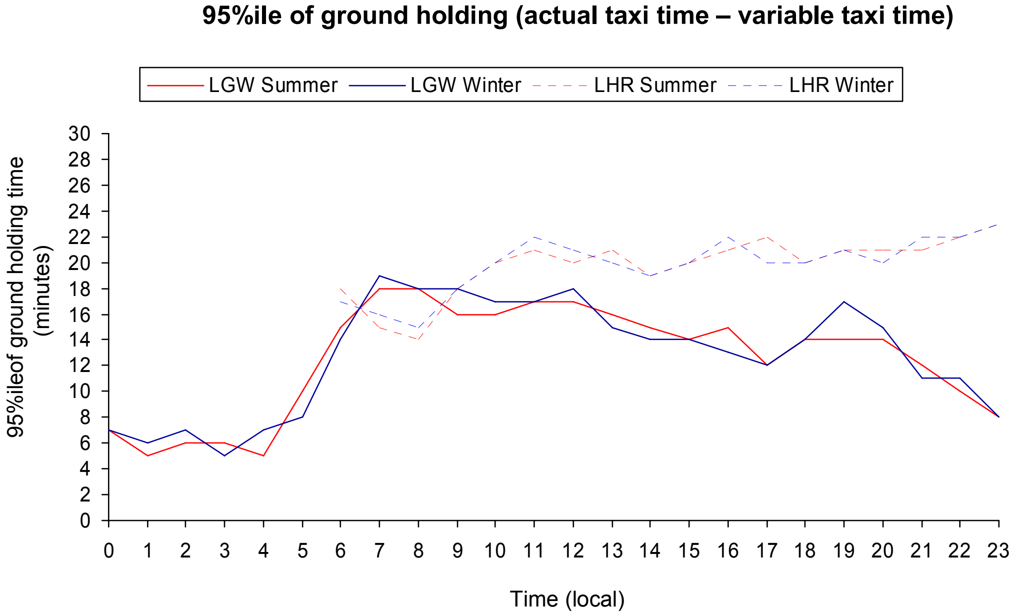
Exhibit 4-43: Average ground hold per departure from Gatwick compared to Heathrow over the last two seasons



Source: NATS, Eurocontrol, Helios analysis

4.69 The behaviour of the peak ground holding at Gatwick, as described by the 95th percentile of the ground holding time, is shown in the following figure and compared to the equivalent data for Heathrow. Again the magnitude of peak ground holding at Gatwick is similar to that at Heathrow with Gatwick's performance being slightly worse than Heathrow's in the early morning but improving in relative and absolute terms as the day progresses.

Exhibit 4-44: 95th percentiles of the ground holding times observed at Gatwick compared to Heathrow in the last two complete seasons

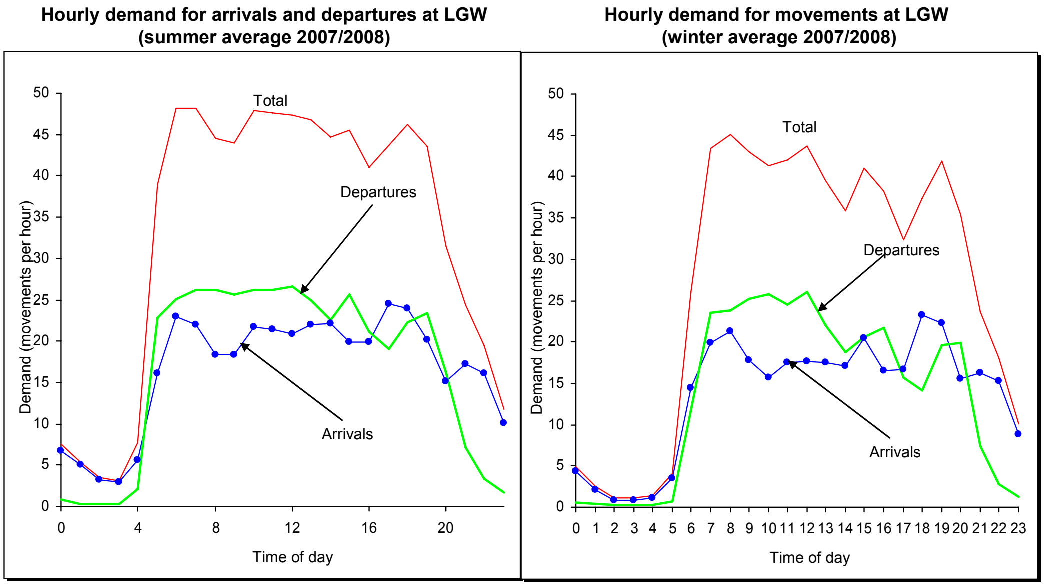


Source: NATS, Eurocontrol, Helios analysis

4.70 The poor performance of Gatwick at ground holding (compared to stack holding and ATFM delays) is probably exlained by priority being given to arrivals over departures for access to the single runway. The poor performance in the early morning is due to the high demand for both arrivals and departures at that time, as shown in the following figure. The improvement throughout the day is probably due to:

- periods of high demand for arrivals and departures mainly being in anti-phase
- the gradual decline in demand for arrivals as the day progresses.

Exhibit 4-45: Relationship between arrivals and departures demand at Gatwick



Hourly demand for arrivals and departures at LGW (summer average 2007/2008)

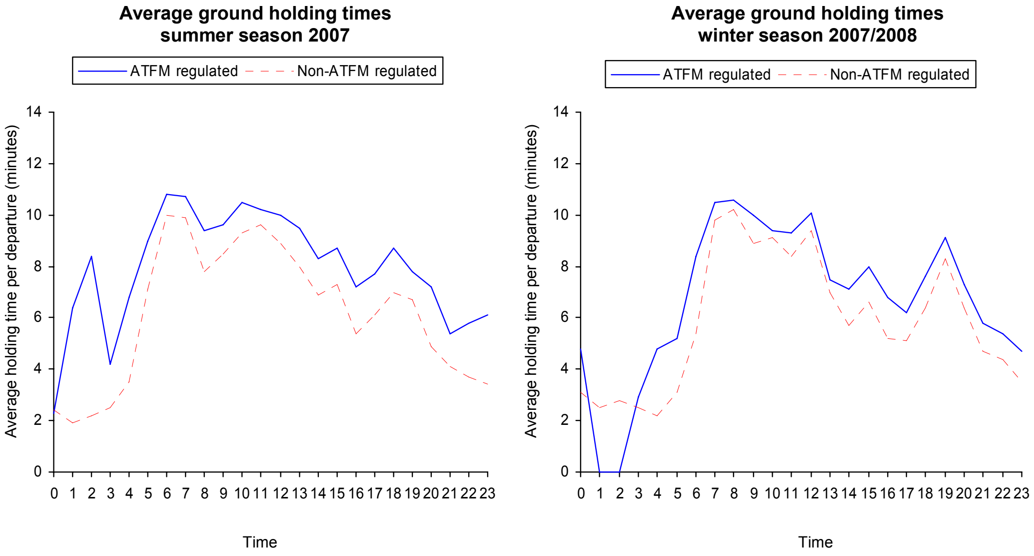
Hourly demand for movements at LGW (winter average 2007/2008)

Source: CFMU

The impact of ATFM restrictions

4.71 The comparison of ground holding between departures from Gatwick that are ATFM-regulated and those that are not is made in Exhibit 4-38. As with Heathrow, this comparison shows that flights that are subject to ATFM regulations on average have longer taxi times than unregulated flights, again indicating that the controller absorbs part of the ATFM delay in the taxi time – at the penalty of the engines running for longer than is necessary increasing fuel costs and environmental impact. The difference between ATFM-regulated and non-ATFM-regulated departures is slightly smaller for Gatwick than for Heathrow.

Exhibit 4-46: Comparison of ground holding at Gatwick for flights with and without ATFM regulations



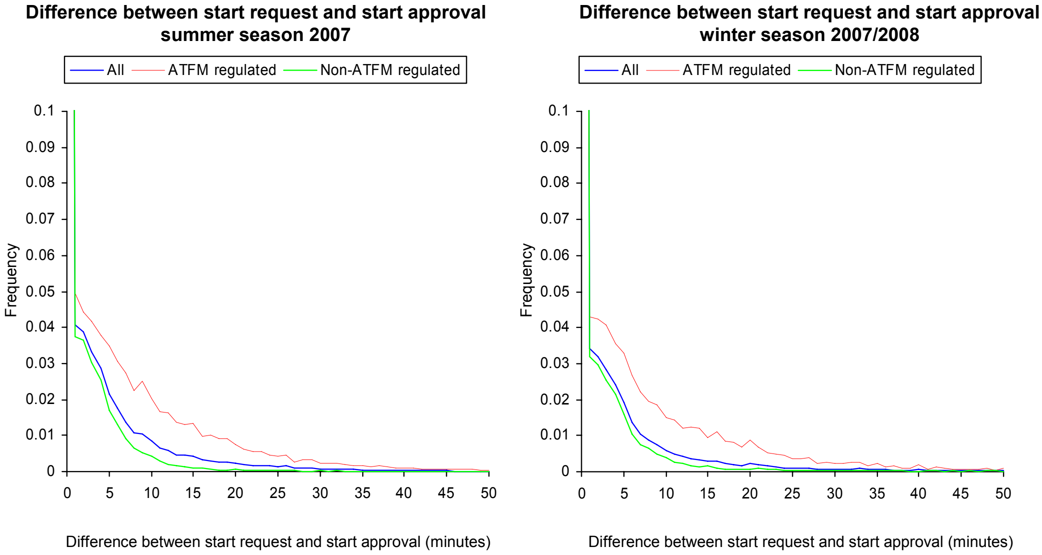
Pre-start-up holding

4.72 The distributions of this pre-start-up holding time at Gatwick are shown in Exhibit 4-39 for all flights, for flights subject to ATFM regulations and for flights that were not subject to ATFM regulations. The distributions are qualitatively different to those observed at Heathrow in that they decrease continuously and do not have side peaks, as is observed for Heathrow.

4.73 The key parameters of the distributions are summarised in Exhibit 4-47 and the following observations can be made:

- there is very little difference between the summer and winter seasons
- just over half of all departures are granted start-up approval with no delay, with this figure dropping to just over 40% for ATFM regulated flights and rising to around 60% for non-ATFM regulated flights
- there is little qualitative difference between the distributions for aircraft that are subject to ATFM regulation and those that are not but the average difference rises from around 3.7 minutes for non-ATFM regulated flights to 6 to 7 minutes for ATFM regulated flights
- the 95th percentile of the difference between start-up request and start-up approval is approximately 17 minutes for non-ATFM regulated flights and 25 minutes for ATFM regulated flights.

Exhibit 4-47: Time lag between start-up request and start-up approval for flights departing Gatwick for the last two complete seasons



Source: NATS, Helios analysis

4.74 Following the same premise as in paragraph 4.66 , the proportion of ATFM-regulated flights that have a start-up delay of greater than 15 minutes (and hence may have difficulty in meeting their CTOT window) is around 12%.

Exhibit 4-48: Key parameters of the distribution of time lags between start-up request and start-up approval for flights departing Gatwick

	Parameter	Total sample	ATFM regulated flights	Non-ATFM regulated flights
Summer season 2007	Proportion of flights that are not held	71%	48%	80%
	Average hold per flight	2.2	5.7	1.0
	95%ile of hold	12	24	5
Winter season 2007/2008	Proportion of flights that are not held	76%	52%	82%
	Average hold per flight	2.2	5.7	1.4
	95%ile of hold	11	26	6

Source: NATS, Helios analysis

SIGNIFICANT DISRUPTION

Frequency of major disruptions at Heathrow

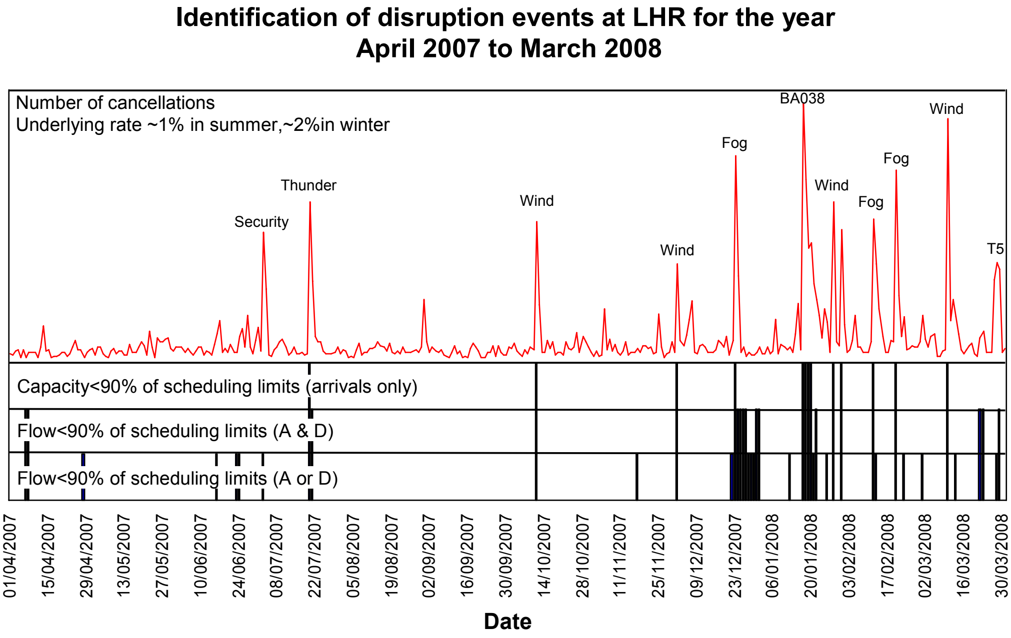
4.75 Significant disruption to the runway operations at an airport can be characterised by three main parameters:

- reduced flow rates for arrivals, departures or both
- significantly reduced runway capacity
- increased levels of operational (rather than economic – e.g. for flights with very low load factors) cancellations of flights.

4.76 Exhibit 4-49 illustrates these parameters for Heathrow over the year starting 1April 2007 and ending 31 March 2008. The top part of the chart shows the number of operational cancellations that occurred, with the cause of the disruption by day, when the level of cancellations reached about 10%. The three tramlines at the bottom of the chart show:

- the days on which the actual flow rate for arrivals was below 90% of the scheduling limits, that is very restricted arrivals (bottom tramline)
- the days on which the actual flow rate for both arrivals and departures was below 90% of the scheduling limits (middle tramline)
- the days on which the declared capacity was below 90% of the scheduling limits (top tramline).

Exhibit 4-49: Significant disruptions at Heathrow between April 2007 and March 2008 inclusive



Source: ACL, CFMU, Helios analysis

4.77 The figure shows that during the period investigated:

- there were 13 days when arrivals capacity was restricted to less than 90% of the norm taken over the normal operating day from 06:00 to 22:00. Together these days resulted in over 2000 cancellations and on 8 of the 13 days, more than 10% of Heathrow's flights were cancelled

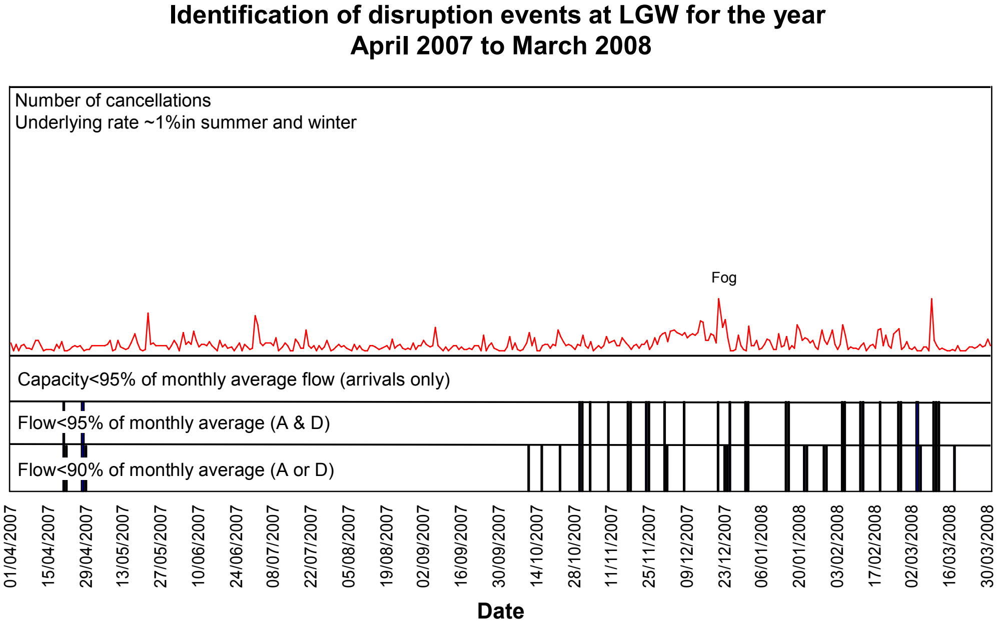
- weather was the principal cause of these disruptions, in addition to the BA038 accident
- there were 31 more days during the year when either arrivals or departures flow rates were lower than 90% of the scheduling limits
- there were 16 additional days over the year where there were more than 20 cancellations but less severe flow restrictions indicating that recovery from the disruption was possible or the disruption was not associated with the runway, for example the opening of terminal 5.

4.78 In summary, during the year April 2007 to March 2008 there were around 8 to 13 days when Heathrow's operations were disastrously disrupted and a further 47 to 52 days when there was major disruption.

Frequency of major disruptions at Gatwick

4.79 Exhibit 4-50 uses the same format as exhibit 4-38 to show the occurrence of major disruptions at Gatwick over the year April 2007 to March 2008. In this case there were no events where the flow rate was reduced to 90% of the norm, so in the Gatwick case the criteria for assessment has been set as the flow rate or capacity reduced to 95% of the scheduling limits. Despite this being a tighter threshold than that used for Heathrow, there were no events where the declared capacity was reduced to 95% of the norm. The number of cancellation events is also much lower than that experienced at Heathrow although the underlying rate of cancellations is around the same at the two airports in summer at around 1% but is lower at Gatwick in the winter at around 1% compared to 2% at Heathrow.

Exhibit 4-50: Significant disruptions at Gatwick between April 2007 and March 2008 inclusive



Source: ACL, CFMU, Helios analysis

4.80 The conclusion from Exhibit 4-49 and Exhibit 4-50 is that there were no major disruptions at Gatwick on the same scale as experienced at Heathrow during the period of analysis.

Recovery from disruption

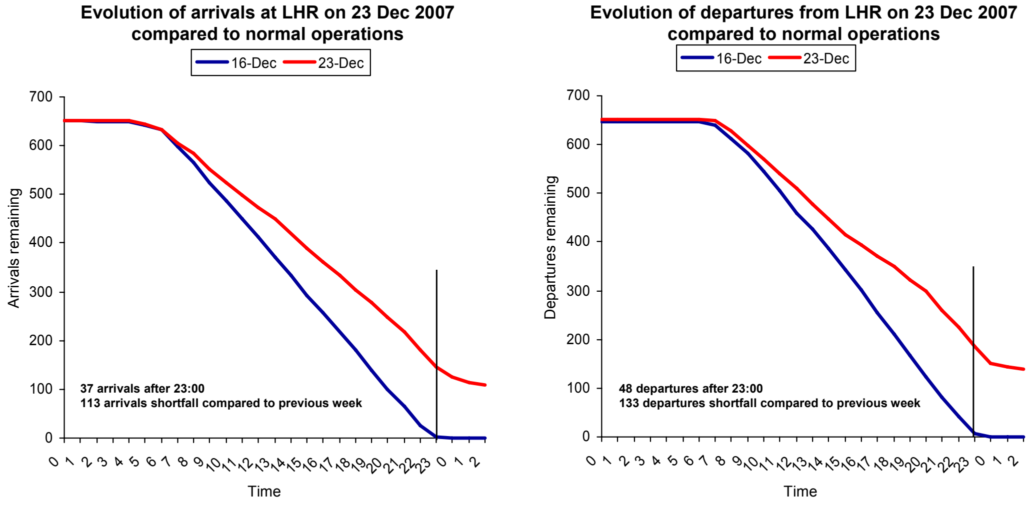
4.81 The following sections illustrate how Heathrow and Gatwick recover from events that disrupt their runway operations using three example disrupted days:

- 23 December 2007 where both airports were subject to severe fog that persisted for most of the day. As a baseline for normal operations at that time of year, the same weekday one week earlier – 16 December 2007 – which was not disrupted is used for comparison
- 5 November 2007 where both airports were subject to early morning fog that cleared during the day allowing scope for recovery. The day used for the normal baseline operations in this example is 12 November, one week later (the week earlier is not used as it is very close to the changeover between the summer and winter seasons)
- 2 December 2007 where both airports were subjected to high winds. Mean wind speeds at Heathrow and Gatwick were 34km/h and 22km/h with gusts of up to 78km/h and 50 km/h respectively.

Example – 23 December 2007

4.82 Exhibit 4-51 shows the evolution of Heathrow's arrivals and departures on 23 December compared to virtually the same schedule on 16 December.

Exhibit 4-51: Evolution of arrivals and departures at Heathrow throughout the day on 23 December compared to the baseline



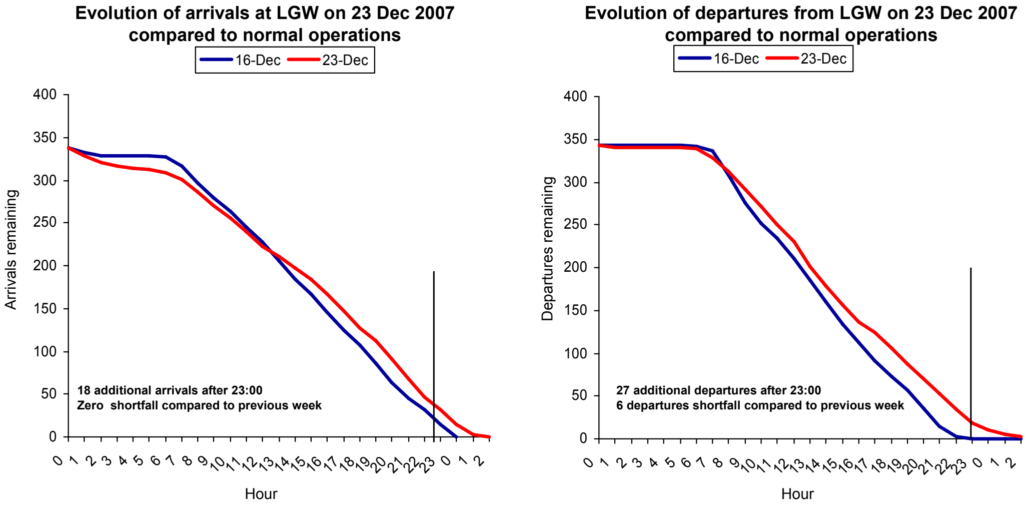
Source: ACL, CFMU, Helios analysis

The figure shows that the rate of both arrivals and departures is significantly reduced compared to the baseline resulting in:

- shortfalls in arrivals and departures of 113 and 133 respectively compared to the baseline
- overspill of normal operations into the night time, comprising 37 arrivals and 48 departures

4.83 Exhibit 4-52 shows the evolution of arrivals and departures at Gatwick on 23 December compared to the baseline of 16 December. The figure shows that disruption on the scale of that experienced at Heathrow was avoided at Gatwick with very few cancellations and a limited number of additional night time operations.

Exhibit 4-52: Evolution of arrivals and departures at Heathrow throughout the day on 23 December compared to the baseline



Source: ACL, CFMU, Helios analysis

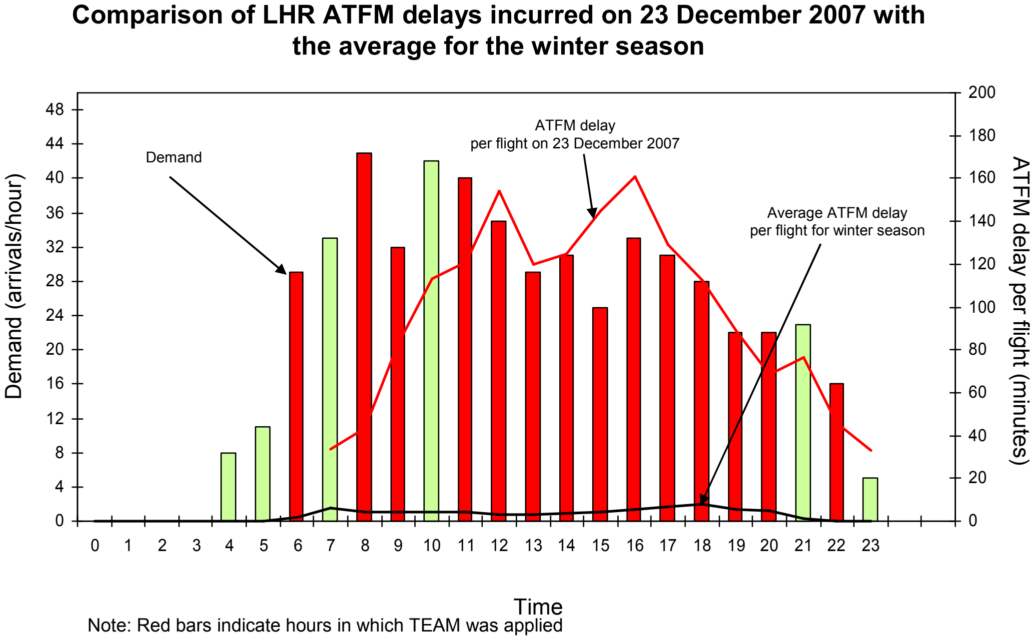
4.84 A second measure of disruption is the delays that are experienced by inbound flights due to ATFM regulations. Exhibit 4-53 and Exhibit 4-54 show the average airport ATFM delay per flight inbound to Heathrow and Gatwick on 23 December and compare these with the averages for the winter season. The figures also show the runway demand in terms of arrivals per hour, as derived from the CFMU data for the day.

4.85 The figures show:

- at their peak the airport ATFM delays per flight for each airport are very significant, at up to 3 hours per flight
- the airport ATFM delays ramp up more quickly to their peak at Heathrow than at Gatwick

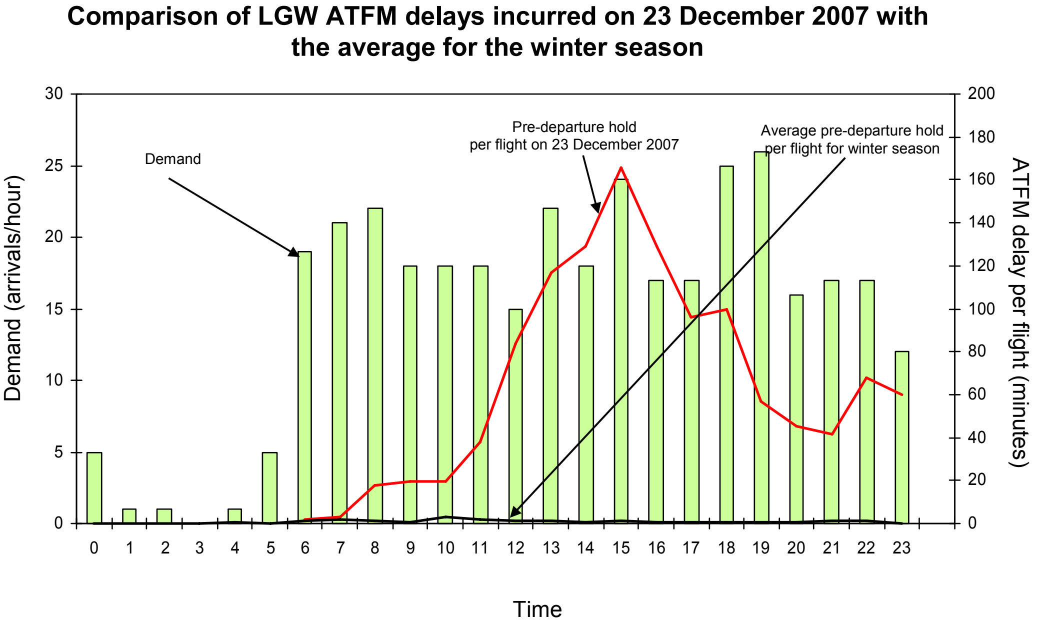
- by the end of the day, flights are still suffering serious airport ATFM delays of around 40 minutes at Heathrow and 60 minutes at Gatwick
- the arrivals demand at Heathrow drops off during the day from the norm at around 40 per hour to between 20 and 30 per hour reflecting the number of cancellations made.

Exhibit 4-53: Average airport ATFM delay per flight inbound to Heathrow and hourly arrivals demand on 23 December 2007



Source: CFMU, Airline data, Helios analysis

Exhibit 4-54: Average airport ATFM delay per flight inbound to Gatwick and hourly arrivals demand on 23 December 2007



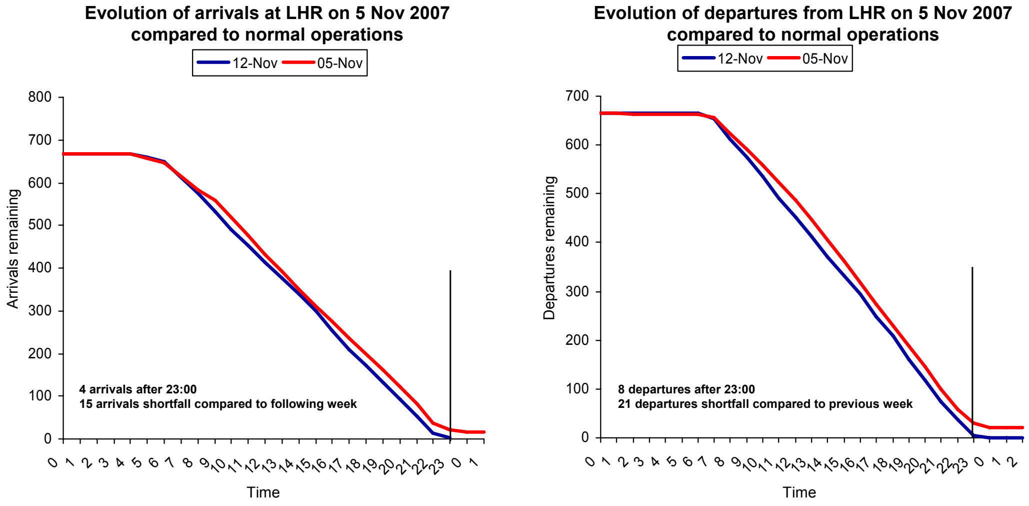
Source: CFMU, Helios analysis

4.86 Exhibit 4-53 shows that NATS uses TEAM to expedite arrival flows during the majority of the day. This application is made possible by the large number of cancellations reducing demand for the departures runway and allowing its use for arrivals which are more seriously affected by low visibility conditions than departures.

Example – 5 November 2007

4.87 Exhibit 4-55 shows the evolution of Heathrow's arrivals and departures on 5 November compared to the baseline of 12 November.

Exhibit 4-55: Evolution of arrivals and departures at Heathrow throughout the day on 5 November compared to the baseline


Evolution of arrivals at LHR on 5 Nov 2007 compared to normal operations

4 arrivals after 23:00
15 arrivals shortfall compared to following week

Evolution of departures from LHR on 5 Nov 2007 compared to normal operations

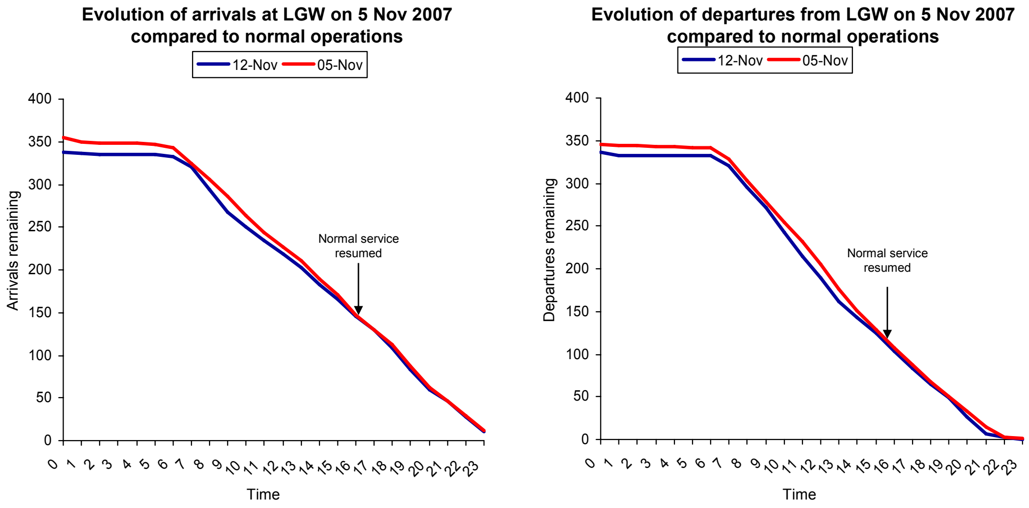
8 departures after 23:00
21 departures shortfall compared to previous week

Source: CFMU, Helios analysis

4.88 The figure shows that there was significantly less disruption on 5 November than on 23 December. There were shortfalls in arrivals and departures of 15 and 21 respectively compared to the baseline, with a limited number of operations taking pace after 23:00. However, the evolution of the traffic remains behind the baseline throughout the day starting from the early morning.

4.89 Exhibit 4-56 shows the evolution of traffic at Gatwick on 5 November compared to the baseline of 12 November. This figure shows that there is a shortfall in movements compared to the baseline between approximately 08:00 and 15:00 but that after about 15:00 both the rate of and the cumulative number of movements has recovered completely.

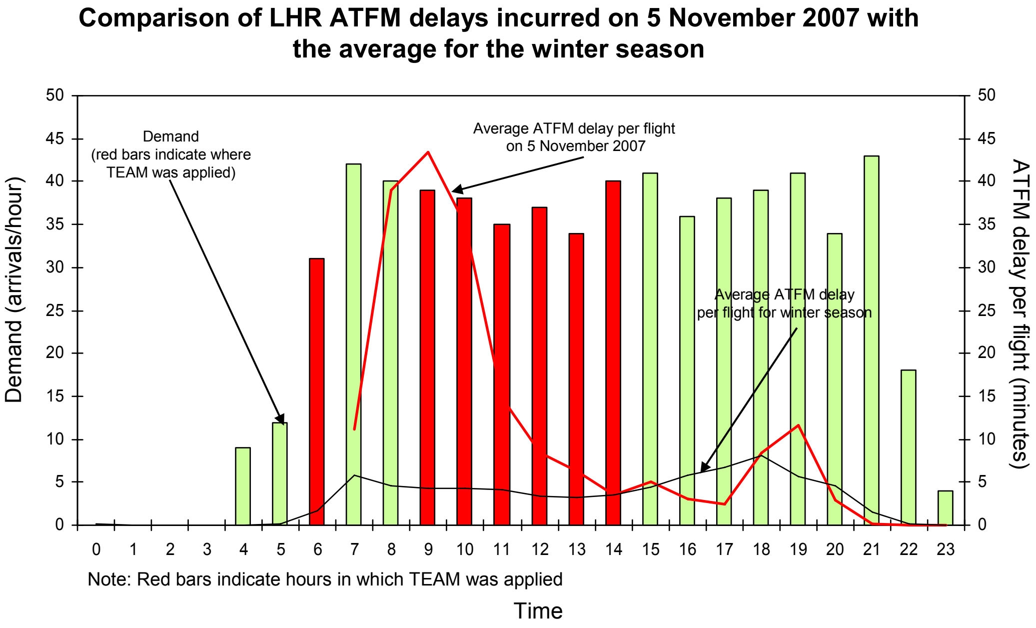
Exhibit 4-56: Evolution of arrivals and departures at Gatwick throughout the day on 5 November compared to the baseline



Source: CFMU, Helios analysis

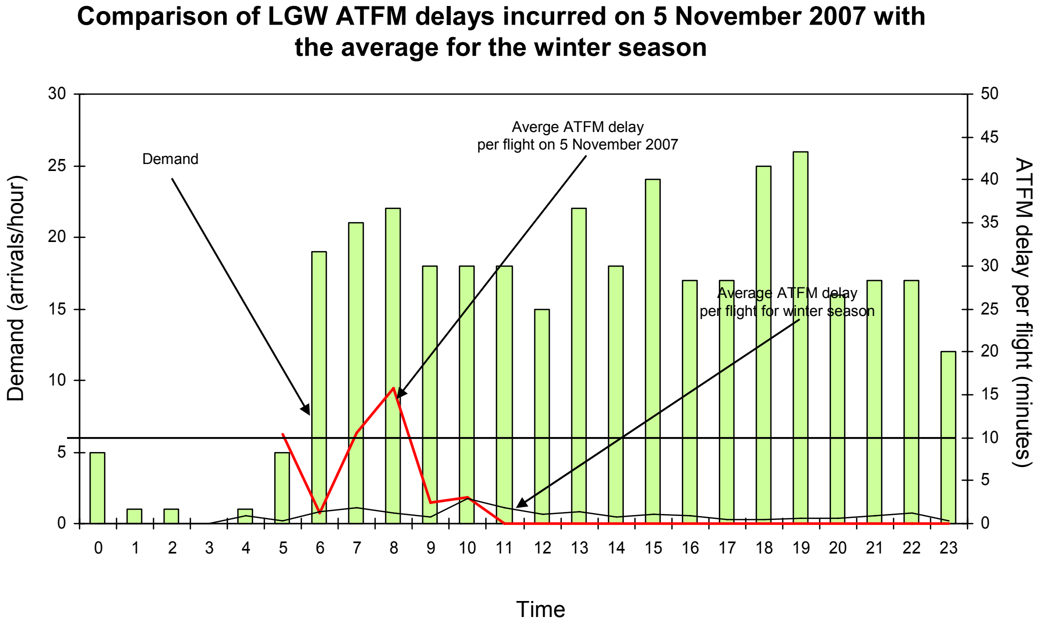
4.90 Exhibit 4-57 shows for arrivals the airport ATFM delays incurred at Heathrow on 5 November along with the hourly demand, derived from CFMU data. Exhibit 4-58 shows the same data for Gatwick.

Exhibit 4-57: Average airport ATFM delay per flight inbound to Heathrow and hourly arrivals demand on 5 November 2007



Source: CFMU, Airline data, Helios analysis

Exhibit 4-58: Average airport ATFM delay per flight inbound to Gatwick and hourly arrivals demand on 5 November 2007



Source: CFMU, Helios analysis

4.91 Comparison of Exhibit 4-57 and Exhibit 4-58 shows:

- airport ATFM delays due to Gatwick, at around 15 minutes in the peak at around 08:00, were considerably lower than those suffered due to Heathrow which were 45 minutes in the peak at around 09:00
- Gatwick had recovered to normal levels of airport ATFM delay by around 10:00 whereas Heathrow's recovery to normal delay levels took until around 14:00
- Gatwick did not suffer any real suppression of demand (i.e. cancellations) whereas Heathrow's demand was reduced to between 35 and 40 arrivals for parts of the day
- NATS applied TEAM to expedite arrivals from 09:00 to 14:00 in addition to its normal application at 06:00
- NATS can also apply mixed mode operations in some circumstances to alleviate severe disruption.

Example – 2 December 2007

4.92 Exhibit 4-59 and Exhibit 4-60 show the evolution of traffic at Heathrow and Gatwick on 2 December respectively compared to the evolution of traffic on the equivalent day one week earlier, when weather conditions were reasonably good.

4.93 The figures show that Gatwick was unaffected by wind conditions but that there was considerable disruption at Heathrow, albeit caused by winds that were stronger than experienced at Gatwick.

Exhibit 4-59: Evolution of arrivals and departures at Heathrow throughout the day on 2 December compared to the baseline

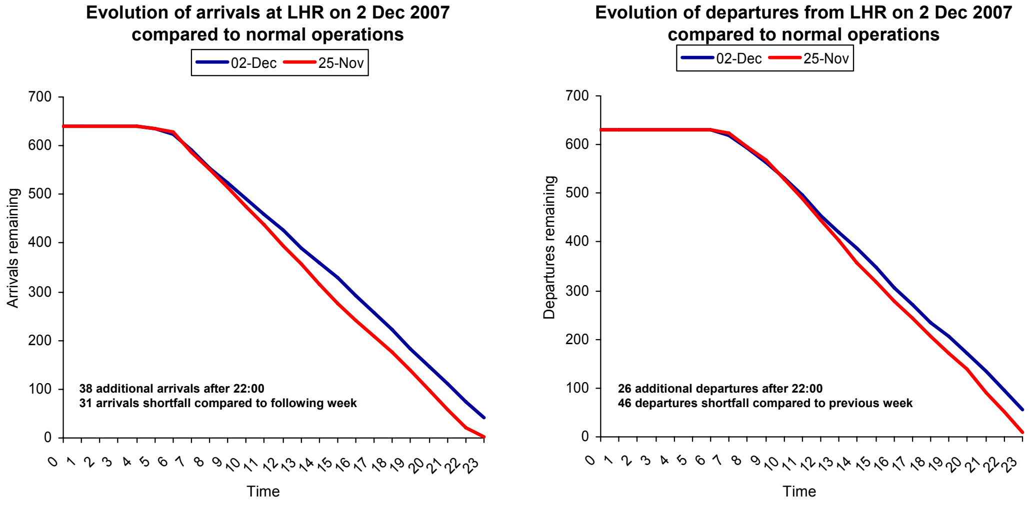
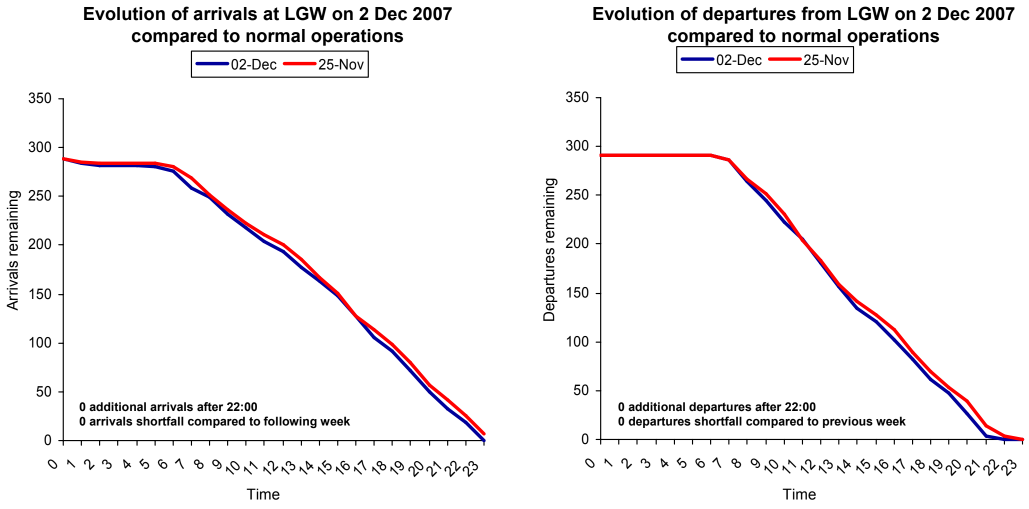


Exhibit 4-60: Evolution of arrivals and departures at Gatwick throughout the day on 2 December compared to the baseline



4.94 During the day at Heathrow, the arrival and departure rates were restricted to the low to mid 30s as opposed to high 30s and low 40s of the previous week. There was no extensive operation of TEAM in contrast to the low visibility days. At Gatwick the arrivals and departure rates were largely unaffected by the conditions, presumably due to the additional spacing needed to operate mixed mode.

CURRENT SITUATION - CONCLUSIONS

4.95 The performance of Heathrow and Gatwick airports in term of stack holding, airport ATFM delays and ground holding are summarised in the following table.

Exhibit 4-61: Summary of different delay types at Heathrow and Gatwick

		Heathrow				Gatwick			
		Stack	ATFM	Ground	Pre-start-up	Stack	ATFM	Ground	Pre-start-up
Summer	Total (000s mins)	565	389	1404	537	93	28	603	167
	Average (mins)	5.3	2.8	10.0	4.6	1.2	0.4	7.8	2.2
	95th %ile	10-15	15-25	14-22	19	0	0	12-18	12
Winter	Total (000s mins)	602	625	942	409	44	53	381	108
	Average (mins)	6.0	5.3	9.2	4.4	0.8	1.0	6.9	2.2
	95th %ile	15-20	35-45	14-22	18	0	0-12	12-18	12

4.96 Heathrow's runways are currently operating at or very near their capacity giving very limited scope to buffer against the normal perturbations in the air traffic network or to cope with or recover from disruptions to operations. The very high utilisation at Heathrow is also reflected in its low robustness to and limited ability to recover from major disruption when compared to Gatwick.

4.97 This fragility appears to be exacerbated by the use of the runways in segregated mode with the minimum spacing between arriving aircraft when compared to the additional, buffer spacing that naturally occurs when runways are operated for both arrivals and departures.

4.98 As a consequence of operating very near to capacity, Heathrow's current performance is significantly worse than that at Gatwick in terms of stack holding and inbound airport ATFM delays. The performance of the two airports is comparable for ground holding for departures. Gatwick's poor performance in ground holding, relative to stack holding and ATFM delays, is probably due to priority being given to arrivals for access to the mixed mode runway.

4.99 In addition, Heathrow's performance in terms of airport ATFM delays is worse than the two of its main European hub competitors that have greater capacity (Amsterdam Schiphol and Paris Charles de Gaulle) and on a par with Frankfurt with equivalent capacity. Heathrow does, however, show better resilience against adverse weather conditions than both Amsterdam Schiphol and Paris Charles de Gaulle.

5

OPERATIONAL ANALYSIS & RESULTS

SCENARIOS

5.1 The remit for the study required examination of a range of different scenarios as described below. The analysis compares these to a Base Case scenario which is the seasons of Summer 2007 and Winter 2007/2008. The scenarios are considered under Normal Operations with recovery from Severe Disruption being assessed through a set of case studies.

Normal operations

5.2 These scenarios can be grouped under the following headings:

- **sensitivity testing** to determine the impact of adding or removing a flight from a given hour;
- **reducing the number of flights** to a level at around 5% below the current level (around 2 arrivals and 2 departures per hour) for example by restricting slots both broadly across the day and in the delay peaks. This scenario is consistent with London First's proposal[9] to reduce the number of air traffic movements (ATMs) at Heathrow below the current level and is included as an illustration of the degree to which the balance has tipped in favour of additional flights in preference to resilience;
- **increased application of TEAM** to better manage periods of peak arrivals holding acknowledging and investigating the negative impact that this might have on departures;
- **application of mixed mode** delivering 15%, 10% and 5% additional capacity respectively with no additional demand[10], corresponding to the scenarios investigated by NATS and BAA in the recent Heathrow consultation[11]:
    - maximum capacity mixed mode giving 15% additional capacity with a fully flexible arrival and departure system coupled with extended airspace facilitating fully continuous descent approach (CDA) compliant approaches. NATS has some reservations about the viability of this scenario;

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[9] Imagine a world class Heathrow, London First, June 2008

[10] In its report, "Imagine a world class Heathrow", London First highlights the short-term use of mixed mode operations with no corresponding increase in ATMs and this scenario was also considered as part of the recent Heathrow consultation process (http://www.dft.gov.uk/162259/165220/302152/completecondoc.pdf page 92)

[11] Heathrow Mixed Mode Scenarios, Consultation Issue, prepared by NATS for BAA, October 2007

- a scenario giving around 10% additional capacity using TWin Arrival Streams maintaining Standard Separation (TWASS) as the arrival regime, but retaining the maximum capacity mixed mode SID structure with a CDA compliant arrivals regime but with significant airspace changes required to the departure regime. NATS estimates that it would require around 4 years to make the necessary changes to support this scenario;
- a scenario, delivering around 5% capacity increase, based on TWASS but using the current SID structure. The scenario is again CDA compliant but requires smaller changes than either of the other two mixed mode scenarios and hence could be delivered more quickly within, in NATS opinion, 2 years.

The scenarios are summarised in Exhibit 5-1.

Exhibit 5-1: Summary of the scenarios investigated

	Sensitivity testing	Additional TEAM	Mixed mode	Indicative reduction of demand
Demand added	1) Flight added in each hour separately, no capacity added			
Number of flights reduced	2) Flight removed from each hour separately, demand held at current levels			7) 5% of flights removed each hour, current capacity
Capacity added, current movement levels retained		3) application of TEAM extended across the delay peaks, demand held at current levels	4) maximum capacity mixed mode, giving 15% capacity increase 5) TWASS mixed mode with amended SID structure, giving 10% capacity increase 6) TWASS mixed mode with current SID structure, giving 5% capacity increase	

Severe disruption

5.3 The impact of severe disruption is assessed separately to normal operations, investigating how the different capacity enhancements or a reduction in demand might aid recovery based on the two case study days, 23 December and 5 November. The scenarios are:

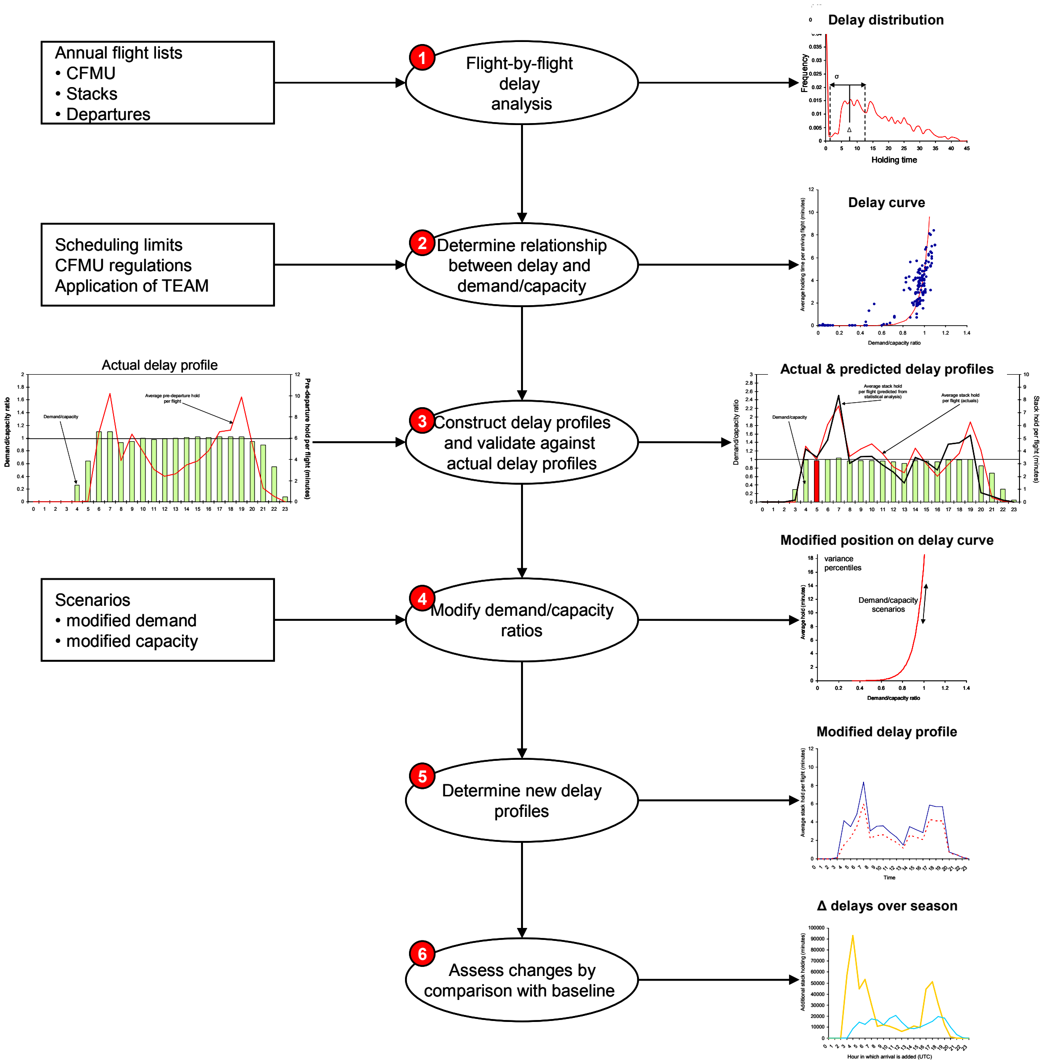
- assessment of the impact of TEAM (note that TEAM is applied currently to relieve disruption so the analysis has take the approach of determining the outcome were TEAM not to be applied);
- addition of 5% extra capacity through minimal mixed mode operations;
- reduction of 5% in demand; and
- operation of full capacity mixed mode, providing around an additional 15% of capacity.

OVERVIEW OF OPERATIONAL MODELLING

Normal operations

5.4 The approach taken to the operational modelling is statistical and is based on and validated against a large sample of operational data. Statistical techniques are very good for the rapid investigation of the large-scale properties of large systems where the mode detailed interactions are very complex and not necessarily fully understood. The same modelling process, based on a standard queuing approach, has been applied to all three elements of delay/holding: ATFM delays, stack holding for arrivals and ground holding for departures. The general approach consists of six main steps, is summarised below with an overview being given in Exhibit 5-2.

Exhibit 5-2: Overview of the analysis process



- Step 1 in the analysis process comprises analysis of flight-by-flight data to determine so-called delay distributions for each of the three types of delay or holding time. These delay distributions were calculated for each hour of operation over the two seasons and characterised by the average, the 95th percentile and the proportion of flights that were not delayed

- Step 2 in the analysis process used the delay distributions, hourly demand derived from the flight-by-flight data and capacity derived from the scheduling limits or CFMU regulations when these were in place, to determine the relationship between delay (average and 95th percentile) and the ratio of demand to capacity for each type of delay and each season independently. As all three delay types are essentially forms of queue, the relationships followed the expected exponential or power law

- Step 3 of the process used the delay, demand/capacity relationship to reconstruct the hourly delay profile for each season and to compare this predicted profile with the one actually observed for each season as a means of validating the approach

- Step 4 modified the demand/capacity ratios based on the scenarios being assessed by addition or subtraction of flights or capacity in the specific hour or hours being assessed. The new delay was predicted from the position on the delay curve of the modified demand/capacity ratio
- in Step 5, the new hourly delay profiles were constructed from the new delays derived in Step 4. Rollover effects from hour to hour were incorporated by adding an additional flight to the subsequent hour if the modified demand/capacity ratio was greater than unity
- Step 6 compared the new delay profile with the baseline and calculated the new total delays over the season accounting for changes in traffic caused by the addition or subtraction of demand.

5.5 The majority of the scenarios were based on existing or only slightly changed operational procedures and relatively marginal changes in demand or capacity. These scenarios were, therefore, based on statistical analysis using distributions derived from operational observations. As most of the analysis involved interpolation along the delay, demand/capacity curve (increased capacity or reduced demand), the curve is valid for all scenarios. This is also the case for small additions of demand.

5.6 However, in the case of the more extreme mixed mode scenarios (10 and 15% capacity increases) the delay, demand/capacity curves will be shifted because of the major operational change, that is the full mixed mode scenario is so different to the current situation that the current statistics will no longer be valid. Therefore, a specific delay, demand/capacity curve was derived to assess the mixed mode scenario using output from the NATS' HERMES model used in the recent Heathrow consultation process.

5.7 The approach used for the modelling is based on the current traffic mix, as it is derived from current operational data. It is expected, however, that the traffic mix at Heathrow will evolve (there is evidence that this is already happening) to include a higher proportion of heavy, wide body aircraft. The overall result of that will be an increase in aircraft separation caused by wake vortex consideration and a corresponding decrease in runway capacity. Ongoing operational and technological improvements such as time-based separation (TBS), improved wake vortex separation techniques, the advanced arrival manager (AMAN) and improved collaborative decision making (CDM) will address the effects of this change in traffic mix, amongst other things. These developments are investigated in Part 4 of this report.

Recovery from severe disruption

5.8 Various scenarios have been assessed for their potential for recovery from two case studies:

- 23 December 2007, when there was disruption caused by low visibility that persisted throughout the day, severely constraining the runway flow rate throughout the day and allowing no scope for recovery
- 5 December 2007, when there was a significant disruption caused by low visibility that was dissipated a few hours into the day allowing scope for recovery.

5.9 The method used to assess the scope for recovery under the scenarios is to adjust either the demand or the capacity to determine the degree to which the scenario can approach normal operations.

Presentation of results

5.10 The results of the analysis are presented here under the headings of each of the four sets of scenarios:

- sensitivity testing
- additional application of TEAM
- application of mixed mode operations
- reduction of demand.

5.11 For completeness the derived relationships between delay, demand and capacity are also illustrated as is the validation of the predictions of the statistical analysis against the observed behaviour over the last year.

Delay curves

5.12 Establishing the relationship between (holding) delay demand and capacity is the key and initial part of the analysis. This was achieved by determining the hourly demand, the hourly capacity and the average delay/hold per flight in each hour over the summer and winter seasons, as follows:

- for the stack and ground holding analysis, demand was determined from the number of aircraft exiting the stack or pushing back from the stand in a given hour
- for the airport ATFM analysis, the hourly demand was determined as the number of aircraft that would use the runway after all non-airport related ATFM restrictions had been taken into account but prior to the airport restrictions being applied, that is the number of aircraft that would have

arrived in a given hour had there been no airport related ATFM restrictions

- capacity was defined as the hourly scheduling limit when no airport related ATFM restrictions had been applied or the ATFM regulated hourly flow rate when ATFM restrictions were in place
- delay or holding was defined as: 1) the time spent in the stack for arrivals holding; 2) the ATFM delay attributed to the airport when the airport was the cause of the most penalising regulation for the flight; and 3) the difference between the variable taxi time (VTT) (defined as the unimpeded taxi time from the departure stand to the departure runway) and the actual taxi time between the departure stand and the departure runway for ground holding
- mixed mode relationships were derived from the output of the NATS HERMES model scenario describing the maximum capacity mixed mode situation using 2015 traffic schedules. To perform this analysis it was necessary to combine the results of HERMES simulations for use of the Easterly and Westerly runways. This was done using a weighted average with the ratio of 30% easterlies to 70% westerlies[12] as is observed in current operations
- the relationship was determined for the average delay per flight in the hour as well as the 95th percentile of the delay in the hour.

5.13 As each of the delays takes the form of a queue, the relationship was investigated in terms of assessing the average delay or holding time as a function of the ratio of demand to capacity. The relationship was defined by taking the best curve fit to the observed data using either standard power law curve or exponential relationships[13], whichever gave the best fit, in line with queuing theory. The relationships between average delay and demand/capacity are therefore empirical in nature but are consistent with queuing theory.

5.14 The derived relationships for average ATFM, stack holding and ground holding are shown in the following three sections for ATFM delays, stack holding and ground holding derived from the current operations and for mixed mode operations derived from the NATS HERMES mode in the fourth section.

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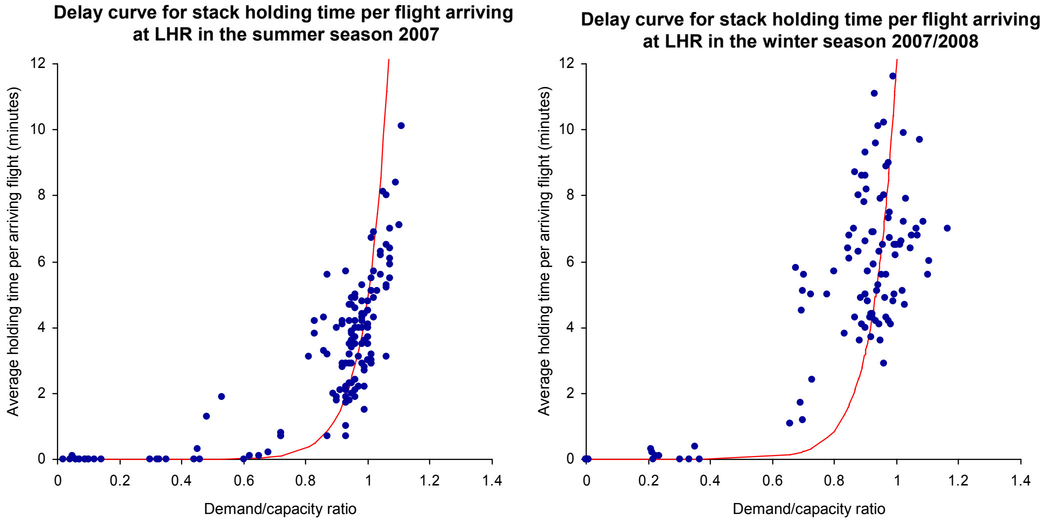
[12] http://www.heathrowairport.com/portal/page/HeathrowNoise%5ENoise+explained%5EFAQs/925ee8dae5709010VgnVCM10000036821c0a____/448c6a4c7f1b0010VgnVCM200000357e120a____/)

[13] Different queuing relationships are best described by exponential relationships of the form $Aexp^{(bx)}$ or power law relationship of the form Ax^b depending whether the inputs and outputs of the queue are ordered or random in nature

Stack holding

5.15 The relationship between the average stack holding time and the demand/capacity ratio is shown in Exhibit 5-1 for both the summer and winter seasons.

Exhibit 5-3: The relationship between the average stack holding time per flight and the demand/capacity ratio at Heathrow



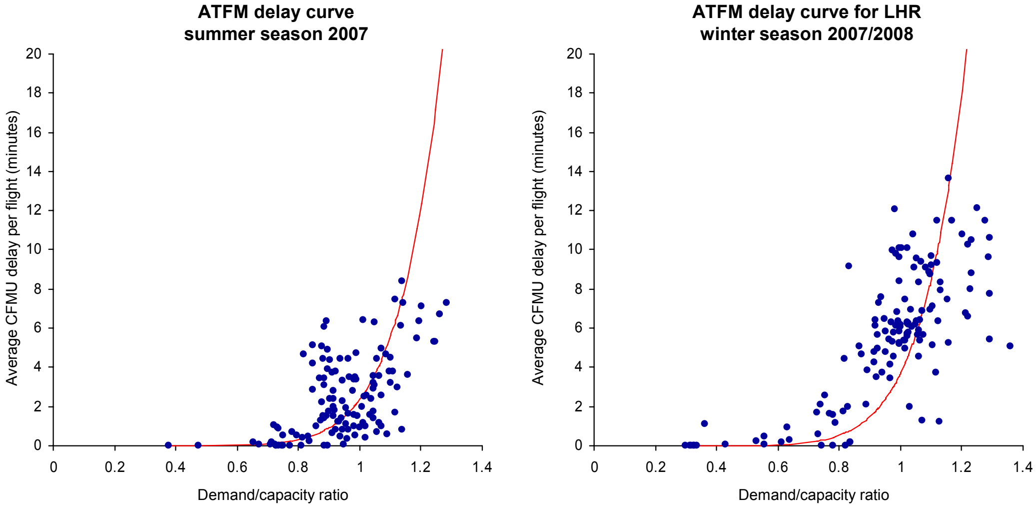
Source: NATS, Helios analysis

5.16 There is less scatter on the observed data points for stack holding than there is for ATFM delays, probably reflecting the higher complexity network effects that are likely to influence the ATFM situation. There is a strong visible relationship between the holding times and the demand/capacity ratio that is best described by an exponential relationship below a demand/capacity ratio of around 0.8 and a power law relationship above this value. Correlation coefficients are around 0.8 for both summer and winter seasons confirming the strong relationship.

ATFM delays

5.17 Exhibit 5-4 shows the observed average ATFM delays per flight on an hourly basis averaged as a function of the demand/capacity ratio as points. The solid curves show the best curve fits to the observed data (from which the severely disrupted days were excluded as they were treated separately) using a power law relationship for both summer and winter curves. Power law curves gave a better fit in this case than the alternative exponential function.

Exhibit 5-4: The relationship between average ATFM delay per flight and the demand/capacity ratio at Heathrow


ATFM delay curve summer season 2007

ATFM delay curve for LHR winter season 2007/2008

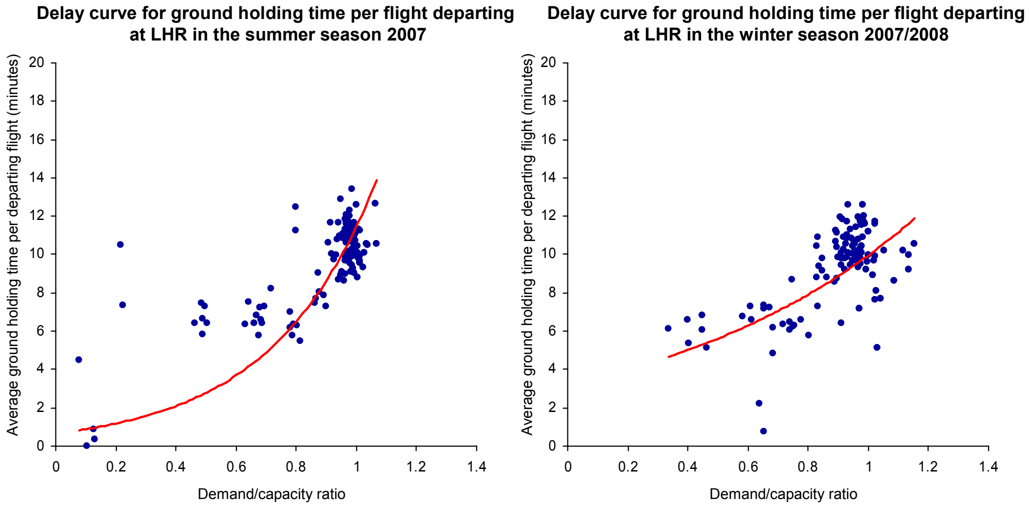
Source: CFMU, Helios analysis

5.18 Although there is a clear relationship between the ATFM delay and the demand/capacity relationship, the observed points show considerable scatter about the best fit curves indicating that the relationship is weak, with a correlation coefficient of approximately 0.3 in summer and 0.6 in winter, and may be masked by other effects. The implication of the relatively loose fit of the curve to the data is that there will be a greater error in results derived from the curve than in the case where the fit is better, as above.

Ground holding

5.19 Exhibit 5-5 shows the relationship between average ground holding time per flight (defined as the difference between the actual and perfect taxi time) and the demand/capacity ratio.

Exhibit 5-5: The relationship between the average ground holding time per flight and the demand/capacity ratio at Heathrow


Delay curve for ground holding time per flight departing at LHR in the summer season 2007

Delay curve for ground holding time per flight departing at LHR in the winter season 2007/2008

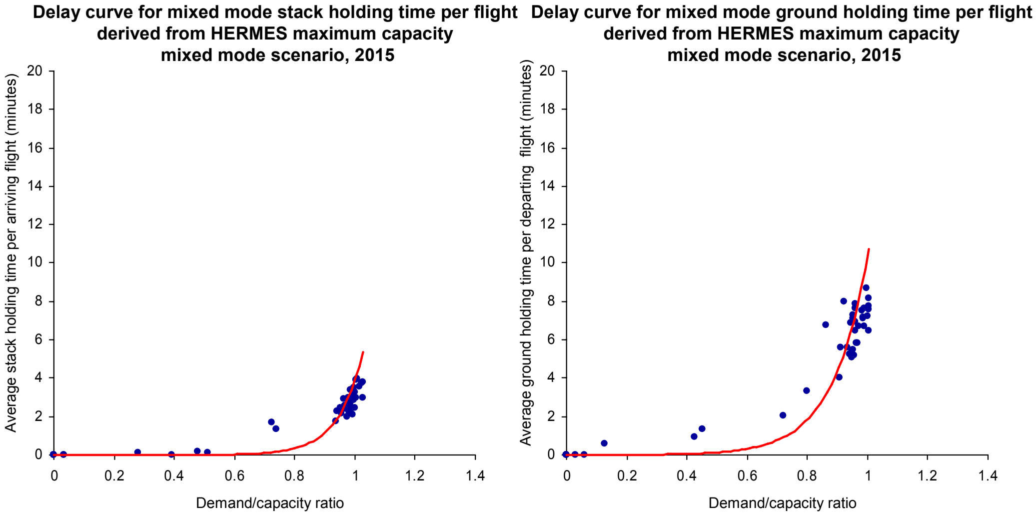
Source: NATS, Helios analysis

5.20 For ground holding there is a high degree of scatter of the observed points around the best fit curves, which in this case are exponential with correlation coefficients of around 0.3. This again indicates the complexity of the situation and the presence of other interactions which may be masking the situation. Another indication of the presence of other influences is provided by the observation that the intercept on the y-axis does not occur at zero – it occurs at around 0.6 for the summer curve and around 3.1 for the winter curve. This suggests that when demand approaches zero (and the taxi time would be expected to approach its perfect value) that there is 0.6 and 3.1 minutes additional taxi time in summer and winter respectively. If these differences were solely due to errors in the variable taxi time (the measure of the perfect taxi time) then they might be expected to be approximately the same value in summer and winter. However, the difference between the summer and winter intercept values indicates that there is some other, as yet not understood, systematic influence in addition to the variable taxi time, which may be associated, for example, with slower taxi speeds in winter due to adverse weather.

Mixed mode

5.21 Exhibit 5-6 shows the relationship between the average stack holding and ground holding times and the demand/capacity ratio derived from the results of the NATS HERMES simulation of the maximum capacity mixed mode scenario with 2015 traffic. In performing the analysis it was necessary to combine the HERMES results, which are derived for easterly and westerly runway operations separately, into a weighted average. The accepted ratio of 70% westerly to 30% easterly operations was used.

Exhibit 5-6: The relationship between the average stack and ground holding times per flight and the demand/capacity ratio predicted by HERMES for the maximum capacity mixed mode scenario with 2015 traffic



Delay curve for mixed mode stack holding time per flight derived from HERMES maximum capacity mixed mode scenario, 2015

Delay curve for mixed mode ground holding time per flight derived from HERMES maximum capacity mixed mode scenario, 2015

Source: NATS, Helios analysis

5.22 The scatter of the points generated by HERMES around the best fit curves is considerably less than that observed in any of the other cases where the operational data were derived from real observations and not a simulation. This is to be expected as HERMES cannot capture the true complexity of the situation and, in fact, does not address the ATFM component at all. The correlation coefficients in this case are greater than 0.9 for both arrivals and departures.

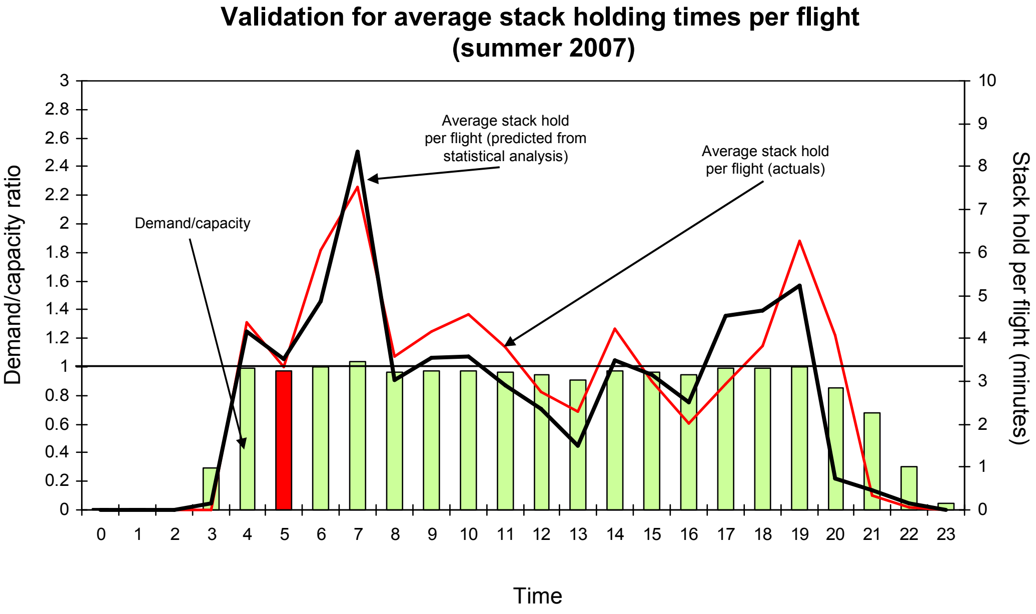
Validation

5.23 This section shows the results of comparing predicted delay profiles generated from the delay curves described above with the actual observed delay profiles as a means of validating the modelling approach.

Stack holding

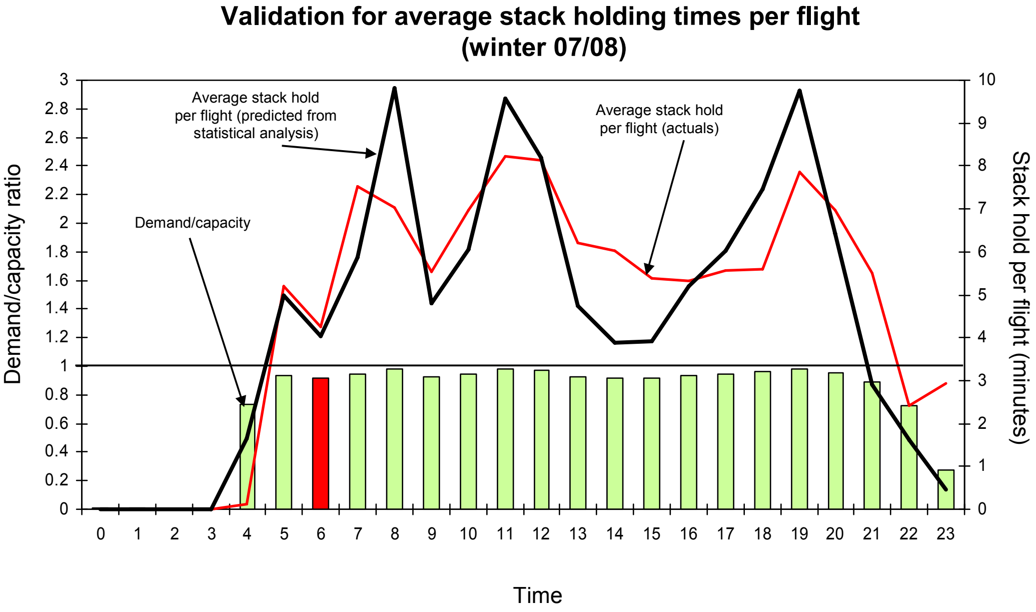
5.24 Exhibits 5-7 and 5-8 show the comparisons between the average stack holding times per flight observed and predicted from the curves in Exhibit 5-3. The bars show the demand/capacity ratio and the red bar shows the hour in which TEAM is applied.

Exhibit 5-7: Comparison of predicted and actual average stack holding times per flight for the summer season 2007



Source: NATS, Helios analysis

Exhibit 5-8: Comparison of predicted and actual average stack holding times per flight for the winter season 2007/2008



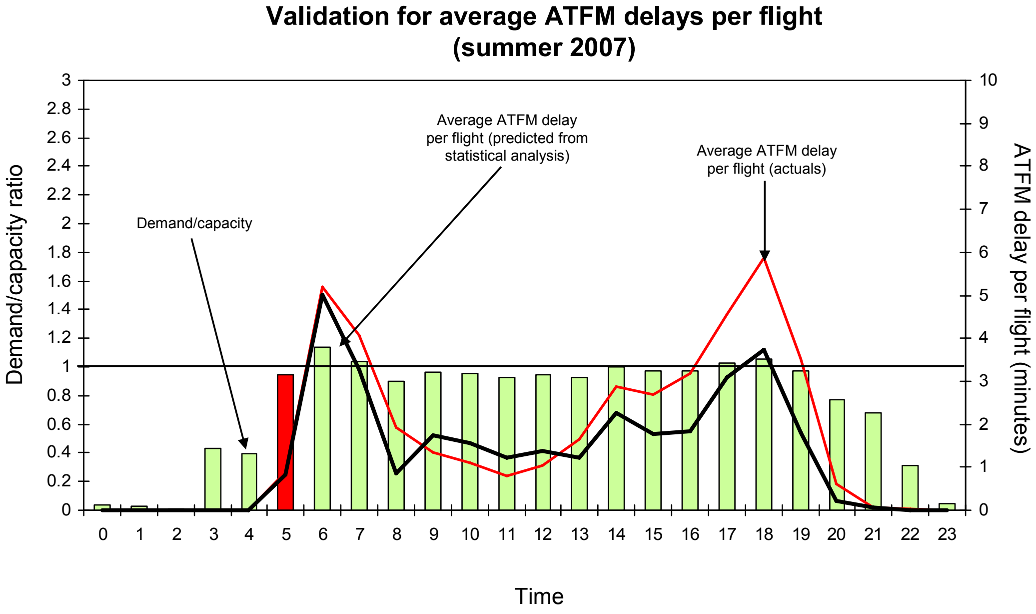
Source: NATS, Helios analysis

5.25 The match between the shape of the observed and predicted curves is good for both summer and winter seasons. The difference between the total observed delays and the total predicted delays is an underestimate of around 8% for the summer season and around 3% for the winter season.

Airport ATFM delays

5.26 Exhibit 5-9 compares, as lines, the observed average ATFM delays per flight for each hour over the summer season with those predicted using the summer delay curve shown in Exhibit 5-4 with the average hourly demand/capacity ratios observed over the season. The bars on the chart show the demand/capacity ratio for each hour with the red bar indicating that TEAM is applied in the 05:00 UTC hour and that the capacity has been adjusted accordingly.

Exhibit 5-9: Comparison of predicted and actual average ATFM delays per flight for the summer season 2007



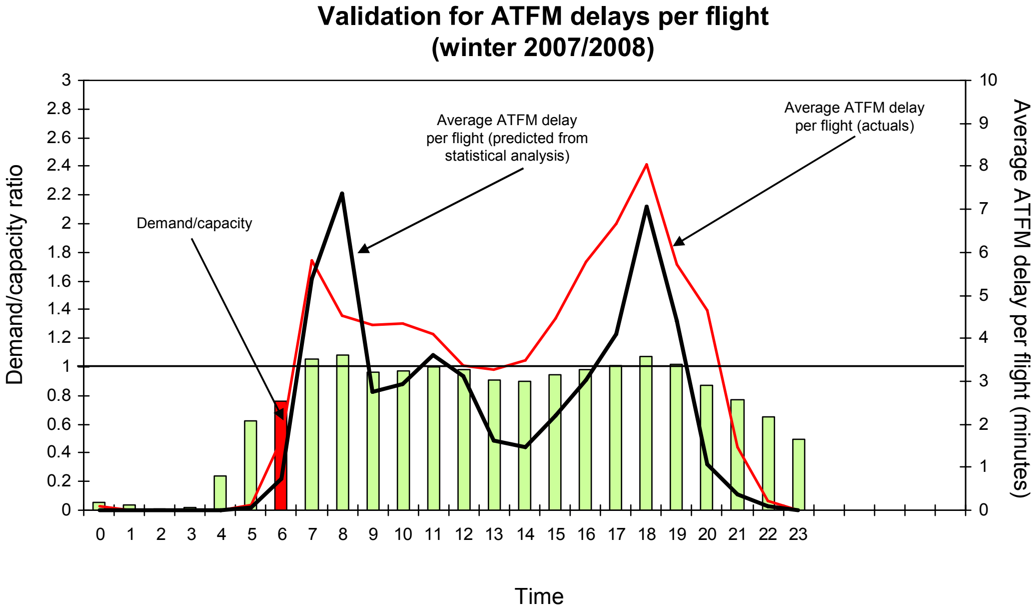
Source: CFMU, Helios analysis

5.27 The match of the general shapes of the observed and predicted ATFM delay profiles shown in Exhibit 5-9 is good but the predicted curve underestimates the total delay over the season by approximately 22%. Given the scatter of the points around the best fit line in Exhibit 5-4, this error range is surprisingly good.

5.28 Exhibit 5-10 makes the same comparison between the predicted and observed average ATFM hourly profiles for the winter season. The demand/capacity ratios are shown as bars and the delays are shown as lines. The red bar indicates the hour in which TEAM is applied and the appropriate adjustment has been made to the capacity. Again the match of the general shapes of the two curves is reasonable and in this case the prediction underestimates the actual total delays by around 28%.

5.29 The relatively large errors in the predictions of ATFM delays are primarily caused by the large scatter of points around the derived delay curve, which is probably caused by the complex network interactions associated with the ATFM system. This will cause a large uncertainty in the cost modelling but as costs are being compared to the baseline also derived from the modelling results, systematic errors will be minimised in the subtraction process.

Exhibit 5-10: Comparison of predicted and actual average ATFM delays per flight for the winter season 2007/2008



Source: CFMU, Helios analysis

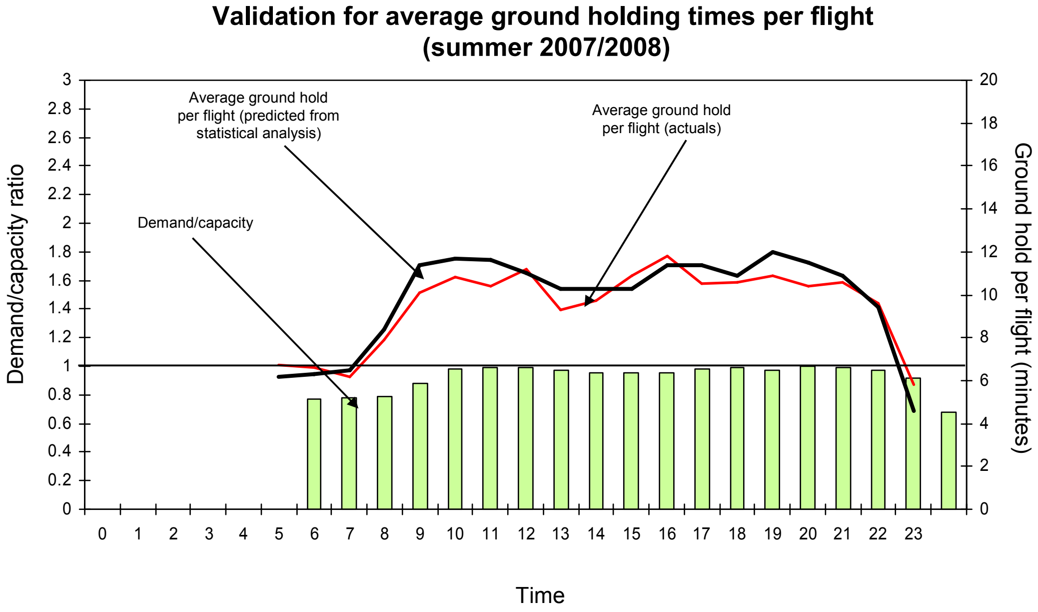
Ground holding

5.30 Exhibits 5-11 and 5-12 show the comparisons between the observed average ground holding delays and those predicted using the curves shown in Exhibit 5-5 combined with the demand/capacity ratios shown as bars in Exhibits 5-11 and 5-12. Both sets of delay profiles are generally featureless and the statistical model predicts the magnitude of the delays reasonably well in both summer and winter with an overestimate of approximately 5% and an underestimate of approximately 7% respectively.

5.31 It is interesting to note the relatively low demand/capacity ratios in the departure profiles in the early morning, indicating that the use of the departures runway for arrivals in TEAM would not have any great effect on departures capacity at that time. At other times in the day, however, the demand/capacity ratio for departures approaches 1 so there would likely be a negative impact of applying TEAM.

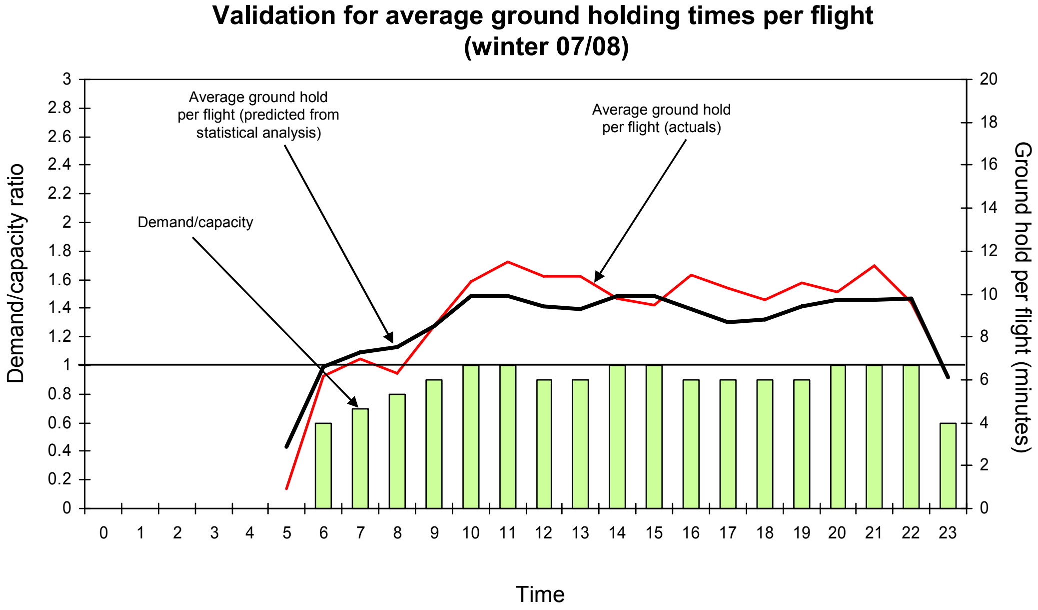
5.32 It is also interesting to note that the demand/capacity ratio for departures never exceeds 1, which it does for arrivals (see Exhibits 5-5 and 5-6), indicating that arrivals demand is managed better than arrivals demand.

Exhibit 5-11: Comparison of predicted and actual average ground holding times per flight for the summer season 2007



Source: NATS, Helios analysis

Exhibit 5-12: Comparison of predicted and actual average ground holding times per flight for the winter season 2007/2008

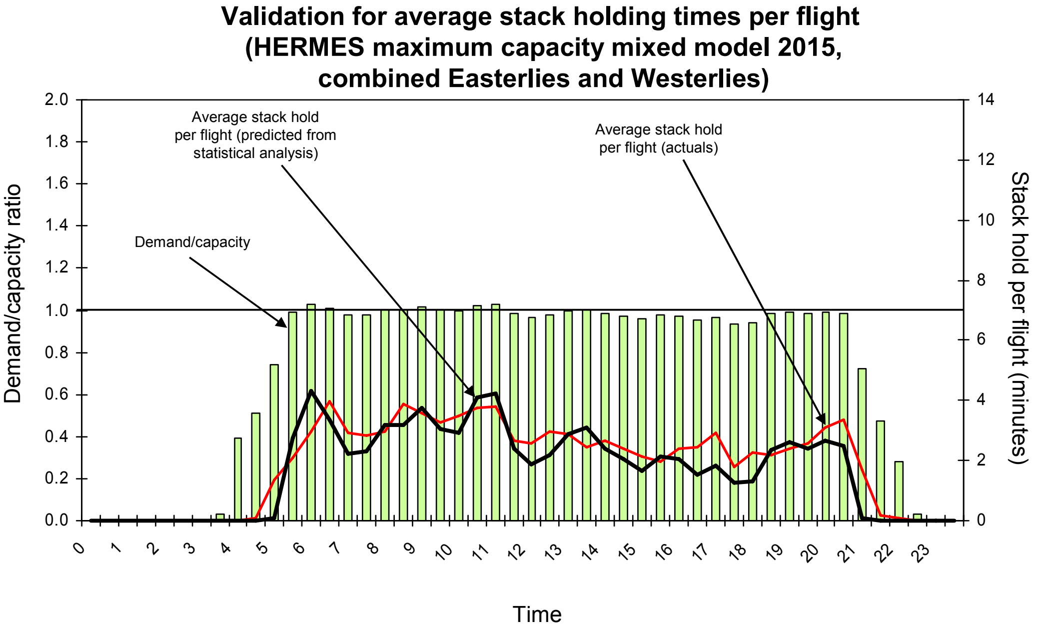


Source: NATS, Helios analysis

Mixed mode

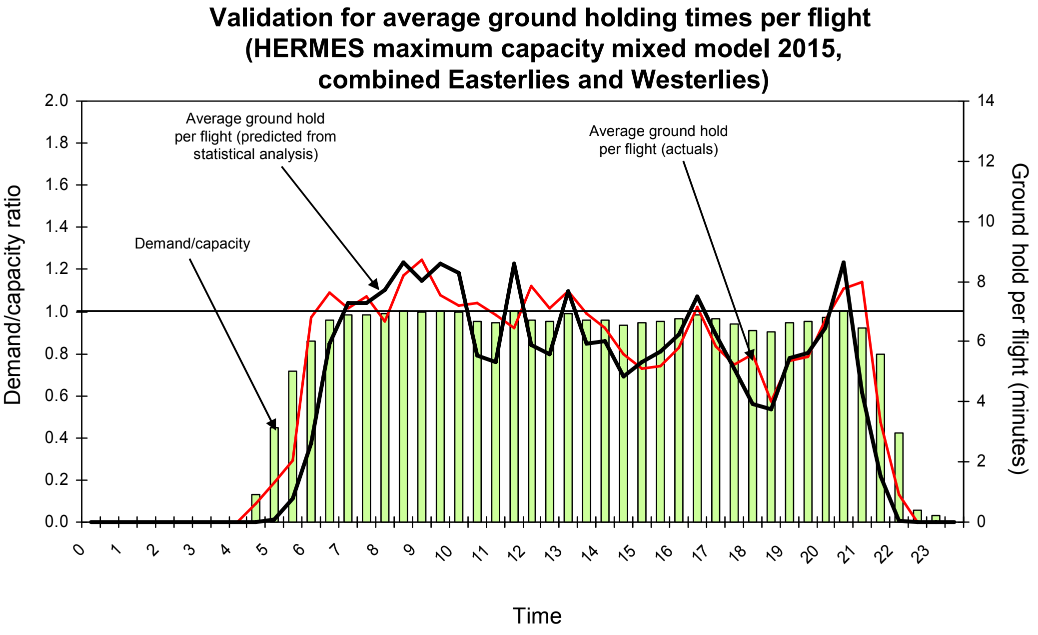
5.33 The comparison of the HERMES results for the full capacity mixed mode scenario and those predicted from the statistical model is made in Exhibits 5-13 and 5-14 for stack and ground holding traffic profiles. The data available for this validation for HERMES only covers the summer season.

Exhibit 5-13: Comparison of predicted and HERMES generated average stack holding times per flight for 2015



Source: NATS, Helios analysis

Exhibit 5-14: Comparison of predicted and HERMES generated average ground holding times per flight for 2015



Source: NATS, Helios analysis

The statistical model underestimates the total delay predicted by HERMES by around 11% for arrivals and 9% for departures.

Sensitivity testing

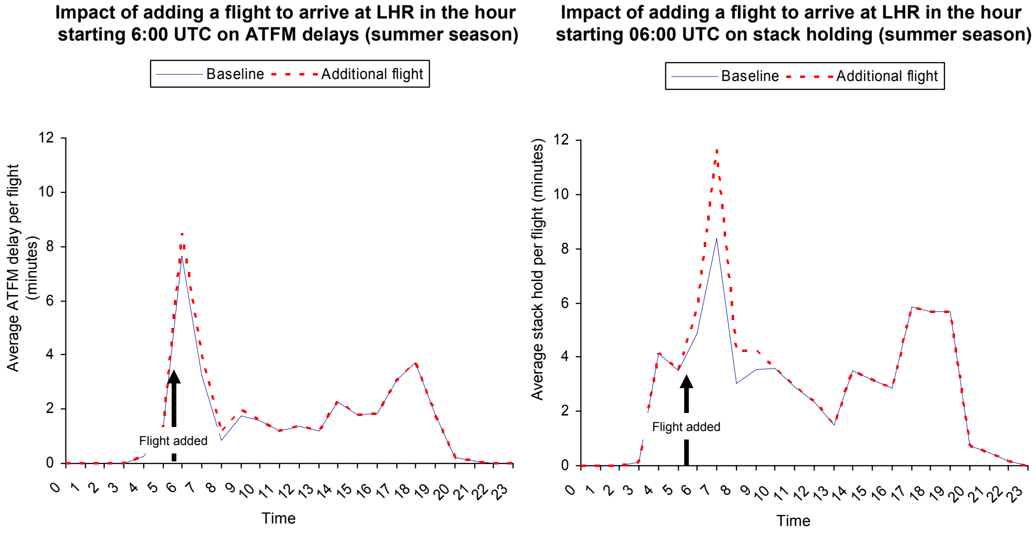
5.34 To test the sensitivity of the current situation at Heathrow to small perturbations, an analysis has been performed using the statistical models described above to assess the impact of adding or removing a single flight from a given hour compared to the baseline predicted by the model. The results of this analysis are presented below for arrivals and departures (no attempt has been made to link the additional arrival with the additional departure).

Adding a flight in a given hour

Arrivals

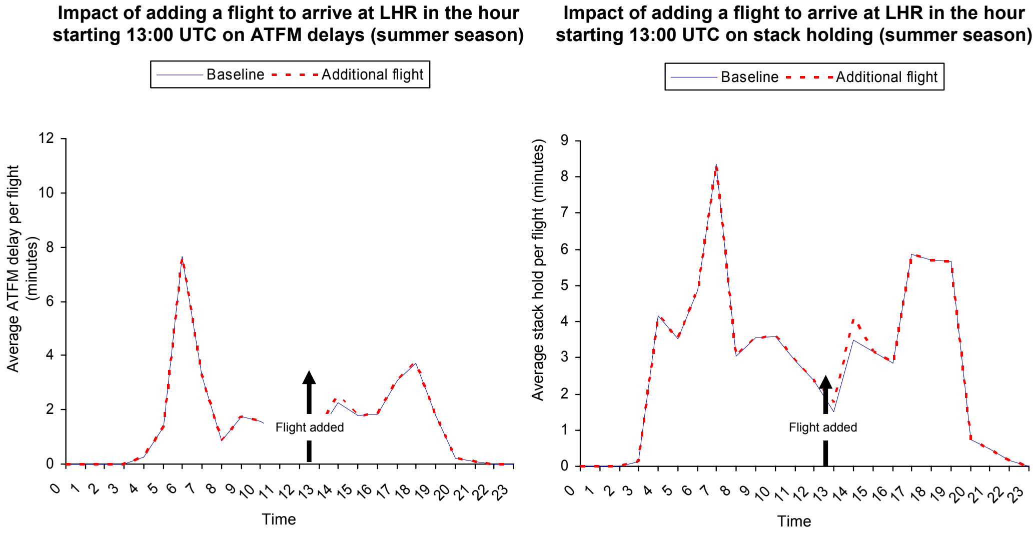
5.35 Exhibit 5-15 shows the impact of adding an additional flight to arrive at Heathrow at a high demand time at 06:00 UTC (07:00 local time) on both ATFM delays and stack holding. The figure shows that the impact on ATFM is limited whereas the impact on stack holding is more significant, increasing the average hold per flight from around 8 minutes to around 12 minutes at 07:00 (the hour following that in which the extra flight was added) with further knock-on effects until around10:00 when demand has decreased sufficiently for the system to recover its equilibrium.

Exhibit 5-15: Impact on airport ATFM delays and stack holding of adding an additional flight at 06:00 UTC in the summer season



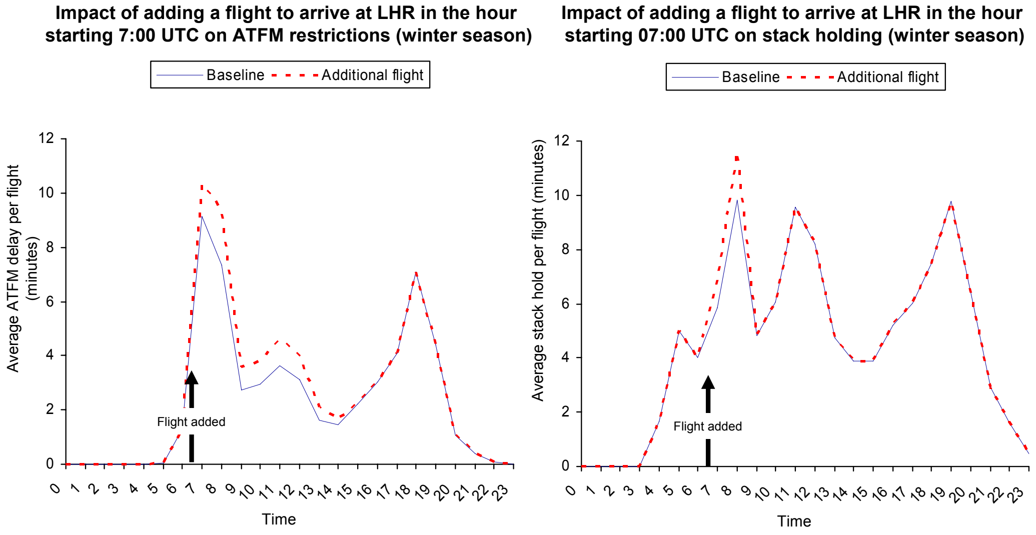
5.36 Exhibit 5-16 shows the impact on arrivals delays of adding a flight at a (for Heathrow) low demand time at around 13:00 UTC in the summer season. In this case the impact on both ATFM delays and stack holding is minimal.

Exhibit 5-16: Impact on ATFM delays and stack holding of adding an additional flight at 13:00 UTC in the summer season



5.37 For comparison purposes, Exhibit 5-17 shows the impact of adding an extra arrival at 07:00 UTC on arrivals delays in the winter season. In this case, there is an increase in average ATFM delays and average stack holding times at and shortly after 07:00. The impact on the stacks quickly dissipates but the increased average ATFM delay per flight persists until around 15:00. This persistence is due to the demand/capacity ratio of the hours subsequent to 07:00 being greater or near to 1 causing a knock-on effect from hour-to-hour until the demand/capacity ratio is sufficiently less than 1 to create a fire-break.

Exhibit 5-17: Impact on ATFM delays and stack holding of adding an additional flight at 07:00 UTC in the winter season

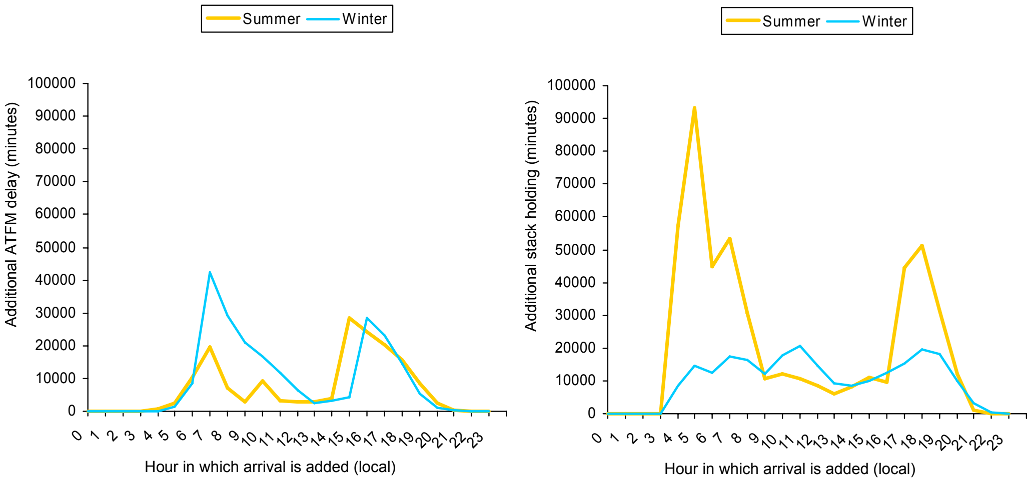


5.38 Exhibit 5-18 shows the impact in terms of total additional ATFM delays and total additional stack holding time cause by adding a flight at a given hour in the summer and winter seasons. The figure shows that when the flight is added just before or at a peak in the average delay curves, the impact can be very large.

For example, Exhibit 5-18 shows that adding a flight at 05:00 local time in summer results in an increase in stack holding time of around 90000 minutes over the whole year – equivalent to the entire stack holding at Gatwick over the same period. This occurs because the demand/capacity ratio for the stacks at 05:00 local time and the following few hours is high; the demand/capacity ratio at that hour and subsequently is very near to or above 1 meaning that the gradient of the delay curve (Exhibit 5-3) is very steep and increasing. Together these factors mean that the average delay is very sensitive to even small additions of demand. This sensitivity is confirmed through operational observations (see section 4) where small changes in demand (from 39 to 40 an hour) cause a very large increase in holding. This scenario, of course, does not correspond to an operational reality because before incurring such a high increase in stack holding, NATS would extend the use of TEAM to manage the situation. The impact of TEAM at 06:00 local time can be seen in the large fall in the increase in delays caused by adding a flight at 06:00 compared to adding one at 05:00.

5.39 The impact of adding the additional flight at 05:00 local time on ATFM delays is much lower than that on the stacks because at that time there is very little demand at Heathrow for arrivals from Europe, most arrivals being intercontinental flights.

Exhibit 5-18: Summary of the impact of adding a flight in a given hour on ATFM delays and stack holding in the summer and winter seasons



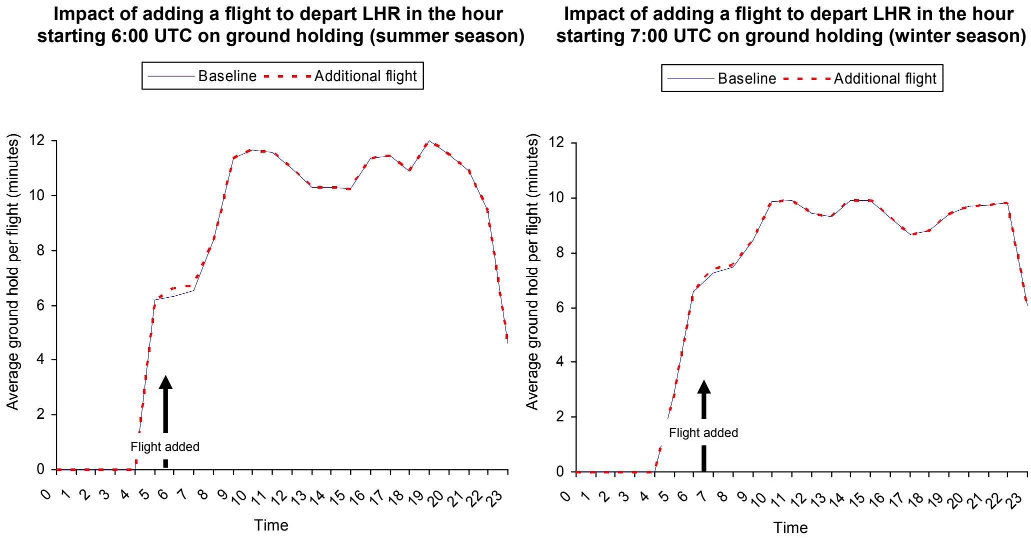
5.40 Exhibit 5-18 also shows that in summer addition of a flight has a greater impact on stack holding than on ATFM delays whereas the reverse is observed in winter.

Departures

5.41 Exhibit 5-19 shows the impact of adding an additional flight on average ground holding times for a flight added at 07:00 local time in the summer and winter seasons.

5.42 The figure indicates that at this time, ground holding is largely insensitive to the addition of a flight because of the low level of the demand/capacity ratio at that time (see Exhibits 5-11 and 5-12).

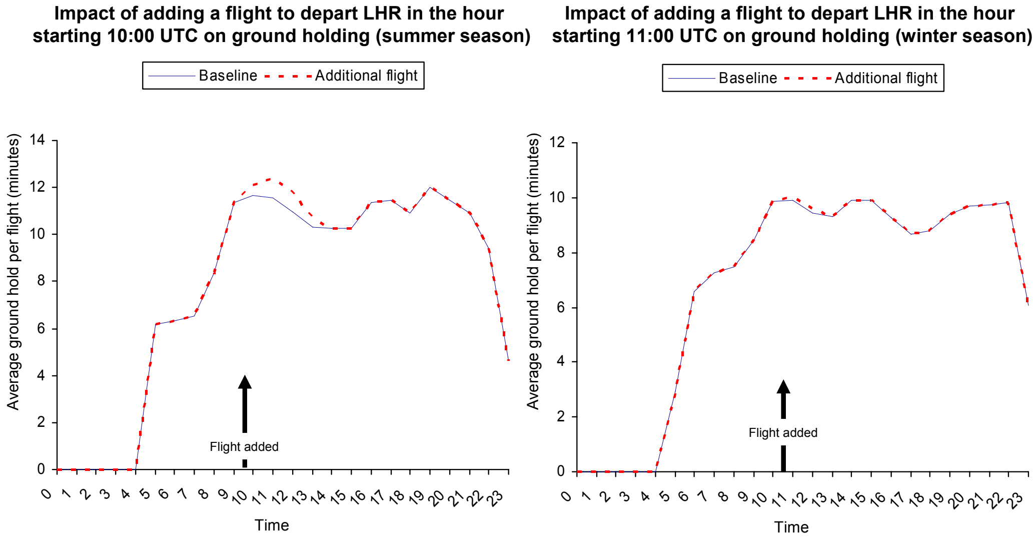
Exhibit 5-19: Impact on ground holding of adding an additional flight at 07:00 local time in the summer and winter seasons


Impact of adding a flight to depart LHR in the hour starting 6:00 UTC on ground holding (summer season)

Impact of adding a flight to depart LHR in the hour starting 7:00 UTC on ground holding (winter season)

5.43 In contrast, Exhibit 5-20 shows the impact on ground holding of adding an additional flight at 11:00 local time in the summer and winter seasons. In the summer season, the average ground holding time per departure is increased by up to one minute in the hour that the flight is added and the two subsequent hours. The equivalent impact in the winter season is minimal. Again this impact is due to the demand/capacity ratio at the time the flight is added and shortly afterwards.

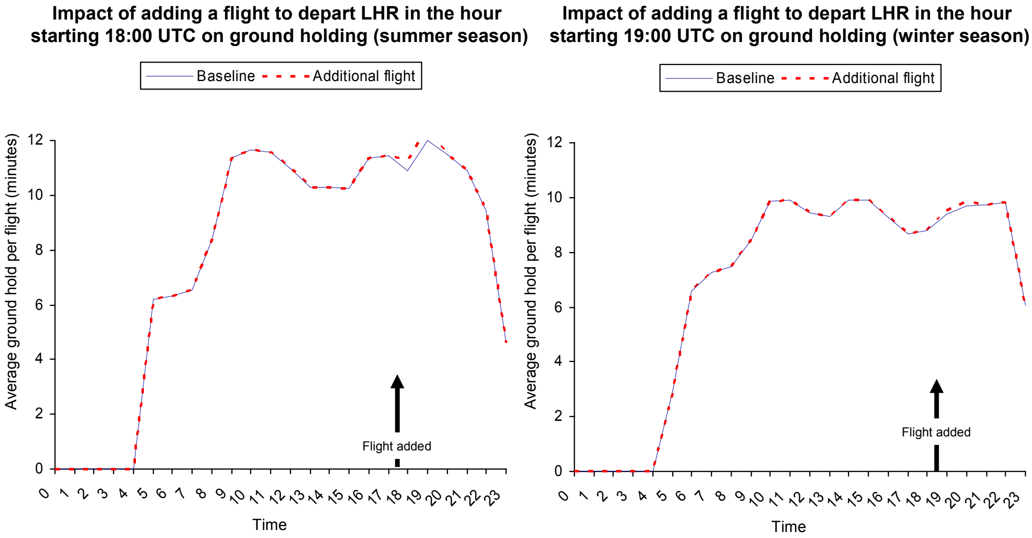
Exhibit 5-20: Impact on ground holding of adding an additional flight at 11:00 local time in the summer and winter seasons


Impact of adding a flight to depart LHR in the hour starting 10:00 UTC on ground holding (summer season)

Impact of adding a flight to depart LHR in the hour starting 11:00 UTC on ground holding (winter season)

Exhibit 5-21 shows that the average ground holding time per flight is insensitive to addition of a flight in the early evening at 19:00 in both summer and winter seasons.

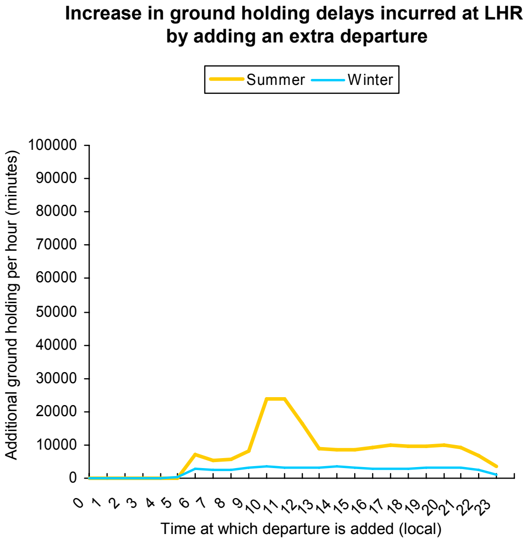
Exhibit 5-21: Impact on ground holding of adding an additional flight at 19:00 local time in the summer and winter seasons



5.44 Exhibit 5-22 summarises the impact of adding a flight on ground holding by showing the total additional ground holding time that would be generated by adding a flight in a particular hour. The main feature in the curve describing the impact of adding an additional flight on ground holding is a peak in the summer season when a flight is added between 10:00 and 13:00 local time. This peak occurs because of the high demand/capacity ratio at those times.

5.45 More generally, adding a flight has much less impact on ground holding than it has on ATFM delays and stack holding. Mathematically this is explained by the fact that the delay curves for ground holding (Exhibit 5-5 are significantly flatter than the equivalent curves for ATFM delays and stack holding (Exhibits 5-3 and 5-4). Operationally, the demand/capacity ratio for ground holding has a value that does not exceed 1 whereas for both ATFM and stack holding there are peaks during the day where the demand/capacity ratio exceeds 1. This indicates that the ground situation is more controllable – for example aircraft are not allowed to push back until the system can cope with them – than the airborne situation where aircraft actually arrive or are predicted to arrive at the top of stack in a more random, less controlled fashion influencing both ATFM delays and the stacks themselves.

Exhibit 5-22: Summary of the impact on ground holding of adding a flight in a given hour on departure delays in the summer and winter seasons



Subtracting a flight in a given hour

Arrivals

5.46 The converse of adding a flight at a given hour, is subtracting a flight from a given hour – this could be realised by not reallocating a slot when it has been given up. Exhibits 5-23 and 5-24 illustrate the impact of subtracting a flight at times around the morning and evening peaks of the average ATFM delay and stack holding curves.

Exhibit 5-23: Impact on ATFM delays and stack holding of removing a flight at 06:00 UTC

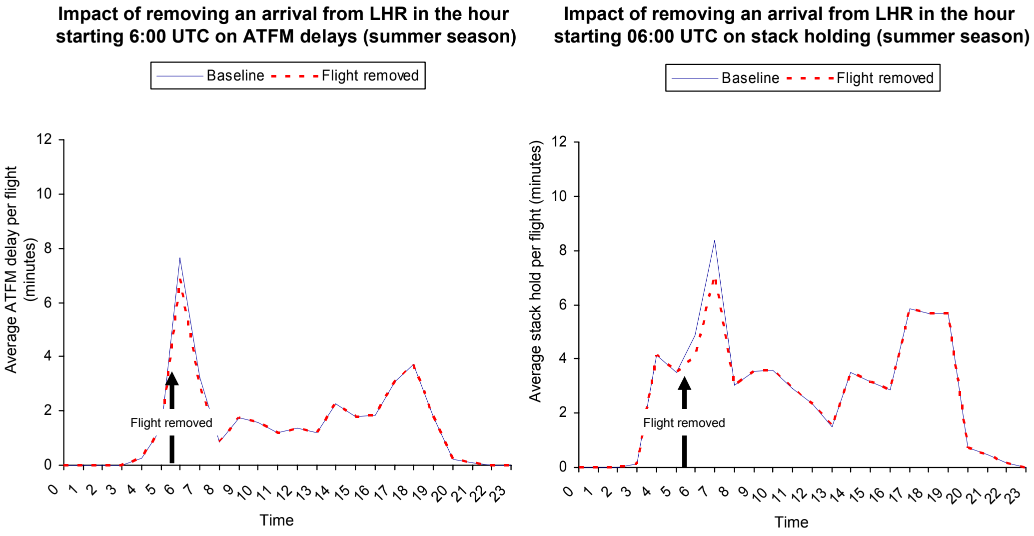
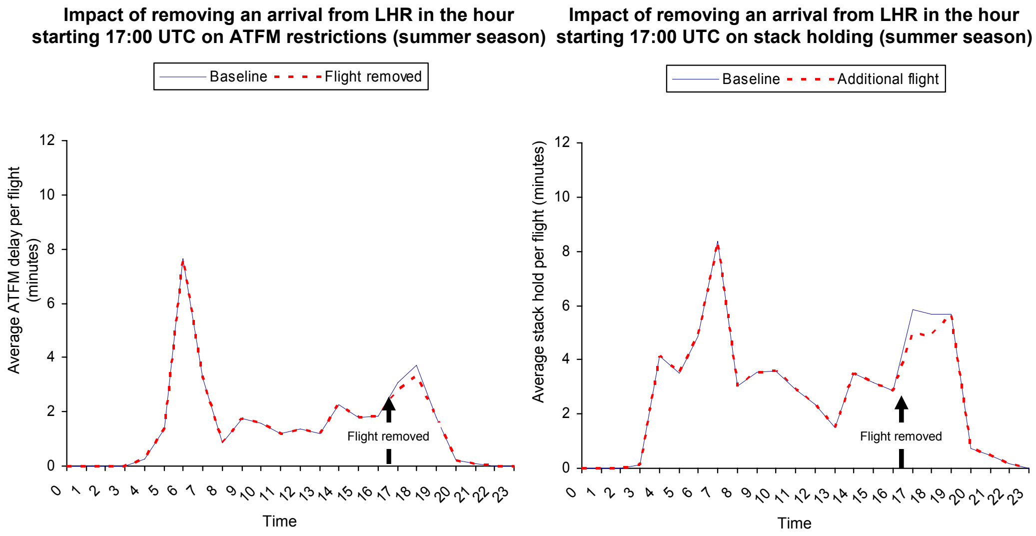


Exhibit 5-24: Impact on ATFM delays and stack holding of removing a flight at 17:00 UTC

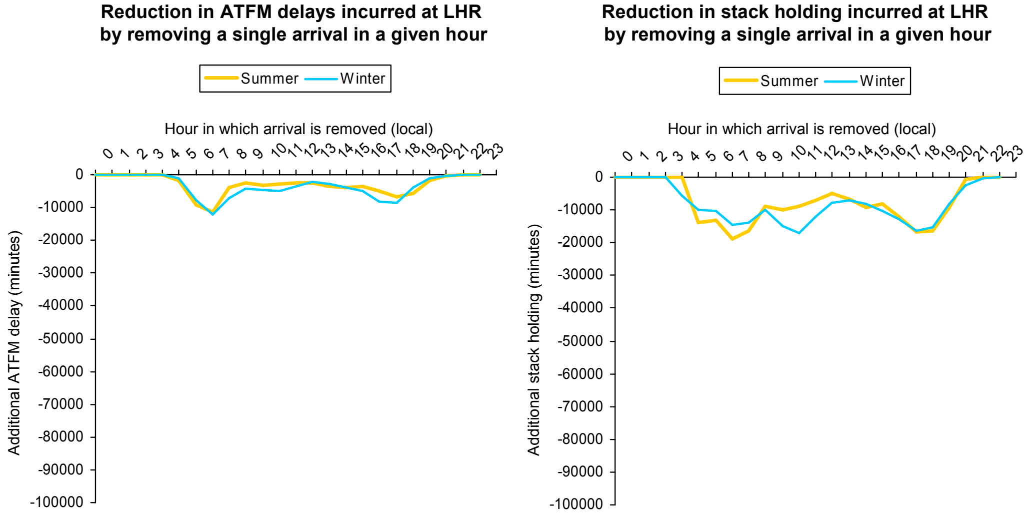


5.47 The sensitivity of the average ATFM and stack holding delays is much less when a flight is subtracted than when one is added for two main reasons:

- subtracting a flight moves the demand/capacity ratio down the delay curve whose gradient, being exponential in nature, becomes flatter as the demand/capacity ratio decreases; hence the removal of a flight would be expected to have less impact than the addition of a flight. For example, moving down the curve from a demand/capacity ratio of 1.0 to 0.95 reduces the average stack holding time by around 2.4 minutes whereas increasing the demand/capacity ratio to 1.05 increased the average stack holding time by around 4.8 minutes
- the knock-on effects to subsequent hours are much less pronounced when removing a flight than adding one
- adding flights multiplies the average by a higher number than the baseline to reach the total delay whereas subtracting flights reduces the factor by which the average is multiplied to determine the total stack holding time.

5.48 Exhibit 5-25 illustrates the impact of these effects showing that removal of a flight around one of the peaks results in a reduction of around 20000 minutes of stack holding over the season as opposed to the 90000 additional stack holding minutes that result from the addition of a flight at the same time.

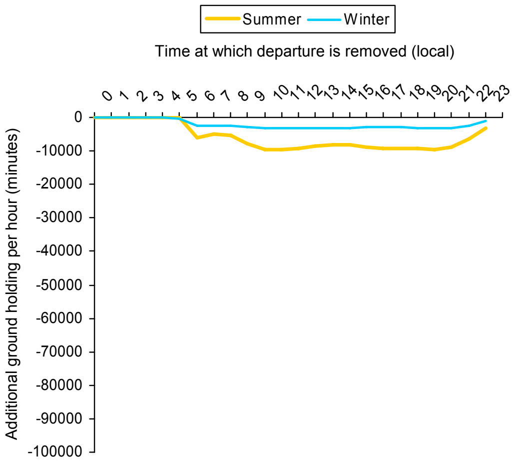
Exhibit 5-25: Summary of the impact of removing a flight in a given hour on ATFM delays and stack holding in the summer and winter seasons



Departures

5.49 Exhibit 5-26 summarises the impact on the total ground holding time of subtracting a flight at a given hour for both the summer and winter seasons. As the delay curves for ground holding are much shallower and flatter than they are for stack holding, the impact of removing a flight is much closer in magnitude to the impact of adding a flight with the exception of the peak in the middle of the day observed when adding a flight in the summer season.

Exhibit 5-26: Summary of the impact of removing a flight in a given hour on ground holding in the summer and winter seasons



Additional TEAM

5.50 The first realistic scenario investigated concerns extending the application of TEAM beyond 06:00 local time where it is consistently applied at present (as well as being used on an ad hoc basis when necessary). TEAM delivers benefits for arrivals around the times when there are peaks in the average stack holding time, that is to relieve pressure on the stacks when it is building up. The benefits of applying TEAM at other times are likely to be more limited. Therefore the scenario has been defined to investigate the impacts on both arrivals and departures of the additional application of TEAM around the morning peak, extending its application to cover the three hour period from 06:00 to 08:00 local time as well as applying it consistently over a three hour period in the evening peak from 17:00 to 20:00 local time.

Arrivals

5.51 Exhibit 5-27 shows the impact on the average ATFM delay per flight and the average stack holding time per flight of the extended application of TEAM in the summer season. In all cases there is a significant reduction in the peaks by a factor of around 50%.

Exhibit 5-27: Impact on ATFM delays and stack holding of operating TEAM from 04:00 to 07:00 and from 16:00 to 19:00 UTC in the summer season

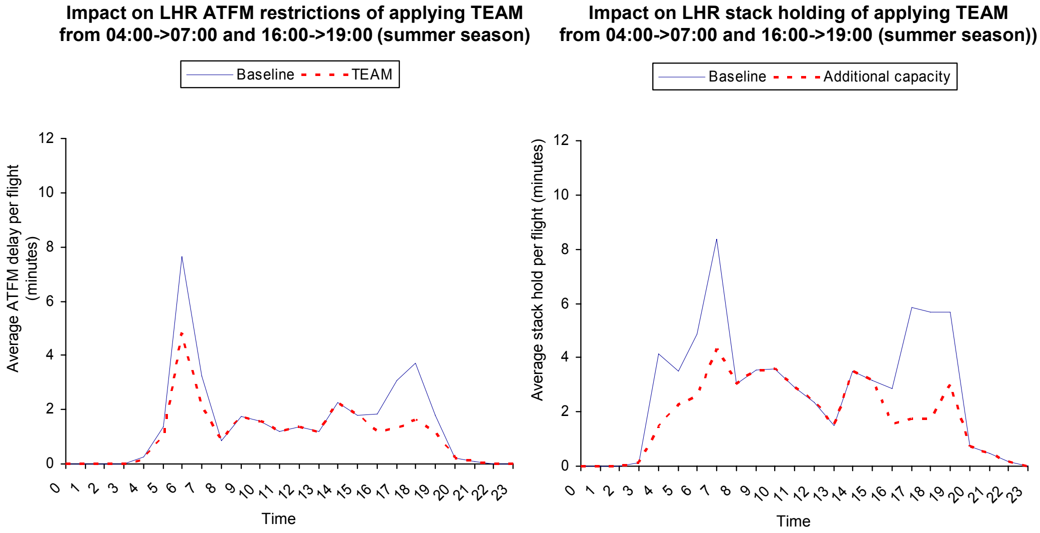
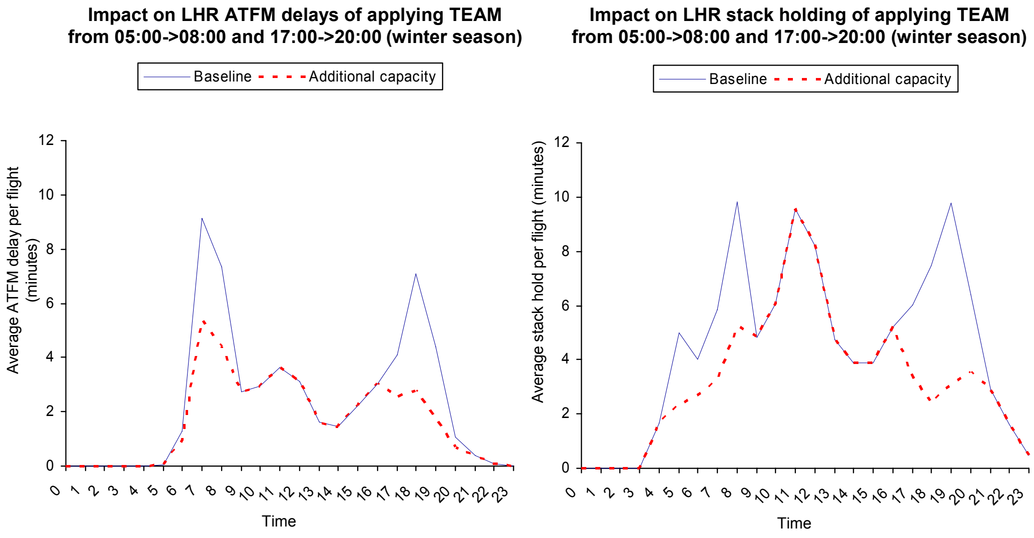


Exhibit 5-28 shows the impact of the additional application of TEAM on arrivals during the winter season. Again, there are marked reductions in the scale of the ATFM delay and stack holding peaks.

Exhibit 5-28: Impact on ATFM delays and stack holding of operating TEAM from 05:00 to 08:00 and from 17:00 to 20:00 UTC in the winter season

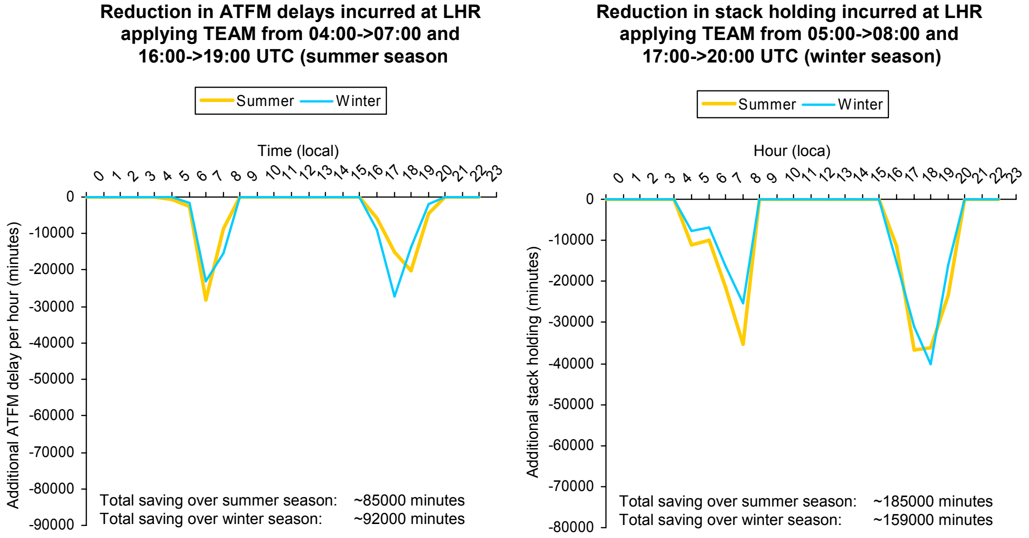

Impact on LHR ATFM delays of applying TEAM from 05:00->08:00 and 17:00->20:00 (winter season)

Impact on LHR stack holding of applying TEAM from 05:00->08:00 and 17:00->20:00 (winter season)

5.52 Exhibit 5-29 summarises the impact of additional TEAM on arrivals through the total savings achieved in ATFM delays and stack holding over the summer and winter seasons. The figure shows that this application of TEAM might be expected to save:

- approximately 85000 minutes of ATFM delays over the summer season and approximately 92000 minutes of ATFM delay over the winter season
- approximately 185000 minutes of stack holding over the summer season and approximately159000 minutes of stack holding over the winter season.

Exhibit 5-29: Summary of the impact on ATFM delays and stack holding of additional deployment of TEAM

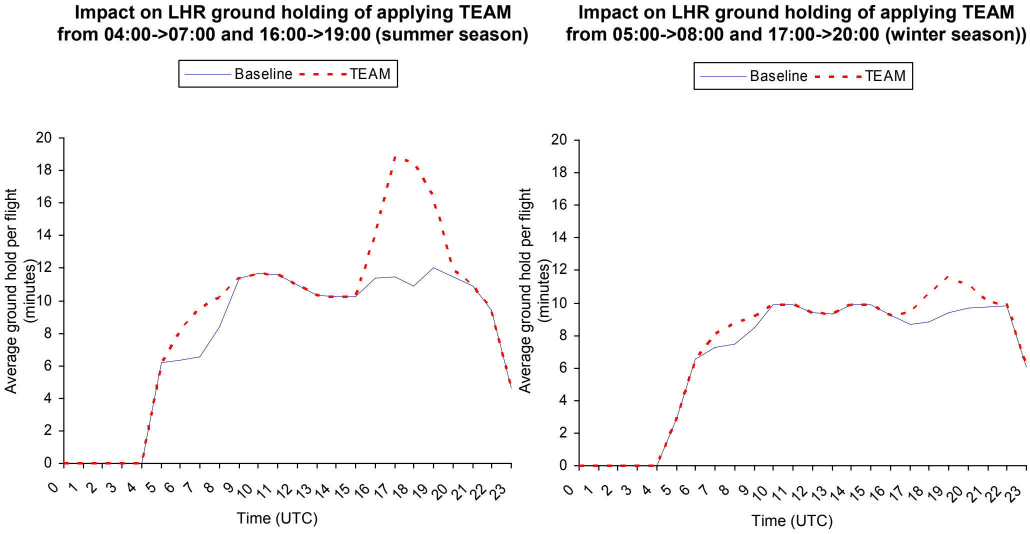

Reduction in ATFM delays incurred at LHR applying TEAM from 04:00->07:00 and 16:00->19:00 UTC (summer season

Reduction in stack holding incurred at LHR applying TEAM from 05:00->08:00 and 17:00->20:00 UTC (winter season)

Departures

5.53 TEAM, although a benefit to arrivals, is expected to have a negative impact on departures as it effectively reduces the capacity of the departures runway. This has been investigated by assuming that TEAM reduces the capacity of the departures runway by around 4 to 6 movements an hour when it is applied. The results of this capacity constraint on the average ground holding times per flight in summer and winter seasons are shown in Exhibit 5-30 where it can be seen that the impact is greatest in the evening where the demand for departures is higher than in the morning.

Exhibit 5-30: Impact on ground holding of additional operation of TEAM

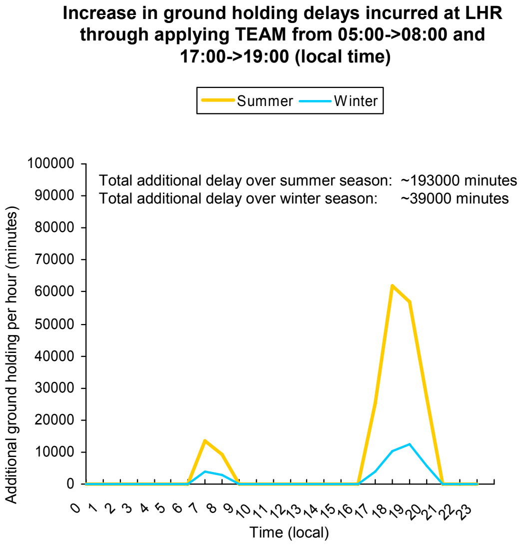


5.54 Exhibit 5-31 shows the total increase in ground holding over the summer and winter seasons caused by the additional application of TEAM:

- in the summer season it might be expected that total ground holding would increase by around 193000 minutes
- in the winter season it might be expected that total ground holding would increased by around 39000 minutes.

5.55 The large difference in the impact in the summer and winter is caused by the higher levels of demand for departures at the times TEAM has been assumed to be applied during the summer season than in the winter season.

Exhibit 5-31: Summary of the impact on ground holding of additional deployment of TEAM



5.56 Purely in terms of operational minutes lost and saved (irrespective of the differential costs of those minutes) additional application of TEAM appears to be positive in summer (where approximately 270000 minutes in saved on arrivals at a cost of an additional 193000 minutes lost on departures) and strongly beneficial in winter (where the total saving on arrivals is around 251000 minutes compared to a loss of 39000 minutes on departures).

Mixed mode – 5% capacity increase

5.57 The minimal application of mixed mode operations is expected to deliver around a 5% capacity increased across the day. The impact of this level of mixed mode operation has been assessed based on the delay curves derived from current operations on the assumptions that:

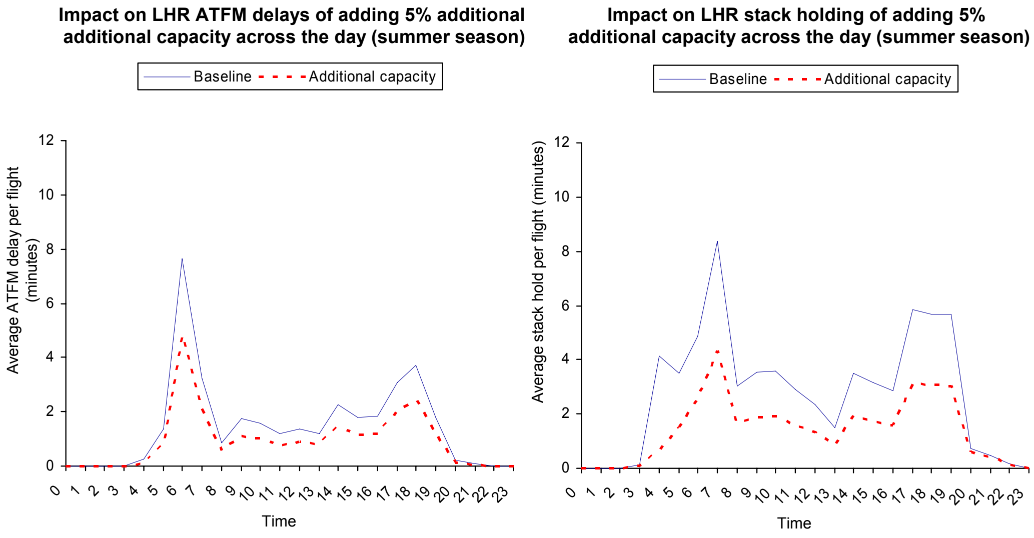
- the increase in capacity
- the change in operational procedures

are not too great to invalidate this approach.

Arrivals

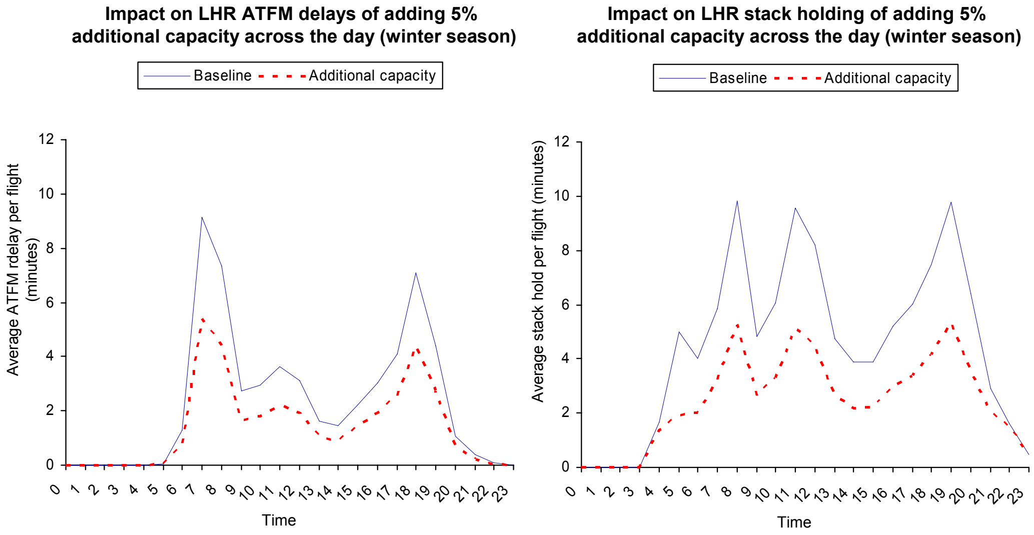
5.58 The impact of this 5% capacity increase on average ATFM delays and average stack holding in the summer season is shown in Exhibit 5-32. As expected the increase in capacity reduces the average delay/holding time across the day with the reduction being greatest in the peaks.

Exhibit 5-32: Impact on ATFM delays and stack holding of additional 5%capacity throughout the day in the summer season



5.59 Similarly, Exhibit 5-33 shows the decrease in average ATFM delays and stack holding times predicted for the winter season. The decreases in the average delays in the winter season is greater than the decreases predicted in the summer season.

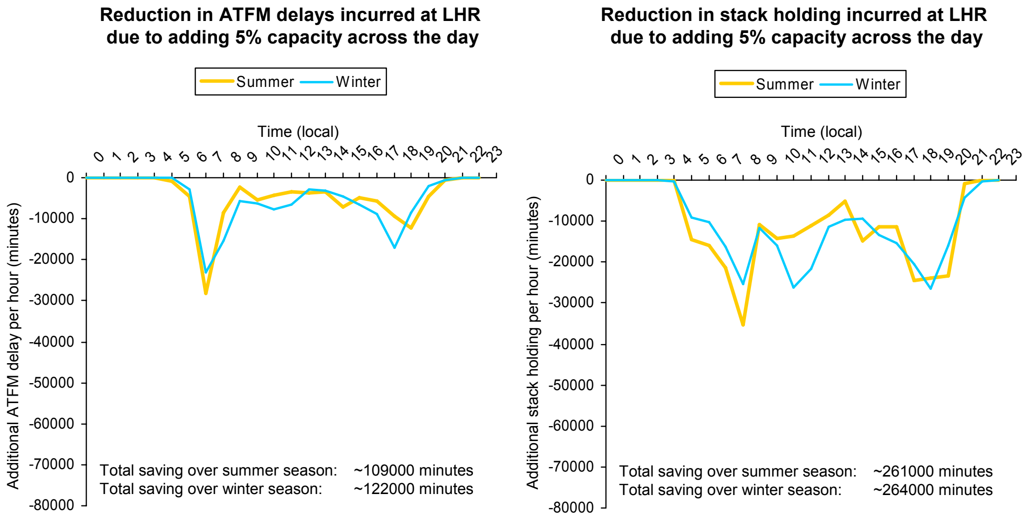
Exhibit 5-33: Impact on ATFM delays and stack holding of additional 5% capacity throughout the day in the winter season



5.60 Exhibit 5-34 shows the total time savings predicted for ATFM delays and stack holding for the summer and winter seasons. Application of minimal mixed mode that delivers a 5% capacity increase might be expected to deliver:

- total savings in ATFM delays of approximately 109000 minutes in the summer season and 122000 minutes in the winter season
- total savings in stack holding of approximately 261000 minutes in the summer season and 264000 minutes in the winter season.

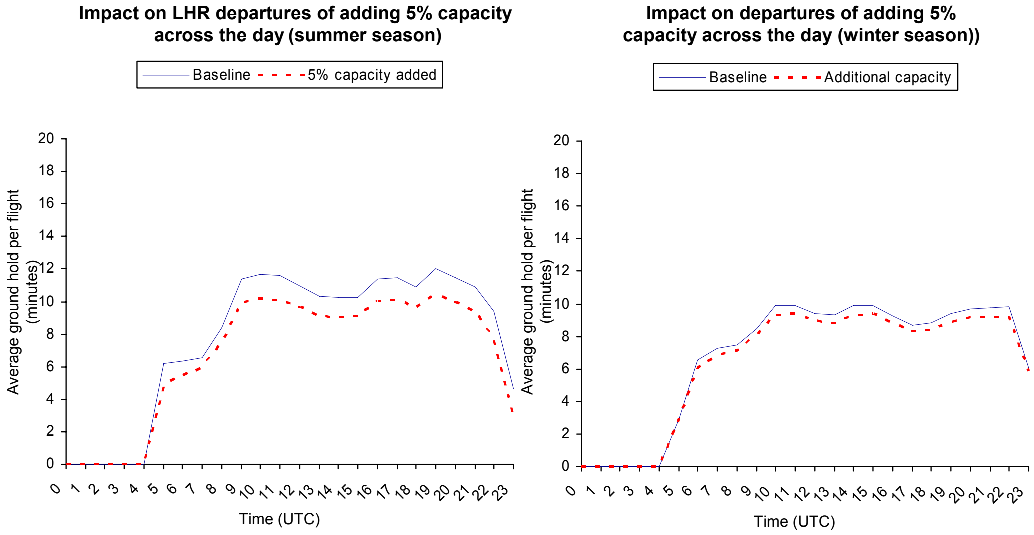
Exhibit 5-34: Summary of the impact on ATFM delays and stack holding of additional 5% capacity throughout the day



Departures

5.61 The impact of a minimal mixed mode on average ground holding for departures is illustrated in Exhibit 5-35. In this case the impact is greater in the summer season than in the winter season because the delay curve for the summer season is steeper than the delay curve for the winter season (see Exhibit 5-5).

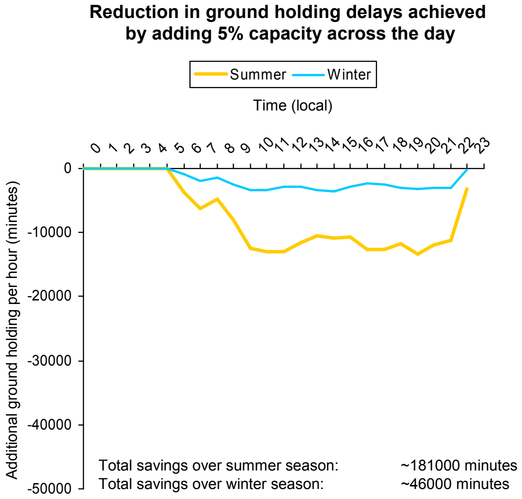
Exhibit 5-35: Impact on ground holding of additional 5% capacity throughout the day in the summer and winter seasons



5.62 Exhibit 5-36 shows the total savings in ground holding achieved by a 5% mixed mode for the summer and winter seasons:

- in the summer season the reduction in total ground holding is predicted to be around 181000 minutes
- in the winter, the reduction in total ground holding is predicted to be approximately 46000 minutes.

Exhibit 5-36: Summary of the impact on ground holding of additional 5% capacity throughout the day



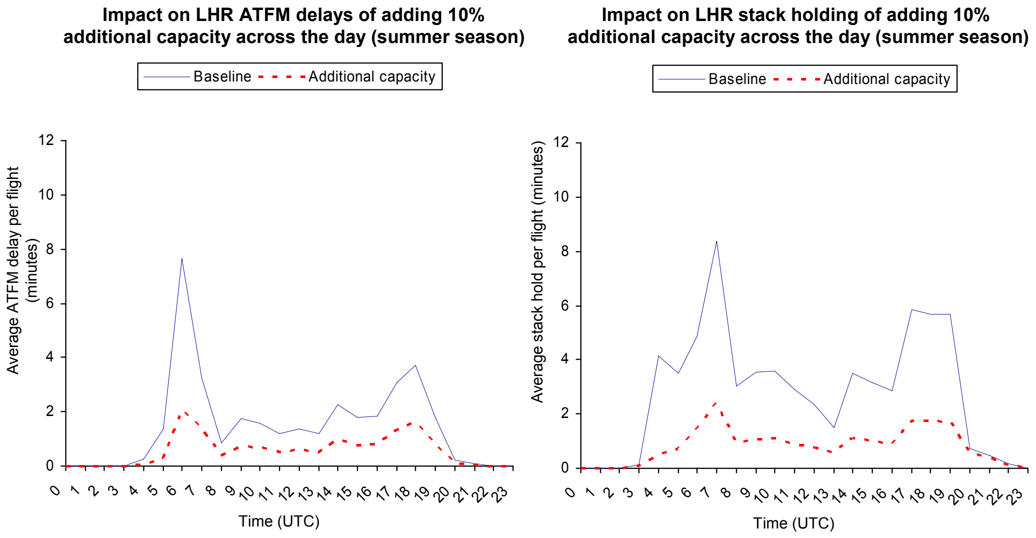
Mixed mode – 10% capacity increase

5.63 As with the 5% application of mixed mode, an intermediate step to full capacity mixed mode giving a 10% increase in capacity has been assessed using the delay curves derived from the current operational situation. This assessment is probably at the limit of the validity of the method derived using current operational data as the increase in capacity is substantial and the operational procedures applied may be significantly from those in current use. However, the results are useful in giving an indication of the impact of a 10% capacity increase.

Arrivals

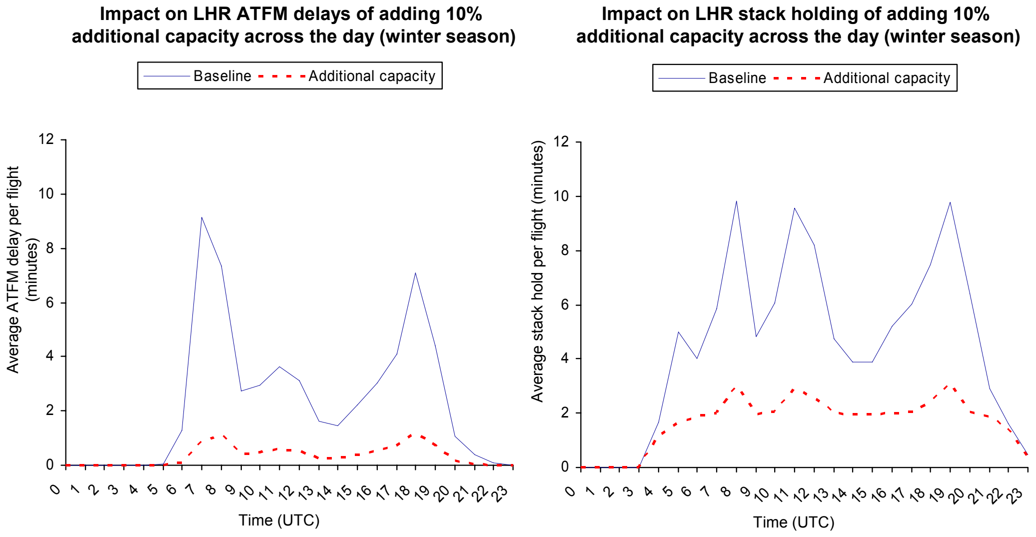
5.64 Exhibits 5-37 and 5-38 illustrate the impact on the average ATFM delays and average stack holding times of increasing capacity by 10% across the day. The reductions are substantial, especially in the peaks, and the time series profiles of the delays across the day are starting to lose their peaks and become flat and featureless.

Exhibit 5-37: Impact on ATFM delays and stack holding of additional 10% capacity throughout the day in the summer season


Impact on LHR ATFM delays of adding 10% additional capacity across the day (summer season)

Impact on LHR stack holding of adding 10% additional capacity across the day (summer season)

Exhibit 5-38: Impact on ATFM delays and stack holding of additional 10% capacity throughout the day in the winter season

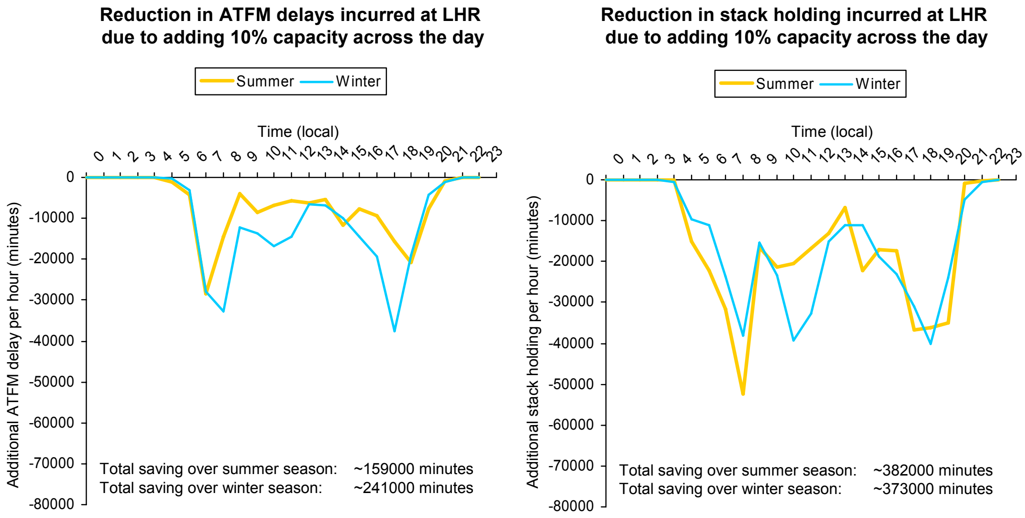

Impact on LHR ATFM delays of adding 10% additional capacity across the day (winter season)

Impact on LHR stack holding of adding 10% additional capacity across the day (winter season)

5.65 Exhibit 5-39 shows the reduction in total ATFM delays and stack holding times for the summer and winter seasons that are predicted for a mixed mode implementation that delivers a 10% capacity increase:

- total ATFM delays are predicted to be reduced by approximately 159000 minutes in summer and 241000 minutes in winter
- total stack holding times are predicted to be reduced by 382000 minutes in summer and 373000 minutes in winter.

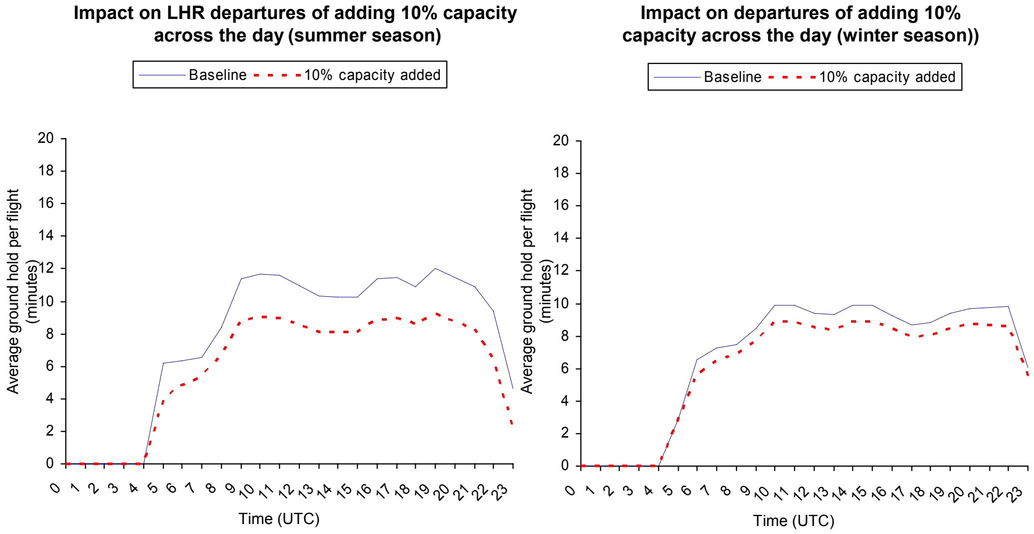
Exhibit 5-39: Summary of the impact on ATFM delays and stack holding of additional 10% capacity throughout the day



Departures

5.66 Exhibit 5-40 shows the impact on ground holding of adding 10% additional capacity across the day.

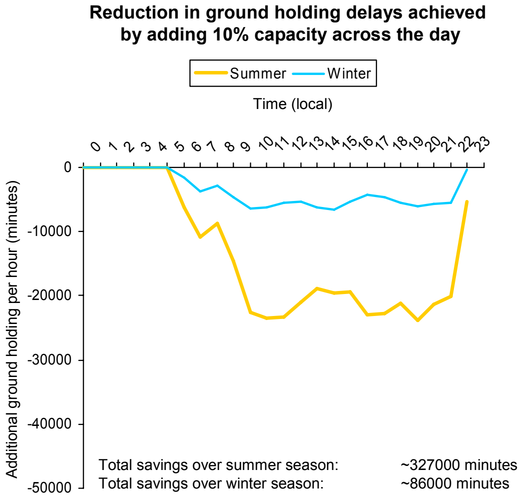
Exhibit 5-40: Impact on average ground holding per departure of additional 10% capacity throughout the day in the summer and winter seasons



5.67 Exhibit 5-41 illustrates the savings in total ground holding time that might be expected from a 10% increase in capacity:

- savings over the summer season are predicted to total around 327000 minutes
- savings over the winter season are expected to total approximately 86000 minutes.

Exhibit 5-41: Summary of the impact on total ground holding of additional 10% capacity throughout the day



Mixed mode – 15% capacity increase

5.68 The penultimate scenario is the application of full capacity mixed mode operations. This cannot be modelled using statistics derived from current operations as the expected increase of around 15% in capacity and the much changed operational procedures cannot be reasonably extrapolated from the current situation. For this reason, the delay curve and validation of the statistical approach have been performed using data obtained from NATS HERMES simulation, which gives the only accepted prediction of mixed mode operations at Heathrow.

Arrivals

5.69 Exhibits 5-42 and 5-43 show the impact of full capacity mixed mode operations on average ATFM delays and stack holding for the summer and winter seasons. In all cases, the delay is much reduced to below around 1minute across the day, except for morning peak in average ATFM delays at around 07:00 UTC in the summer season.

The average delay profiles become flat and featureless and resemble those observed in reality for Gatwick (see for example Exhibit 4-30) where there is an excess of capacity over demand except in the summer peaks.

Exhibit 5-42: Impact on ATFM delays and stack holding of maximum capacity mixed mode operations throughout the day in the summer season

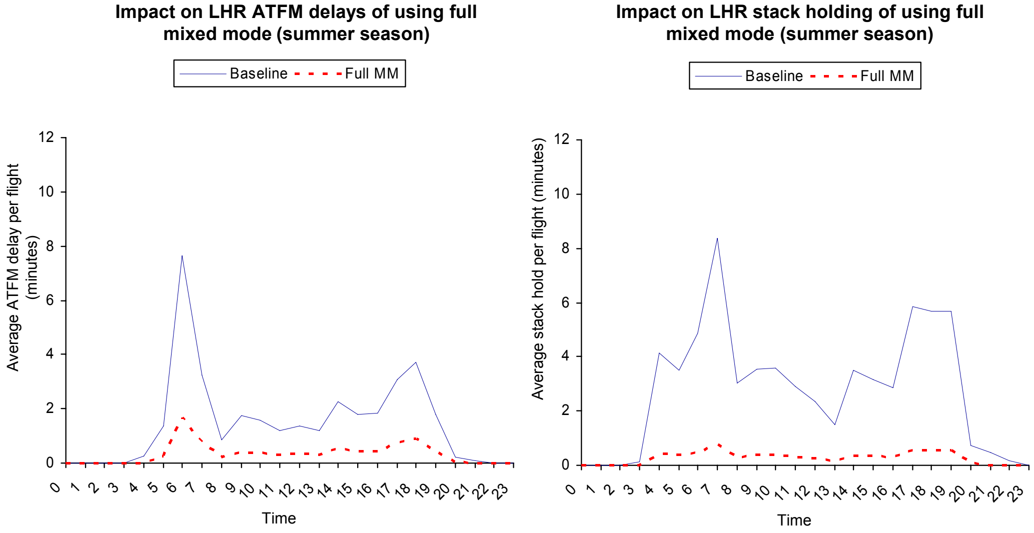
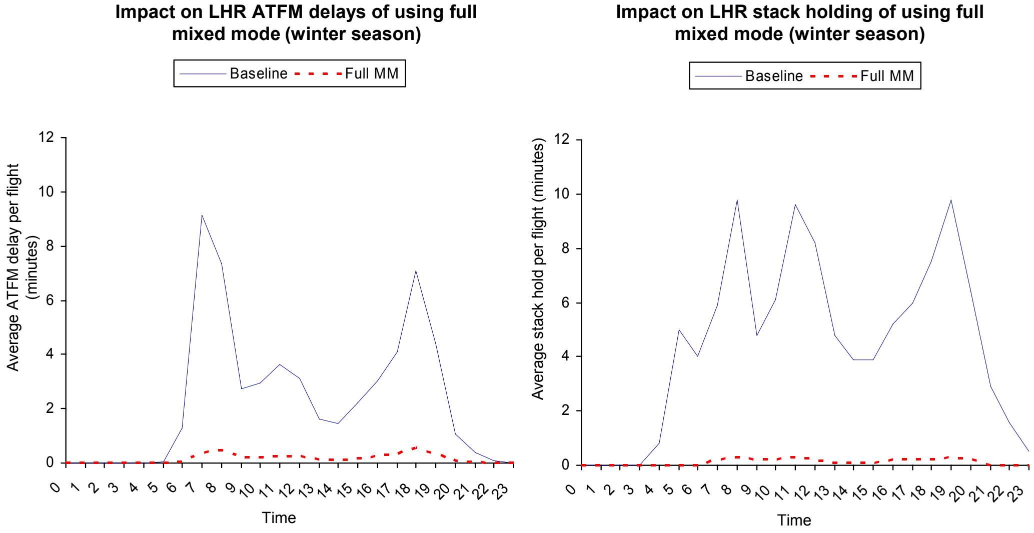


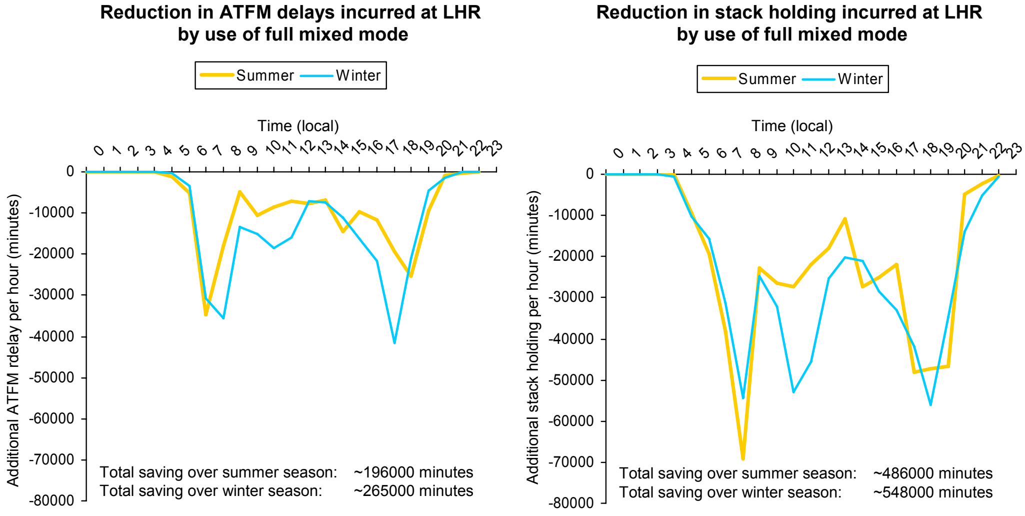
Exhibit 5-43: Impact on ATFM delays and stack holding of maximum capacity mixed mode operations throughout the day in the winter season



5.70 Exhibit 5-44 summarises the impact of full capacity mixed mode on total ATFM delays and total stack holding times over the summer and winter seasons. The following savings are predicted:

- total ATFM delays are expected to be reduced by approximately 196000 minutes and 265000 minutes in the summer and winter seasons respectively
- total stack holding is expected to be reduced by approximately 486000 minutes and 548000 minutes in the summer and winter seasons respectively.

Exhibit 5-44: Summary of the impact on ATFM delays and stack holding of maximum capacity mixed mode operations throughout the day


Reduction in ATFM delays incurred at LHR by use of full mixed mode

Total saving over summer season: ~196000 minutes
Total saving over winter season: ~265000 minutes

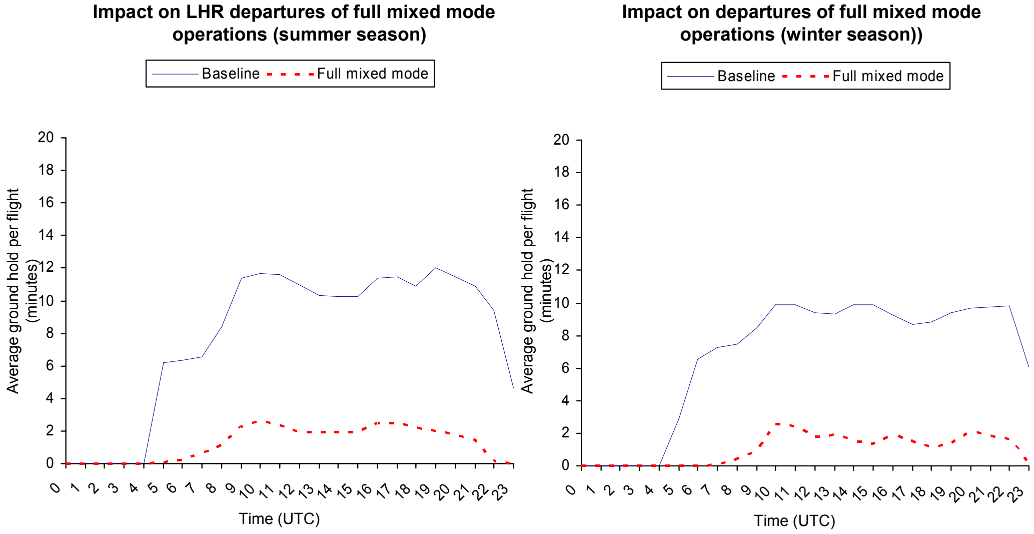
Reduction in stack holding incurred at LHR by use of full mixed mode

Total saving over summer season: ~486000 minutes
Total saving over winter season: ~548000 minutes

Departures

5.71 Exhibit 5-45 shows the impact of full capacity mixed mode operations on average ground holding predicted for the summer and winter seasons. Although there are substantial reductions in ground holding, these are not to the same extent as for arrivals adding weight to the hypothesis that there are other factors than the runway that contribute to ground holding.

Exhibit 5-45: Impact on average ground holding of additional maximum capacity mixed mode operations throughout the day in the summer and winter seasons

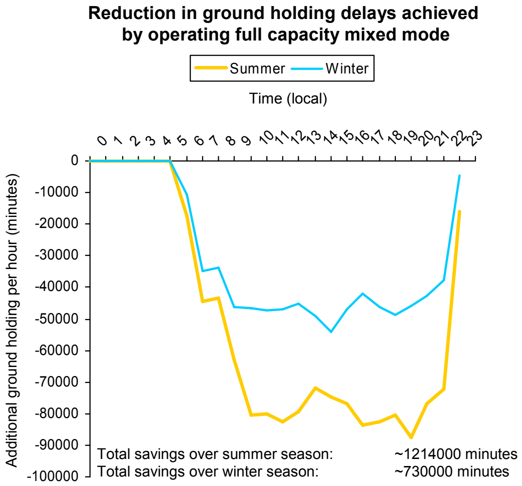

Impact on LHR departures of full mixed mode operations (summer season)

Impact on departures of full mixed mode operations (winter season))

5.72 Exhibit 5-46 shows the total savings in ground holding achieved by full capacity mixed mode over the summer and winter seasons:

- in the summer the total saving is predicted to be approximately 1214000 minutes
- in the winter the total saving is predicted to be approximately 730000 minutes.

Exhibit 5-46: Summary of the impact on ground holding of maximum capacity mixed mode operations throughout the day


Reduction in ground holding delays achieved by operating full capacity mixed mode

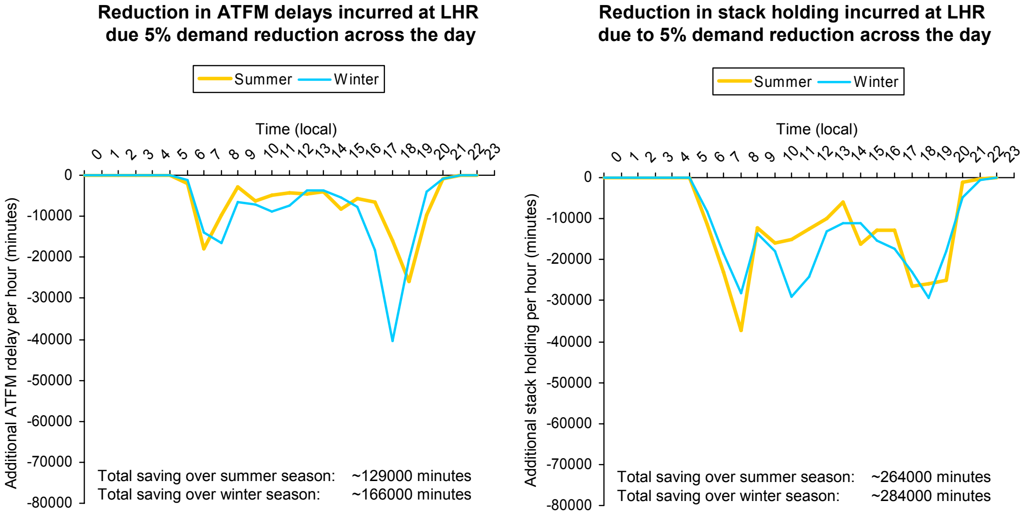
Total savings over summer season: ~1214000 minutes
Total savings over winter season: ~730000 minutes

Indicative reduction of demand by 5%

5.73 The final scenario investigates the theoretical situation that demand be reduced and capped around 5% below its current level. This would equate to the removal of approximately 2 arrivals and departures slots per hour.

Arrivals

Exhibit 5-47: Summary of the impact on ATFM delays and stack holding of suppressing demand at 5% below its current levels throughout the day


Reduction in ATFM delays incurred at LHR due 5% demand reduction across the day

Total saving over summer season: ~129000 minutes
Total saving over winter season: ~166000 minutes

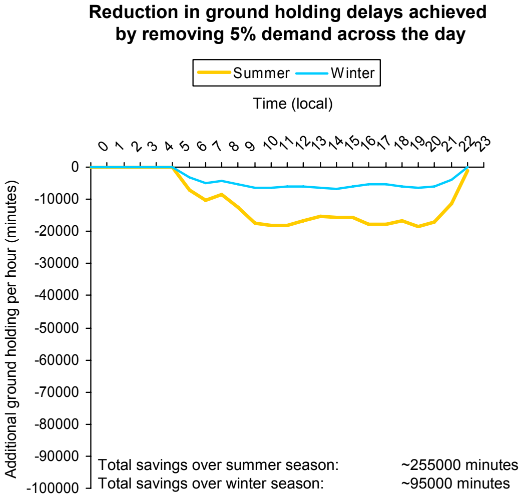
Reduction in stack holding incurred at LHR due to 5% demand reduction across the day

Total saving over summer season: ~264000 minutes
Total saving over winter season: ~284000 minutes

5.74 Exhibits 5-47 and 5-48 summarise the impact on total airport ATFM delays, total stack holding and total ground holding of capping demand at 5% below its current level:

- total ATFM delays would be expected to be reduced by around 129000 minutes in summer and 166000 minutes in winter
- total stack holding would be expected to be reduced by around 264000 minutes in summer and 284000 minutes in winter
- total ground holding would be expected to be reduced by around 255000 minutes in summer and 95000 minutes in winter.

Exhibit 5-48: Summary of the impact on ground holding of suppressing demand at 5% below its current levels throughout the day



RECOVERY FROM DISRUPTION

Introduction

5.75 At Heathrow, disruption associated with the runway is due to a reduction in the runway flow rate caused principally by either low visibility conditions or adverse wind conditions. As Heathrow operates in segregated mode, the spacing between arriving aircraft must be minimised to maximise the flow rate. Both adverse wind conditions and low visibility cause the spacing between (principally) arriving aircraft to be extended beyond the minimum separation applied on normal operating days.

5.76 Under good visibility and appropriate headwind conditions aloft, the minimum spacing between aircraft pairs can be as low as 2.5 nautical miles (nmi) on final approach once established on the localiser and within 20nmi of the runway threshold. The headwind conditions must be such that the application of the 2.5nmi radar separation minimum results in the appropriate spacing being achieved approaching the runway threshold for the clearance to land procedures.

5.77 The separation of the aircraft is monitored by the air traffic controller using radar, who intervenes if separation minima look like being infringed (either by updated speed instructions, or missed approach procedures). Distance separation fluctuates on approach as the ground speed changes under changing wind conditions and reducing airspeeds. If the wind speed and direction is such that the spacing between aircraft pairs is likely to be compressed beyond a minimum level then the separation between the aircraft must be increased and, hence, the runway flow rate reduced.

5.78 In the case of low visibility conditions, the leading aircraft must clear both the runway and the landing aids' protection area before the trailing aircraft reaches a specified point on its approach. This clearance takes a longer time than simply clearing the runway and, hence, the separation between successive aircraft must be extended. Separation can be increased up to 8nmi if there is very poor visibility indicating greater than 50% capacity reduction compared to the best separation minimum of 2.5nmi.

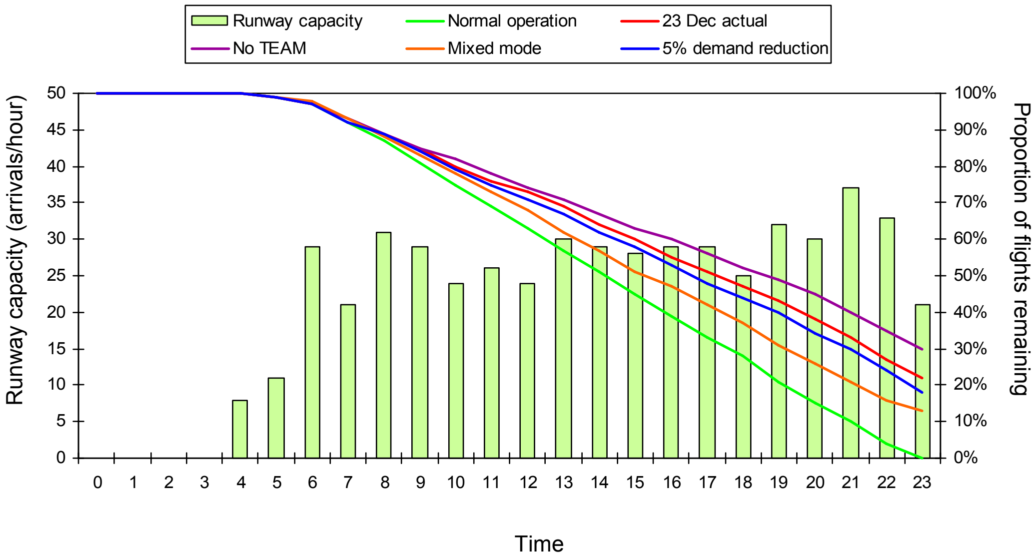
5.79 Gatwick, as a single runway airport, however, operates in mixed mode with interspersed arrivals and departures using the same runway. The spacing between arriving aircraft is therefore naturally greater at Gatwick than at Heathrow and Gatwick is less affected by adverse wind and visibility than is Heathrow (see Exhibit 4-49 and Exhibit 4-50).

Disaster days

5.80 Disaster days at Heathrow occur around 10 to 15 times per year and result in large number of cancellations, very significant ATFM delays and increased night movements. On these days the runway flow rate is severely restricted over the whole day by wind or fog. 23 December 2007 is an example of such a day.

5.81 As the restriction persists across the day there is no time when the restriction is lifted to recover to normal operations. Under current operations a simple addition of capacity cannot, therefore, add to the runway resilience – the runway flow rate is restricted to well below its maximum by the adverse conditions and will negate any additional capacity.

Exhibit 5-49: Impact of various demand reduction scenarios on recovery rates during disaster days



5.82 Resilience on these so-called disaster days must rely, therefore, on a change in operations, such as a move towards time-based separations (TBS) which could make a contribution to resilience when operations are disrupted by wind by reducing the impact that variable wind conditions have compared to the current situation where separation is defined on a distance basis.

5.83 Exhibit 5-49 shows the evolution of arrivals at Heathrow as experienced on 23 December compared to normal operations (see Exhibit 4-51) together with the runway capacity in terms of arrivals per hour achieved through the day. The exhibit illustrates that increasing the nominal runway capacity in segregated mode operations would not be beneficial as the realised capacity is much reduced. The figure also illustrates the impact of possible changes of operations that might be used to manage the disruption:

- removing the use of TEAM would significantly worsen the situation with around a 30% shortfall of arrivals over the day compared to a shortfall of around 20% with TEAM. The no-TEAM scenario was investigated by removing the flights that actually arrived on the departures runway during the day.
- capping the demand at 5% below the current level (scenario 7 in Exhibit 5-1) would mean that a lower proportion of flights were cancelled but at the cost of fewer flights on non-disrupted days. Cancellation of flights is effectively a reduction of demand to enable operations to continue as best as possible and to minimise the cost of recovery
- mixed mode operations would increase runway resilience by naturally increasing the spacing between arrivals at Heathrow (cf Gatwick) and therefore minimising the impact of the increased separation necessitated

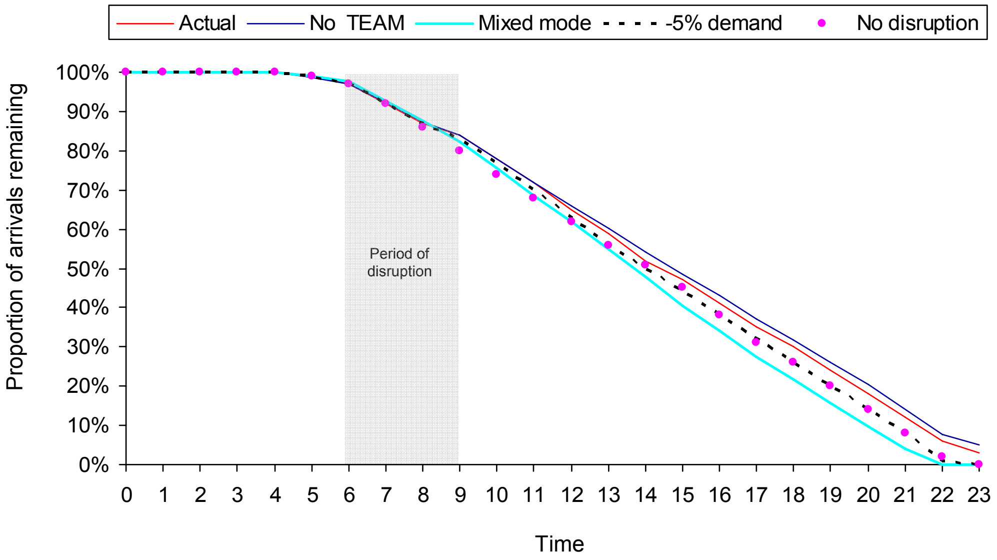
by the adverse conditions. This would not make use of the additional capacity provided by mixed mode operations but rather take advantage of the increased robustness that the concept provides

5.84 The case study comparing Heathrow and Gatwick performance on 23 December reported in section 4 shows that during the normal operating day Heathrow suffered a capacity reduction of around 25% whereas over the same time Gatwick suffered a capacity reduction of around 12%. Exhibit 5-49 shows the benefit that could be generated from mixed mode operations at Heathrow on a day such as 23 December, assuming a reduction of 12% capacity rather than the 25% currently experienced. This simple scenario shows that the benefit of mixed mode would be to reduce the number of flights that could not arrive during the disrupted day from around 22% (~113 flights) to around 13% (67 flights), a reduction of around 40%.

Recoverable days

5.85 In contrast to the disaster days above, recoverable days comprise a period of disruption followed by a return to normal operations. In theory, if additional capacity were available in the return to normal operations it should be possible to catch up, at least partially, by the end of the day. The 5 November case study reported in section 4 is an example of this type of day, which occurs typically 40 to 50 times per year at Heathrow. Exhibit 5-50 shows the evolution of arrivals throughout the day comparing the actual situation on 5 November (red line) with an equivalent day with no disruption (purple points) and various strategies for recovering after the period of the disruption, which is shown as the grey shaded area on the chart (from 06:00 to 09:00). In the following, mixed mode refers to a full mixed mode scenario with a capacity increase of around 15%.

Exhibit 5-50: Impact of various capacity enhancement and demand reduction scenarios on recovery rates during recoverable days



5.86 During the actual day of 5 November, TEAM was applied during and after the period of disruption until ATFM delays recovered to their normal levels at around 14:00 when the evolution of arrivals also matched that of the normal day. Subsequently, the rate of arrivals reduced again and by the end of the day there was a significant shortfall of arrivals, compared to the normal days. Exhibit 5-50 shows that without the application of TEAM (derived by subtracting the arrivals on the departures runway from the overall arrivals flow rate) after the period of disruption, the traffic evolution would not have caught up at 14:00 and there would have been an even greater shortfall at the end of the day.

5.87 Exhibit 5-50 shows that a reduction of 5% in demand would also enable operations to recover by around 14:00 and to remain at the norm for the rest of the day. In effect, the reduction in demand more than compensates for the 3.5% cancellations that took place on 5 November.

5.88 Exhibit 5-50 also shows the evolution of traffic that could be achieved with mixed mode operations. During the period of disruption mixed mode would allow a higher flow rate than for segregated mode operations and the 15% capacity increase would allow traffic to recover to the norm by around 12:00. Subsequently, the additional capacity and robust operations during the day would ensure no further disruption.

5.89 Exhibit 5-51 shows the hourly arrivals runway flow rates supporting these scenarios and, in particular, illustrates the effect of TEAM and mixed mode.

Exhibit 5-51: Illustrative arrivals flow rates for various capacity enhancement and demand reduction scenarios on recovery rates during recoverable days

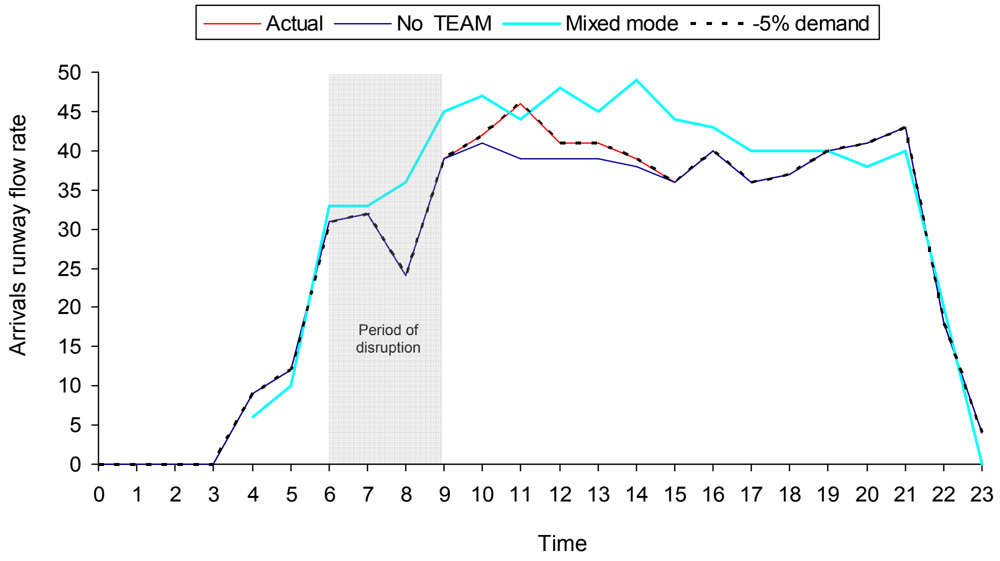


Exhibit 5-52 summarises the performance of each of the scenarios.

Exhibit 5-52: Comparison of the performance of the various scenarios to aid recovery

Actual	Never	15
No TEAM	Never	29
-5% demand	14:00	33[14]
Mixed mode	12:00	0

Conclusions

5.90 The analysis of the case studies shows that:

- the application of TEAM on both disaster and recoverable days eases the situation compared to that in which TEAM is not applied. Without TEAM on the disaster day, the shortfall in arrivals would have been up to around 40% greater than that achieved and around 50% greater than that achieved on the recoverable day
- management of disruptions by reducing or capping demand would require the cap to be set at or below the number of cancellations that occur, and its benefits would likely be outweighed by the fact that the capped flights would not be able to operate during the remainder of the time. Cancellations are, in fact, a mechanism used by the airlines to cap demand to allow some operations on disrupted days

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[14] This shortfall is compared to the current situation and not the schedule with reduced demand

- it is not possible to recover from the disaster days that occur between 10 and 15 days per year. However, use of mixed mode operations on these days would ease the situation and could result in a reduction in shortfall of flights (and cancellations depending on particular airline policy) by around 40%. This benefit arises from the natural robustness of mixed mode operations against the requirement to impose increased separation for arriving aircraft in adverse wind and visibility conditions. Simple addition of capacity would not ease the situation on disaster days in segregated mode operations as the operational capacity is already reduced well below that available on normal days
- use of mixed mode on recoverable days at Heathrow would allow full recovery similar to that achieved at Gatwick on similar types of day. There is a dual benefit on the recoverable day in that mixed mode reduces the impact of the disruption (wind or fog) as well as speeding up the recovery by providing additional capacity.

SUMMARY

5.91 The following table (Exhibit 5-53) summarises the impact of the various scenarios on ATFM delays, stack holding times and ground holding times compared to baseline of the current situation whereas Exhibit 5-54 shows the same data normalised to the number of flights operating in each season.

Exhibit 5-53: Summary of the impact of each scenario on total ATFM delays, stack holding and ground holding times

	ATFM delays (000s minutes)		Stack holding (000s minutes)		Ground holding (000s minutes)	
Scenario	**Summer**	**Winter**	**Summer**	**Winter**	**Summer**	**Winter**
Baseline (excludes severely disrupted days which are treated separately)	352	396	565	602	1404	924
Change due to each scenario						
Additional flight (worst case)	+29	+42	+93	+21	+24	+3
Flight removed (best case)	-12	-12	-19	-17	-10	-3
Additional TEAM	-85	-92	-185	-159	193	39
TWASS MM, current SIDs (+5%) capacity	-109	-122	-261	-264	-181	-46
TWASS MM, enhanced SIDS (+10%) capacity	-159	-241	-382	-373	-327	-86
Full capacity MM +15% capacity	-196	-265	-486	-548	-1214	-730
5% reduction in demand	-129	-166	-264	-284	-255	-95

Exhibit 5-54: Summary of the impact of each scenario on the seasonal average ATFM delays, stack holding and ground holding times per flight

	ATFM delays (minutes per flight)		Stack holding (minutes per flight)		Ground holding (minutes per flight)	
Scenario	**Summer**	**Winter**	**Summer**	**Winter**	**Summer**	**Winter**
Baseline (excludes severely disrupted days which are treated separately)	2.49	3.98	4.00	6.05	10.02	9.20
Change due to each scenario						
Additional flight (worst case)	0.20	0.42	0.66	0.21	0.17	0.03
Flight removed (best case)	-0.09	-0.12	-0.13	-0.17	-0.07	-0.03
Additional TEAM	-0.60	-0.92	-1.31	-1.60	1. 38	0.39
TWASS MM, current SIDs (+5%) capacity	-0.77	-1.23	-1.85	-2.65	-1.28	-0.46
TWASS MM, enhanced SIDS (+10%) capacity	-1.13	-2.42	-2.71	-3.75	-2.32	-0.86
Full capacity MM +15% capacity	-1.39	-2.66	-3.44	-5.50	-8.60	-7.33
5% reduction in demand	-0.96	-1.75	-1.97	-3.00	-1.90	-1.00

5.92 The qualitative impact of the scenarios can be summarised as:

- in terms of sensitivity, adding a flight, especially at an inappropriate time has significantly more negative impact than removing a flight, that is the addition or subtraction of flights is asymmetric
- additional TEAM can deliver benefits in terms of reduced ATFM delays and stack holding times for arrivals but there is an associated but not equivalent cost in increased ground holding, especially if TEAM is applied at times when the demand for departures is high
- in terms of the pure operational benefit of reducing holding times and discounting economic effects, the scenarios in order of increasing preference would be: i) TWASS mixed mode, current SIDs adding 5% capacity; ii) a 5% reduction in demand; iii) TWASS mixed mode, with enhanced SIDS adding 10%; iv) full capacity mixed mode.

When considering the ability to increase robustness against both severe and recoverable disruption, mixed mode is clearly the preferred option. The use of both runways for arrivals and departures gives improved resilience against the types of conditions that most usually cause disruption - adverse wind conditions and fog – and the greater the availability of spare capacity after a disruption event has ended, the quicker that the situation can be recovered.

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Part III:
ECONOMIC ANALYSIS

6

ECONOMIC ANALYSIS METHODOLOGY

OVERVIEW

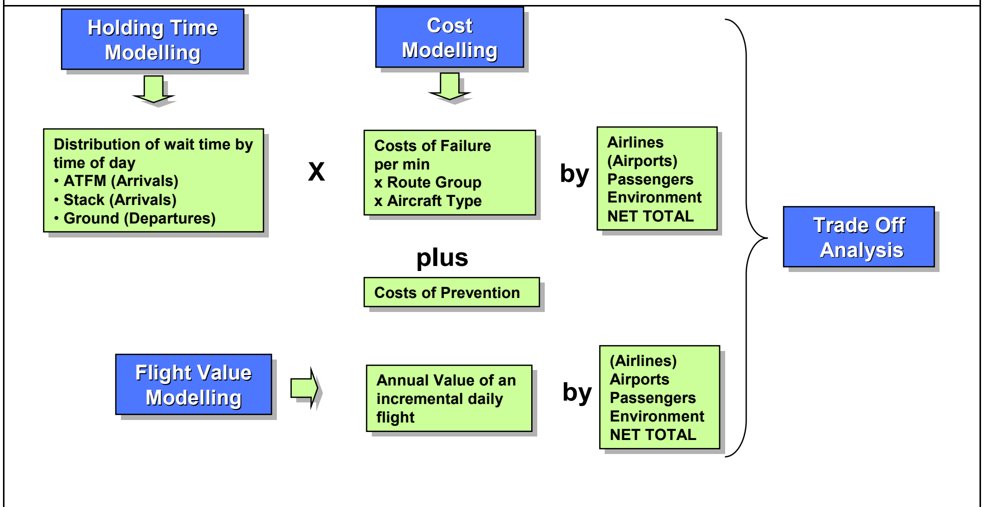
6.1 Runway capacity at Heathrow and Gatwick constrains the number of flights that can be operated and also the level of performance that can be achieved. The number of flights operated has a direct impact on the airlines' and airports' earnings, and the benefits associated with users of the flights. At the same time additional flights increase the airport's contribution to noise and other forms of pollution, and the flights themselves have a further environmental impact through fuel burned and resulting CO2 and other emissions.

6.2 As the number of flights increases, so does the risk of delay as queues form to access the runway for both arrivals and departures, as described in the previous sections. Overall delay performance is also affected by many other factors including airlines' despatch performance, stand and taxiway congestion, air traffic restrictions en-route and congestion at destination airports. The capacity of the overall system is regularly reduced by weather and other events which can affect any one or all of these components. To minimise the impact of increased congestion on delays and punctuality, airlines extend their planned block times with further costs incurred.

6.3 The study focuses specifically on the impact of marginal changes in demand relative to capacity in three stages of the flight operation:

- Airborne holding in the arrivals stack prior to landing
- ATFM holding at out-stations
- Departure holding at prior to take-off.

Exhibit 6-1: Analysis Overview



Source: SH&E

6.4 Exhibit 6-1 shows the stages of analysis conducted. The Holding Time analysis examines current performance of the runways at Heathrow and Gatwick, and the distribution of the holding times by time of day. This was used to calibrate the models so that various possible scenarios could be evaluated to estimate the change in holding times. Each scenario looked at the difference in the mean and also in the distribution of delay duration, and reflected a change in the balance between demand (aircraft take-offs and landings) and runway capacity. The scenarios are described below.

6.5 The outputs from this stage were then used to assess the costs and benefits for airlines, passengers, airports and impact on the environment. In parallel the costs and benefits of adding or removing additional flights were calculated. The analysis also assessed the fixed costs that airlines incur in providing aircraft, crew and other resources to mitigate the effects of extended queuing times (Costs of Prevention).

6.6 Finally, the trade-offs between the component benefits and costs were considered together to develop our conclusions.

OVERVIEW OF ECONOMIC MODELLING

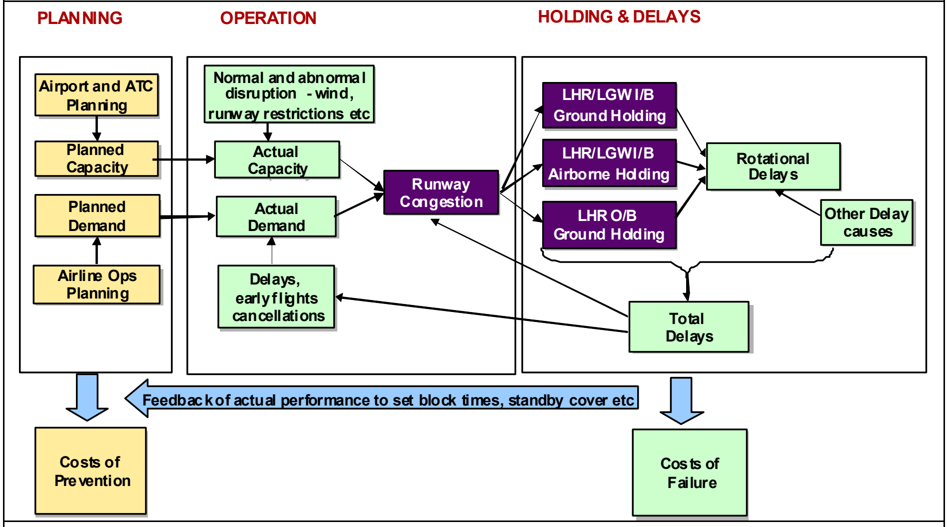
Scope of Economic Evaluation

6.7 Estimation of the costs and benefits associated with the scenarios listed in Exhibit 5-1 requires the modelling of a complex set of interacting relationships. The scope includes the impact of changing the balance between demand for and capacity of the runway resource at Heathrow and Gatwick Airports on holding times and consequential economic impacts, but does not attempt to assess the total costs of poor performance leading to delays and cancellations. The focus of the economic evaluation therefore is the changes in costs and benefits for airlines, airports and their passengers, plus the environmental impact of changes to holding times during normal operations (around 300 days a year) and also on the further 50 or so days where there is already significant delay due to runway congestion, usually associated with flow rate restrictions because of weather.

6.8 We have not attempted to assess the economic consequences of major disruption, nor the benefits of increased runway resilience in improving the recovery time from such events. Many of the costs and impacts associated with such events are not routinely collected by airlines and airports in a way which enables costs to be easily allocated to specific events. It is also difficult to see what action could be taken in terms of restricting flights year round which could be justified economically given the relatively few days (around 15 a year) when major disruption occurs.

6.9 We have broadly followed the approach recommended by the DfT[15] in assessing the cost-benefit impact on passengers, airlines, airports and the environment. However there are some differences in the detail – for example we have not modelled the change in the passengers spilled to other UK airports. We have not attempted to quantify broader economic impacts such as those on the UK economy or employment, nor have we distinguished the geographical location of where the costs and benefits accrue. The details of the method and assumptions used are given in Appendix C.

Exhibit 6-2: Impacts of Holding Times on Costs



Source:SH&E Analysis

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[15] DfT website, Appendix H of “UK Air Passenger Demand and CO2 Forecasts”, November 2007.

6.10 Exhibit 6-2 shows the interaction between ***planning processes***, on the day ***operation*** including the ***holding times***, the impact then on ***airlines' delays***, and how this then feeds back into the planning of subsequent seasons. Airlines plan their schedules assuming that time will be spent holding based on experience of previous seasons. In the short term flights held for longer than the planned holding time have an impact on departure and arrival delays. There are then knock-on effects on subsequent flights (rotational delays). The cumulative effect of persistent increased holding is then reflected in the sector block times airlines use to construct their schedules, which in turn creates an increase in the number of aircraft and crew required for any given operation. Because airlines set planned block times at a percentile of actual block times (for example the 65%ile) then these costs can be higher than is required on average. Airlines can also and do build in extra resilience by increasing the number of standby crew and aircraft beyond that needed for sickness and aircraft un-serviceability.

Costs of Prevention versus Costs of Failure

6.11 Costs are incurred at the planning stage (extra crews and aircraft for example to cover expected holding) and at the operations stage (fuel burned, passengers compensated when delays occur for example). We refer to planned expenditure as ***Costs of Prevention*** – investments made to minimise the impact or incidence of delays – and costs incurred as a direct or indirect result of delays occurring as ***Costs of Failure***. In the short term Costs of Prevention can be considered as fixed, i.e. if holding times extend then the airline experiences worse departure and arrivals punctuality with cost impacts for the directly affected airline and passengers. In the longer term, however, most of these costs are "planned out" by airlines adjusting their schedules and resourcing.

6.12 Clearly for airlines there is a trade off between the Costs of Prevention (which primarily fall to them) and the Costs of Failure which affect them and their passengers. Existing schedules already reflect some of the costs of extended sector times. For the Baseline Case (i.e. performance as in Summer 2007 and Winter 2007/08) we have calculated the total "cost of holding" with current performance, and then the change to this figure in each scenario. In evaluating the impact of shorter or longer holding times we have assumed that airlines continue to reflect the change in their block times, and do not simply allow performance for themselves and their passengers to deteriorate.

6.13 We separately discuss the direct and immediate increases in delays if holding times increase within a season i.e. delays worsen because sector times are unrealistic. Given the lags in the airline planning processes, in the short term this is what is most likely to happen. See paragraph 6.11 .

Uncertainty in holding time duration

6.14 Airlines and passengers are affected by any increase in the duration of holding times and delays. The impact is worsened by the need to plan for these delays which themselves are variable and uncertain. So one question we have been asked to address is what is the additional cost associated with this uncertainty, and how does this element change under each scenario. See paragraph 7.47

Costs and Benefits of Additional Flights

6.15 On the other side of the equation we have derived the ***benefits of additional flights*** to passengers (User Benefits), and to airlines and airports (Producer Benefits), and to the UK (Air Passenger Duty revenue). The DfT methodology assumes that all the Producer Benefit accrues to the airport in terms of a pro rata increase their profits. Passengers benefit from time saved through having a more convenient and time-efficient schedule, as well as the incremental value obtained by new passengers who benefit from lower fares.

6.16 Finally, we have assessed the ***environmental impact*** of additional flights and of increased holding time, both airborne and on the ground. The main impacts considered are those of carbon emissions and noise. CO2 emissions have been estimated based on the ICAO Engine Emissions Databank, Issue 15-B, with costs applied using DEFRA guidance, and in line with the DfT's usage in their November 2007 paper[16]. This includes the additional impact of CO2 emissions at altitude through the application of a "radiative forcing factor" as a simple multiplier: we have used the value of 1.9 in line with current DfT assumptions.

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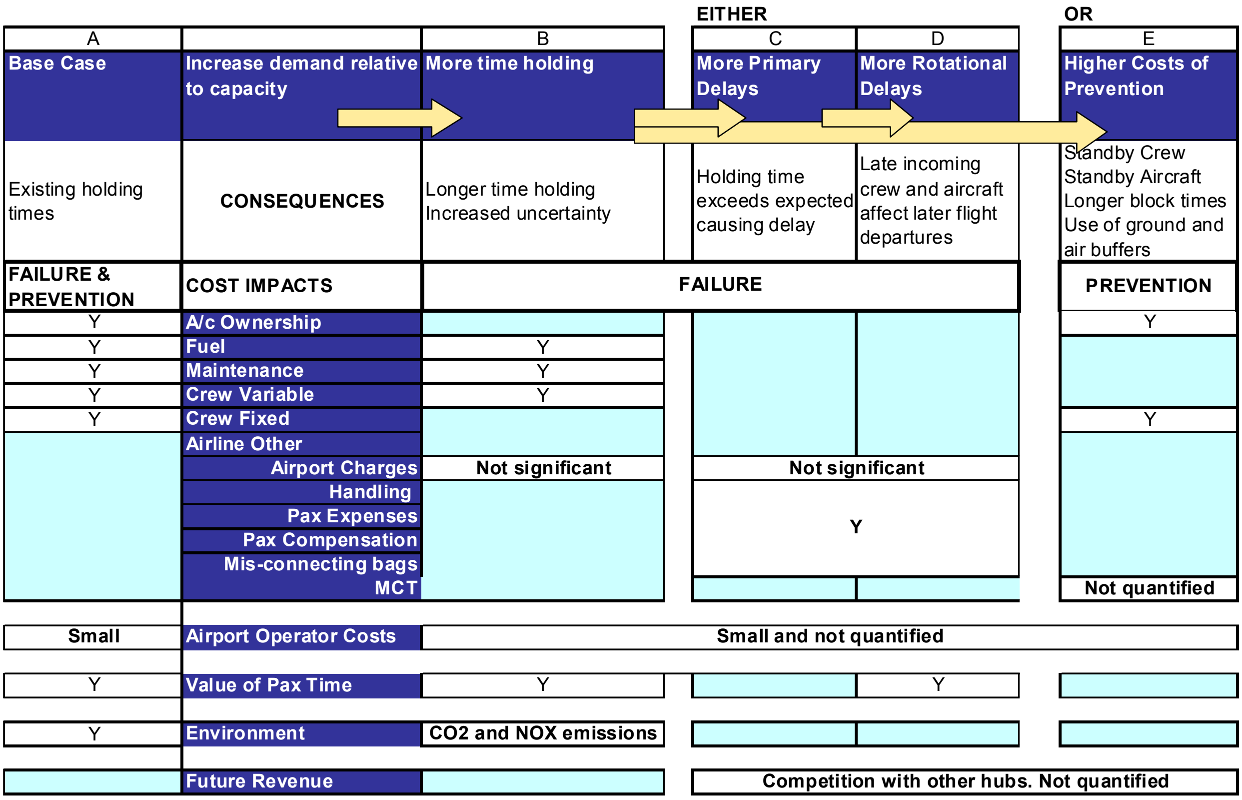
[16] DfT website, "UK Air Passenger Demand and CO2 Forecasts", November 2007

ASSESSING THE COST IMPACT OF INCREASING RUNWAY CONGESTION

6.17 Exhibit 6-3 shows the main cost items affected by holding. This framework describes which costs we have included and under what circumstances.

Exhibit 6-3: Cost Impact Framework



			EITHER		OR
A		B	C	D	E
Base Case	**Increase demand relative to capacity**	**More time holding**	**More Primary Delays**	**More Rotational Delays**	**Higher Costs of Prevention**
Existing holding times	**CONSEQUENCES**	Longer time holding Increased uncertainty	Holding time exceeds expected causing delay	Late incoming crew and aircraft affect later flight departures	Standby Crew Standby Aircraft Longer block times Use of ground and air buffers
FAILURE & PREVENTION	**COST IMPACTS**	**FAILURE**			**PREVENTION**
Y	**A/c Ownership**				Y
Y	**Fuel**	Y			
Y	**Maintenance**	Y			
Y	**Crew Variable**	Y			
Y	**Crew Fixed**				Y
	Airline Other				
	Airport Charges	**Not significant**	**Not significant**		
	Handling		**Y**		
	Pax Expenses				
	Pax Compensation				
	Mis-connecting bags				
	MCT				**Not quantified**
Small	**Airport Operator Costs**	**Small and not quantified**			
Y	**Value of Pax Time**	Y		Y	
Y	**Environment**	**CO2 and NOX emissions**			
	Future Revenue		**Competition with other hubs. Not quantified**		

Source: SH&E

6.18 Column A defines which costs and impacts are included in calculating the Base Case Holding Costs. The assumption is that time spent holding ties up aircraft, crews and passengers and that the time released could be fully utilised, so all costs of owning aircraft and employing crew are included. This includes both Failure and Prevention costs in that we do not separate out how much of the current holding time is built in to airlines' schedules, and how much is additional and contributing to further delays: as we are measuring the marginal change this has not been necessary.

6.19 Column B indicates those costs that are directly affected by an increase in holding times in the short term i.e. regardless of whether additional holding times are subsequently incorporated in to airlines' schedules.

6.20 Columns C & D indicate those costs which are incurred if the increased holding times are not incorporated but result in delays, and Column E indicates those which are incurred if holding times are incorporated and there is minimal impact on delays. When delays do occur many flying costs are not increased but just occur later. However some passenger related costs such as compensation and missed connections are driven by delays and not directly by the holding times. Similarly rotational delays cause the same costs on later flights, even though most operating costs can be assumed to be unchanged.

6.21 Our analysis of the delay statistics of carriers based at Heathrow and other carriers operating there shows that around 20% of all delays at the airport can be attributed to holding. The carriers which are not based at Heathrow and only perform turnarounds at the airport suffer a larger proportion of their delays due to holding.

Exhibit 6-4. Holding Related Delays vs. All Delays

	Holding-related delays		
	Arriving	Departing	ATMs
	Share	Share	Share
Base carriers	12%	15%	54%
Other carriers	29%	29%	46%
Combined	20%	21%	

Source: SH&E Analysis

Airline Specific Costs of Failure

6.22 The direct costs for airlines when extended holding or delays occur, as outlined in Exhibit 6-3, include:

- Additional fuel costs due to holding on the ground and in the air;
- Increased maintenance costs;
- Increased crew costs;
- The costs of providing delayed passengers with food and refreshments and possible over-night hotel accommodation;
- The costs of re-booking and accommodating passengers on other airlines when connections are missed;
- The costs of handling mis-connecting bags for connecting passengers; and
- Loss of business from passengers who change their travel plans and either cancel their journeys completely or travel by a surface mode.

Passenger Value of Time (VOT)

6.23 We have used the following figures from the DfT to put a monetary value to the time passengers spend in holding and delays:

Passengers travelling on business purpose:	0.91 GBP / min
Passengers travelling on leisure purpose:	0.14 GBP / min

6.24 These figures are linked to earnings levels. We have not varied this with duration of delay or circumstance beyond a simple Business/Leisure split. The University of Westminster study highlights some of the potential pitfalls when applying a Value of Time approach, particularly the diversity of values estimated by different sources. See Appendix E: for a summary of alternative sources contained in the "Standard Inputs for Eurocontrol Cost Benefit Analyses", 2005 Edition.

6.25 The "Heathrow Economics Study" report, Buchanan for GLA, September 2006, argues that business passengers' flights outside "the standard working day" should have less than 20% of the normal rate applied. For most business travellers today the concept of "the standard working day" is not particularly relevant: time spent on travelling is an integral (but unwelcome) part of adding value for their company and it is difficult to see how a 20 minute delay at 15:30 is worth 5 times more than a 20 minute delay at 19:30. Business travellers expect to be compensated for the social costs (such as late arrivals home) within their overall package; increasing those costs must surely increase an expectation of increased compensation. It could also be argued that applying salary linked costs as the Value of Time does not recognise fully the added value derived from the activity, just the marginal cost to the company.

Impact on Airline Revenue

6.26 We have excluded any assessment of the impact of delays and/or lengthened sector times on the airlines' revenue in that if one airline experiences worse performance then although it may lose passengers, another airline will probably gain them, so the net result is zero. This argument does, however, overlook one of the main concerns expressed by airlines, which is that if performance at Heathrow deteriorates then connecting passengers will switch to other hubs such as Amsterdam, Paris and Frankfurt to avoid Heathrow.

6.27 This latter argument is more applicable if the increased holding resulting from adding flights were not compensated for by lengthening sector times. Our assumption is that they will continue to be so, and so actual delays and misconnections should be no worse. The main impact then is that by lengthening total journey time, some journeys via Heathrow will appear lower in the Global

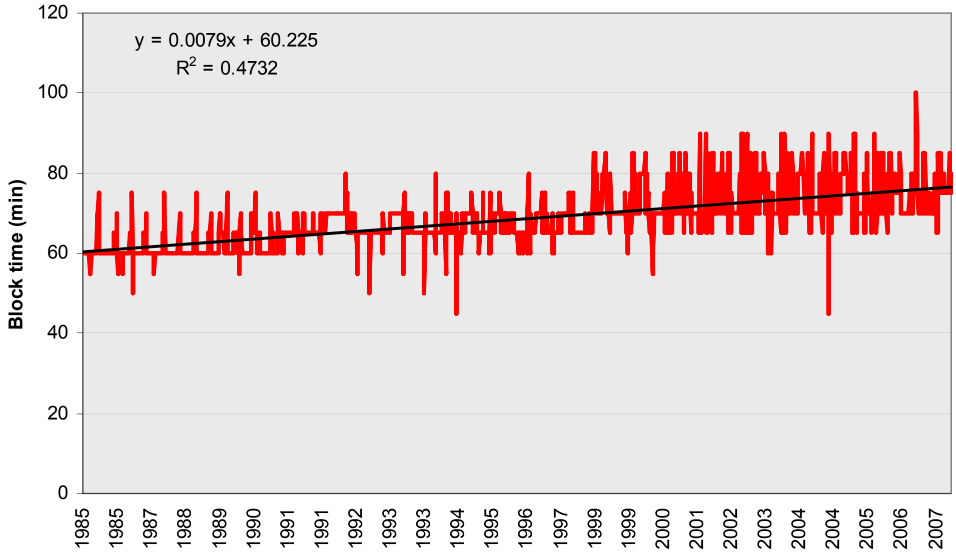
Distribution Systems screens relative to journeys connecting at other airports, resulting also in a loss of share for Heathrow, and at the margin some connections will become unviable as they fall below the Minimum Connection Time.

Airline Specific Costs of Prevention

Increased Sector Times

6.28 From previous studies and interviews with airlines we know that the most significant Costs of Prevention are aircraft time and crew time. Airlines use sector block times based on actual achieved times; by definition any additional delays occurring between push-back and arrival on stand are reflected in later seasons in the block times. Expanded block times increase flying hours and hence the total number of aircraft and crew required to cover a given schedule. The inclusion of scheduling buffers either on the ground or in the air has a similar effect.

Exhibit 6-5. The Increase of Scheduled Block Times on the CDG-LHR Route



Source: OAG

6.29 Block times to and from Heathrow have grown steadily over many years; see the example of Heathrow to Paris CDG in Exhibit 6-5 above. The result is that although punctuality may not have appreciably worsened, average journey times have increased which is costing all airlines operating there considerable sums each year. This effect is relatively stronger on short-haul routes where the total block times are smaller; hence the holding time is relatively larger. In addition to the airline costs, there is the cost of passengers' time and the environmental cost of the fuel burned.

6.30 In calculating these costs we have assumed that additional time spent holding is added incrementally to current block times, minute for minute. In practice, airlines use a percentile measure (typically the 65th percentile) so an increase in holding times of 5 minutes say may result in an increase in block times of 6 minutes. So our approach possibly underestimates the incremental change.

6.31 An argument put forward in previous work is that the marginal increase in crew and aircraft flying time is unlikely to generate the need for an extra crew member or aircraft in the fleet for any one airline. In practice, of course, each airline will decide how to respond given its own circumstances. If an airline has a large fleet based at Heathrow, then 5 minutes a sector on a shorthaul aircraft could add up to 30 minutes in a day. Over a fleet of 30 aircraft this can easily add up to an extra aircraft or more. Smaller and non-UK based airlines may not suffer from this directly, but have to sacrifice some other flying opportunities instead. If they are unable to adjust their departure/arrival times because of slot constraints then the cost would be incurred in worse performance, which may cost more or less.

6.32 Many longhaul operators' schedules are heavily constrained by time differences, jet curfews and the difficulty of scheduling extra sectors with their aircraft. So a marginal increase in block time may have no impact. Equally there will be some carriers for which aircraft or crew integrations only just work, and even a small increase in block times could have a step change in crewing and/or aircraft required.

6.33 For the purposes of this study we argue that the simple "fixed cost per block hour" approach is the most reasonable when looking at the total impact on all operators at Heathrow.

Standby Crews and Aircraft

6.34 Airlines often acquire additional spare crews and aircraft to improve their operational resilience and to cope with aircraft technical problems or peaks in crew sickness. The resourcing philosophy and the proportion of standby crews and aircraft vary from airline to airline. For small airlines the costs of having a standby aircraft are too high relative to the total cost base to be justified. Larger airlines can allocate yet further crew and aircraft to standby to give cover for operational disruption and delays. Again practice varies between airlines. Some airlines' philosophy is that standby aircraft are only to cover technical despatch problems. Others will say that 50%, for example of the cover is specifically committed to improving punctuality: the standby aircraft on shorthaul fleets can be deployed to break the chain of rotational delays that can occur through the day.

6.35 Because of this variability in practice between airlines we have calculated the potential costs of holding standby crews and aircraft base on the following assumptions:

- Standby crews and aircraft are only deployed on shorthaul operations;
- The ratio of standby aircraft to total fleet is 1 in 30;
- The total fleet required to operate Heathrow is derived from total block hours on flights in and out of Heathrow divided by industry standard daily utilisation for shorthaul aircraft.
- 50% of the standby is allocated to operational performance and delay management
- Holding delays (i.e. departure delays accredited to holding) account for 20% of the total delay minutes.
- Each standby aircraft attracts pro-rata a normal crew complement and the associated fixed costs.

Minimum Connection Times

6.36 Minimum Connection Times (MCT) at Heathrow have increased over time and are longer than at comparable European hubs. Most of this relates to congestion within the airport rather than to late arrivals, but with uncertainty in arrival times it becomes more difficult for connecting passengers and their bags to make their onward flights. So an element of the MCT covers expected arrival delays. From our discussions with airlines we have not been able to attribute a proportion of the existing MCT to late arrivals i.e. by how much would the MCT be reduced if all holding related arrival delays could be eliminated. Same terminal MCTs at Heathrow are currently 60 minutes.

6.37 The benefits of a reduced MCT would be that some connecting passengers may be able to connect to a more convenient flight (passenger time saved), and airlines may be able to attract new passengers from other European hubs by offering more and/or better connections. The benefits for airports and airlines of reduced MCT are considerable as significant investments are made to improve the infrastructure and facilities for transfer passengers.

6.38 However, we have not quantified this cost, and believe that the expected benefit (i.e. the probability of being able to reduce MCT with increased runway resilience multiplied the incremental value gained by passengers and airlines) is low relative to other costs because:

- It only affects transfer passengers. So around two thirds of Heathrow's passengers are unaffected. Of current possible connections being sold many are not constrained by the Minimum Connection Time;

- Most LHR arrival delays are caused by factors other than LHR runway related constraints;
- Even if holding delays were reduced, other aspects of the LHR system for connecting passengers may mitigate against reducing the MCT.

Rotational Delays

6.39 When delays (primary delays) occur they impact later flights causing further delays (rotational delays) on flights operated by the same crew or the same aircraft. This has an impact mainly on passengers; costs such as fuel are unaffected. To estimate this effect we have examined the relationship between primary delays and rotational delays using three airlines' Heathrow and Gatwick data which together account for over 55% of the Heathrow arrivals and departures. We have looked at long-haul flights separately from short-haul, and also the differences between Heathrow-based and non-Heathrow carriers: non-Heathrow carriers will minimise the ground time, so there is less opportunity for recovering from a late inbound flight. A carrier based at Heathrow will usually schedule any spare non-flying time to be at Heathrow to give greater flexibility in controlling operations.

Relationship between holding (ground, airborne) and delays

6.40 An underlying assumption in our analysis is that the more time that is spent holding (within a given season), the worse punctuality becomes. This assumption allows us simply to sum the changes in the expected holding times and infer the increase in arrival and departure delays.

6.41 The statistical modelling referred to in Exhibit 4-28 and Exhibit 4-29 shows that although for longer ATFM delays and stack holding there is a clear 1-to-1 relationship with expected delay (i.e. one minute increase in ATFM delay or stack holding increases average delays by one minute), for shorter holding times there is no statistically clear conclusion. A pattern cannot be discerned because of many other factors which can cause delays are masking the contribution of ATFM delays. Also, scheduled arrival times reflect the historic average AFTM delay. Similar analysis for the stacks (not included in the report) gives a matching result. However, a reasonable assumption would be to conclude that if an aircraft has to circle above London for 3 minutes longer than was planned, or was held on the ground prior to departure for 3 minutes longer, then the expected arrival delay would also increase by 3 minutes: this is the relationship we have assumed. This relationship has been used to translate the modelled change in holding delays into changes in total delay minutes for purposes of economic analysis. In practice, this only affects the calculation of passenger related costs and the Value of Time calculation for rotational delays in the case where airlines do not incorporate increased holding into their block times.

6.42 A plausible further argument is that if the mean holding time were to increase then the incidence of holding delays (i.e. flights arrive later than scheduled because of extended holding) would also increase. The associated increased costs would be incurred even when the increase in the mean is reflected in the scheduled block times. We have calculated these costs on the assumption that they increase by the same % as the mean holding time, but not included them in the main analysis and results as it is an unproven hypothesis: to test this we would have to analyse airline punctuality data over several years to determine the relationship between holding times and delays attributed to holding.

Relationship between Primary Delays and Rotational Delays

6.43 We have used airline delay statistics (three airlines combined) to understand the impact of primary delays on rotational delays, deriving the factor by which to scale primary delays up. The accuracy of these numbers depends on the consistent and accurate attribution of delays to codes, but the results are broadly in line with the factors used by the University of Westminster, which were based on an American Airlines study of its US domestic operation.

7

ECONOMIC ANALYSIS RESULTS

COST OF HOLDING

7.1 We have analysed the Base Case for the seasons of Summer 2007 and Winter 2008/08 to calculate how much cost is incurred at current levels of operation and delay. The original intent was to assess the impact of changing demand versus capacity at both Heathrow and Gatwick. Because Gatwick is not as fully utilised, the resulting change in holding delays is much smaller and so the balance of benefits of extra flights are most likely to outweigh the incremental holding costs. As a result the scope of the detailed economic analysis and discussion has been restricted to Heathrow only.

7.2 The total annual "cost of holding"[17] at LHR amounts to £433 M as detailed in the following Exhibit 7-1.

Exhibit 7-1: Annual Costs of Holding at LHR

		Annual			
Baseline	Unit	ATFM	Stack	Ground	**Total**
Measures					
Delay	min 000s	617	1,133	2,351	**4,100**
CO2	tonnes	-	227,506 t	75,452 t	**302,957 t**
NOx	tonnes	-	1,146 t	378 t	**1,524 t**
Costs					
Fuel	million GBP	-	£ 48.7 m	£ 16.1 m	**£ 64.8 m**
Aircraft maintenance	million GBP	-	£ 7.6 m	£ 16.0 m	**£ 23.6 m**
Aircraft ownership	million GBP	£ 5.9 m	£ 14.5 m	£ 30.5 m	**£ 50.9 m**
Crew	million GBP	£ 6.7 m	£ 12.2 m	£ 24.9 m	**£ 43.7 m**
Other passenger costs	million GBP	£ 0.4 m	£ 1.6 m	£ 2.3 m	**£ 4.3 m**
Passenger VOT	million GBP	£ 29.9 m	£ 65.5 m	£ 130.5 m	**£ 225.9 m**
CO2 cost	million GBP	-	£ 9.4 m	£ 10.7 m	**£ 20.1 m**
Total costs	million GBP	**£ 43.0 m**	**£ 159.5 m**	**£ 230.9 m**	**£ 433.4 m**

Source: SH&E Analysis

7.3 These figures include the costs directly incurred by holding, plus the resources committed to operating the longer flight times that holding requires. To this can be added a further allowance of £3 million to £5 million annually for a share of standby aircraft, crews and ground staff used to protect poor punctuality attributable to extended holding. This figure reflects only the share of standby costs attributed by airlines to runway congestion; this attribution is based on a combination of the full cost, airline delay statistics and also their judgment about how standby resources are justified and utilised.

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[17] See earlier discussion in paragraph 6.17 for definition of "cost of holding".

7.4 Other Passenger Costs are those costs incurred by airlines and passengers when congestion builds and extended holding times affect punctuality. These costs are more difficult to calculate precisely, but cover such things as mis-connecting passengers and bags as well as passenger compensation. Holding delays are largely compensated for by extending scheduled sector times, but even so holding related delays account for up to 20%[18] of the total delay minutes at Heathrow.

7.5 Of the airlines we spoke with, many of the costs reported such as the need for overnight accommodation and meals were incurred most often on the small number of days when there was significant disruption. Many of the passenger related costs (e.g. compensation) are only applicable when delays are extended – EC compensation for example only applies for flights delayed by at least 2 hours. Holding delays account for around 20% of the total delay minutes and only a proportion of the passengers on those flights were delayed long enough to incur costs. Only 3% of passengers are delayed more than 2 hours[19] which is the minimum period to qualify for compensation under EU legislation.

7.6 By applying airline reported costs to holding related delays we have estimated an overall cost for passenger costs which is low. We have included a notional 1% of total holding costs as an upper bound to be added to cover all these costs together. The relationship between holding delays and the associated uncertainty in punctuality is discussed in 7.50 and the following paragraphs

7.7 As well as directly measurable costs such as fuel the £433 million figure include the cost of the value of passengers' time (VOT) and also the cost of CO2 emissions. The importance of passenger VOT is more clearly shown in Exhibit 7-2 below.

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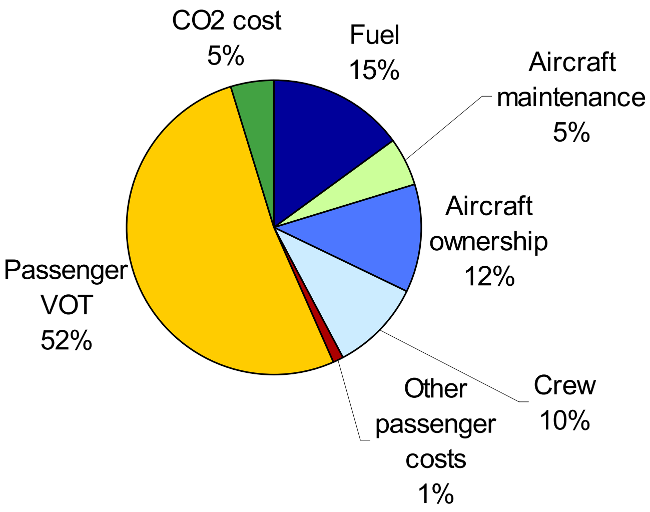
[18] Based on 12 S07 and W07/08 LHR and Arrival and Departure punctuality data from BA, bmi and Lufthansa. This data reflects individual airline practice in allocating codes, and unique and consistent identification of runway congestion as opposed to other air traffic control causes is not possible.

[19] Based on the same punctuality data, adjusted for typical aircraft configurations and passenger load factors.

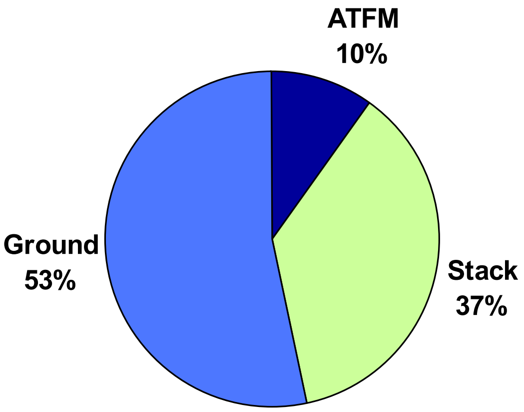
Exhibit 7-2: Holding Costs Breakdown



Source: SH&E Analysis

7.8 The break down between the departure and arriving queues is summarised in the next two exhibits (Exhibit 7-3, Exhibit 7-4), together with their share of the total costs. The airborne stack costs are the most expensive per minute, but ground holding is the largest absolute cost because of the number of minutes spent holding. Ground holding for inbound flights is a much smaller figure because the delays are less and the engines are not started generally until the captain receives slot clearance.

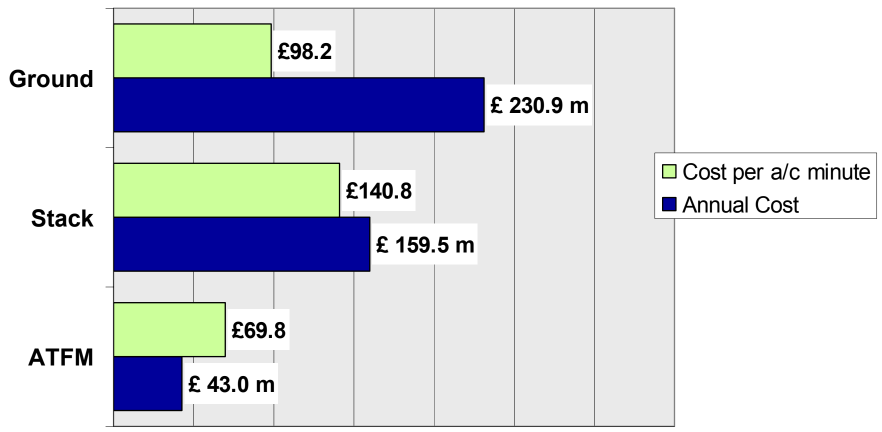
Exhibit 7-3: Holding Costs by Type



Source: SH&E Analysis

7.9 These total holding delays are equivalent to 8.5 minutes per flight, 7.3 minutes for arrivals and 9.7 minutes for departures, and the cost per minute of holding delay is £ 105 per minute.

Exhibit 7-4: Annual Holding Cost Totals and Per Minute



Source: SH&E Analysis

7.10 The cost equates to approximately £900 for each aircraft landing and each aircraft departing, compared to an overall cost per flight of £30,000 to £35,000. These figures obviously vary according to flight length and size of aircraft. The ATFM costs for example are only incurred by shorthaul flights, and larger aircraft burn more fuel. At around 3% the holding costs are of the same order of magnitude as airline operating margins, implying that any worsening of this situation will have a direct and measurable impact on airline profitability that will in some cases make the difference between a profit and a loss.

7.11 The difference in operating conditions and airlines schedules between summer and winter does not give rise to significant differences in the costs. The seven month summer period has a Cost of Holding equal to £247 million while the shorter five month winter period has a cost of £160 million. The slightly more costly winter months experience more weather related delays.

7.12 Details of the cost calculations are given in Appendix B: Costs of Holding and Delays. A summary of the key economic assumptions and factors which drive these results is given in the following table:

Item	Value	Source
Fuel Cost	0.70 GBP / kg	Average price of AMS-ROT Jet type kerosene for May 2008.
Passenger Value of Time	Business: 0.91 GBP / min Leisure: 0.14 GBP / min	Department for Transport
Cost of Carbon	21.8 GBP / tonne	2007 value, based on the DEFRA and DfT methodology
Airline Costs	Various	AEA, ICAO, individual airlines, US Form 41, Airline Fleet and Network Management

RESULTS OF THE SCENARIOS

7.13 The holding costs in Exhibit 7-1 above are the baseline against which the scenarios defined in Exhibit 5-1 and listed below are now compared:

- Scenarios 1 & 2: Sensitivity testing: flights added or removed each hour;
- Scenario 3: Additional application of TEAM;
- Scenarios 4,5,6: Application of Mixed Mode operations: +5%, +10%, +15% capacity;
- Scenario 7: Reduction of demand across the day.

7.14 For Scenarios 1 & 2, where flights are added or removed each hour, we have calculated the change in Net Benefits. The Net Benefits of the extra flights are made up of several elements:

- The benefits new passengers gain from the additional flights (Generated User Benefits)
- The value of time saved by existing passengers who benefit from more convenient schedules (Existing User Benefits)
- Additional profits airports make from additional passengers (Producer Benefits)
- Increased Air Passenger Duty (APD Revenue)

Less the offsetting costs incurred

- The environmental costs of extra flights
- The increased costs of holding, as summarised in Exhibit 1-6 above.

While the actual benefits from any additional flights may vary by time of day and also depend on the flight destination and aircraft size, the methodology of benefit estimation works at a more aggregate level and does not allow that level of differentiation.

7.15 For the other scenarios we have calculated the change in holding costs only, assuming that the flight schedule does not change. The holding costs are incurred by all flights operating in and out of Heathrow during the affected period, whereas the additional flight benefits accrue only to the additional flight itself.

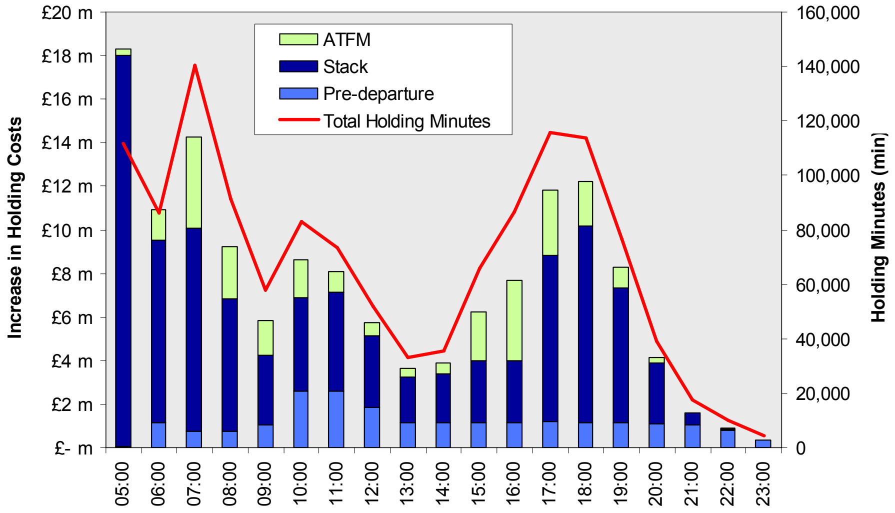
Evaluation of Scenarios

Scenario 1: Impact of adding one flight each hour

7.16 In this scenario we firstly look at the impact on Heathrow holding costs (including passenger "value of time" and the cost of carbon) when flights are added each hour. We then look at the costs and benefits derived from the extra flight itself, and finally at the net benefit.

7.17 The effects of adding one arrival and one departure flight in each hour on holding times were described and discussed in 5.44 and subsequent paragraphs. The annualised cost impact of adding flights is illustrated in the following exhibit.

Exhibit 7-5: Extra Holding Cost for Additional Flights



Source: SH&E Analysis

7.18 This shows that the increased costs are highest for stack holding, accounting for over 66% of the incremental costs. Overall incremental costs are particularly high in the early morning arrivals peak when there is a high proportion of wide-bodied aircraft, and also the evening peak. The peak is £18.3 million and the **average across the operating day is £7.5 M.**

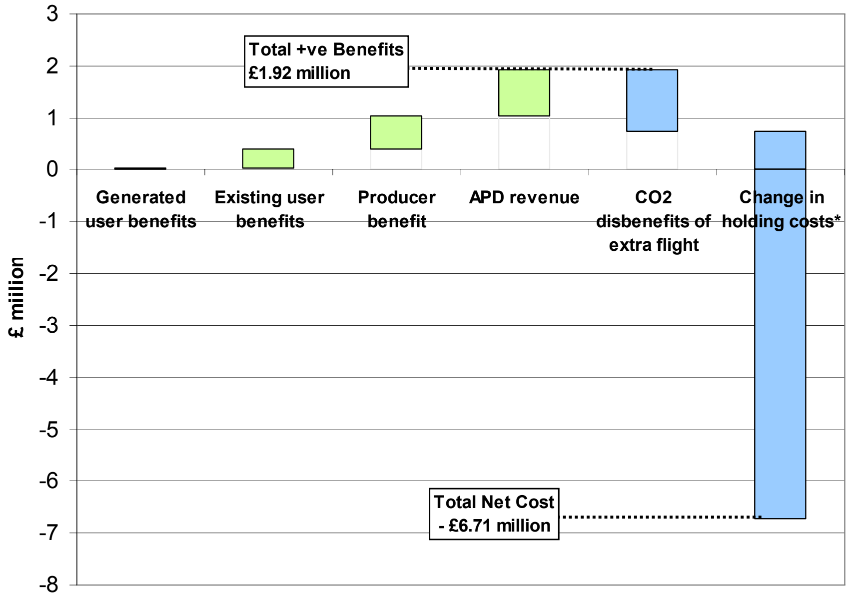
Benefit from extra flights

7.19 When flights are added there is an expected benefit to the airport (additional profit), to passengers (increase in consumer surplus) and also from additional APD collected. At the same time there is the Carbon Cost from the extra flights. We have calculated the Net Gain from adding an additional frequency averaged across all routes and all times of day. As discussed in Appendix C:, the expected profit based on the DfT methodology uses airport aggregate data and does not reflect specific variations by airline, route, season, day of week or time of day. Whilst conceptually the approach could be refined to reflect some of these factors such as the mix of business and leisure passengers – a departure at 0700 on a Monday to Milan will have a different mix and seat factor to an 1100 departure on a Saturday to Barcelona - for this analysis we have assumed each extra flight has the same average costs and benefits.

Net Benefit(Loss) after Holding Cost impacts are included

7.20 We have then calculated the combined change in Total Net Benefit of adding an arrival and a departure in the exhibit below:

Exhibit 7-6: The average net loss from adding a daily pair of flights at LHR



Source: SH&E Analysis

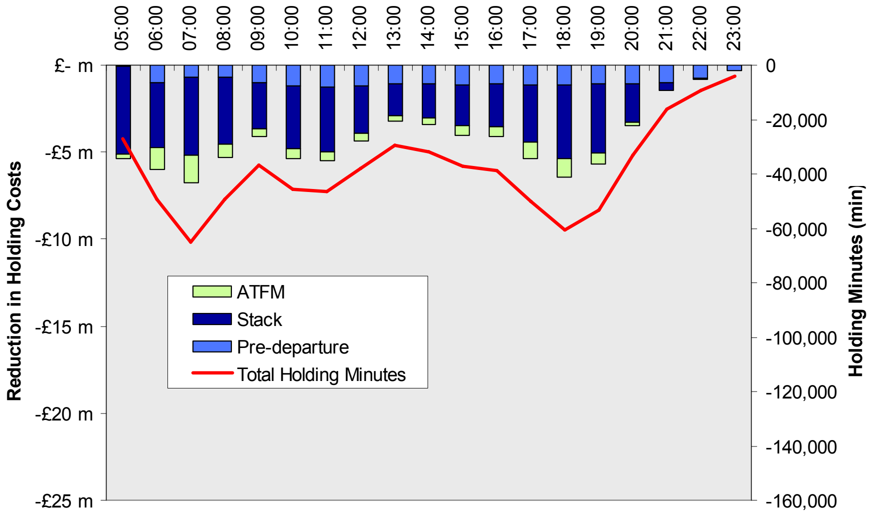
7.21 The total average annual benefit from adding an extra flight is £0.74 million. **This gives a net result per flight pair added of a loss of -£6.71 million when the increased holding costs are considered.**

7.22 The total net effect of adding flights is a loss regardless of when the flights are added during the day. The benefits that airlines and passengers might achieve with the new flights are outweighed by the negative effects imposed on other airlines and passengers in terms of increased holding costs.

Scenario 2: Impact of withdrawing a flight each hour

7.23 Within this scenario we have looked at the net impact of withdrawing a flight pair each hour. The gain in terms of reduced holding costs of removing flights, shown in the following exhibit, is less than the increased costs when adding flights. The annual average gain has a peak of £6.8 million and an **average across the operating day of £4.3 M.** The difference between adding and subtracting flights of roughly two-to-one is simply a function of the corresponding change in delay minutes, and the fact that as demand is added without any increase in capacity the deterioration in performance becomes ever faster.

Exhibit 7-7. Reduction in holding costs if flights are removed in each hour



Source: SH&E Analysis

7.24 When we then consider the lost benefit (User, Producer, APD, CO2) of the withdrawn flights, **the average total net gain reduces to £3.52 million a year.**

7.25 In making this calculation we have assumed that the impact on producer and user benefits are the same as the gain when adding a flight, but in the opposite direction. In practice the decision making process is unlikely to be this symmetrical. Flights will be added where the airline that can afford the risk and investment, and can acquire the slots needed, sees the greatest opportunity. When flights are withdrawn it is likely to be from destinations which would provide the poorest returns. It could be argued that the spread for an individual airline between adding and subtracting a flight is not that great because airlines have the option of either making those changes within their own slot portfolio, or negotiating slot swaps through the IATA scheduling process to secure the changes they want.

7.26 It would still seem beneficial overall to reduce flights if that were a practical proposition.

Conclusions from Scenarios 1& 2

7.27 The conclusions from the sensitivity test scenarios are as follows:

- The additional holding costs and environmental impact outweigh the potential combined gains to airlines, airports, passengers and APD from adding extra flights.
- The average net additional cost is £6.7 million a year for each flight pair.
- The net cost of adding extra flights is highest in the morning and evening peaks, with a reduced impact during the middle of the day.
- Similarly there is a smaller average net gain of £3.5 million a year theoretically realised if one flight pair is reduced in any hour.

Other Scenarios 3 to 7: Extended TEAM , Mixed Mode and Reduced Demand

7.28 For the remaining scenarios it has only been necessary to estimate the change in holding costs as the flying programme is assumed to be constant, except for Scenario 7, Reduced Demand. The reduction in total annual holding costs is shown in the following exhibit. Note that Holding Costs includes both the passenger value of time, and also the CO2 costs which are shown separately in the table.

Exhibit 7-8: Scenarios 3 to 7 - Annual Reduction in Holding Costs

Nr	Scenario	Holding Costs	Holding time	CO2 emission	CO2 costs	Nox emission
		million GBP	min 000s	tonnes	million GBP	tonnes
3	Extended TEAM	£ -32.3 m	-251 min	-59,000 t	£ -2.7 m	-293 t
4	Full Mixed Mode 15%	£ -348.2 m	-3,459 min	-273,000 t	£ -10.1 m	-1,366 t
5	Mixed Mode 10%	£ -164.2 m	-1,568 min	-164,000 t	£ -6.6 m	-826 t
6	Mixed Mode 5%	£ -106.2 m	-983 min	-114,000 t	£ -4.6 m	-575 t
7	Reduction of Demand	£ -122.5 m	-1,193 min	-116,000 t	£ -4.6 m	-578 t

Source: SH&E Analysis

7.29 The scenario 3, extended application of TEAM, shows a decrease of holding costs in the range of £32 million despite the fact that the pre-departure holding in this scenario increases: this effect is counterbalanced by the larger reduction in ATFM holding and stack holding times which have significantly higher costs per minute.

7.30 The scenarios where Mixed Mode is applied to different levels all show decreases in holding costs and emissions attributable to lower congestion.

Scenario 7: 5% Reduced Demand

7.31 In this scenario we have removed two flights in each hour (Arrivals and Departures) to give an approximately 5% reduction in demand. We have not modelled the flight benefits explicitly, but have assumed the marginal gains/(losses) from subtracting flights are the reverse of adding flights, as for Scenario 2, Withdrawing one flight per hour, and multiplied by 19, the number of commercial hours in the day.

Exhibit 7-9: Impact of Reducing Flights on Holding Costs

Season	Change in				
	Holding costs (incl. CO2) million GBP	Holding time min	CO2 emission tonnes	CO2 costs million GBP	Nox emission tonnes
S07	£ -66.1 m	-648,648 min	-58,546 t	£ -2.3 m	-292 t
W0708	£ -56.4 m	-544,587 min	-57,597 t	£ -2.3 m	-286 t
Annual	£ -122.5 m	-1,193,235 min	-116,143 t	£ -4.6 m	-578 t

Source: SH&E Analysis

7.32 In this scenario the costs and emissions go down as a consequence of the reduced holding times, but this gain is offset by loss of benefits from the cancelled flights which would amount to £14.1 million annually per fight pair, giving **a Net Benefit for this scenario of £108 million a year**.

SENSITIVITY OF RESULTS TO KEY ASSUMPTIONS

7.33 The sensitivity analysis has examined the trade-off between Cost of Holding affecting all flights, versus the benefits that might accrue should a single extra flight be added in each hour, i.e. Scenario 1. We have tested the sensitivity under this scenario of the User and Producer Benefits, APD, Environmental Costs, the Holding Costs (including C02) and the change in Net Benefit with respect to the following critical assumptions:

- Fare elasticity;

- Passenger VOT.
- Fare levels of the extra business passengers
- Radiative Forcing Factor
- Cost of Fuel
- Cost of Carbon

7.34 The following table shows the impact on the change in the benefits from adding a flight pair, on the change in Holding Costs, and on the net resulting benefits when the above parameters are varied by +/- 25%:

Exhibit 7-10: Sensitivity to Key Assumptions for Scenario 1

Parameter to change	Parameter value			Change in benefits		Change in holding costs		Change in net benefits	
				Annual benefit £0.74		**Annual Cost £ 7.46**		**Annual Net £ 6.71**	
	Base value	+25%	-25%	+25%	-25%	+25%	-25%	+25%	-25%
Average fare	£284.8	£356.0	£213.6	+1%	-1%			-0%	+0%
Passenger value of time / hr	£25.1	£31.4	£18.9	+12%	-12%	+12%	-12%	+12%	-12%
Price elasticity	-1.00	-1.25	-0.75	-1%	+1%			+0%	-0%
Radiative forcing factor	1.90	2.38	1.43	-39%	+39%	+1%	-1%	+5%	-5%
Fuel price / kg	£0.7	£0.9	£0.5			+5%	-5%	+5%	-5%
Cost of CO2 / tonne	£21.8	£27.3	£16.4	-39%	+39%	+1%	-1%	+5%	-5%

Source: SH&E Analysis

7.35 We have not tested the sensitivity for all scenarios, as the calculation method and assumptions are similar in each scenario and would yield similar results.

7.36 The results of the sensitivity analysis show that even relatively large changes in the key parameters do not have a significant effect on the overall results. The most sensitive parameter is the Passenger Value of time which accounts for a significant proportion of the Holding Costs and hence the net benefit.

7.37 Fuel accounts for around 15% of Holding Costs, and any change in Fuel Cost has a direct pro-rata effect on the incremental costs. So a 25% change in the price of fuel has a roughly a 5% change on the Net Benefits.

7.38 The combined effect of the cost of CO2 and the Radiative Forcing Facto assumptions are of the same order of magnitude as fuel, and changes in either of these assumptions have the same effect.

7.39 The overall conclusion is that even with significant changes to the various parameters used, the main result that costs of holding heavily outweigh the benefits of incremental flights is unchanged.

COSTS OF PREVENTION VERSUS COST OF FAILURE

7.40 In calculating the impact on Holding Costs in the above scenarios we have assumed that any increase in expected holding times is incorporated in a procedural way into subsequent seasons' sector block times. An alternative strategy would be for airlines to limit further sector time increases and instead accept a worsening of on-time punctuality for both arrivals and departures. To understand the economic consequences of such a policy we have calculated the increased incidence of delayed departures and arrivals, and the associated impact on costs.

7.41 Based on airline supplied total costs of delay and passenger disruption and allocating this cost to all passengers delayed more than one hour, we have derived an upper bound of £15 for a cost per passenger (delayed more than one hour).

7.42 The distribution of current departure delays weighted by the average number of passengers per flight indicated that an extra minute of delay for all passengers would increase the number of those delayed over an hour by around 75,000 passengers a year. At £15 per passenger this would add £1,112,500 of passenger delay related cost to all airlines. This is a fairly crude measure but it does give an indication of the sensitivity of delay costs to an increase of one minute in holding delays if block times are not increased.

7.43 The Costs of Prevention associated with holding are primarily the costs of assigning additional crews, aircraft and ground staff to cover the increased schedule time. This excludes the Failure Costs of Passenger VOT, fuel burned, passenger disruption costs and the cost of carbon. By dividing theses costs by the delay minutes we derive a typical Holding Cost of Prevention of £23 per minute. (data used is as shown in Exhibit 7-1: Annual Costs of Holding). If this cost is added to every departure and arrival then the approximate LHR Holding Cost of Prevention for an incremental minute in the buffers = 480,000 ATMs per year x £23 = £11,000,000. This far outweighs the simplistic calculation of Failure Costs above at £1.1 M for an increase of one minute in the average holding time.

7.44 The implication of this is that purely from an airline cost perspective, the airlines current approach of building increased holding delays into the schedule only makes sense if they also place a significant value on protecting customer service standards.

Passenger Time Buffers

7.45 Airlines and their passengers both argue that it is not just longer time holding or mean delays that are costly, but that there is an additional cost in the uncertainty of delays or actual arrival time. For passengers this would translate into either taking an earlier flight than maybe would be needed if schedules were reliable, or allowing a buffer in the working day on arrival and not scheduling meetings as early as they could have been. Either way there is likely to be some time wasted in the form of a passenger "time buffer" which is analogous to the schedule buffers used by airlines.

7.46 A measure of the level of uncertainty is the 95th percentile of the various distributions as described earlier. The Heathrow data shown in Exhibit 4-61 is reproduced below:

Exhibit 7-11 Summary of Heathrow Holding Delays

		Stack	ATFM	Ground	Pre-start-up
Summer	Total (000s mins)	565	389	1404	537
	Average (mins)	5.3	2.8	10.0	4.6
	95th %ile	10-15	15-25	14-22	19
Winter	Total (000s mins)	602	625	942	409
	Average (mins)	6.0	5.3	9.2	4.4
	95th %ile	15-20	35-45	14-22	18

Source: Helios Analysis

7.47 From this we can see that for the Stack and Ground delays the 95th percentile is roughly double the average. For AFTM and pre-start-up the spread of delay times is much larger. An extremely cautious passenger who wanted to ensure a 95% chance of being on time at their final destination would have to add a buffer into their journey plan at least equal to the current average holding minutes. If this were the case, and all this time were wasted then this would effectively double the cost of passengers Value of Time as calculated in the Cost of Holding in Exhibit 7-1, which would mean an additional £226 million annually.

7.48 In practice few people are this cautious, and not all trips are time critical so many passengers take the risk of a delay rather than trying to insure against it – planning to waste some time on every trip to avoid the risk of being delayed one trip in twenty is not practical. Secondly the time will not all be wasted, as it will most likely result in passengers taking an earlier flight if one is available and as this is a planned event, they should be able to re-organise their day around that. Thirdly, for many trips there may not be a practical option of taking an earlier flight or setting a planned meeting on arrival at a later time. Fourthly the buffer would not be planned to cover solely the runway congestion triggered delays, but also problems on arrival such as baggage and onward journey to the final destination.

7.49 Our conclusion is that only a small proportion of the theoretical upper bound of £226 M is likely to be incurred in practice, but without further research into actual passenger behaviour when planning trips it is difficult to judge how small.

Effects of uncertainty in holding times on airlines

7.50 A similar argument applies to airlines. The extent to which they build buffers in to cover the mean holding delay is already included the Costs of Holding as calculated. We have also calculated the holding delay share of standby cover as being between £3 and 5 million. We have not however estimated the cost of further buffers being built into airlines plans which occur in two ways.

7.51 Firstly the practice when setting schedule block times is to use a percentile of historic actual times, usually 65% or higher, and not the mean. The logic behind this is that by planning to the mean (or at least the median which will be close but different) would result in 50% of flights arriving later than scheduled. Adding a buffer large enough to ensure all only a few flights arrive late would extend block times to an uneconomic extent, and would also result in most flights arriving early which in itself can cause problems. The percentile chosen is then a compromise.

7.52 Secondly airlines build some slack into the schedule by either extending minimum working times for turn-rounds, or deliberately not scheduling too tightly to allow some resilience and ability to recover from delays when they occur. This has not been measure as it varies from carrier to carrier, and also from year to year as aircraft availability cannot always be adjusted in line with demand.

7.53 The current Cost of Holding relating to aircraft ownership at Heathrow is, from Exhibit 7-1, around £50 million. A judgement based on our discussions with airlines would be that there is at least a further £10 million of hidden cost driven by the uncertainty in delays which is additional to the costs given to cover the average holding delays. This figure would need to be validated but is consistent with estimates made by British Airways.

ENVIRONMENTAL IMPACT

7.54 There are several potential environmental impacts to consider both from additional flights on one hand, and from increased holding delays on the other. These are primarily carbon emissions from fuel burned, other emissions (nitrous oxides), noise, and the local impact of additional traffic to and from the airport.

7.55 The only element measured in economic terms is the carbon consumption, although the NOx emissions were also calculated. There is no noise impact from ATFM Ground Holding, and only a very small impact from increased time in the stacks or taxiing.

7.56 The increased release of carbon dioxide and nitrous oxides were calculated similarly to the fuel burn of the airlines. We have estimated the CO2 and NOx emissions that correspond to the typical fuel burn values of aircraft operating to Heathrow using the values from the ICAO Engine Emissions Database. (see values in Exhibit 9-1) Then we scaled up these numbers according to the traffic mix and holding times of each scenario. We have then applied the Radiative Forcing Factor of 1.9 for CO2 in the stacks, following the DfT methodology, to reflect the expected greater impact on CO2 released at altitude

7.57 We have also expressed the CO2 emissions in monetary terms, using the DEFRA recommended £19/tonne increasing by 2% a year in real terms from the base year value in 2000.

Part IV:
ROOT CAUSE ANALYSIS

8

ROOT CAUSE ANALYSIS

INTRODUCTION

8.1 This part of the report, prepared by XPX Consulting, can be read as a stand-alone document, but most benefit is gained if read in conjunction with the other parts. The root cause analysis concentrated on a thorough assessment of the current operation, modelling of some optional scenarios in terms of the impact on airborne and ground holding and quantifying the economic impact of these changes to the capacity/demand balance – all in order to inform policy development on that balance. The scope of the main study was both Heathrow and Gatwick airports.

8.2 This section of the document reflects the work, undertaken by XPX Consulting, which is directed at understanding better why the current position has evolved in the way it has and to postulate directions of improvement opportunities – compatible with the optional scenarios of the modelling and also to help ensure that any implementation arising from policy and operational changes would have the best possible chance of success.

8.3 By common consent, and by comparison with benchmarks, the operational performance and robustness at Heathrow, in particular, are unsatisfactory. There are numerous causes – many going beyond runway demand and capacity, and therefore outside the scope of this study – but nevertheless, sound runway performance and resilience are essential conditions of overall airport success.

8.4 The focus of this section of the report will be on Heathrow – the operational analysis has demonstrated for Gatwick that the combination of overall spare capacity and mixed mode operation creates less pressure on runway performance, resulting in much lower levels of queuing (for arrivals at least) and cancellations and, therefore, fewer seriously disrupted days. The overall level of runway resilience at Gatwick can be expected to remain acceptable unless and until the demand levels increase in the afternoon period and/or excessive delays on departures cause a knock-on effect to arrivals.

8.5 Also the bias will be towards arrivals rather than departures. Departures runway scheduling limits are higher than for arrivals and therefore are less of a constraint, unless TEAM is in operation. Holds in the departures process are also more difficult to analyse at a root cause level within the scope of this short exercise. Queuing for arrivals is largely transparent through ATFM data and airborne holds – only speed controls and/or re-directed flight plans are difficult to assess – whereas the operational analysis has demonstrated for departures the difficulty in separating different causes of demand bunching and the capacity restrictions implied in MDIs and intermediate forms of queuing.

8.6 The views expressed are based on review of the same data as used in the operational analysis, additional data and analyses from stakeholders, the outcomes of previous exercises and discussions with a wide cross-section of stakeholders. In addition, at the request of the CAA, in order to aid debate XPX has incorporated some of its own viewpoints and tentative suggestions for future work to improve runway resilience, based on its own experience and informed by the operational analysis in the main report.

SUMMARY

8.7 The discussion will point to four main strands of root cause issues:

- Pressure on the Capacity Declaration procedures to create additional capacity – but with a process which does not have, nor is asked to have, a full set of planning parameters, metrics, and targets to make it sufficiently operationally realistic. An example is in-bound pre-departure ATFM delays which, although often caused by factors beyond the airport’s control, happen on a daily basis - it would therefore seem prudent to have a collective stakeholder response in addition to the schedule buffering introduced by airlines (using their own internal assumptions). The process also lacks any real power to drive any difficult changes – particularly reductions in capacity/demand. This is exacerbated by the current lack of economic trade-off metrics.
- Pressure on tactical ATC management to correct the imbalances created by weaknesses in the plan, airline adherence to plan and factors outside their control. Over time, tactical reserve positions have been eroded and effectively incorporated into the assumed operation e.g. TEAM in the early morning. Small but measurable increases in demand and adverse trends in aircraft mix are adding to the problems and potentially further weakening resilience.
- Bunching of runway demand, caused in part by peaks within the schedule but also by airline processes and performance which do not consistently deliver aircraft on plan (although again recognising network factors which may be beyond their control).
- Gaps in the governance structure and processes which result in limited incentives and sanctions around adherence to plan and responses to endemic issues. While there are many planning and performance committees and improvement initiatives, there are few system-wide key

performance indicators (KPIs) – resulting in gaps e.g. again relating to the ATFM delay problem described above and, until recent community effort, a fully co-ordinated response to days of serious disruption. This can be exacerbated by funding debates where benefits and costs accumulate in different organisations.

8.8 It should be stressed that the airport and its community of airline users have a set of planning, governance and performance review structures which are fully compliant with EU slot regulations, safety and DfT regulations, and IATA scheduling guidelines, and which are highly respected in the aviation industry. However, the problems of congestion, environment and disruption specific to Heathrow appear now to demand a new and higher order of targeting, planning and managing at the airport. We have assumed for the purposes of this study that the legislative and regulatory frameworks mentioned above will remain in place as the context for Heathrow operational planning, albeit that some of the parameters affecting demand and/or capacity may be modified.

8.9 Clearly, there are no simple solutions – different levels of mixed mode have been modelled in the main exercise (and in other studies) and operationally it has the advantage of potentially allowing increased demand and/or restoring tactical capacity (and increased arrival separations) to improve resilience.

8.10 Short of mixed mode, or alongside it, there are a number of options which could be developed – some of which are already on the continuous improvement agenda and some of which could be addressed through a co-ordinated effort if the relevant targets, objectives and amended governance structures could be agreed. Examples include:

- Changes to the shape of the schedule and incorporation of more extensive and realistic planning parameters to smooth patterns of capacity and demand. Subject to technical feasibility and further detailed modelling (beyond the scope of this study), holds should be reduced by levelling flows over the day. It is possible that technical constraints associated with such a move could lead to a marginal reduction in capacity – which may carry economic penalties to airlines as a result of losing some commercially valuable slots in the peaks.
- Targeted reductions in capacity to induce a reduction in demand. Some modelling has been reported in the main report on general reductions – in practice there would be a range of options, the most valuable in terms of operational performance concentrating on “firebreaks” – short gaps or reductions in the airport’s daily schedule - to relieve the impact of the peaks. The resultant loss in aircraft traffic movements would be off-set, in terms of passengers, through demand shifting to other services either

side of the change in the schedule (leading to higher load factor and/or reinforcing trends to larger aircraft).

- Resilience and operational control improvements to help restore tactical resilience. These measures are unlikely to allow increases in demand but would assist resilience and facilitate punctuality improvement. Examples include:
    - Improved control and process discipline from implementation of wider Collaborative Decision Making – this is in development at Heathrow.
    - Time-based separation – this would be a significant development requiring substantial work on the safety case for moving from current distance-based separation.
    - Extended application of TEAM – there are detailed options which are more specific than those modelled in the main project. This may require Government policy approval, given the noise implications, depending on the level of change required to the guidelines.
- A fuller package of targets, planning parameters and KPIs within a strengthened governance structure could tighten control of the operation and introduce more sanctions and incentives. Steps might include changes to the “first come, first served” procedures, new measurement points in the processes and trade-off decision support.
- Achieving change of this kind would also tighten the distribution curves to improve predictability - other drivers of poor punctuality at the airport could then be addressed with greater confidence and less interaction with runway performance.

8.11 These approaches address the identified root causes, but in terms of measured impact, most would be reflected in specific elements of performance (e.g. ATFM holds or cancellations) - rather than the fundamentals of the relationship between capacity and demand which was the focus of the main study. Therefore, rather than talk about overall improvement, it is necessary either to construct a package of changes or to specify more granular targets (e.g. reduced number of disrupted days) and to prioritise relevant initiatives.

8.12 In any event, a more holistic view of targets and governance is likely to be required to balance the historic pressures to increase the level of demand with acceptable operational integrity.

8.13 The rest of this section sets out a more detailed examination of the root cause issues and realistic responses.

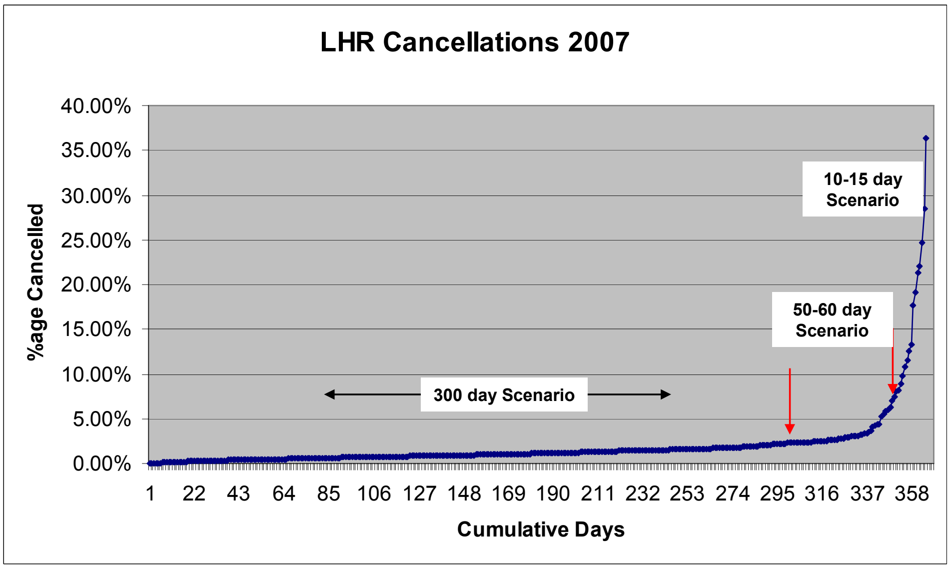
APPROACH TO ROOT CAUSE UNDERSTANDING

8.14 To understand the underlying issues and possible mitigating solutions it is useful to look at three different operational scenarios at the airport (simplified from the spectrum observed):

- For 300 days of the year, the runway and airport system achieve at least 98% of the planned programme – i.e. less than 2% of flights are cancelled for operational reasons (although this does not necessarily imply high levels of punctuality)
- For 50-60 days the corresponding completion is between 93 and 98% - disruption and delays are significant but, by and large, the airport is able to recover back to schedule in time for the following day. Airlines may have to make major operational changes (e.g. to aircraft and crew allocations) to achieve this.
- For the other 10-15 days the figure is less than 93%, equating to at least 50 flight-pair cancellations - disruption and delays are very significant, often with repercussions to schedules and operations on the following days.

8.15 These scenarios are consistent with the test conditions used in the main report. The number of days at each cancellation level is shown in Exhibit 8-1.

Exhibit 8-1: Distribution of Number of Cancellations for Heathrow in 2007



Source: XPX analysis of ACL data

8.16 The 10-15 day scenario usually is driven by severe weather conditions significantly reducing runway capacity (or occasionally, a major bottleneck somewhere else in the system e.g. caused by a security incident). The number of actual events may have been smaller but can have generated serious knock-on effects into the following day(s).

8.17 The 50-60 day scenario can be caused by a large variety of conditions – most commonly related to weather but also a range of issues such as short operational incidents or problems elsewhere in the European network.

8.18 As well as almost certainly leading to serious punctuality problems, both scenarios will threaten Night Jet Movement quotas at LHR and lead to steps to avoid breaching curfews at some destination airports. They will also cause punctuality and cancellation problems to be disproportionately concentrated into shorthaul routes as longhaul inbounds will be prioritised by the ATFM system and longhaul departures will be protected by the airlines for a series of operational and commercial reasons. The problems may be further concentrated by the biasing of cancellations by base airlines into routes which provide the quickest and least penalising relief – hence domestic and near continental routes will tend to suffer more.

8.19 In the 300 day scenario, the runway does not inhibit the completion of the programme in total – but other issues can cause a pattern of capacity and demand which creates significant punctuality problems and knock-on problems for the runway

8.20 For a complete picture, each “regularity” scenario should be accompanied by a hold pattern as illustrated in the main report (covering the basic data and the case studies of December and November last year), and relevant punctuality data (which is beyond the scope of this phase).

8.21 To a large extent, the pattern of the three (simplified) scenarios described above is an inevitable consequence of a “full” airport, driven by the commercial pressures to maximise schedule slots. However, there are no structured policy, planning or operational processes which consider whether the above pattern is acceptable, exacerbated by the lack of trade-off criteria, which this overall initiative should help to inform.

8.22 While any improvement initiative would benefit all these situations, there are differences in their characteristics and root causes and therefore in the steps which might create opportunities.

8.23 Each of these three scenarios is now considered in a little more detail.

10-15 day scenario

8.24 It is almost impossible to plan strategically for the 10-15 day scenario, or substantially to improve resilience, short of radical action to support flow-rates through Mixed Mode or to reduce capacity substantially (- virtually certain to be uneconomic). The benefit of Mixed Mode and spare capacity was illustrated in the case study comparison between Heathrow and Gatwick in the main report.

8.25 Within the existing broad operating regime (i.e. predominantly Segregated Mode) the focus needs to be on anticipation of problems, protocols to govern cancellations equitably and beneficially, contingency plans for all aspects of the airport system (extending to hotels etc) and procedures to apply for possible relaxation of the NJM[20] quota. These topics are currently the subject of an airport community consultation and policy development process – in response to some of the experiences of recent seasons.

50-60 day scenario

8.26 It is difficult to plan strategically for this scenario. From time to time consideration has been given to, say, schedules which vary by the month to reflect differing anticipated weather and global wind conditions – but the current Northern Hemisphere 2-season approach has always been concluded to be the "least worst" approach. The observations which underpin the modelling of airborne and outbound ground holds in the Capacity Declaration Process are based on "normal" days but an average cannot realistically embrace the range of conditions experienced.

8.27 In some ways, this is the category which would benefit most from policy, technological and operational improvements. Typically in this scenario, the cause of disruption is a particular issue (e.g. wind) and therefore may be mitigated by specific improvements which address that cause – in the case of winds, Time Based Separation. (Time Based Separation is the most effective antidote to the reduced flow rate normally connected with high winds).

8.28 On the schedule front, relatively small reductions in demand might be expected to generate significant results (as discussed again in the main report). Although full impact assessment has not been done, it is possible that focussed "firebreaks" might be more beneficial than across-the-board reductions. This is because gaps or reductions of this nature may allow airlines to re-establish their operations for the rest of the day. Benefits may, therefore, be felt more in

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[20] Night Jet Movement – the number of aircraft movements outside normal operating hours

punctuality than in measured runway performance – however, this would clearly be to the overall benefit of the airport.

8.29 Operationally TEAM is already used within guidelines with a net benefit in runway utilisation, but currently there are few other tactical alleviation options remaining. Some airlines have been forced to generate tactical cancellation algorithms to address the situation. Although difficult to quantify, it also appears that in this 50-60 day scenario (when the European network is stretched), the way in which the CFMU[21] system works, combined with pilot behaviours, may exacerbate recovery difficulties. Issues include the ways in which flight plans are/are not deleted or up-dated and the use of EOBT (Estimated Off-Block Time) figures in the process of assigning CTOTs[22]. These issues can have the effect of rendering some of the information used in the CFMU allocation system as inaccurate – the net effect being that potential take-off slots can go unused, slowing recovery.

8.30 It would be technically possible for the anticipation and contingency approaches being developed for the 10-15 day scenario to be extended – but this is not planned at present.

8.31 More detail on optional solutions is discussed below.

BASE CASE – THE 300 DAY SCENARIO

8.32 This is effectively the base case scenario. Some level of operational cancellation will be inevitable in response to technical problems and punctuality recovery. The remainder of any disruption may relate to runway issues, but the runway contribution to any operational difficulties is driven more by the detailed way in which demand and capacity are distributed over the day. Comprehensive benchmarking on cancellations is difficult as different airports use different reporting methods and definitions. However, restricting the benchmarks to LGW shows similar patterns up to this 300 day level.

8.33 In this “300 day scenario” operational cancellations remain below 2% (as seen in Exhibit 1)This does not imply that 2% is necessarily an acceptable level of cancellations – it is around 14 flight pairs per day – but it seems to represent the upper level of relatively typical current operations, with no significant external pressures.

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[21] Central Flow Management Unit – the Eurocontrol organisation which co-ordinates the network response to capacity bottlenecks

[22] Calculated Take-off Time – the take-off time assigned by the CFMU to balance capacity and demand in constrained elements of the European network

8.34 To understand the issues in this base case it is valuable to pose four questions:

- Is the base plan realistic and feasible?
- Is there a systemic pattern to operational outcomes which could be understood and addressed?
- Are variances managed adequately through the airport's performance management system?
- Do the governance, regulatory and policy frameworks help or hinder performance?

The Plan

8.35 The Capacity Declaration and Scheduling processes deliver a plan (both for demand and capacity) which should, in theory, produce no more operational difficulties than holds – airborne inbound and ground outbound – which can be reasonably anticipated by airlines in their block-time assumptions and therefore their schedules. Although this has obvious cost and environmental penalties, the historic view has been that this was acceptable to maximise runway utilisation. A maximum of 10 minutes average hold[23] (arrivals and departures) has been set as a standard within the process, although for arrivals this is compromised by the facility to introduce ATFM holds.

8.36 These are the key runway parameters that are assumed in the Capacity Declaration Process and the assessment of whether any additional demand can be met within the runway scheduling limits.

8.37 The process is intended to be a pragmatic reflection of what is achievable rather than a calculation of a theoretical capacity with contingency allowances. The process is illustrated in Exhibit 8-2.

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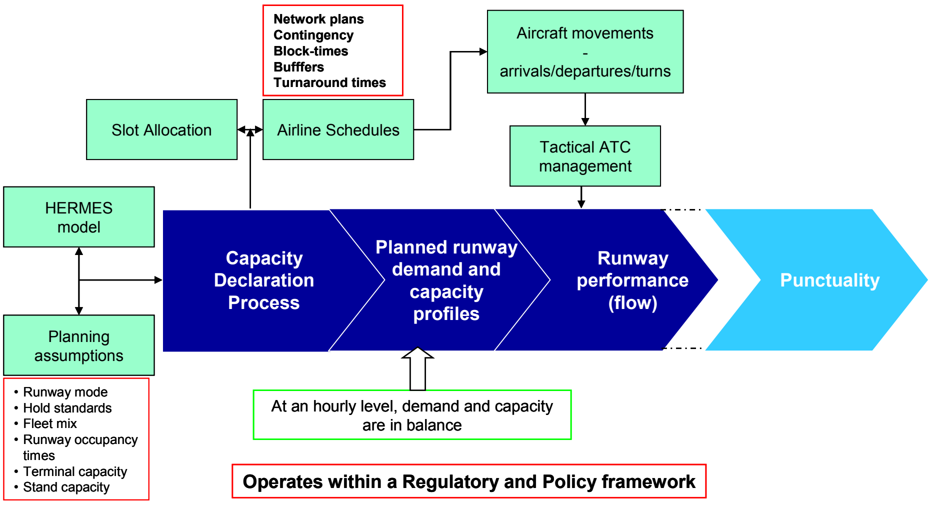
[23] The average 10 minute delay criterion was first introduced in the early 1990's to respond to excessive delays in the busy hours. This pre-dates more sophisticated co-ordination processes and ATFM procedures.

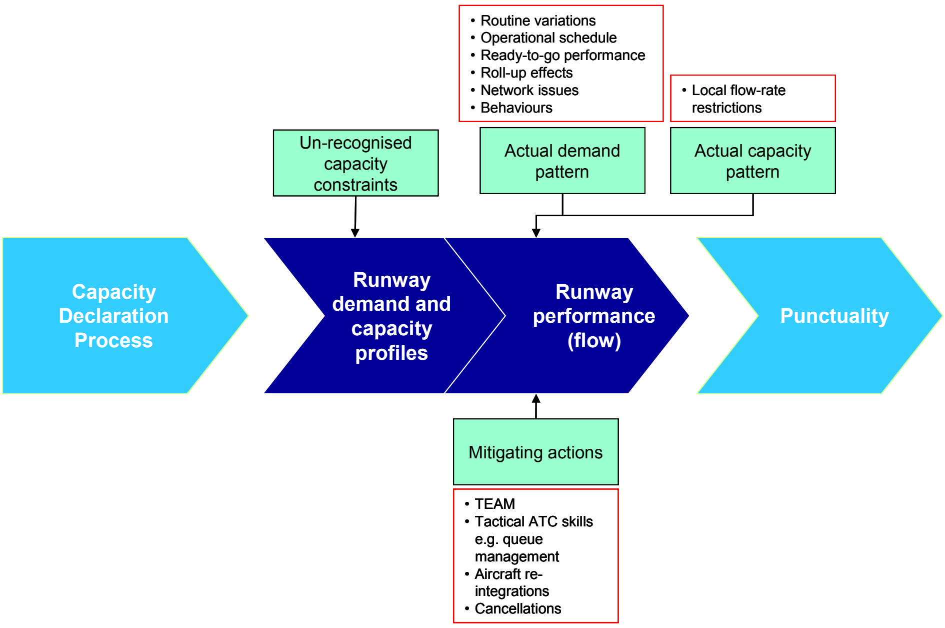
Exhibit 8-2: Relationship of Capacity Declaration and Runway Performance



Source: XPX Consulting

8.38 Clearly it does not produce the intended result in practice, typically resulting in peaks in the runway demand:capacity ratio which underpin much of the operational challenge. There are a host of reasons for poor runway performance (and resultant punctuality problems) in a highly complex set of interdependencies – many of which are connected to the rest of the European network, the ability of airlines to execute processes on time and the levels of contingency which can be justified. The main ones are shown in Exhibit 8-33 below.

Exhibit 8-3: "On-the-day" Influences on Runway Performance



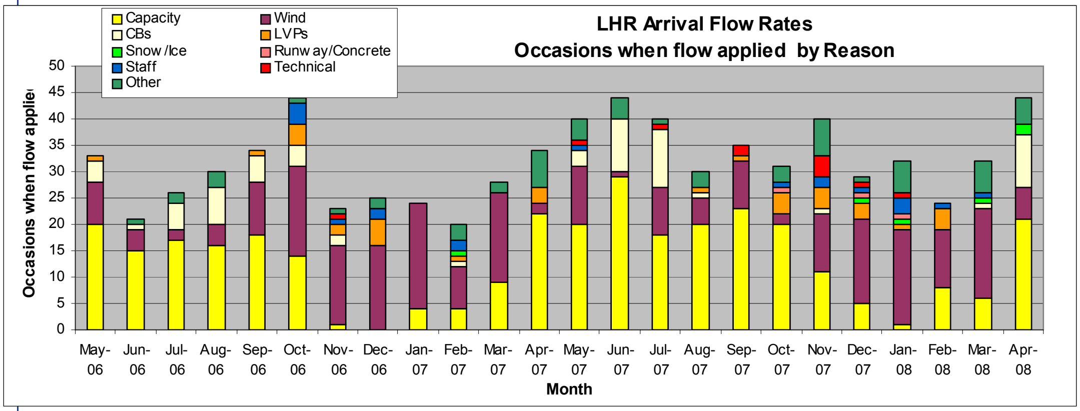
Source: XPX Consulting

8.39 The collective planning process is restricted to the airport and its immediate environment. Although the Runway Scheduling Limits meetings do report some pre-departure delays and undelayed demand in the observed data for the previous season, no specific account is taken in the agreed schedule pattern. As LHR flow restrictions and the resultant pre-departure holds occur on an almost daily basis and result in ATFM holds of the same order of magnitude as airborne holds, this seems a significant and systemic gap, which is likely to contribute to the observed lack of resilience in runway operations. (Source of quantification: Helios analysis). Airlines can introduce additional buffers but they are difficult to target and very expensive in shorthaul aircraft utilisation, again as quantified in the main report. The process has also continued to squeeze more slots into the schedule over recent seasons, although at a marginal level. Between Summer 2003 and Summer 2007 the Runway Scheduling Limits for arrivals grew by 4 movements per day (+0.6%) and the average number of scheduled arrivals rose by 19 (+2.9%) for the same period. The difference between the two is created by airline schedules "filling in" the small number of unused airport slots. (Source: XPX analysis of ACL data)

8.40 Airline Block Time calculation processes will potentially capture the effects of airborne holds and ground holding off-blocks but not delays resulting from air traffic flow regulations.

8.41 There is prime facie evidence that the airspace in the adjoining sectors can also inhibit tactical airport capacity – both for arrivals and departures. This initial view has been formed as one possible interpretation of the pattern of regulations observed and reflected in Exhibit 8-4 below.

Exhibit 8-4: Incidence of Flow-rate Regulation



Source: Airline Analysis

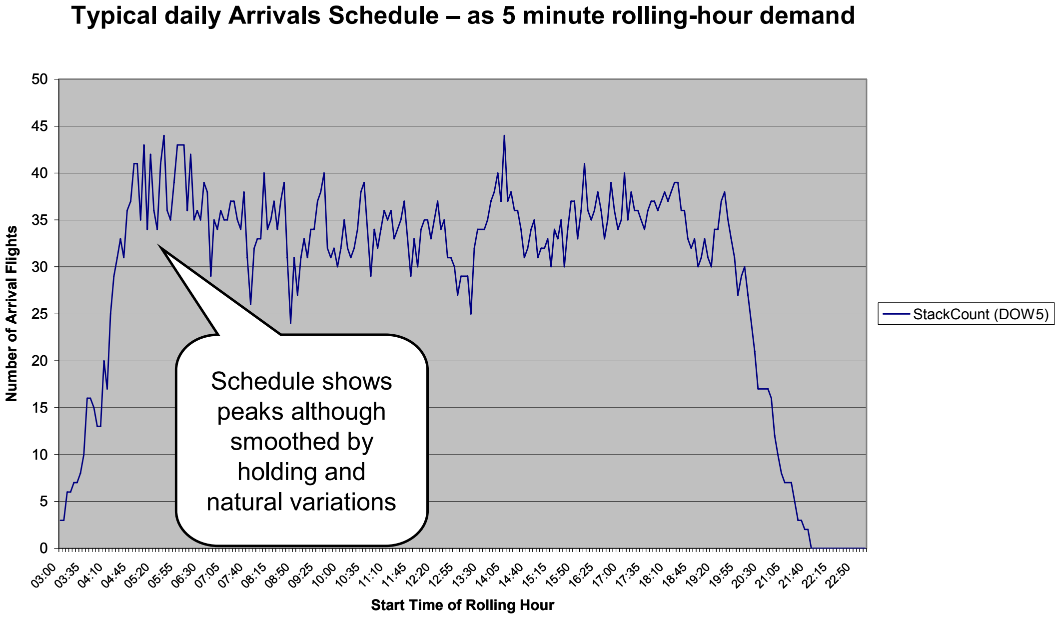
8.42 The numbers of capacity-based regulations (coloured yellow) appear to peak in a seasonal fashion over the summer. There is very little variation in the Heathrow schedule over this time, so a plausible interpretation is that the level of air traffic generally, and specifically in airspace adjacent to Heathrow, may be playing a part – i.e. the total traffic in the airspace around Heathrow does have a seasonal pattern, due to airports such as Luton and Stansted, whereas Heathrow traffic is much less seasonal, other than the general differences between the Winter and Summer seasons.

8.43 It could be postulated that Minimum Departure Intervals (MDIs) could also be influenced in this way, although there is no supporting data as yet. Although the levels of ATFM delay (as measured in minutes) are not large they do initiate restriction processes which can be disruptive beyond their immediate impact due to the periods of recovery from them.

8.44 The trends in some of the variables in the capacity model are also adverse – e.g. the required separation for the A380, and the increasing proportion of “heavy” aircraft to “medium”, particularly at certain times. As an illustration, the proportion of wide-body aircraft at Heathrow has grown from 34% in Summer 2006 to 37% expected in 2008. (Source: ACL). These issues are understood by the community, but if no co-ordination parameter is broken, it is difficult to make any explicit allowance in scheduling for this information. Slots can equally be allocated to Long- or Short-haul without regard to the impact on the arrivals flow rate arising from the mix of aircraft types – the binding constraint on scheduling aircraft types are constraints from stand or terminal capacities.

8.45 A contribution to the problem is also found in the shape of the schedule which bunches within the hour around commercially attractive times. However, there are detailed co-ordination constraints which will limit the effect. This effect is illustrated by looking at a rolling hour schedule, based on 5 minute intervals as shown in the Exhibit below. Of course, within a clock hour, the schedule always remains within the Scheduling Limits.

Exhibit 8-5: Schedule expressed as a Rolling-Hour Demand



Source: XPX Analysis of ACL data

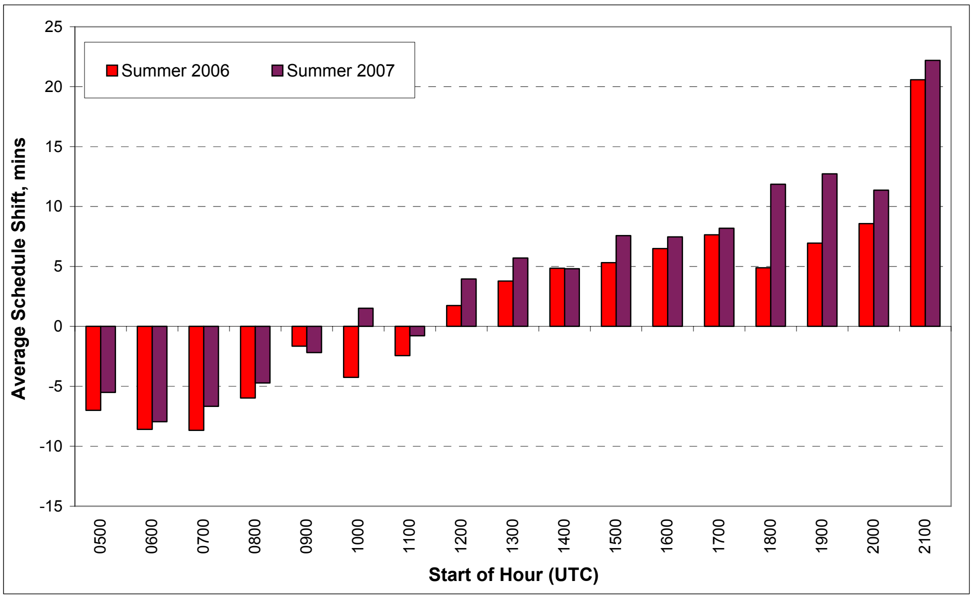
8.46 The improvement challenge in these areas is therefore to smooth the capacity and demand better over the day, and to recognise the full set of constraints and operational realities. Potential techniques are discussed later. These are not without penalties – the longhaul peaks are there for commercial and operational reasons. However, if holds could be materially reduced there would be prospects for a significant net benefit. ACL have been progressively attempting to achieve a level of smoothing through a process of slot flexing around the peaks.

Operations

8.47 In practice, actual demand patterns vary from plan. Particular difficulty is created when over-demand is anticipated, which prompts flow-rate regulation to manage the number of aircraft down to safe levels in airspace sectors or the stacks. Equivalent over-demand can be produced in departures. The reasons for over-demand are complex – combining the “self-fulfilling” element of planning for a hold in airline block-time assumptions, pilot behaviours, airline delays, the natural variations in block-times that result from winds, and changed flight plan routings and aircraft speeds.

8.48 The extent of “schedule shift” – i.e. the amount that aircraft are off-schedule, varies over the day, so the original schedule and plan are no longer being adhered to, and pressure is put on tactical ATC to increase flow-rates, if possible, or to initiate regulation procedures which will restore the demand: capacity balance. An example is shown below in Exhibit 8-6

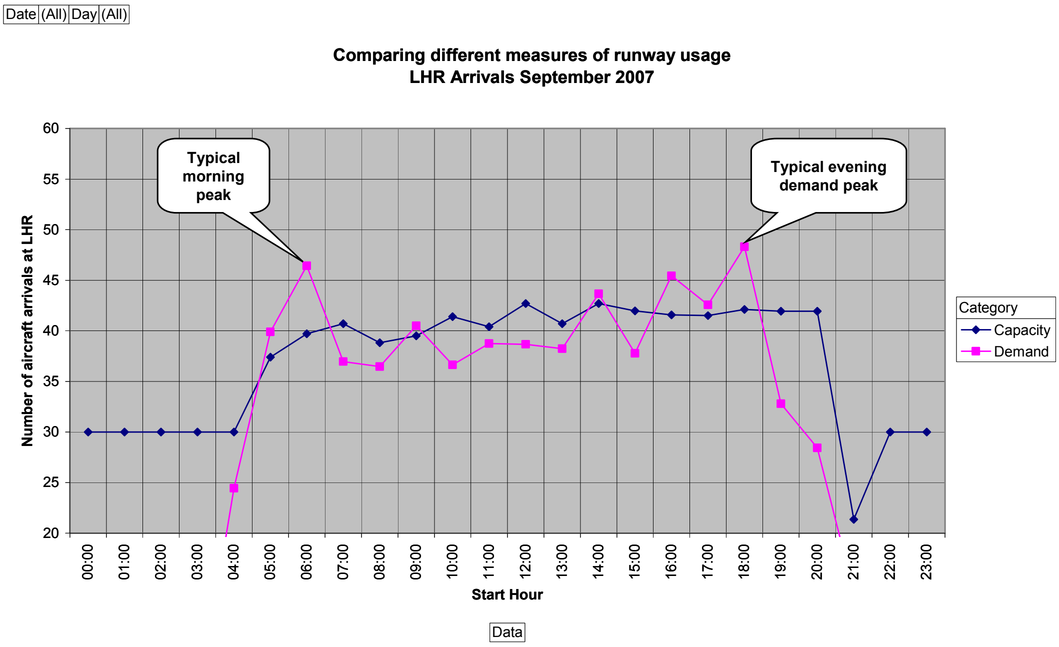
Exhibit 8-6: Short-haul Schedule Shift for Arrivals



Source: NATS Capacity Studies

8.49 A negative figure indicates arrival into area at a time in advance of what would be strictly necessary to match the schedule – a positive indicates delay. Different patterns exist for Long-haul and for departures, but the same basic point applies. These figures also appear to be worsening over recent years (Source: XPX analysis of NATS Capacity Studies). "Early" arrivals can be absorbed to an extent with airborne holds – "late" obviously cannot. It can be seen how the above pattern would help create the bi-modal distribution characterised so consistently in the main report, ands illustrated in Exhibit 8-7 below

Exhibit 8-7: Typical Distribution of Capacity and Demand over the Day

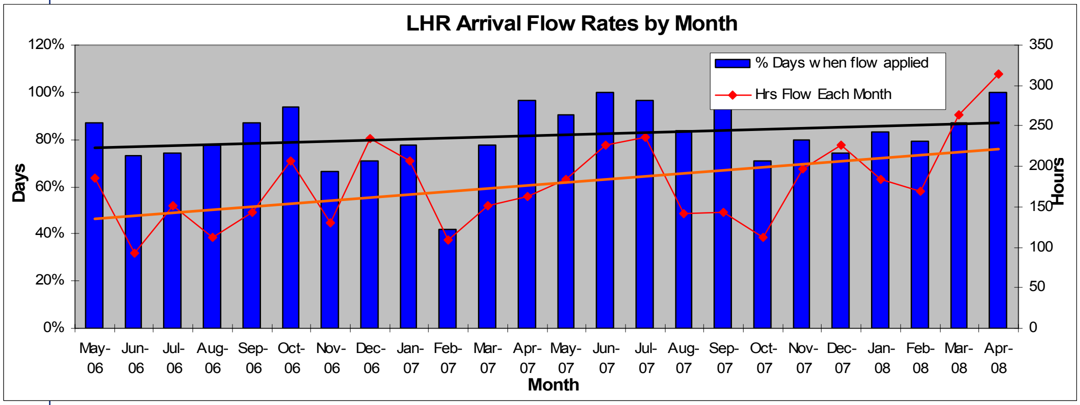


Source: XPX Analysis of Helios and CFMU data

8.50 The demand bunching from that bi-polar picture can be mitigated early in the morning with TEAM (which is applied now at Heathrow on an almost daily basis). The evening peak is more difficult, and is an increasing problem, based on delayed short-haul flights and a number of long-haul flights arriving at the same time. Thus the same basic conditions are re-created but with less flexibility due to departures demand.

8.51 Capacity may also be limited in the base case scenario owing to a short-duration weather or capacity issue. Flow-rate regulations are common and have trended upwards in recent years. Exhibit 8-8 illustrates.

Exhibit 8-8: Occurrence of Regulation at Heathrow

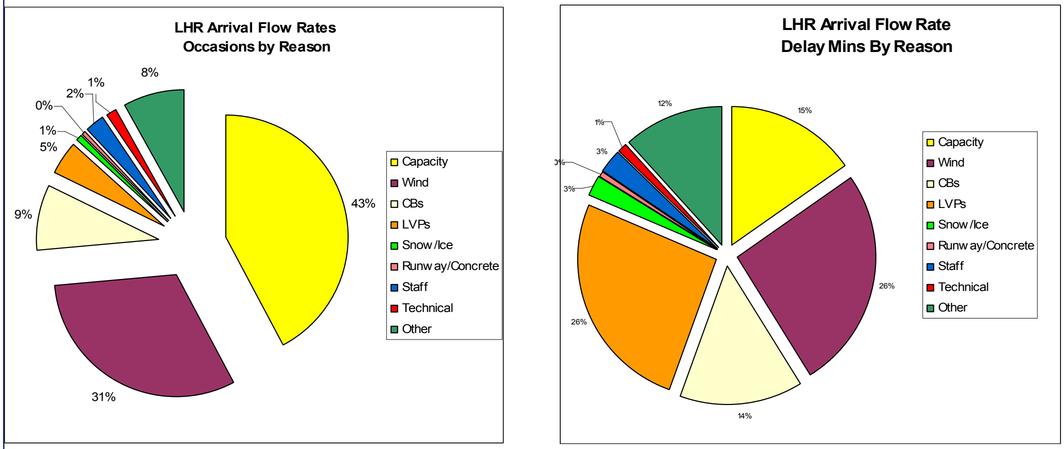


Source: Airline Analysis

8.52 The average over this 2-year period is regulation occurring on 25 days per month for a total of 184 operating hours per month, i.e. around 7 hours per affected day on average. Of course, not all are equally penalising as was illustrated in the main report.

8.53 In order to get a fuller picture, one should also look at the cause and extent of delays generated. Exhibit 9 shows the number of occurrences broken down by reason the resulting minutes of ATFM hold broken down by the same reason code.

Exhibit 8-9: Occurrence of Regulation and Level of Delay – by Reason



Source: Airline Analysis

8.54 It can be seen that three most interesting situations are:- capacity-related accounting for 43% of occasions and 15% of delay; wind-related accounting for 31% of occasions and 26% of delay; and Low Visibility accounting for 5% of occasions but 26% of delay.

8.55 However, whatever the reason and severity, flow-rate regulation is a fairly “blunt instrument” in the way in which the CFMU process works and the time-lag to restoring full flow. Judgement is involved for NATS Traffic Managers in both applying and relaxing constraints. In the base case scenario flow rate levels are unlikely to drop to the point of generating significant cancellations (of the order of 38 movements per hour for two hours as a guideline).

8.56 Possible improvement initiatives are discussed shortly, including ones already on the agenda of the airport.

8.57 Many operational improvement initiatives are assumed and/or supported and facilitated as part of the SESAR initiative (or the intermediate Eurocontrol DMEAN and TMA2010 programmes) as the airport contribution to increasing capacity and performance in the European network. To derive maximum benefit, similar processes should be adopted in a “critical mass” of European airports.

Performance Management

8.58 There are a number of community committees which monitor aspects of performance – the most relevant being the Slot Performance Committee, the Flight Operations Performance Committee and the Capacity Limits and Runway Performance Improvement Groups. In addition, the airlines will have their own measures, particularly around on- and off-stand punctuality.

8.59 However, the process measurements which underpin the data submitted to these groups do not always facilitate removing the layers of a problem to get at underlying causes.

8.60 As an example, the lack of transparent data around MDIs and their impact blurs understanding issues such as airspace limitations on outbound SIDs24.

8.61 As a final comment in this section, care should always be exercised in assessing opportunities based solely on delay "codings", i.e. the attribution of delay to one of a number of common causes – they can sometimes mask other factors at play and, therefore, action which appears to eliminate a problem may only reveal another, previously hidden, one. Thus impact analyses should always attempt to measure the success of underlying processes and not only their apparent results.

Governance and Policy and Regulatory Frameworks

8.62 This is a large topic and will form the focus of discussions on how the conclusions of this study can be used to inform policy development. At this stage, however, a few observations can be made on how the current framework can inhibit the development of solutions.

8.63 The combination of slot regulations, the Capacity Declaration Process (all of which are consistent with IATA Worldwide Scheduling Guidelines) and slot exchange practices creates, in effect, a "one-way valve" with limited opportunities to reduce capacity – slots in peak periods are unlikely to return to the pool. The performance of the slot management arrangements is subject to a limited number of metrics, designed to ensure that as demand rises, capacity is not created at the expense of degradation in service (i.e. longer delays). There are, however, a number of 'missing metrics' which would be needed to be factored into a more comprehensive management of demand versus capacity. There is also clear evidence, from the operational and financial analysis in the main report, which indicates clearly that the current and prospective balance of the system is not at an economic optimum – in other words, current regulations, slot

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[24] Standard Instrument Departure – the routing allocated to departing aircraft

coordination and airlines’ operational performance have resulted in economically wasteful ‘over-scheduling’ (with associated adverse environmental impacts).

8.64 The lack of performance standards has already been mentioned – in practice there are very few binding external constraints, sharp sanctions and / or incentives to motivate collective performance development among stakeholders. Clearly each individual stakeholder experiences “pain” as a result of collective failure (and contributes to it) but the commercial and competitive pressures, allied to differing KPI structures and corporate ambitions, slow the pace of development. Airlines in particular are locked into a ‘free rider’ problem as a result of their slot ownership – marginal additional slots have a high positive value to airline acquiring them, as illustrated by values attached to slots in the secondary market, but impose a higher negative cost on Heathrow airlines and passengers in general.

8.65 In essence, the governance mechanisms in these operational areas lack some of the checks and balances required to match the obvious and appropriate desire to maximise throughput.

OPTIONAL IMPROVEMENT INITIATIVES

8.66 The only strategies which could be expected to achieve an “across-the-board” step change improvement in runway performance and resilience at LHR are Mixed Mode operation or significant demand reduction. Mixed Mode has been modelled in the main report (and other studies) and is, of course, the subject of consultation by the Government involving many factors beyond operational resilience. Reduced demand has been modelled at both the general level and for reductions at specific times. These both move performance along the demand: capacity power-law curve and in the model produce a range of quantified impacts.

8.67 Short of Mixed Mode, there are a number of options which could be beneficial in the medium term – although individually on a smaller scale and influencing specific aspects of performance (e.g. cancellation levels or ATFM delays as opposed to broad improvement). Many are already on the agenda of the airport community in terms of continuous improvement initiatives or the larger-scale developments of airspace design and technologies in the UK and Europe. Others are not and are within the scope of stakeholders and policy-makers to move forward.

8.68 Qualitative indications of impacts and benefits; and implementation and accountability issues are discussed later. Quantitative analysis and detailed feasibility assessments have not been undertaken as part of this study.

8.69 At present we will simply list the main elements of the "menu". For the purposes of this section, improvements could arise from one or more of:

- Targeted and specific reductions in movements.
- Sustaining landing rates (in particular) over a wider range of weather and operational conditions
- Smoothing and matching realistic demand and capacity more evenly over the operating day
- Optimising all relevant operational processes
- Tightening control and adherence to plan through performance management

8.70 Some improvements would be necessary just to reverse the downward graph over the last few years and future adverse trends – although the early signs from T5 operation indicate that improved operating processes can improve punctuality which in turn should feed through to consistency of the runway operation.

8.71 In more detail, the main current and optional initiatives are as follows.

8.72 Optional demand reduction scenarios are modelled in the main report. For individual airlines there are obvious commercial penalties as well as the collective resilience benefits. With <u>targeted and specific demand reduction</u> the downside could be minimised if aimed at consistent problem periods and linked to mechanisms to maintain passenger throughput and schedule connectivity. To avoid specific disadvantages to any individual airline this would need to be implemented progressively through the re-timing of historic slots and/or the management of slots returned to the pool.

8.73 Extension of TEAM has also been modelled at a general level. There may be additional opportunities for <u>very targeted extension of the application of TEAM</u>. A specific example includes landing A380s under TEAM rules to minimise separation problems (an idea which has been raised in the community – and will be considered in more depth as their numbers and schedule timing begin to affect the airport). Another example is using TEAM to change the balance of arrival and departure delays i.e. deliberately increasing average departure delays to reduce arrivals delays, under normal conditions. (This is already effectively done under stretched circumstances). There may also be a small number of opportunities for tactical enhancement of departures – i.e. at certain times introducing specific departures on the arrival runway

8.74 Smoothing of the schedule can reduce periods where actual demand exceeds capacity on a consistent basis. This is achieved to a limited extent at present by voluntary flexing within the Scheduling processes (i.e. decreasing slots in one period and increasing by the same amount in another). Total runway capacity is not affected.

8.75 Extension and revision of the Capacity Declaration planning parameters would aim to better reflect the operational realities of the airport. Example areas are

1. pre-departure delays, particularly if these cannot be removed by smoothing techniques and operational improvements
2. possible airspace constraints for both arrivals and departures, and incorporating these into the planning process or taking mitigating action
3. possible changes to the standards applied e.g. targeting a reduction in airborne hold averages
4. co-ordination parameters which might limit the “heavy/medium” mix at certain hours of the day

There would thus be a significant extension of the parameters used in the co-ordination process, and a probable re-design of some of the mechanics, particularly to ensure that any process changes and results stayed within EU legislation and industry standards.

8.76 The community has been working recently on protocols for disruption management at times of capacity restriction. This has been in response to some major issues in the recent past when days of serious runway flow-restriction (or other incidents) have been compounded by failure in other aspects of airport logistics. Excessive weight can also be placed on base carriers who feel the greatest pressure to implement cancellations – to the benefit of the airport, but also competitors! Work is in progress to finalise protocols and procedures which would help mitigate the issues and set up control and decision-making structures. This is, however, restricted to days of significant disruption – i.e. the 10 – 15 day scenario of this report. In principle, such protocols and structures could be applied more broadly, into the 50-60 day scenario, in tandem with process and data improvements to better share operational status and plan information among stakeholders.

8.77 Time-Based Separation is an approach which has been mooted for many years and is the subject of both local and European research and development. At present, wake vortex separations, based on distance, necessarily imply a reduction in flow-rate when headwinds cause a reduction in the effective speed of arriving aircraft. Switching to separations based on time would obviously sustain landing rates at planned levels when they would otherwise drop. It is a large topic within the industry, and within programmes such as SESAR, but has major procedural and safety questions, which would need to be answered. For these reasons, it cannot be viewed as a "quick" solution, and is likely to require improvements in meteorological inputs. However, given the potential local benefits, there is a case for Heathrow to play a significant role in further development and validation of the concept.

8.78 Research and development, again at both local and European/Industry levels, continues into technologies and techniques which might reduce effective/average separations for both arrivals and departures. This includes a group of techniques with different characteristics but the same overall objective. Included are

- Wake vortex detection techniques which could increase both arrival and departure flow rates, at a tactical level, when cross-winds and climatic conditions disperse vortices rapidly.
- Arrival management software and procedures (AMAN) which can "fine-tune" sequencing and approach and implement any changes to sequencing policies, i.e. prioritise arrival and/or departure sequences according to a broader rule set.
- Aircraft equipment levels, and runway features to clear the runway as quickly and safely as possible

8.79 Although outside the direct remit of the local airport community, a number of stakeholders expressed the view the view that the way in which the details of the CFMU procedures work can reduce their effectiveness in balancing equitability of CTOT distribution with maximising the number of aircraft movements achieved. As mentioned earlier this seems to particularly affect significantly disrupted days (which is when they are most needed). A review is well beyond the remit of this study but the topic should be included in the list. (The issues are as much about airline and pilot processes and procedures as about those of CFMU itself – they often take the form of trying to ensure that a flight does not "go to the back of the queue" in the CFMU allocations).

8.80 Similarly some stakeholders felt that the processes by which Heathrow regulations are applied could be improved – principally relating to capacity-based ones. As indicated previously, the number of regulations has been trending upwards. Although based on CFMU data and Traffic Load Prediction calculations, there is still much judgment involved – views have been expressed that strengthening guidelines and data quality might aid the application and, in particular, relaxation processes, subject to safety considerations, of course.

8.81 Collaborative Decision Making is a Eurocontrol-facilitated programme which was founded on the recognition that the overall Air Traffic Management system has good knowledge and control over aircraft in the sky but poor information on the status and plans of aircraft when on the ground. The result is airspace capacity being wasted and growing congestion in airports. The influence on runway performance and resilience is indirect but important. Heathrow has been implementing a CDM programme to improve the tactical knowledge of the status of aircraft, their future movements and threats to the ability to operate to schedule; and to communicate these to all relevant parties. There are full development plans which would also integrate better with the European network. A more disciplined and informed process can assist in better demand information to improve ATFM decision-making and knock-on benefits of tighter punctuality.

8.82 Performance management has already been mentioned as an area of weakness. This is a large topic, but an example of additional data which would be illuminating is the adherence to assumed planned arrival times at the "top of stack" – this is a case where CDM data collection should be able to make a significant contribution, and help to identify why arrival on schedule is not being consistently achieved. It would also separate issues to do with outstation performance and ATFM delays from those concerned with stack holding and punctuality of arrival on stand.

8.83 We have not considered the other impacts of broader airspace re-design, airline contingency initiatives or provisions, or airline and airport improvements aimed at punctuality improvement or other service quality measures.

8.84 All of the above options bring implementation challenges but clearly there is a spectrum in terms of the degree of technology or regulatory issues involved. The notion of selecting a package of potential changes based on scale of impact and ease/speed of implementation is developed in later paragraphs.

8.85 The current policy and regulatory framework is not a barrier to many of the options listed above, for example

- Revision to the Capacity Declaration process within existing legislation, to modify parameters and targets or re-distribute demand
- Enhancement of Performance Management
- Stakeholder process improvements e.g. relating to flow-rate regulations or aligned planning procedures
- Collaborative Decision Making

- Tactical extension of TEAM

Of course, it is possible that implementation could be improved or accelerated by policy changes, for example relating to reporting requirements or governance. Also, at some point these changes could develop to the point of reaching the limits of current regulation e.g. extension of TEAM.

8.86 Other options would require significant technological development and/or safety regulatory approval. The main ones in this category are Time-Based Separation, any technologies to reduce separations and significant changes to TEAM, as indicated above

8.87 Clearly any developments which went beyond this range into Mixed Mode scenarios bring another higher level of policy and regulatory implications.

IMPACT AND BENEFITS

8.88 From the above list, no single initiative can make a dramatic improvement against the fundamentals of the capacity and demand positions and the likelihood of influences outside local control. While any of them could feed through into broad performance improvement, the immediate benefit would typically be felt in more granular aspects of performance under each of the three scenarios.

8.89 Therefore, to achieve measurable impact, a package of steps would probably be needed, combined with wider stakeholder process developments and performance management to ensure delivery. Perhaps as important would be to establish the structural and governance changes which could sustain improvement and prevent re-emergence of the declining trends of recent years – whether or not additional capacity were available. We will return to this question later.

8.90 A tabular representation is given in Appendix A, relating the list of possible initiatives to the aspects of performance influenced and an indicative scale of impact. For the base case scenario, these aspects of performance are the different types of holding incurred, the amount of tactical flow-rate headroom (i.e. a measure of the tactical scope that ATC management might have), and the levels of cancellations. For the other scenarios, the main consideration is whether the number of days of measurable disruption could be reduced.

8.91 An example of how not all aspects of performance would be affected can be seen in the case of Time-Based Separation. TBS would assist in mitigating the effects of high winds and benefit both delays and cancellations on certain days. It would not, of itself, increase the flow-rate on which the “normal” capacity of the airport is set, nor influence operational problems of demand bunching on non-wind-affected days. Implementation would also be subjected to further relatively lengthy development and safety evaluation.

8.92 However, given that wind accounts for a significant proportion of the problems (25% of ATFM delays as an indicator), it is a potentially attractive approach.

8.93 Similarly, Scheduling Smoothing – probably in conjunction with Revised Planning Parameters – could be constructed in such a way as to reduce both regulation levels and airborne/ground holding. This would, therefore, be particularly valuable for Short-haul operations and hub connections in the base case scenario. However, it would be overwhelmed when weather conditions created prolonged flow-rate reductions.

8.94 Implementation would be sensitive – requiring re-casting of slots and changes to the Capacity Declaration process to be achieved over a number of years and in a manner which respected the relevant EU slot regulations.

8.95 Detailed extended application of TEAM and detailed demand reduction could assist on a broad front as they attack the basics of the capacity: demand relationship – but the realistic scale would be limited. Implementation of any schedule adjustment would be subject to the same issues as mentioned above.

8.96 The quickest form of performance improvement may come from extension of CDM and the data measurement and "Dashboard" opportunities which come from it. Although not directly influencing capacity or demand, the improved knowledge and ability to track more granular levels of process adherence may both improve discipline and lead to better quantification of root cause problems.

8.97 From within the long list of options, the four discussed above (Schedule shaping and planning parameters, TBS, extended specific TEAM operations, and Performance Management) appear to offer a possible core package for improvement, subject to the considerations of governance and emerging policy guidance.

8.98 We have not attempted to prepare business cases for these suggestions. Indeed, lack of trade-off metrics and rapid "what-if" scenario planning tools have inhibited change in the past. The main report itself provides some quantification of the operational and economic trade-offs which would be needed to calibrate such business cases in support of any changes.

8.99 Accountability for implementation is not straightforward. Performance management and process changes which do not require safety clearance can, (and will) obviously proceed through existing structures, although funding issues can be problematic e.g. current CDM development. Similarly, schedule-related issues can be raised in existing structures but are likely to fall foul of disparate stakeholder interests without a directional framework. Technical developments will require safety regulation, although they will simultaneously be on the agenda through European initiatives.

ACHIEVING CHANGE

8.100 The community puts a lot of energy and resource into trying to address the type of issue addressed in this study, as it does into other aspects of safety, infrastructure and performance. In the operational aspects discussed above and the type of improvement ideas outlined, it is difficult to get stakeholder alignment – the interests and benefits for different stakeholder groups (and individual ones within that) are diverse and difficult to embrace within a fully consensual process.

8.101 Therefore, it may be difficult to achieve pace and determination behind improvement opportunities even if business and feasibility cases look attractive.

8.102 A necessary condition for progress, and to withstand the type of pressure which has created the current position, is the strengthening of the governance arrangements – working to a set of agreed operational and developmental changes.

8.103 Through these mechanisms an operational transition could be mapped through to whatever future state is deemed appropriate at a policy level – whether that be improving the quality levels of a fundamentally-similar mode of operation through to a scenario with additional capacity. The prospect of a more robust capacity management governance process, volunteered by the industry, leading to better runway operational resilience and ultimately better passenger experience with lower environmental impact, pro rata, could be attractive to policy makers considering options for Heathrow expansion.

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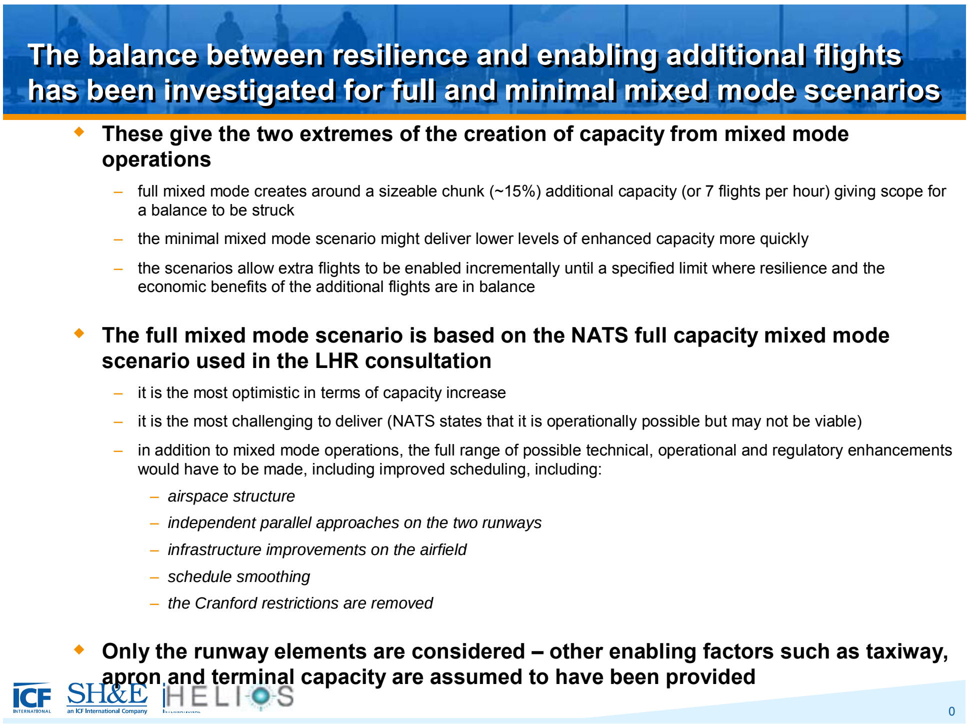
Part V:
BALANCING RESILIENCE AND ADDITIONAL FLIGHTS

9

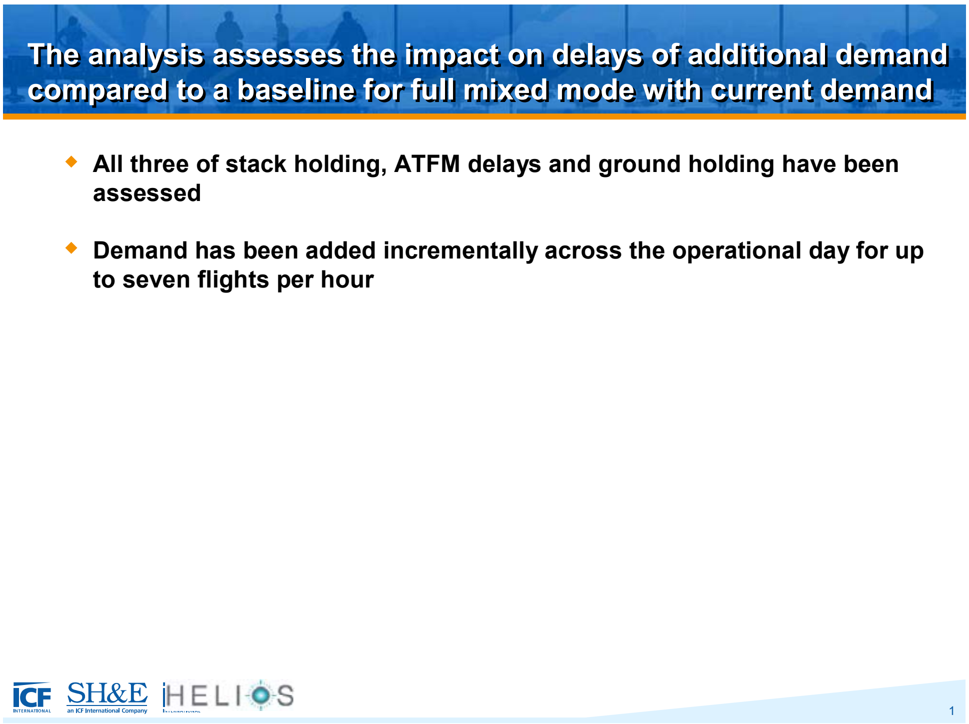
BALANCING RESILIENCE AND ADDITIONAL FLIGHTS

SCENARIOS AND OPERATIONAL RESULTS



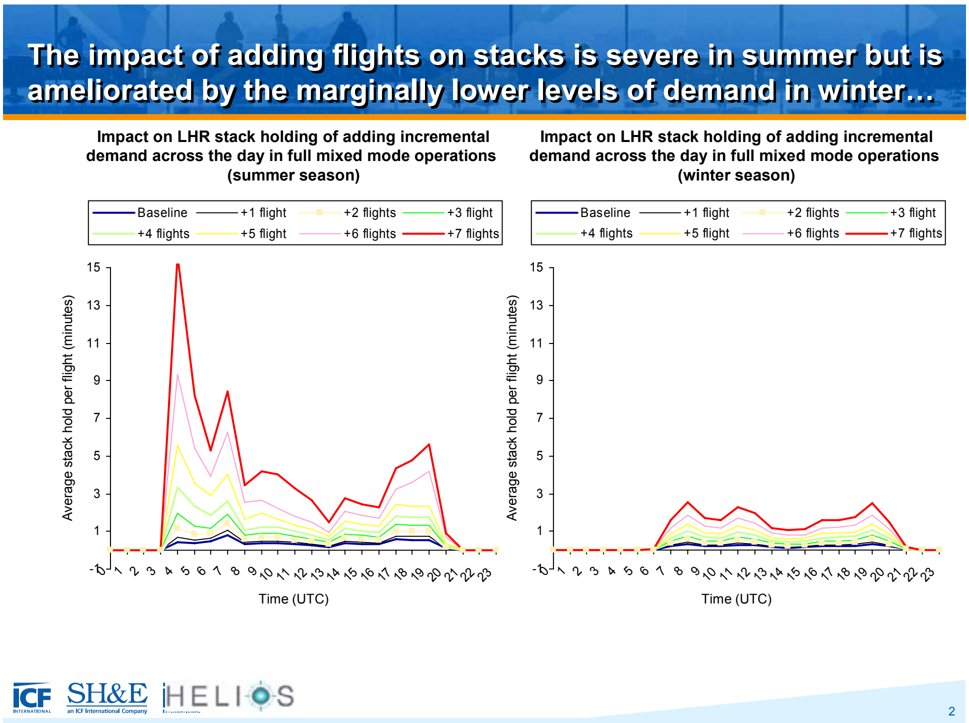
The balance between resilience and enabling additional flights has been investigated for full and minimal mixed mode scenarios

- **These give the two extremes of the creation of capacity from mixed mode operations**
  - full mixed mode creates around a sizeable chunk (~15%) additional capacity (or 7 flights per hour) giving scope for a balance to be struck
  - the minimal mixed mode scenario might deliver lower levels of enhanced capacity more quickly
  - the scenarios allow extra flights to be enabled incrementally until a specified limit where resilience and the economic benefits of the additional flights are in balance
- **The full mixed mode scenario is based on the NATS full capacity mixed mode scenario used in the LHR consultation**
  - it is the most optimistic in terms of capacity increase
  - it is the most challenging to deliver (NATS states that it is operationally possible but may not be viable)
  - in addition to mixed mode operations, the full range of possible technical, operational and regulatory enhancements would have to be made, including improved scheduling, including:
    - *airspace structure*
    - *independent parallel approaches on the two runways*
    - *infrastructure improvements on the airfield*
    - *schedule smoothing*
    - *the Cranford restrictions are removed*
- **Only the runway elements are considered – other enabling factors such as taxiway, apron and terminal capacity are assumed to have been provided**



The analysis assesses the impact on delays of additional demand compared to a baseline for full mixed mode with current demand

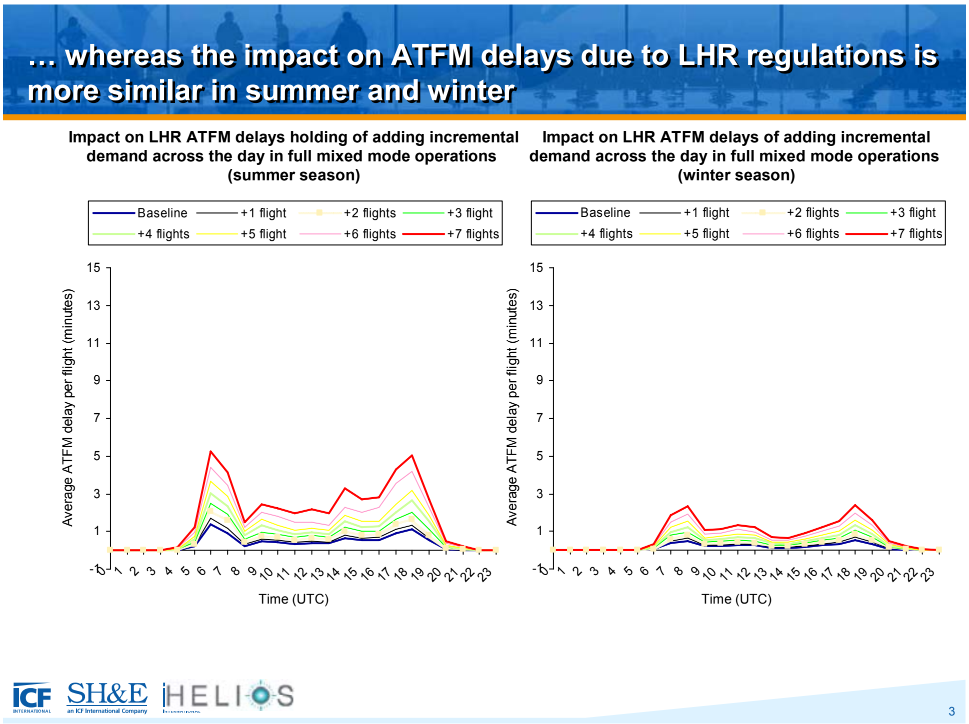
- **All three of stack holding, ATFM delays and ground holding have been assessed**
- **Demand has been added incrementally across the operational day for up to seven flights per hour**



The impact of adding flights on stacks is severe in summer but is ameliorated by the marginally lower levels of demand in winter…

Impact on LHR stack holding of adding incremental demand across the day in full mixed mode operations (summer season)

Impact on LHR stack holding of adding incremental demand across the day in full mixed mode operations (winter season)

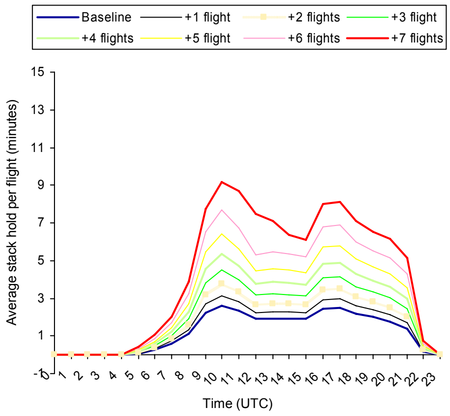


… whereas the impact on ATFM delays due to LHR regulations is more similar in summer and winter

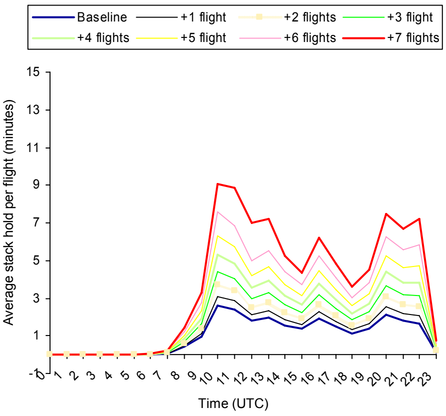
Impact on LHR ATFM delays holding of adding incremental demand across the day in full mixed mode operations (summer season)

Impact on LHR ATFM delays of adding incremental demand across the day in full mixed mode operations (winter season)

There is very little difference between summer and winter in the impact of adding flights on ground holding

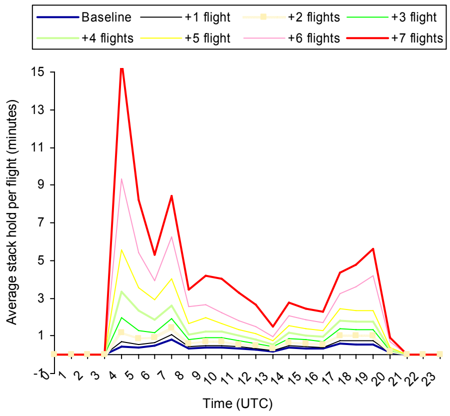


Impact on LHR ground holding of adding incremental demand across the day in full mixed mode operations (summer season)

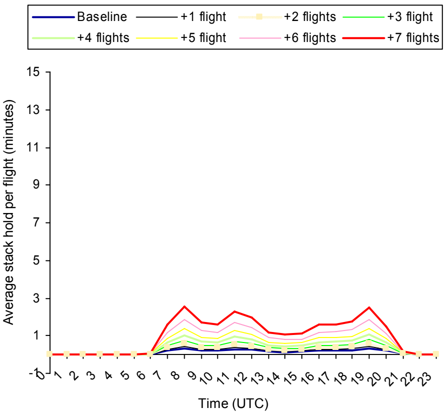


Impact on LHR ground holding of adding incremental demand across the day in full mixed mode operations (winter season)

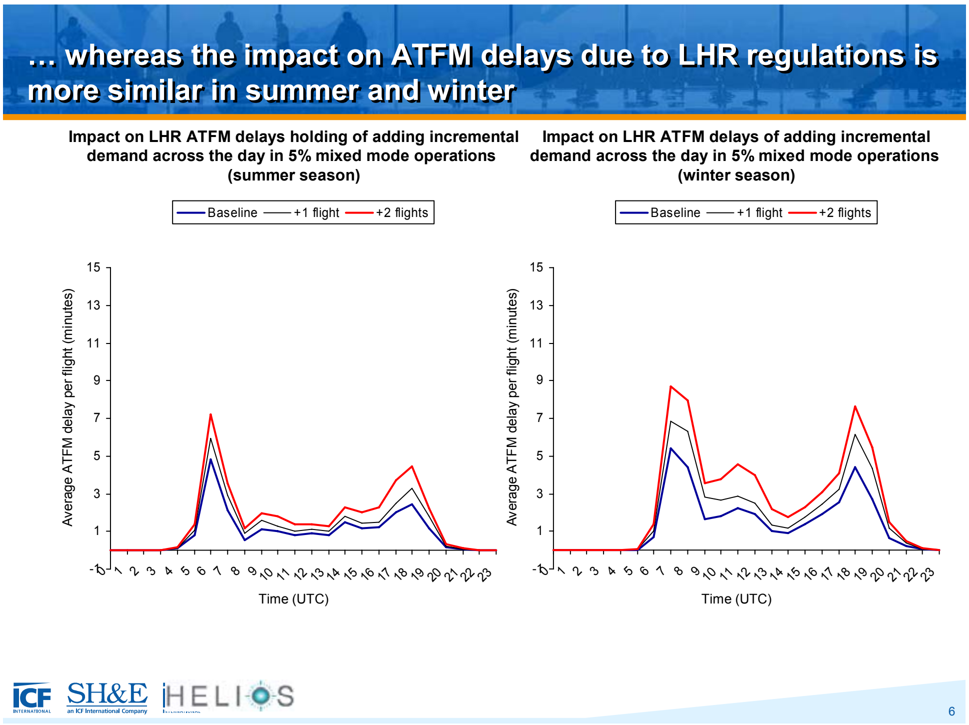
The impact of adding flights on stacks is severe in summer but is ameliorated by the marginally lower levels of demand in winter…



Impact on LHR stack holding of adding incremental demand across the day in full mixed mode operations (summer season)



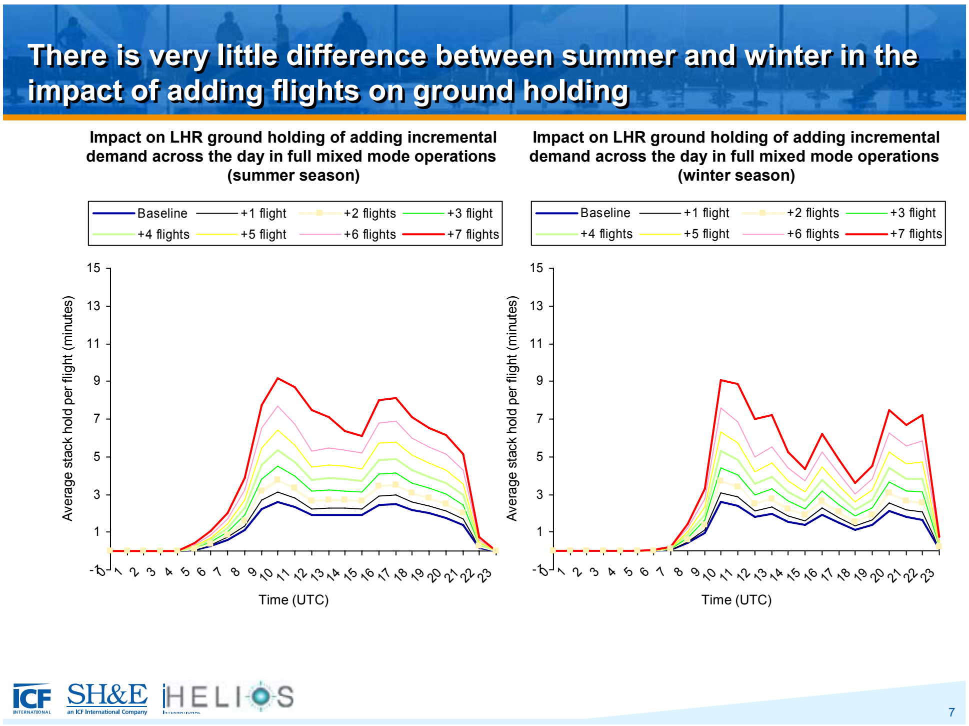
Impact on LHR stack holding of adding incremental demand across the day in full mixed mode operations (winter season)



… whereas the impact on ATFM delays due to LHR regulations is more similar in summer and winter

Impact on LHR ATFM delays holding of adding incremental demand across the day in 5% mixed mode operations (summer season)

Impact on LHR ATFM delays of adding incremental demand across the day in 5% mixed mode operations (winter season)

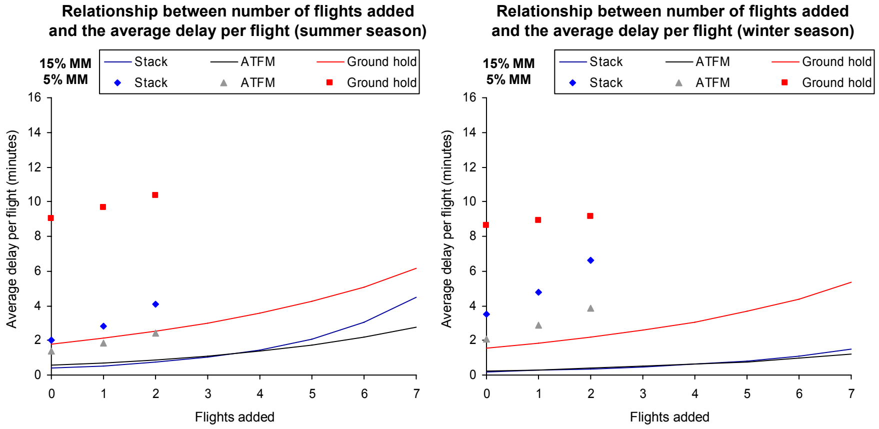


There is very little difference between summer and winter in the impact of adding flights on ground holding

Impact on LHR ground holding of adding incremental demand across the day in full mixed mode operations (summer season)

Impact on LHR ground holding of adding incremental demand across the day in full mixed mode operations (winter season)

There is a clear relationship between the number of flights added and the average of each component of delay


Relationship between number of flights added and the average delay per flight (summer season)

Relationship between number of flights added and the average delay per flight (winter season)

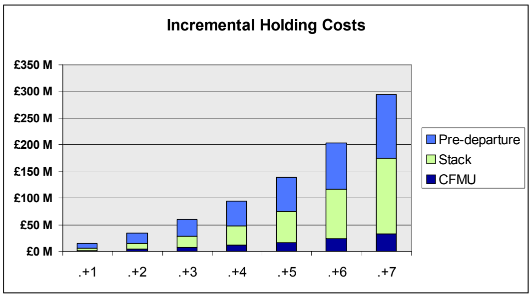
To keep average holding below 5 minutes for full mixed mode, a maximum of 5 of the available 7 slots per hour can be used

- **Ground holding is the dominant factor**
- **However, with 5 slots being used, the peaks for ground holding and stack holding exceed 5 minutes at key times**
- **Use of 4 slots would reduce the peak in the average holding time to below 5 minutes for stack holding but would be marginal at the peaks for ground holding**
- **Use of 3 of the available 7 slots would ensure that average holding did not exceed 5 minutes**
  - peaks for stacks are predicted to be around 2minutes
  - peaks for ATFM delays are predicted to be around 2.5 minutes (but note that these would still be incurred solely by short haul flights and would be much greater for each delayed flight)
  - peaks for ground holding would be expected to be around 4.5 minutes
- **Conclusion: operational considerations indicate that between 40 and 60% of the additional capacity delivered by mixed mode should be reserved for resilience**

We have analysed the economic impact of adding extra flights

- **To recap this means**
  - Calculating the incremental holding costs for airlines and passengers
  - This includes also the costs of the environmental impact in terms of carbon emissions, and also passenger value of time
  - We then estimate the benefits of additional flying and then compare the trade-off between extra holding costs and extra benefits.
- **The benefits of extra flights come from**
  - Existing passengers benefitting from more convenient schedules
  - New passengers gaining from new lower fares
  - Airports from the extra profit derived from additional flights and passengers
  - Additional Air Passenger Duty
  - with costs or dis-benefits coming from the carbon cost of the additional flights
- **In this further analysis we look at the trade off between benefits and increased holding costs as significant additional capacity is added, increasing the number of flights by up to 7 pairs per hour or rouhly 20% of current declared capacity.**

As flights are added, the costs increase exponentially

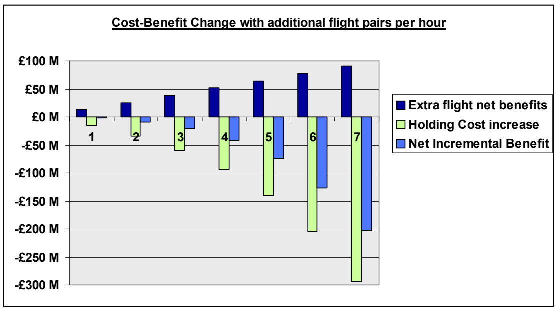


- **This represents the sum of total holding costs for Ground Holding, Inbound Stack and Departure.**
- **This includes the Cost of Carbon and the Radiative Forcing Factor of 1.9**
- **Figures are for one year at 2007 prices**

Estimation of the benefits entails some simplifying assumptions

- **We have assumed that benefits and costs of the extra flights are linear with additional capacity**
- **The only significant difference between our approach and that used by the DfT is in the calculation of Generated User Benefits**
  - we have assumed a fare drop based on a price elasticity; new or "generated" users now travel because the cost (fare) is now below their utility or threshold cost of travel.
  - the DfT would look at the reduction in the LHR shadow cost needed to drive passengers to other UK airports. Without running the DfT model it is not easy to see how quickly the shadow costs would drop as capacity is increased at LHR;
  - as noted in the main body of our report we have probably produced a lower estimate of the Generated User Benefits than would be obtained by completely replicating the DfT analysis.
- **By growing the Generated User Benefits linearly we have not explicitly reflected the fact that with additional capacity the fare itself would also be required to drop further**
  - This would cause the generated user benefits to increase as the square of the increase in capacity which would soon generate a very large figure which not be neither realistic or credible – the additional passengers would come from a combination of suppressed demand and price stimulation, not just the latter.
  - The counter argument is that the most beneficial flights would be added before the less beneficial flights.

The net loss increases steeply as flights are added



- **The figures show the annual costs and benefits as 1,2,3… flights are added in each hour.**
- **The conclusion is that there is no balance point – additional flights increasingly worsen the situation, with increased holding costs outweighing the benefits of extra flights.**

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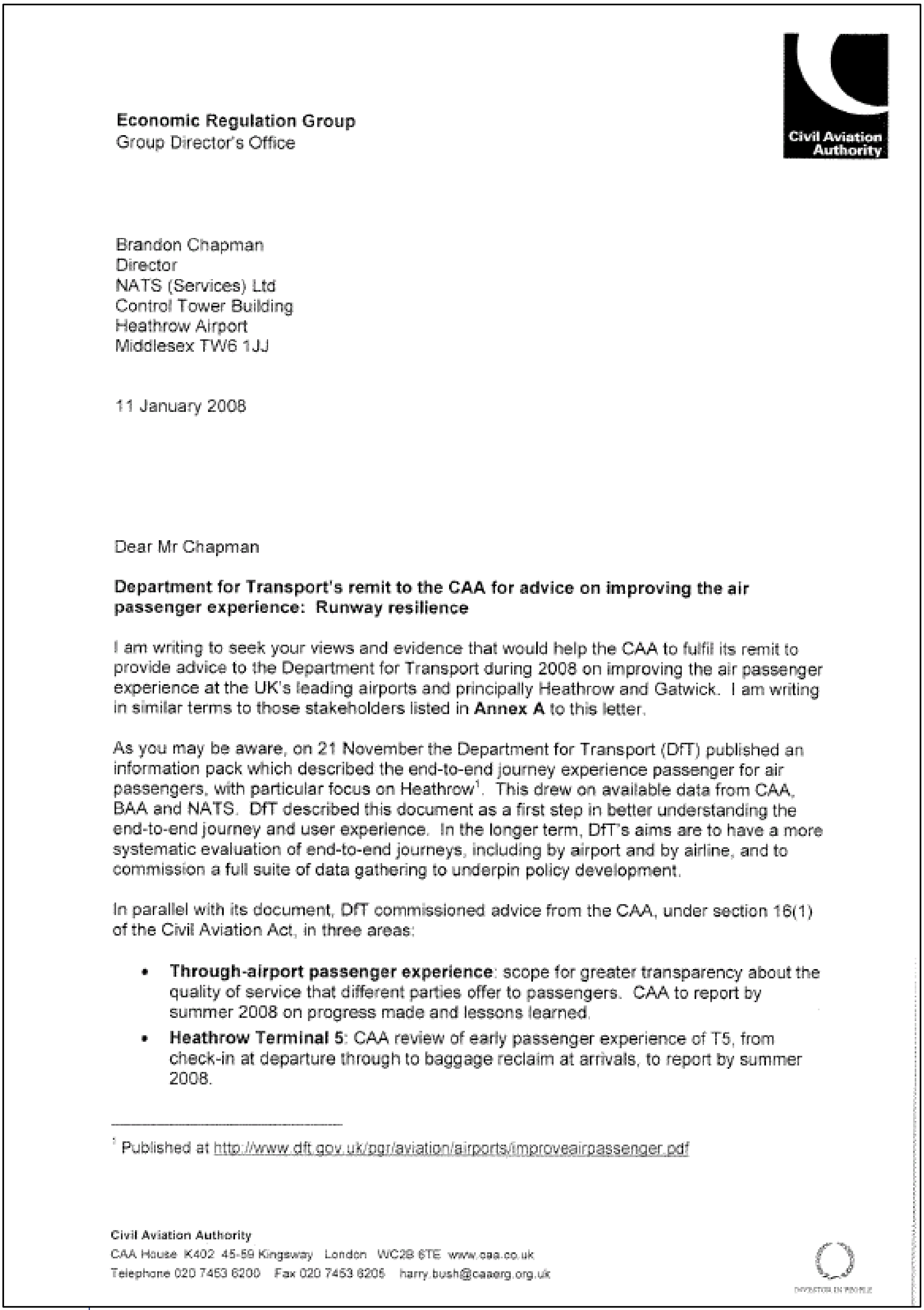
Appendix A:
TERMS OF REFERENCE



Economic Regulation Group
Group Director's Office

Brandon Chapman
Director
NATS (Services) Ltd
Control Tower Building
Heathrow Airport
Middlesex TW6 1JJ

11 January 2008

Dear Mr Chapman

Department for Transport's remit to the CAA for advice on improving the air passenger experience: Runway resilience

I am writing to seek your views and evidence that would help the CAA to fulfil its remit to provide advice to the Department for Transport during 2008 on improving the air passenger experience at the UK's leading airports and principally Heathrow and Gatwick. I am writing in similar terms to those stakeholders listed in **Annex A** to this letter.

As you may be aware, on 21 November the Department for Transport (DfT) published an information pack which described the end-to-end journey experience passenger for air passengers, with particular focus on Heathrow[1]. This drew on available data from CAA, BAA and NATS. DfT described this document as a first step in better understanding the end-to-end journey and user experience. In the longer term, DfT's aims are to have a more systematic evaluation of end-to-end journeys, including by airport and by airline, and to commission a full suite of data gathering to underpin policy development.

In parallel with its document, DfT commissioned advice from the CAA, under section 16(1) of the Civil Aviation Act, in three areas:

- **Through-airport passenger experience**: scope for greater transparency about the quality of service that different parties offer to passengers. CAA to report by summer 2008 on progress made and lessons learned.
- **Heathrow Terminal 5**: CAA review of early passenger experience of T5, from check-in at departure through to baggage reclaim at arrivals, to report by summer 2008.

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[1] Published at http://www.dft.gov.uk/pgr/aviation/airports/improveairpassenger.pdf

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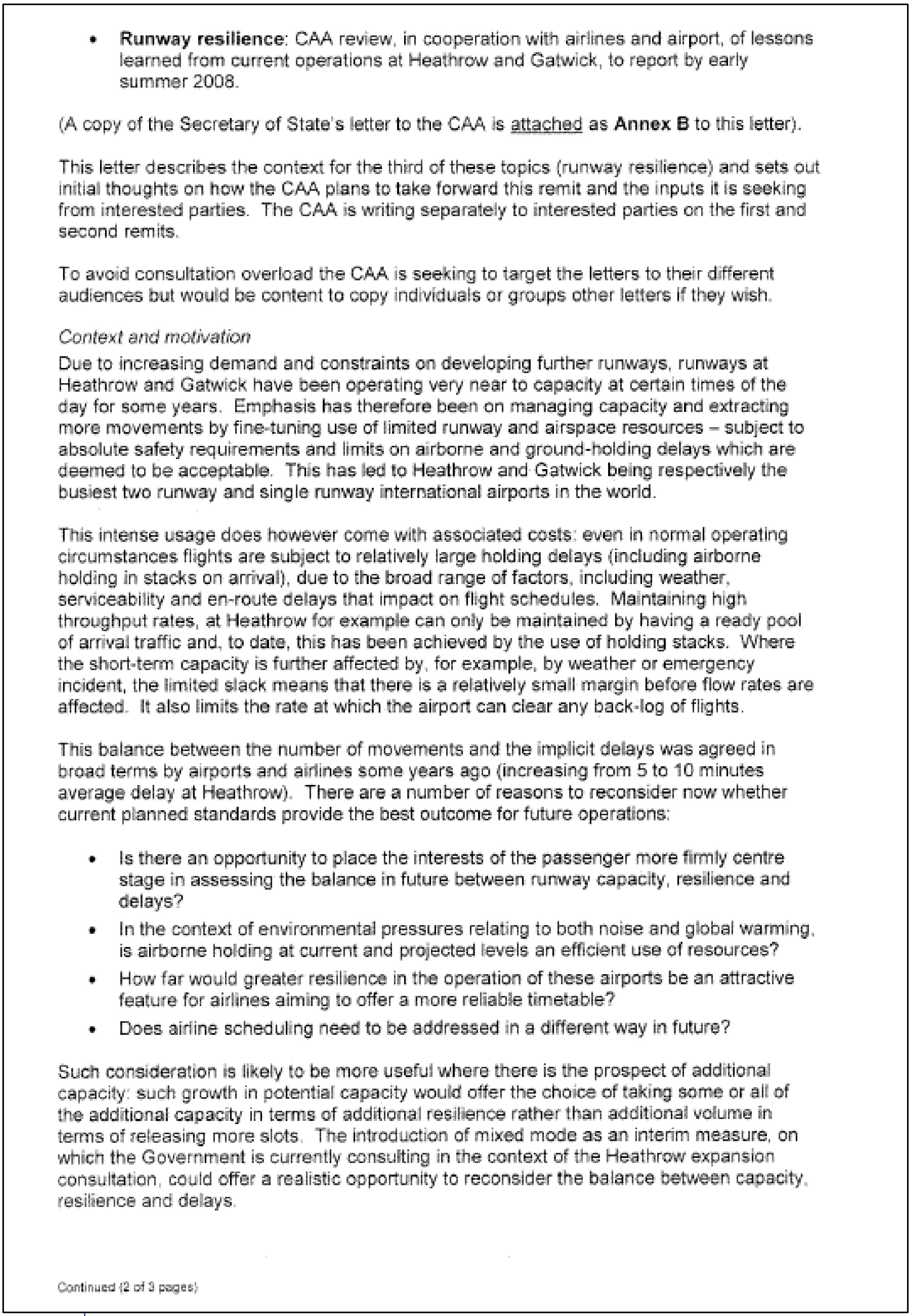

- **Runway resilience**: CAA review, in cooperation with airlines and airport, of lessons learned from current operations at Heathrow and Gatwick, to report by early summer 2008.

(A copy of the Secretary of State's letter to the CAA is attached as **Annex B** to this letter).

This letter describes the context for the third of these topics (runway resilience) and sets out initial thoughts on how the CAA plans to take forward this remit and the inputs it is seeking from interested parties. The CAA is writing separately to interested parties on the first and second remits.

To avoid consultation overload the CAA is seeking to target the letters to their different audiences but would be content to copy individuals or groups other letters if they wish.

Context and motivation

Due to increasing demand and constraints on developing further runways, runways at Heathrow and Gatwick have been operating very near to capacity at certain times of the day for some years. Emphasis has therefore been on managing capacity and extracting more movements by fine-tuning use of limited runway and airspace resources – subject to absolute safety requirements and limits on airborne and ground-holding delays which are deemed to be acceptable. This has led to Heathrow and Gatwick being respectively the busiest two runway and single runway international airports in the world.

This intense usage does however come with associated costs: even in normal operating circumstances flights are subject to relatively large holding delays (including airborne holding in stacks on arrival), due to the broad range of factors, including weather, serviceability and en-route delays that impact on flight schedules. Maintaining high throughput rates, at Heathrow for example can only be maintained by having a ready pool of arrival traffic and, to date, this has been achieved by the use of holding stacks. Where the short-term capacity is further affected by, for example, by weather or emergency incident, the limited slack means that there is a relatively small margin before flow rates are affected. It also limits the rate at which the airport can clear any back-log of flights.

This balance between the number of movements and the implicit delays was agreed in broad terms by airports and airlines some years ago (increasing from 5 to 10 minutes average delay at Heathrow). There are a number of reasons to reconsider now whether current planned standards provide the best outcome for future operations:

- Is there an opportunity to place the interests of the passenger more firmly centre stage in assessing the balance in future between runway capacity, resilience and delays?
- In the context of environmental pressures relating to both noise and global warming, is airborne holding at current and projected levels an efficient use of resources?
- How far would greater resilience in the operation of these airports be an attractive feature for airlines aiming to offer a more reliable timetable?
- Does airline scheduling need to be addressed in a different way in future?

Such consideration is likely to be more useful where there is the prospect of additional capacity: such growth in potential capacity would offer the choice of taking some or all of the additional capacity in terms of additional resilience rather than additional volume in terms of releasing more slots. The introduction of mixed mode as an interim measure, on which the Government is currently consulting in the context of the Heathrow expansion consultation, could offer a realistic opportunity to reconsider the balance between capacity, resilience and delays.

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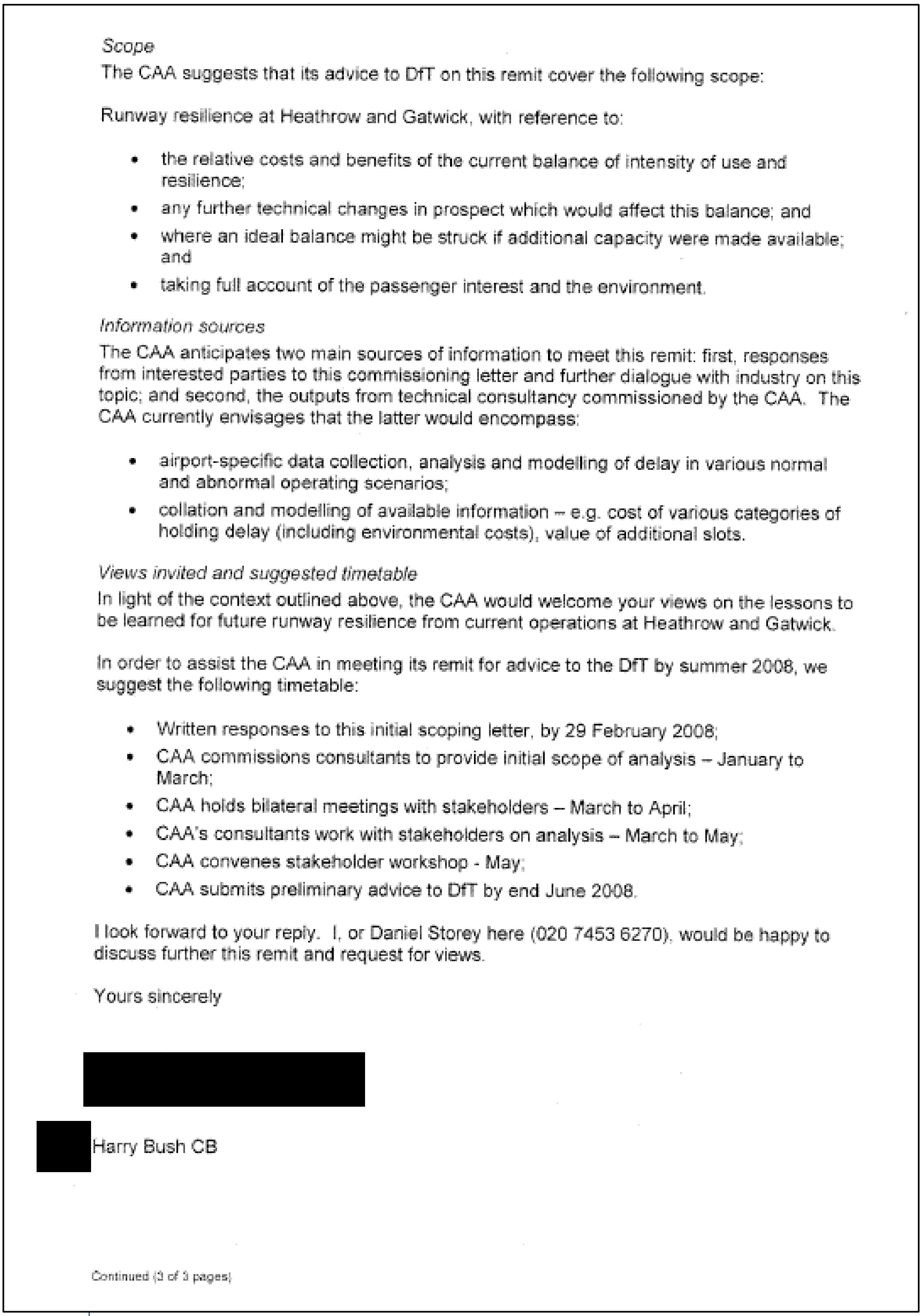


Scope

The CAA suggests that its advice to DfT on this remit cover the following scope:

Runway resilience at Heathrow and Gatwick, with reference to:

- the relative costs and benefits of the current balance of intensity of use and resilience;
- any further technical changes in prospect which would affect this balance; and
- where an ideal balance might be struck if additional capacity were made available; and
- taking full account of the passenger interest and the environment.

Information sources

The CAA anticipates two main sources of information to meet this remit: first, responses from interested parties to this commissioning letter and further dialogue with industry on this topic; and second, the outputs from technical consultancy commissioned by the CAA. The CAA currently envisages that the latter would encompass:

- airport-specific data collection, analysis and modelling of delay in various normal and abnormal operating scenarios;
- collation and modelling of available information – e.g. cost of various categories of holding delay (including environmental costs), value of additional slots.

Views invited and suggested timetable

In light of the context outlined above, the CAA would welcome your views on the lessons to be learned for future runway resilience from current operations at Heathrow and Gatwick.

In order to assist the CAA in meeting its remit for advice to the DfT by summer 2008, we suggest the following timetable:

- Written responses to this initial scoping letter, by 29 February 2008;
- CAA commissions consultants to provide initial scope of analysis – January to March;
- CAA holds bilateral meetings with stakeholders – March to April;
- CAA's consultants work with stakeholders on analysis – March to May;
- CAA convenes stakeholder workshop - May;
- CAA submits preliminary advice to DfT by end June 2008.

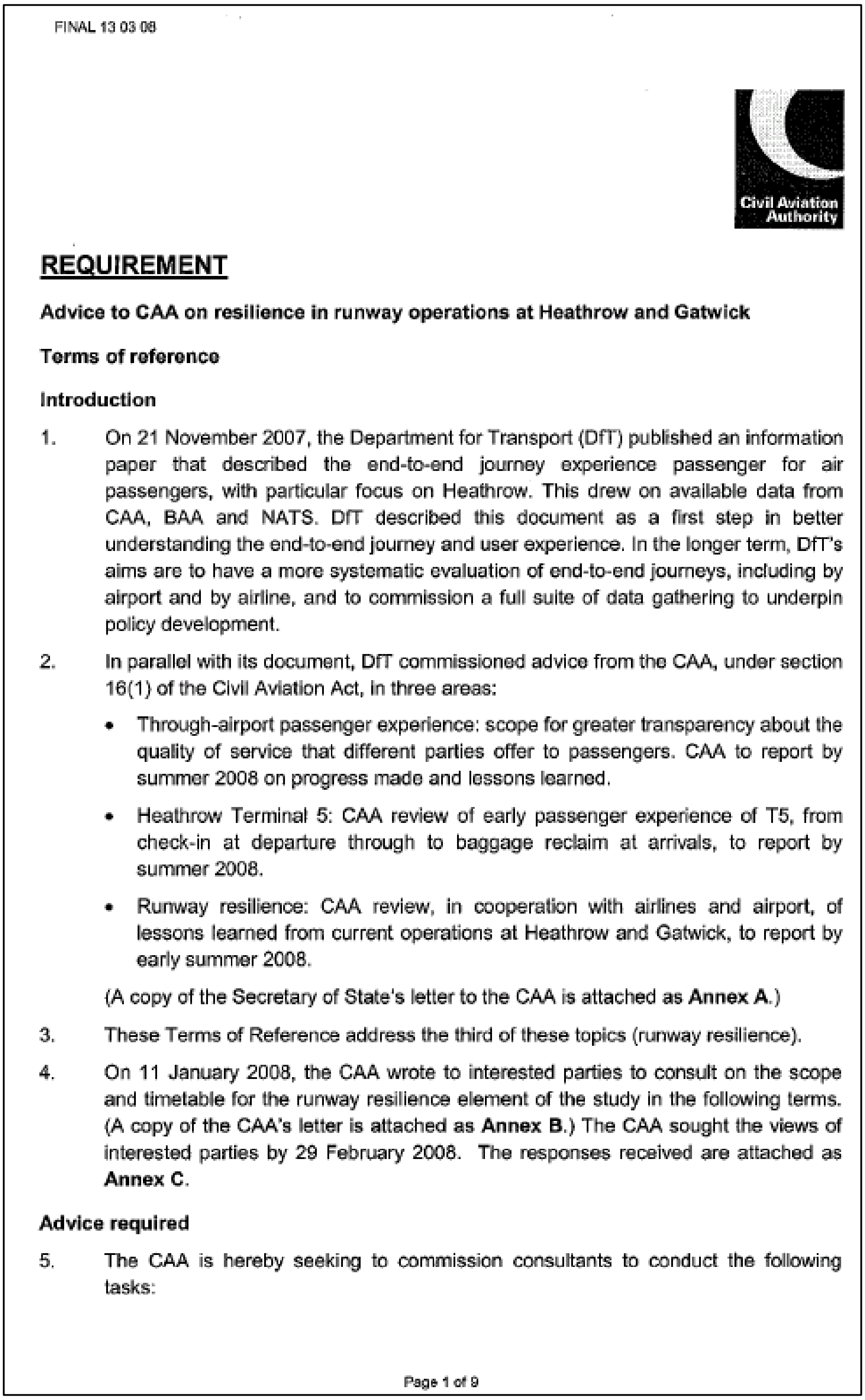
I look forward to your reply. I, or Daniel Storey here (020 7453 6270), would be happy to discuss further this remit and request for views.

Yours sincerely

[redacted]

[redacted] Harry Bush CB

Continued (3 of 3 pages)



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Civil Aviation Authority

REQUIREMENT

Advice to CAA on resilience in runway operations at Heathrow and Gatwick

Terms of reference

Introduction

1. On 21 November 2007, the Department for Transport (DfT) published an information paper that described the end-to-end journey experience passenger for air passengers, with particular focus on Heathrow. This drew on available data from CAA, BAA and NATS. DfT described this document as a first step in better understanding the end-to-end journey and user experience. In the longer term, DfT's aims are to have a more systematic evaluation of end-to-end journeys, including by airport and by airline, and to commission a full suite of data gathering to underpin policy development.

2. In parallel with its document, DfT commissioned advice from the CAA, under section 16(1) of the Civil Aviation Act, in three areas:

   - Through-airport passenger experience: scope for greater transparency about the quality of service that different parties offer to passengers. CAA to report by summer 2008 on progress made and lessons learned.
   - Heathrow Terminal 5: CAA review of early passenger experience of T5, from check-in at departure through to baggage reclaim at arrivals, to report by summer 2008.
   - Runway resilience: CAA review, in cooperation with airlines and airport, of lessons learned from current operations at Heathrow and Gatwick, to report by early summer 2008.

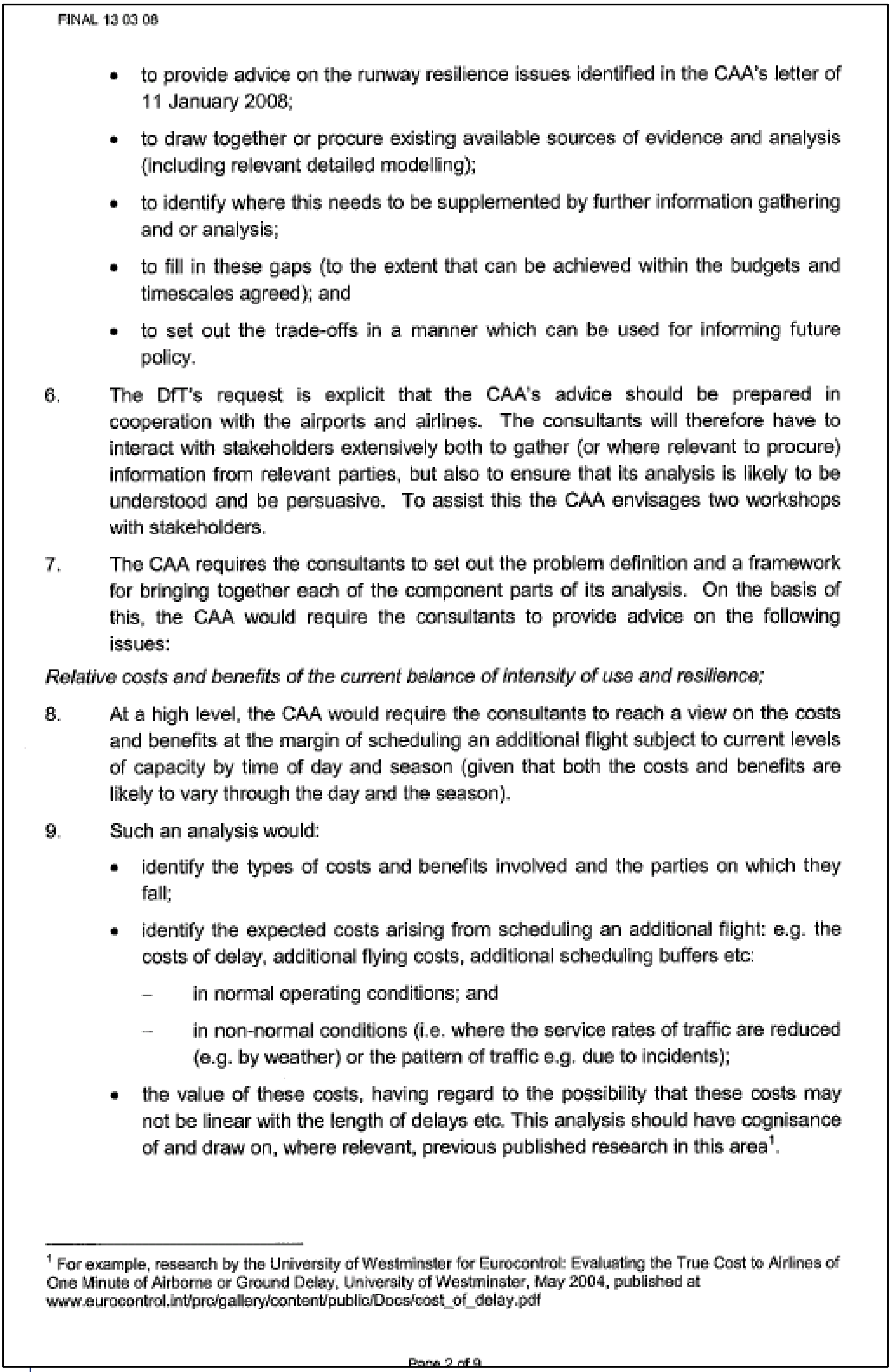
   (A copy of the Secretary of State's letter to the CAA is attached as **Annex A**.)

3. These Terms of Reference address the third of these topics (runway resilience).

4. On 11 January 2008, the CAA wrote to interested parties to consult on the scope and timetable for the runway resilience element of the study in the following terms. (A copy of the CAA's letter is attached as **Annex B**.) The CAA sought the views of interested parties by 29 February 2008. The responses received are attached as **Annex C**.

Advice required

5. The CAA is hereby seeking to commission consultants to conduct the following tasks:



- to provide advice on the runway resilience issues identified in the CAA's letter of 11 January 2008;
- to draw together or procure existing available sources of evidence and analysis (including relevant detailed modelling);
- to identify where this needs to be supplemented by further information gathering and or analysis;
- to fill in these gaps (to the extent that can be achieved within the budgets and timescales agreed); and
- to set out the trade-offs in a manner which can be used for informing future policy.

6. The DfT's request is explicit that the CAA's advice should be prepared in cooperation with the airports and airlines. The consultants will therefore have to interact with stakeholders extensively both to gather (or where relevant to procure) information from relevant parties, but also to ensure that its analysis is likely to be understood and be persuasive. To assist this the CAA envisages two workshops with stakeholders.

7. The CAA requires the consultants to set out the problem definition and a framework for bringing together each of the component parts of its analysis. On the basis of this, the CAA would require the consultants to provide advice on the following issues:

Relative costs and benefits of the current balance of intensity of use and resilience;

8. At a high level, the CAA would require the consultants to reach a view on the costs and benefits at the margin of scheduling an additional flight subject to current levels of capacity by time of day and season (given that both the costs and benefits are likely to vary through the day and the season).

9. Such an analysis would:

   - identify the types of costs and benefits involved and the parties on which they fall;
   - identify the expected costs arising from scheduling an additional flight: e.g. the costs of delay, additional flying costs, additional scheduling buffers etc:
     - in normal operating conditions; and
     - in non-normal conditions (i.e. where the service rates of traffic are reduced (e.g. by weather) or the pattern of traffic e.g. due to incidents);
   - the value of these costs, having regard to the possibility that these costs may not be linear with the length of delays etc. This analysis should have cognisance of and draw on, where relevant, previous published research in this area[1].

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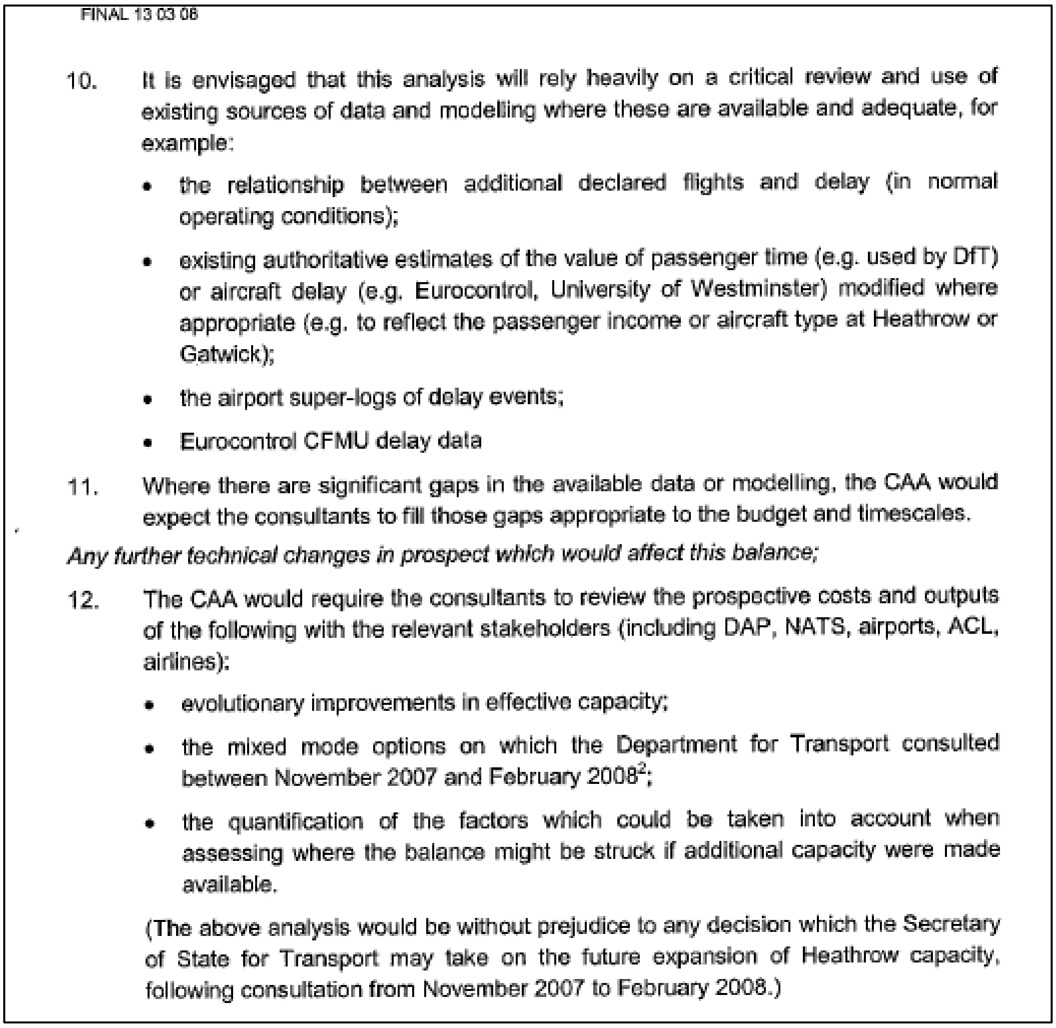
[1] For example, research by the University of Westminster for Eurocontrol: Evaluating the True Cost to Airlines of One Minute of Airborne or Ground Delay, University of Westminster, May 2004, published at www.eurocontrol.int/prc/gallery/content/public/Docs/cost_of_delay.pdf



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10. It is envisaged that this analysis will rely heavily on a critical review and use of existing sources of data and modelling where these are available and adequate, for example:

- the relationship between additional declared flights and delay (in normal operating conditions);
- existing authoritative estimates of the value of passenger time (e.g. used by DfT) or aircraft delay (e.g. Eurocontrol, University of Westminster) modified where appropriate (e.g. to reflect the passenger income or aircraft type at Heathrow or Gatwick);
- the airport super-logs of delay events;
- Eurocontrol CFMU delay data

11. Where there are significant gaps in the available data or modelling, the CAA would expect the consultants to fill those gaps appropriate to the budget and timescales.

Any further technical changes in prospect which would affect this balance;

12. The CAA would require the consultants to review the prospective costs and outputs of the following with the relevant stakeholders (including DAP, NATS, airports, ACL, airlines):

- evolutionary improvements in effective capacity;
- the mixed mode options on which the Department for Transport consulted between November 2007 and February 2008[2];
- the quantification of the factors which could be taken into account when assessing where the balance might be struck if additional capacity were made available.

(The above analysis would be without prejudice to any decision which the Secretary of State for Transport may take on the future expansion of Heathrow capacity, following consultation from November 2007 to February 2008.)

SH&E
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Appendix B:
COSTS OF HOLDING AND DELAYS

COST OF HOLDING AND DELAYS

9.1 There have been several previous studies looking at the economic impact of delays. In particular

- ”Costs of air transport delay in Europe”, Institut du Transport Aerien, November 2000, for Eurocontrol.
- “Evaluating the true cost to airlines of one minute of airborne or ground delay”, University of Westminster, May 2004 for Eurocontrol

The scope of and focus of both studies differed slightly from this study but we have based some parts of our analysis on them where appropriate.

9.2 Time limitation has precluded primary research so we have used previous studies, in particular the UoW supplemented with recent detailed data from several carriers coupled with industry published data e.g. ICAO, CAA Statistics. For carriers cost data we have based our analysis around AEA Data from those carriers that have kindly provided it as this gives a useful breakdown by route group and aircraft type.

Detailed traffic database

9.3 In order to model the correct traffic mix with the needed break-down we relied on the OAG schedules submitted by the airlines monthly. In the case of Heathrow the OAG schedules cover all the traffic of the airport because of the almost complete absence of non-scheduled operations. To fit our needs we have done some conversions on these schedules:

- We have converted the weekly schedules into monthly ones by scaling the frequencies up based on the number of Mondays, Tuesdays, etc… for the affected months of the S07 and W0708 seasons.
- We have matched up the aircraft types in the schedules with the corresponding number of first, business and economy seats of the aircraft of the airlines who operate to Heathrow.
- We have converted the seat capacity from step 2 into business and economy passenger traffic using average load factors for the given regions. The average load factors were those published by AEA for 2007.
- We have matched the typical fares to the passengers by region. Here we relied on the fare values published in the IATA Fare Tracker 2007 adding British Airway’s fuel surcharge values to better represent the current situation.

9.4 The conversions appeared to be precise enough to reproduce Heathrow's overall traffic within a range of 1% compared to the traffic statistics published by the CAA. Our final traffic database broke-up Heathrow's traffic by the following main dimensions:

- Direction of operation (arriving-departing)
- Hour of operation, calendar day and season
- Region of operation (using the 10 standard regions of AEA)
- Operating carriers
- Operating aircraft types (using 27 different aircraft types)
- Scheduled block time of the flights
- Estimated number of passengers
- Estimated revenue

Airport costs

9.5 We have met and interviewed several professionals from BAA in order to try to identify the costs that the airport incurs due to runway-related delays. The result of the interviews was that it is not possible to separate those costs of the airport which relate to delays, or especially to runway-related delays. The general view was that the airport faces no substantial extra costs due to delays. The main reason behind this is that even if some of the traffic is delayed it still passes through the airport. Therefore, the airport generates the same revenue, only some minutes or hours later than originally scheduled.

9.6 BAA has stated it unlikely that longer dwell time of passengers as a consequence of delays would materially increase commercial revenue through the passengers' spending. This is because the average passenger spending profile levels off or even reduces above 151 minutes dwell time.

9.7 An important element in BAA's case is the effect of the single till regulation on the airport. This type of regulation channels back all possible extra revenue of the airport that it collected due to delays to the users at the end of the regulatory periods in the form of lower user charges for the next period. Therefore, any possible gains of the airport in commercial revenues are only temporary.

9.8 BAA has formulated its official view on the subject in a letter that is attached at the end of this appendix.

Impact on airlines

9.9 Our study concentrated on runway-related holding, namely

- ATFM holding,
- stack holding and
- pre-departure holding.

9.10 From an airline's perspective the main difference between the three types of holdings is the wear and tear of the aircraft and the fuel burn. Having consulted professional airline pilots we concluded that generally aircraft do not use their engines during ATFM holding and prefer to avoid using the APU as well. During pre-departure holding the usual practice is to run the engines on idle thrust as this quote from a pilot describes it: *"the taxiing phase is best represented by engines at idle thrust. In most situations, similar to an automatic car, the pilot must apply the brakes to keep the aircraft from moving with the engines at idle power. In certain situations with excessive payloads or the need for acceleration and speed, the pilot may provide a throttle blip to get the aircraft moving or attain a higher ground speed. Because of this reality, we find it appropriate to use the idle thrust levels and fuel burn for the taxiing phase of flight."*

9.11 The following table summarises the different rates used to estimate the fuel burn of the aircraft and the corresponding emissions.

Exhibit 9-1. Fuel Burn Rates and Corresponding CO2 and NOx Emissions

	Pre-departure holding NO APU			STACK			TAXI		
	Fuel burn	CO 2	Nox	Fuel burn	CO 2	Nox	Fuel burn	CO 2	Nox
Aircraft	kg / min	kg / min	kg / min	kg / min	kg / min	kg / min	kg / min	kg / min	kg / min
A300	-	-	-	76	247	1.4	13	44	0.2
A310	-	-	-	71	231	1.2	12	40	0.2
A319	-	-	-	34	111	0.5	7	22	0.1
A320	-	-	-	36	117	0.5	7	23	0.1
A321	-	-	-	46	151	0.6	7	23	0.1
A330	-	-	-	87	284	1.8	15	49	0.3
A340	-	-	-	50	163	0.9	9	30	0.2
ATR	-	-	-	12	40	0.1	3	9	-
B733	-	-	-	35	115	0.3	7	23	0.1
B734	-	-	-	37	121	0.4	7	24	0.1
B735	-	-	-	34	109	0.3	7	24	0.1
B736	-	-	-	35	114	0.3	7	21	0.1
B737	-	-	-	34	110	0.3	7	21	0.1
B738	-	-	-	36	119	0.3	7	21	0.1
B744	-	-	-	155	503	2.7	14	46	0.2
B752	-	-	-	53	173	0.8	10	33	0.2
B763	-	-	-	74	239	1.2	13	42	0.2
B772	-	-	-	102	332	2.3	19	61	0.4
B773	-	-	-	122	397	2.7	22	70	0.5
BAE146	-	-	-	12	40	0.1	3	9	-
CRJ	-	-	-	16	53	0.1	4	13	0.0
E145	-	-	-	16	51	0.2	3	10	0.0
E190	-	-	-	27	88	0.2	4	13	0.0
F50	-	-	-	28	91	0.2	7	23	0.0
MD82	-	-	-	44	144	0.4	8	27	0.1
Q400	-	-	-	12	40	0.1	3	9	-
Other	**-**	**-**	**-**	**61**	**199**	**1.0**	**10**	**32**	**0.2**

Source: US Form 41, ICAO Engine Emissions Database, Boeing (exclude Radiative Forcing Factor)

9.12 Using the typical fuel burn and emissions rates, the traffic database, the holding times, an average fuel price and an average price for CO2 emissions we estimated the cost of fuel and CO2 that airlines face in the different scenarios.

9.13 For CO2 burned in the air (i.e. in flight, in stack holding but not ground holding) we have applied the DEFRA recommended Radiative Forcing Factor of 1.9. [25]

9.14 To estimate the maintenance and aircraft ownership costs we have used average values by block minute of these variables as shown in the table below.

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[25] DEFRA (June 2007) *Act on CO2 Calculator: Public Trial Version Data, Methodology and Assumptions Paper* www.defra.gov.uk/environment/climatechange/uk/individual/pdf/actonco2-calc-methodology.pdf

Exhibit 9-2. Aircraft Maintenance and Ownership Costs

	Maintenance cost	AC ownership costs
Aircraft	GBP / min	GBP / min
A300	17.35	14.02
A310	14.98	6.83
A319	3.96	9.21
A320	4.35	10.03
A321	4.93	11.26
A330	6.44	18.81
A340	10.23	16.32
ATR	2.40	8.74
B733	6.55	6.56
B734	6.42	8.12
B735	4.78	6.20
B736	3.64	8.39
B737	3.85	12.33
B738	4.07	13.20
B744	12.02	17.95
B752	7.94	8.72
B763	8.39	11.97
B772	11.03	22.01
B773	12.14	33.62
BAE146	5.46	5.18
CRJ	2.63	7.81
E145	2.30	4.91
E190	2.88	18.00
F50	3.89	2.70
MD82	4.40	2.63
Q400	2.40	10.26
Other	6.72	12.45

Source: US Form 41 and Airline and Fleet Management

9.15 Using the holding times, the traffic database and the values above we calculated the aircraft ownership and maintenance values corresponding to each scenario. We have assumed that similarly to fuel burn ATFM holding does not generate aircraft maintenance costs, because the aircraft is kept on-blocks and typical maintenance schedules are based on actual off-block times. In the case of aircraft ownership costs we have assumed that the ATFM holding contributes to the costs, because typical lease agreements and accounting practices are based on calendar time instead of block times.

9.16 Crew costs were estimated similarly to the aircraft-related costs with the difference that in this case we have tied the costs to different airlines instead of aircraft types. The ICAO financial databases provided us crew cost levels for many of the airlines operating to Heathrow. We have converted these to per block-minute levels as shown below.

Exhibit 9-3. Crew Costs of Different Airlines

Carrier	Average cost / block min GBP Pilots and co-pilots	 Cabin crew
British Airways	5.61	7.31
Virgin Atlantic	5.57	4.93
British Midland	4.80	2.20
Air Canada	3.76	2.87
Air India	2.79	1.98
Air France	9.51	7.80
American Airlines	5.18	3.42
Austrian Airlines	5.79	2.98
Cathay Pacific	8.70	5.86
Continental	4.22	2.72
CSA	2.45	1.27
Delta	4.66	2.48
Iberia	6.54	5.94
Jet Airways	4.04	0.79
KLM	-	-
Lufthansa	5.28	5.41
Qantas	-	-
SAS	8.57	5.61
Swiss	4.12	3.85
United	4.13	3.08
Other	4.94	4.73

Source: ICAO

9.17 From the interviews with the airlines we have concluded that they normally pay the full crew costs (fixed and variable, salaries and allowances) regardless of whether the flights are delayed or not. Therefore, we assumed that crew costs are incurred during all the three types of holding.

9.18 We have used these crew costs a second time when estimating the costs of keeping standby crews as resilience. At this occasion we have split the above costs into fixed and variable parts, assuming that the variable part is not paid to the crew on stand-by. The split was done based on the airline cost statistics published by the CAA. These only included domestic carriers, therefore we had to assume that foreign carriers split their costs equally to the average of the domestic carriers.

Impact on passengers

9.19 In theory, holding queues do not automatically affect passengers, because passengers are only affected if the flight is delayed compared to the original schedule. Therefore, before applying the holding times directly to the passengers we first had to establish the correlation between these and the schedule punctuality of the airlines. In Heathrow’s example statistical evidence showed that holding times directly convert to flight delays, therefore we assumed that all holding time directly affects passengers in the form of delays.

9.20 Theory also suggests that all primary delays during the day have a knock-on effect called rotational delays on subsequent flights when the aircraft are tightly scheduled to perform several flights during the day. This is irrelevant for those costs which are related to aircraft operations, because the aircraft will still perform the same flight schedule, only somewhat later during the day. On the other hand passengers might be affected by the rotational delays if the schedule gets disrupted by these.

9.21 In Heathrow's case statistics showed that 1 minute of primary delay could cause up to a further 0.55 minutes of rotational delays depending on time of the day, region of operation, etc. However, we had to disregard this fact in our calculations, because our holding and delay data already included the rotational effects. Therefore, scaling them up by a rotational multiplier would have meant double-counting some of the delay time.

Passenger Value of Time

9.22 The DfT suggests the use of the Value of Time (VOT) figures for transport related economic studies. The VOT converts passengers' time into monetary value. It is a relatively recent approach used in transport related economics, and the methodology is still evolving. See Appendix E: Passenger Value of Time – Eurocontrol Figures for a review of other studies.

9.23 We have found two different sets of VOT values, both suggested by the DfT. The first set was published in the "Value of Travel Time Savings in the UK: Summary Report. January 2003". This suggested the following values:

Exhibit 9-4 VOT from "Value of Travel Time Saving in the UK. Summary Report. January 2003" (1997 values)

	Business travellers		Leisure travellers	
	Commuting	Other	Commuting	Other
Income band	GBP / min	GBP / min	GBP / min	GBP / min
0 - 17500	0.036	0.046	0.066	0.059
17500 - 35000	0.059	0.059	0.066	0.059
35000 -	0.086	0.071	0.066	0.059

Source: DfT

9.24 The above values have the advantage that they distinguish between the VOT by different income bands. We have used these values and the passenger traffic break-down by income bands for Heathrow from the Airport Passenger Survey which is published by the CAA to calculate weighted average VOT values for business and leisure purpose travellers. For the business passengers we calculated annual employment costs and divided those by 1808 annual working hours as suggested by the DfT. For the leisure passengers we scaled up the 1997 GBP values to current using the nominal GDP / capita growth rates as suggested by the same study. The results were the following values:

- Business purpose travellers: 0.99 GBP / min (59.64 GBP / hr)
- Leisure purpose travellers: 0.08 GBP / min (4.99 GBP / hr)

9.25 The "Values of time and operating costs. TAG Unit 3.5.6" publication by the DfT suggested somewhat different numbers to use.

Exhibit 9-5. VOT Values from "Values of Time and Operating Costs. TAG 3.5.6" (2002 values)

	Business (average)		Leisure	
	GBP / hr	GBP / min	GBP / hr	GBP / min
Market price	26.73	0.45	4.46	0.07

Source: DfT

9.26 Finally, during the personal interviews with the DfT we came to the final set of values that were used in our own calculations. These values were the following:

Exhibit 9-6 The VOT as Suggested by the DfT During Interviews (2007 values)

VOT	GBP / hour
UK business	50.67
UK leisure	8.48
Foreign business	58.12
Foreign leisure	8.48
Domestic scheduled	33.37

Source: DfT

9.27 Weighting the above values by the corresponding traffic share we calculated the following values that were subsequently used in all other calculations:

- Business purpose travellers: 0.91 GBP / min (54.70 GBP / hr)
- Leisure purpose travellers: 0.14 GBP / min (8.48 GBP / hr)

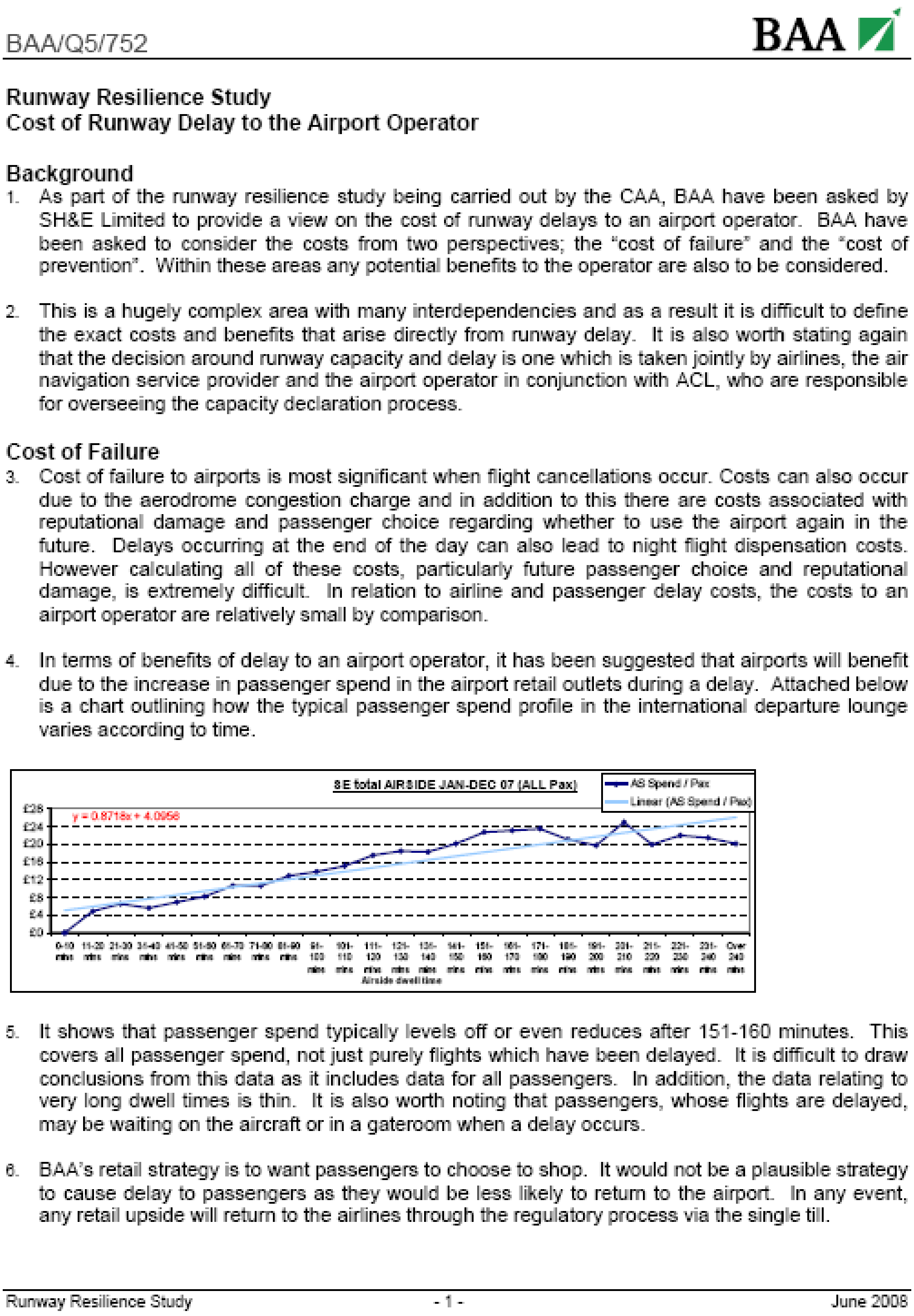
9.28 The traffic database estimated the business and leisure passengers based on the cabin split. Therefore, before using the above VOTs we had to modify this split to reflect purpose of travel. We did this by dividing the total number of passengers on each flight by the business-leisure split provided in the CAA's statistics. Finally, multiplying the holding times with the modified traffic data and the VOTs we calculated the total VOT values for each scenario.

Estimation of environmental impact

9.29 The environmental impacts were calculated similarly to the fuel burn of the airlines. We have estimated the CO2 and NOx emissions that correspond to the typical fuel burn values of aircraft operating to Heathrow using the values from the ICAO Engine Emissions Database. (see values in Exhibit 9-1) Then we scaled up these numbers according to the traffic mix and holding times of each scenario, and included the Radiative Forcing Factor of 1.9.

9.30 We have also expressed the CO2 emissions in monetary terms, using the DEFRA recommended value of £19/tonne in 2000 increasing in real terms by 2% a year.

Exhibit 9-7. Letter from BAA Regarding Costs of Delays to the Airport



BAA/Q5/752 BAA

Runway Resilience Study
Cost of Runway Delay to the Airport Operator

Background

1. As part of the runway resilience study being carried out by the CAA, BAA have been asked by SH&E Limited to provide a view on the cost of runway delays to an airport operator. BAA have been asked to consider the costs from two perspectives; the "cost of failure" and the "cost of prevention". Within these areas any potential benefits to the operator are also to be considered.

2. This is a hugely complex area with many interdependencies and as a result it is difficult to define the exact costs and benefits that arise directly from runway delay. It is also worth stating again that the decision around runway capacity and delay is one which is taken jointly by airlines, the air navigation service provider and the airport operator in conjunction with ACL, who are responsible for overseeing the capacity declaration process.

Cost of Failure

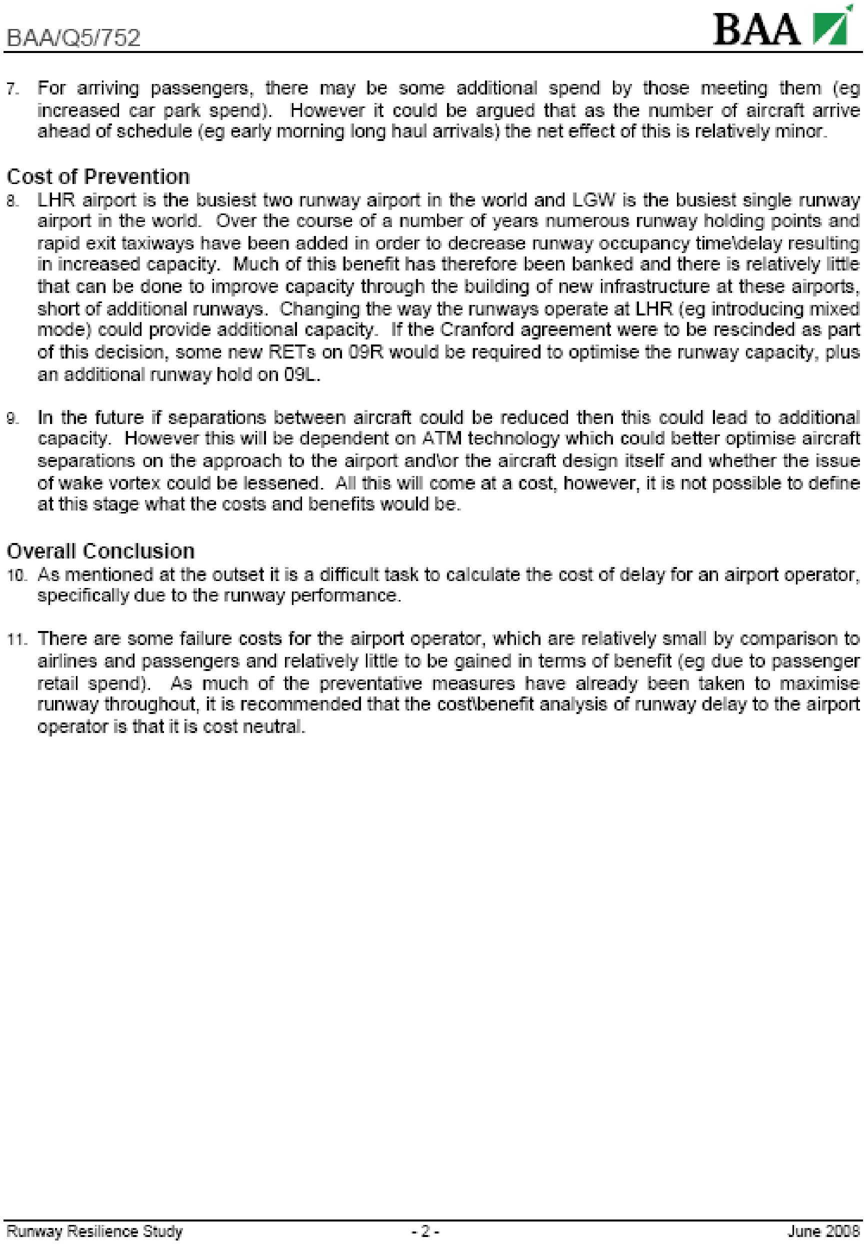
3. Cost of failure to airports is most significant when flight cancellations occur. Costs can also occur due to the aerodrome congestion charge and in addition to this there are costs associated with reputational damage and passenger choice regarding whether to use the airport again in the future. Delays occurring at the end of the day can also lead to night flight dispensation costs. However calculating all of these costs, particularly future passenger choice and reputational damage, is extremely difficult. In relation to airline and passenger delay costs, the costs to an airport operator are relatively small by comparison.

4. In terms of benefits of delay to an airport operator, it has been suggested that airports will benefit due to the increase in passenger spend in the airport retail outlets during a delay. Attached below is a chart outlining how the typical passenger spend profile in the international departure lounge varies according to time.

5. It shows that passenger spend typically levels off or even reduces after 151-160 minutes. This covers all passenger spend, not just purely flights which have been delayed. It is difficult to draw conclusions from this data as it includes data for all passengers. In addition, the data relating to very long dwell times is thin. It is also worth noting that passengers, whose flights are delayed, may be waiting on the aircraft or in a gateroom when a delay occurs.

6. BAA's retail strategy is to want passengers to choose to shop. It would not be a plausible strategy to cause delay to passengers as they would be less likely to return to the airport. In any event, any retail upside will return to the airlines through the regulatory process via the single till.

Runway Resilience Study - 1 - June 2008



BAA/Q5/752 BAA

7. For arriving passengers, there may be some additional spend by those meeting them (eg increased car park spend). However it could be argued that as the number of aircraft arrive ahead of schedule (eg early morning long haul arrivals) the net effect of this is relatively minor.

Cost of Prevention

8. LHR airport is the busiest two runway airport in the world and LGW is the busiest single runway airport in the world. Over the course of a number of years numerous runway holding points and rapid exit taxiways have been added in order to decrease runway occupancy time\delay resulting in increased capacity. Much of this benefit has therefore been banked and there is relatively little that can be done to improve capacity through the building of new infrastructure at these airports, short of additional runways. Changing the way the runways operate at LHR (eg introducing mixed mode) could provide additional capacity. If the Cranford agreement were to be rescinded as part of this decision, some new RETs on 09R would be required to optimise the runway capacity, plus an additional runway hold on 09L.

9. In the future if separations between aircraft could be reduced then this could lead to additional capacity. However this will be dependent on ATM technology which could better optimise aircraft separations on the approach to the airport and\or the aircraft design itself and whether the issue of wake vortex could be lessened. All this will come at a cost, however, it is not possible to define at this stage what the costs and benefits would be.

Overall Conclusion

10. As mentioned at the outset it is a difficult task to calculate the cost of delay for an airport operator, specifically due to the runway performance.

11. There are some failure costs for the airport operator, which are relatively small by comparison to airlines and passengers and relatively little to be gained in terms of benefit (eg due to passenger retail spend). As much of the preventative measures have already been taken to maximise runway throughout, it is recommended that the cost\benefit analysis of runway delay to the airport operator is that it is cost neutral.

Runway Resilience Study - 2 - June 2008

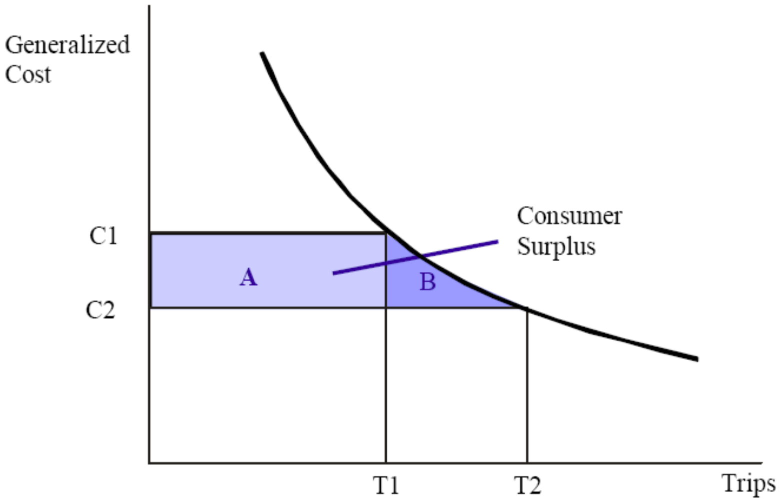
Source: BAA

Appendix C:
EXTRA FLIGHTS – BENEFIT AND COST ASSUMPTIONS

Background- theory of consumer surplus

9.31 When extra flights are added there are changes to the costs and benefits for consumers (passengers) and suppliers (airlines and airports). Economic theory describes these effects as changes to the consumer surplus and supplier surplus. Wider economic considerations such as the impact on local employment and further benefits to the economy of UK or EU have not been considered in this study. The Department for Transport has laid down guidelines[26] for calculating the costs and benefits when evaluating transport infrastructure proposals which we have followed in our evaluation, adapting as appropriate for this assignment. This was extended by 2007 to include Air Passenger Duty and the “cost of carbon” as described in the DfT paper of 2007.[27]

Exhibit 9-8: Theory of Consumer Surplus



Source: US DOT

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[26] DfT, National Transport Model Working Paper 4.

[27] DfT ‘UK Air Passenger Demand and CO2 Forecasts’ (November 2007),

http://www. dft.gov.uk/pgr/aviation/environmentalissues/ukairdemandandco2forecasts/

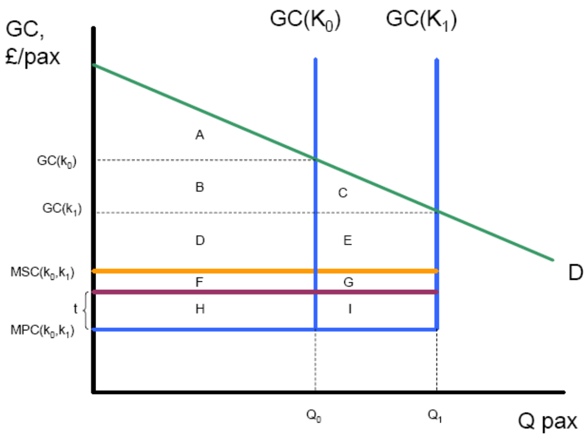
9.32 The conventional calculation of the change in “consumer surplus” assumes a price-demand curve based on price elasticity. In Exhibit 9-8 the price is referred to as the Generalized Cost, which is common in transport studies where there may be no explicit fare paid, and other costs to the consumer such as time spent in traffic jams need to be taken in to account. If the cost is reduced from C1 to C2 then the price demand-curve is used to calculate the extra number of passengers. The “consumer surplus” is defined as the difference between the cost to consumers for a good or service, and the value they place upon the good or service. In the exhibit, this equates to the area above the horizontal line above C1 or C2.

9.33 The change in consumer surplus is then the area between the two horizontal lines C1 and C2, consisting of the rectangle A and the (approximated) triangle B. A = consumer surplus gained by existing passengers; B = consumer surplus gained by new passengers, who will now travel because the cost of travel has dropped below their value.

9.34 In many cases estimating price elasticity is based simply on the fare paid, although there is also recognition that the air fare is only one of the costs of taking a trip, and elasticity with respect to total trip cost would in theory be more meaningful. While leisure passengers are generally considered to be price-sensitive, business passengers are more time-sensitive.

9.35 The DfT method defines the following categories of benefits:

Figure H1: Demand and capacity at a hypothetical airport



- Generated user benefits: C = value gained by new users attracted by the lower “fare”
- Producer benefits: E+G = airport profit per passenger x additional passengers
- APD revenue: +I

- Carbon costs: -G-I = Carbon/ATM x extra ATMs x £/tonne x 1.9 (Radiative Forcing factor)

And, not shown on the diagram,

- Existing User Benefits: +EU = Value of time x time saved from better/more frequent schedules.

9.36 The "fare" used in calculating the "Generated User Benefits" C equates to the average airport revenue/passenger plus a shadow cost, which is the fare premium needed in the DfT's UK airport demand allocation model to switch surplus demand at Heathrow to other UK airports and so balance demand against capacity. When extra capacity is added, or demand changes, the required shadow costs to balance capacity and demand also change. It does not directly relate to the average fare paid by passengers to airlines.

9.37 In our modeling we have not attempted to replicate the DfT modeling of demand at all UK airports and have effectively ignored the change in shadow costs. However we have assumed that the relationship between demand and "fare" is driven by the same price elasticities as calculated for airlines. We have used the price elasticities to calculate the % fare reduction required to generate the incremental demand, assuming passenger load factors are maintained.

9.38 The "Generated User Benefits" we have derived therefore will be lower estimates than those derived by the DfT, since our results do not reflect the change in the shadow costs.

Price Elasticity

9.39 As discussed above, the method to calculate Generated User Benefits depends on fare elasticities. Price elasticities can be calculated at different levels – airline and route specific analysis gives much higher values than analysis at total market or country to country level because of the cross-elasticity effect of passengers switching between airlines, or leisure passengers switching their destination because of price.

9.40 A recent study by IATA[28] estimated worldwide elasticities as -1.4 at the Route/Market level, -0.8 at the National level, and -0.6 at the Pan-National level. The paper gives geographic variants, and also variants for long haul and short haul, but there is no distinction between Business and Leisure.

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[28] "Estimating Air Travel Demand Elasticities", prepared for IATA by Intervistas Consulting, December 2007

9.41 The most recent DfT UK Air Passenger Demand (November 2007) has lower elasticities than previously assumed in their 2000 forecast, and in particular it has zero elasticity assumed for UK Business passengers (-0.5 in 2000), -1 for UK Leisure (-1.3 in 2000) and no elasticity assumption for foreign passengers.

9.42 Analysis of the UK leisure market in 2005[29] by the UK CAA gives leisure figures between -0.7 and -0.8 which are consistent with the IATA figures at National level (e.g. UK to US leisure market).

9.43 For our analysis we need elasticities which are closer to route elasticities as we are assessing the impact of adding capacity and hence fares changes on one route, not the impact on a total market of an average fare change. The elasticities we have used are for Business Passengers -0.3 and for Leisure Passengers -1.

Routes versus Regions

9.44 When modelling the impact of adding an extra flight, we would ideally have some assumptions about which route or region the flight would be added to. In practice the DfT method does not allow this level of differentiation – shadow costs, and producer costs and benefits are single values for each airport - so this aspect has not been modelled either for User Benefits or Producer Benefits.

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[29] “Demand for Outbound Leisure Air Travel and its Key Drivers”, December 2005

Appendix D:
STATISTICAL DISTRIBUTIONS

INTRODUCTION

9.45 This annex contains the statistical distribution functions derived for Heathrow for:

- stack holding times for arrivals
- airport ATFM delays attributed to Heathrow
- ground holding delays for departures.

9.46 The distributions are presented for each hour over the summer and winter seasons and are presented as both the frequency distributions of the holding times/delays as well as the associated cumulative distributions.

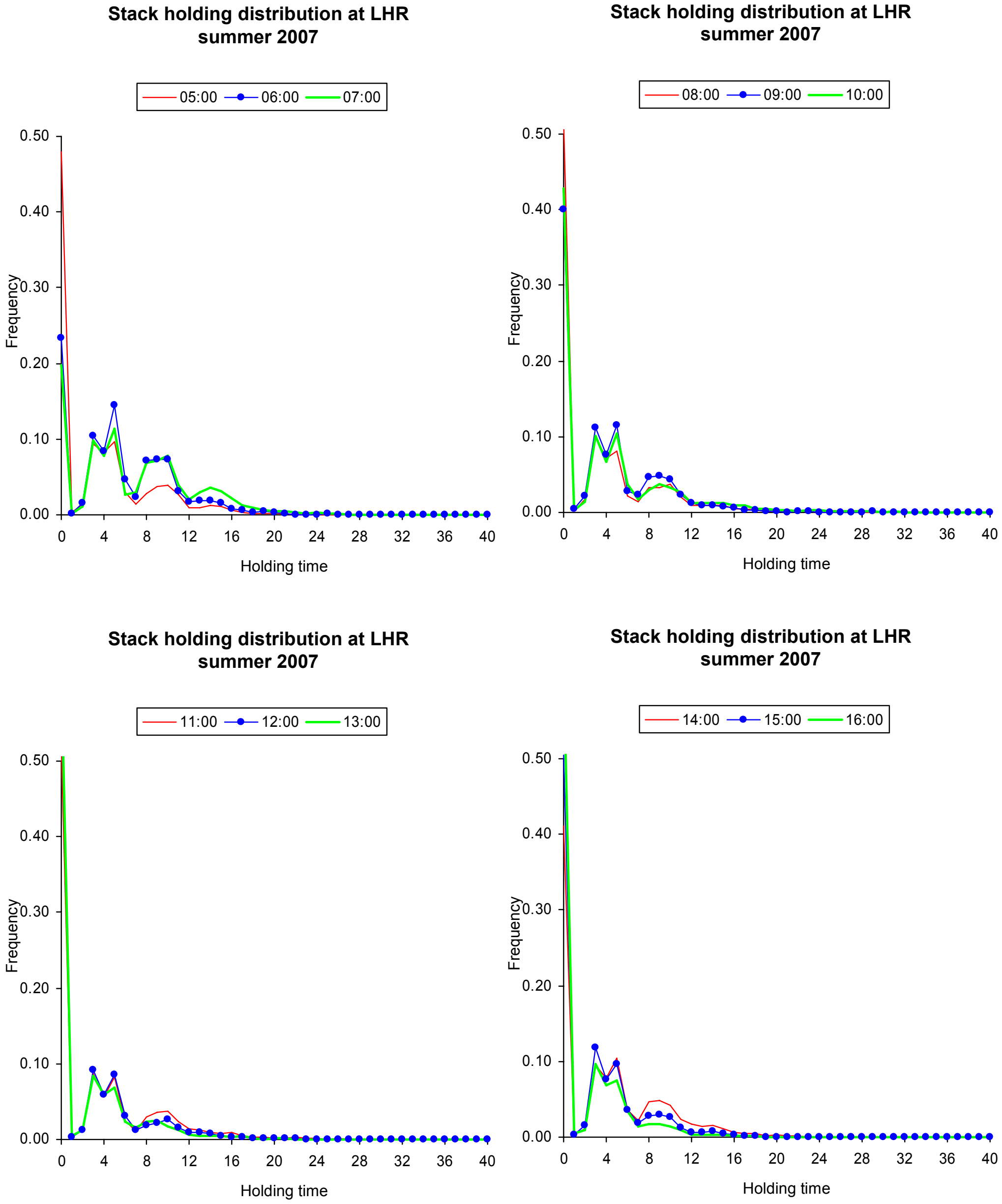
STACK HOLDING TIME DISTRIBUTIONS

Distributions

9.47 The stack holding time distributions are shown in the following exhibits. The main characteristics of the distributions are:

- a main peak at zero holding time corresponding to the aircraft that are not subject to stacking
- a series of side peaks roughly centred on multiples of 2.5 to 3 minutes which corresponds to the time that an aircraft takes to make a complete circuit of the stack.

Exhibit D-9-9: Stack Holding Distributions for Heathrow for Summer 2007



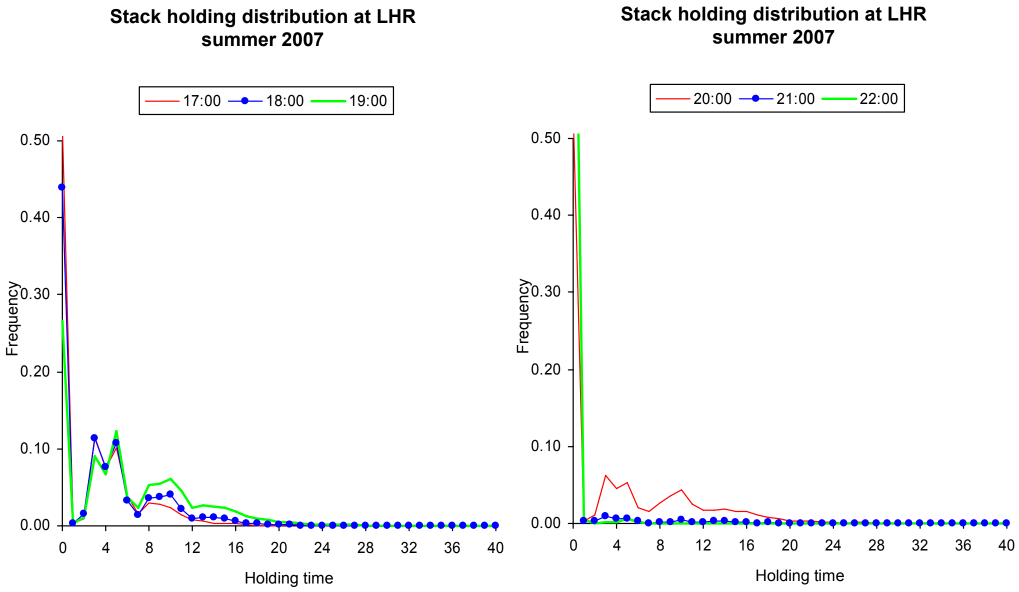
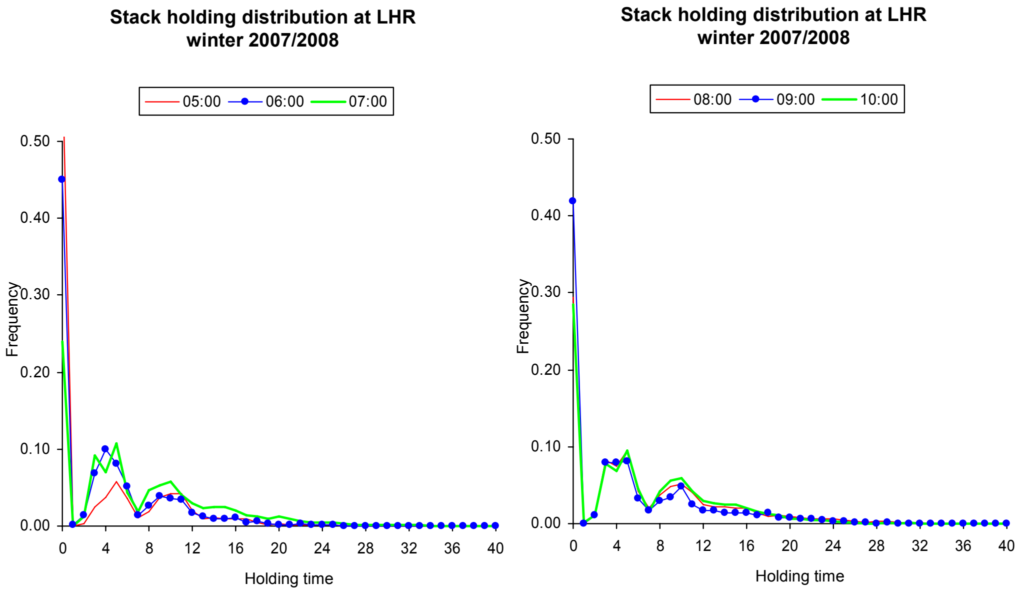
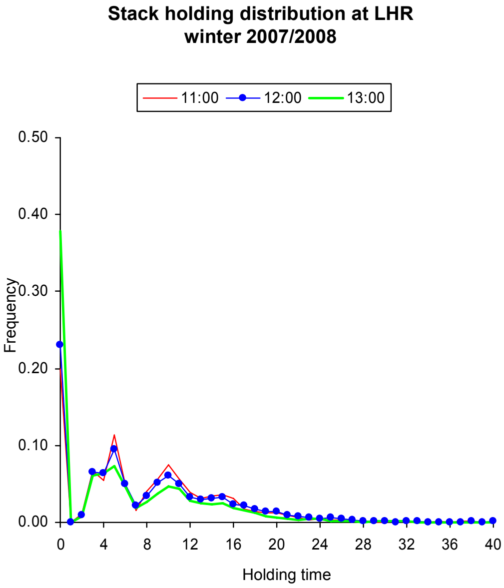
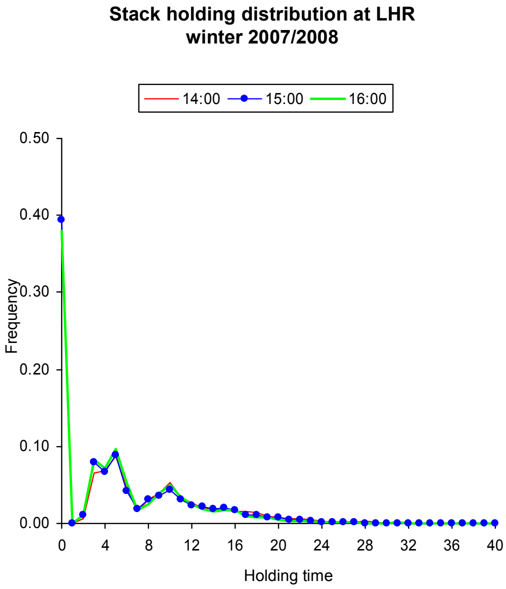
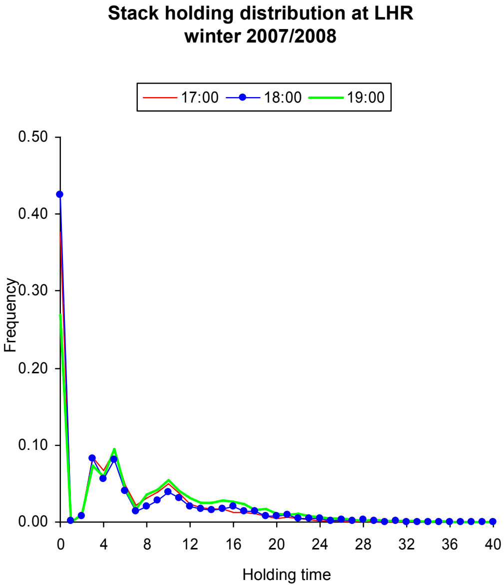


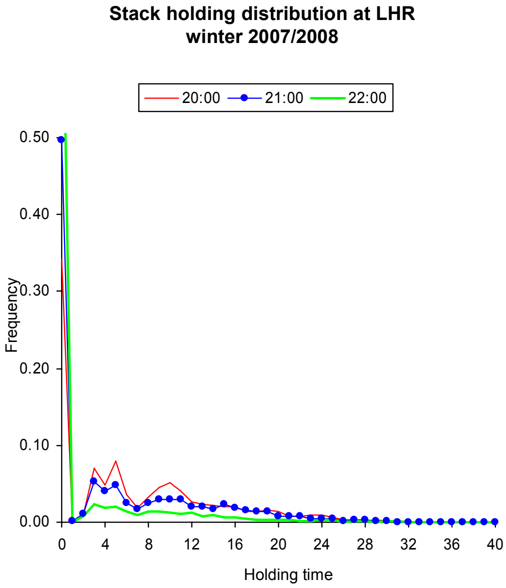
Exhibit D-9-10: Stack Holding Distributions for Heathrow for Winter 2007/2008







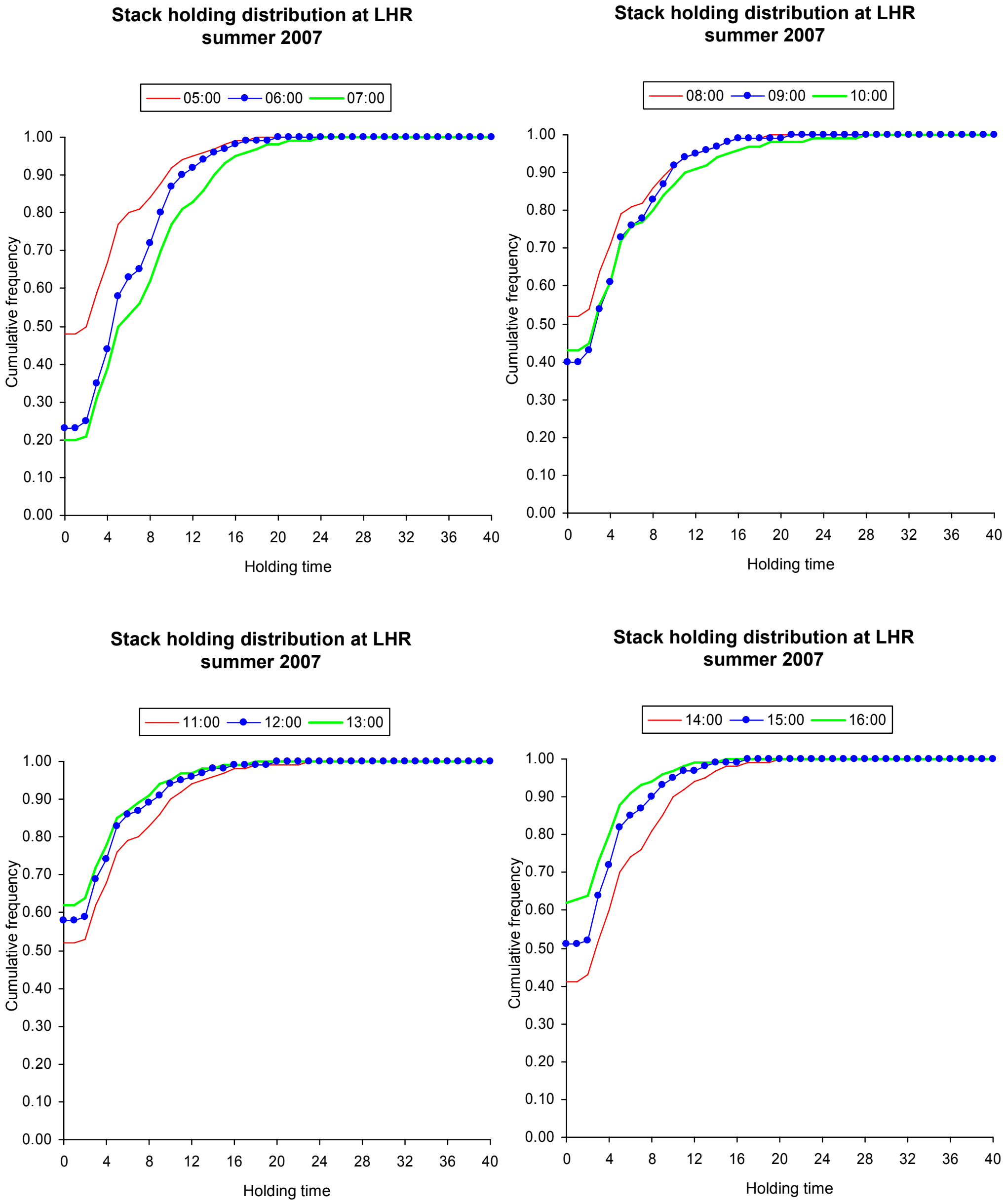




Cumulative distributions

9.48 The following exhibits show the cumulative distributions of stack holding times for Heathrow in the summer 2007 and winter 2007/2008 seasons. In some cases the distributions are modulated at 2.5to 3minute intervals again indicated the average time that aircraft spend in a circuit in the stack.

Exhibit D-9-11: Cumulative Stack Holding Distributions for Heathrow for Summer 2007



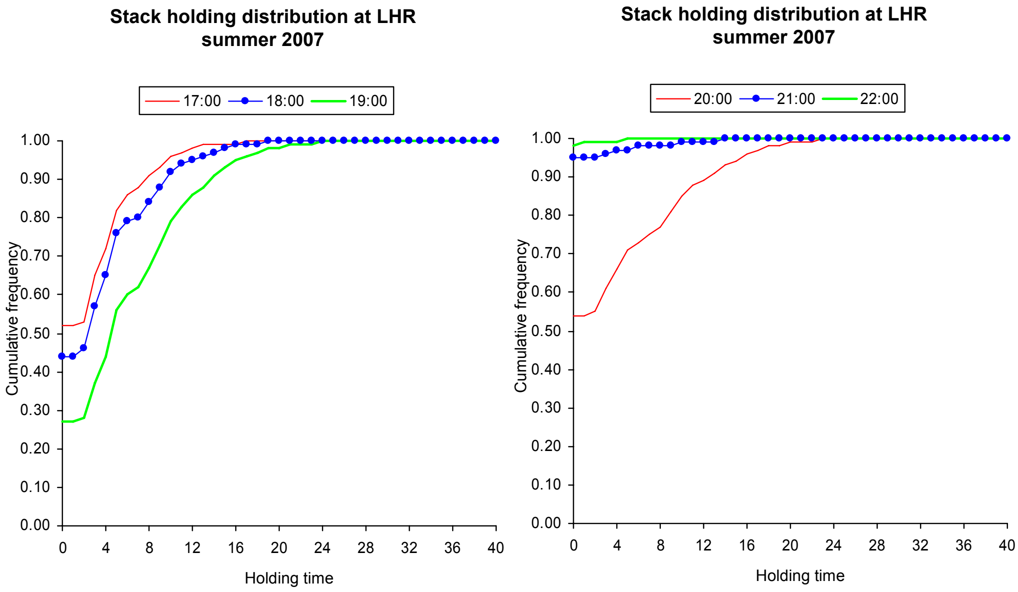
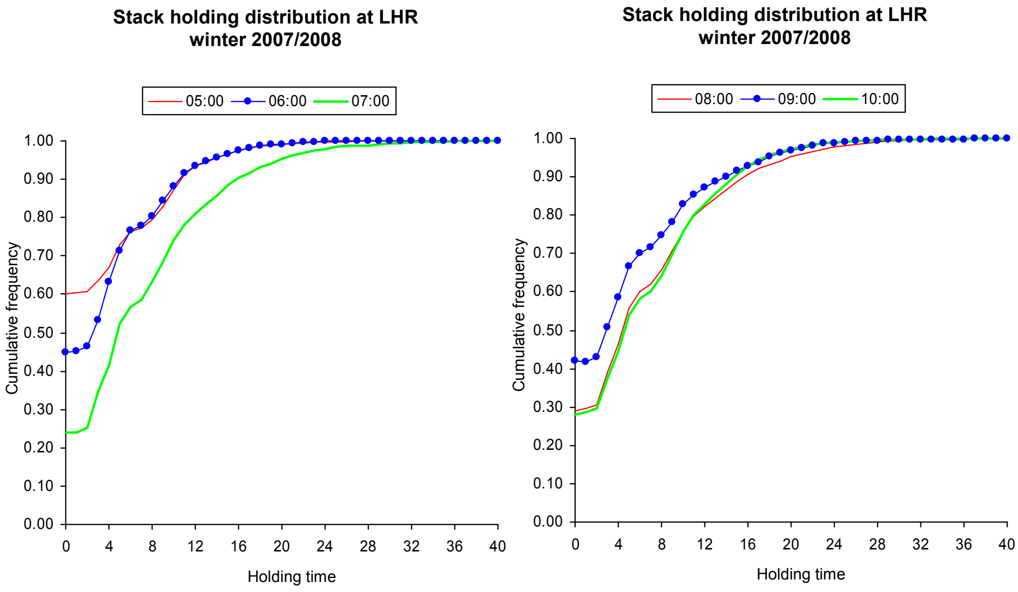
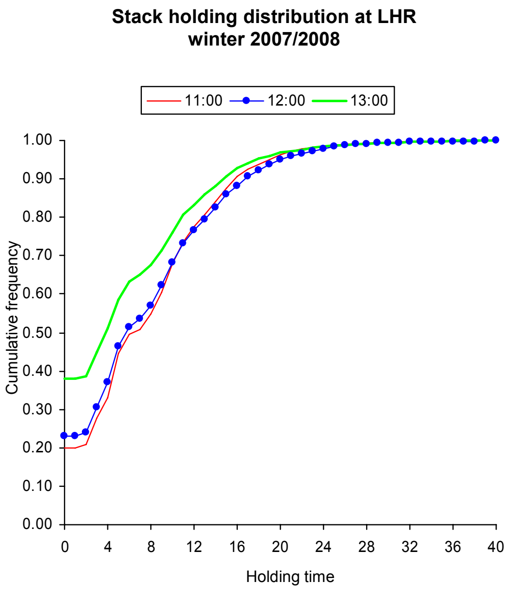
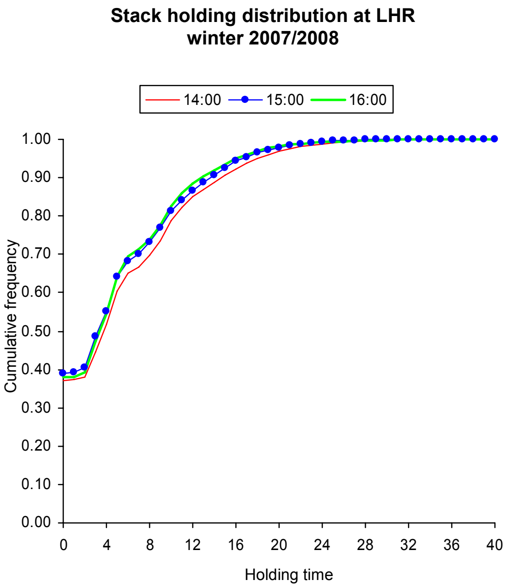
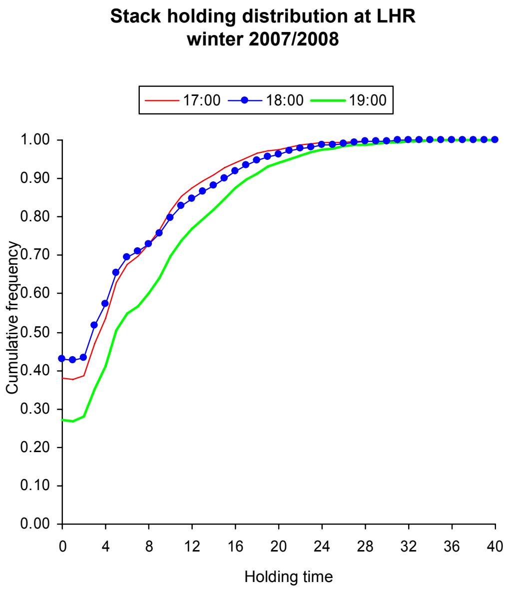


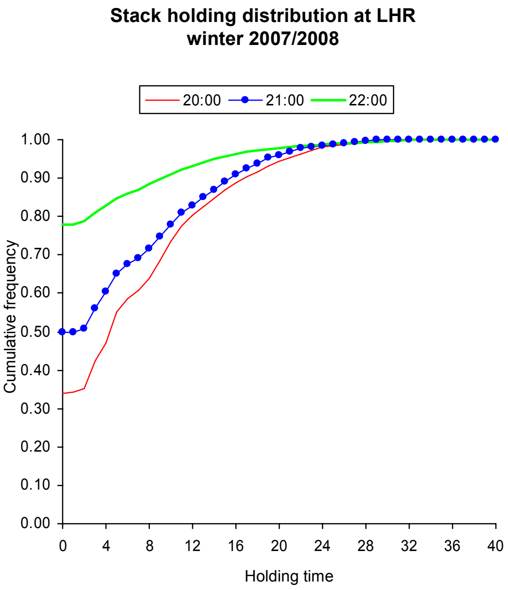
Exhibit D-9-12: Cumulative Stack Holding Distributions for Heathrow for Winter 2007/2008




Stack holding distribution at LHR winter 2007/2008


Stack holding distribution at LHR winter 2007/2008


Stack holding distribution at LHR winter 2007/2008

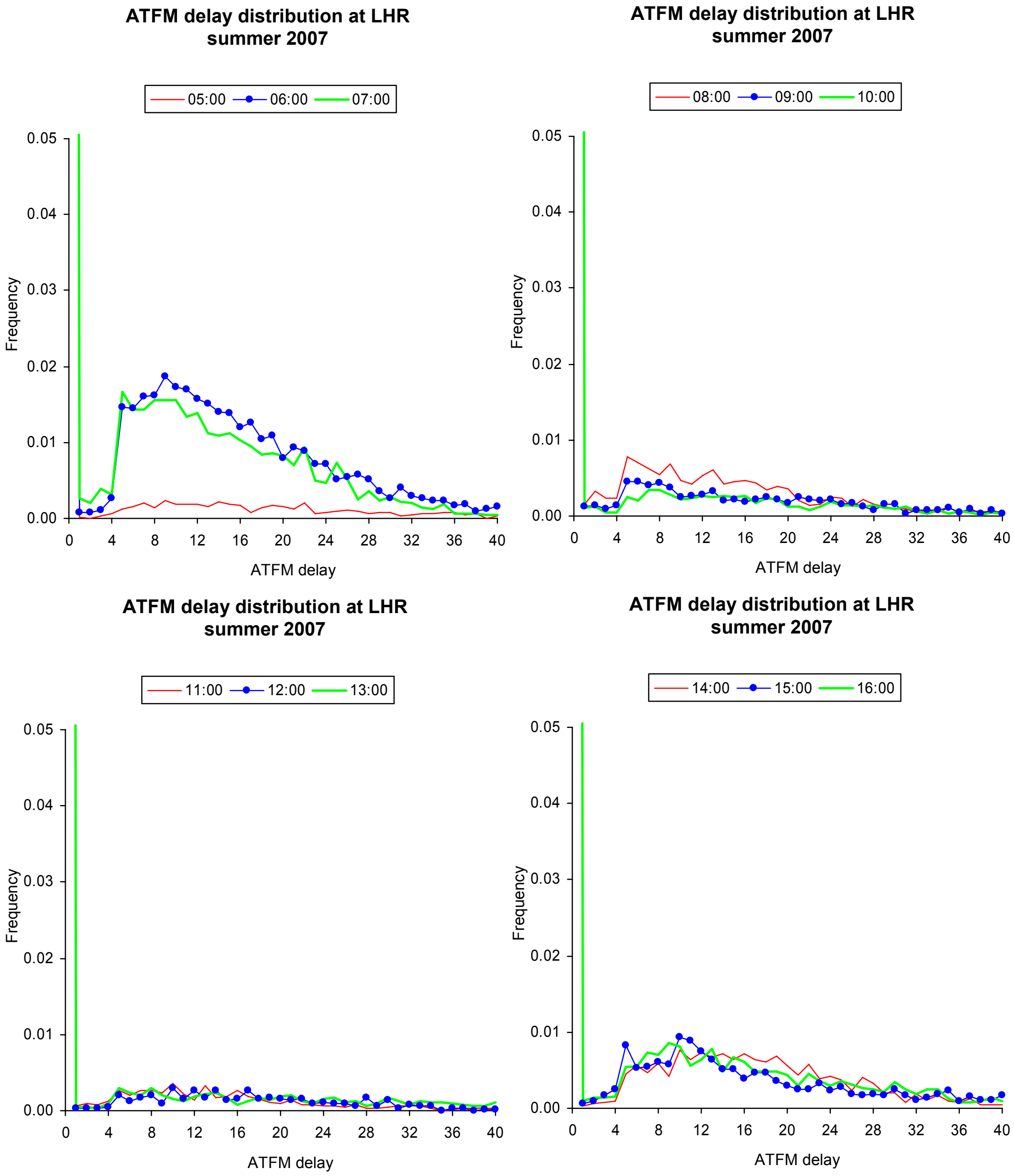

Stack holding distribution at LHR winter 2007/2008

ATFM DISTRIBUTIONS

Distributions

9.49 The following figures show the frequency distributions for ATFM delays attributed to Heathrow. In each case there is a large peak at zero delay indicating the aircraft that are not subject to ATFM delay. At some times, there is also a distinct side peak indicating some structure to the delays. However, in other cases there is very little structure to the distribution indicating that the delays can be random in nature.

Exhibit D-9-13: ATFM Delay Distributions for Heathrow for Summer 2007



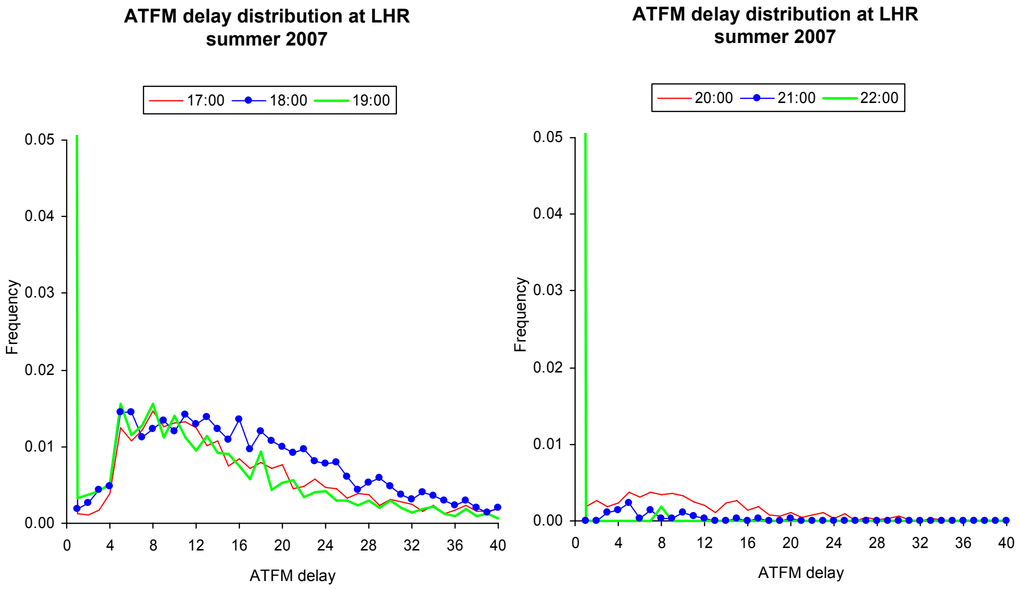
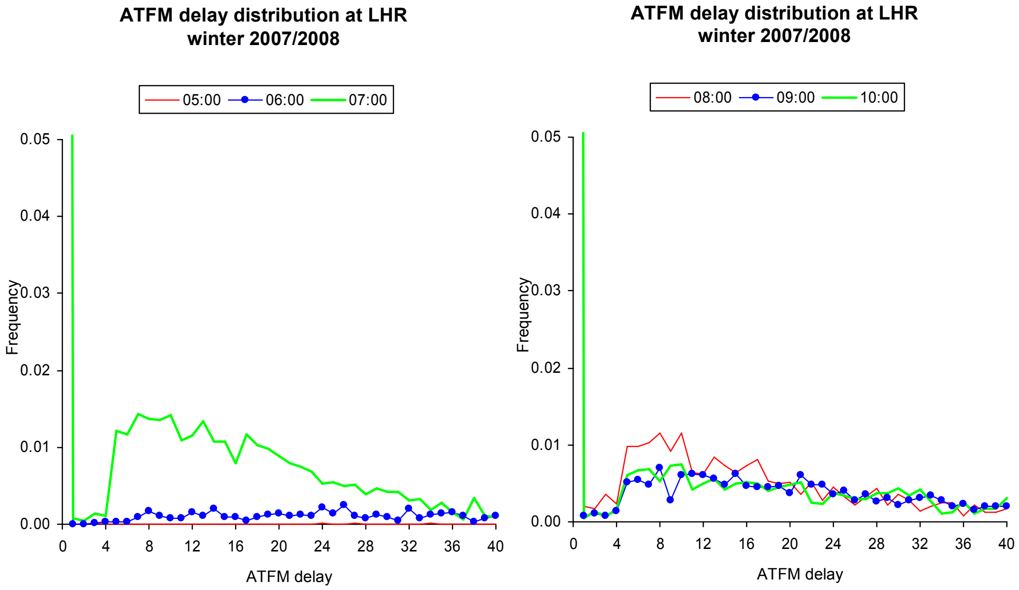
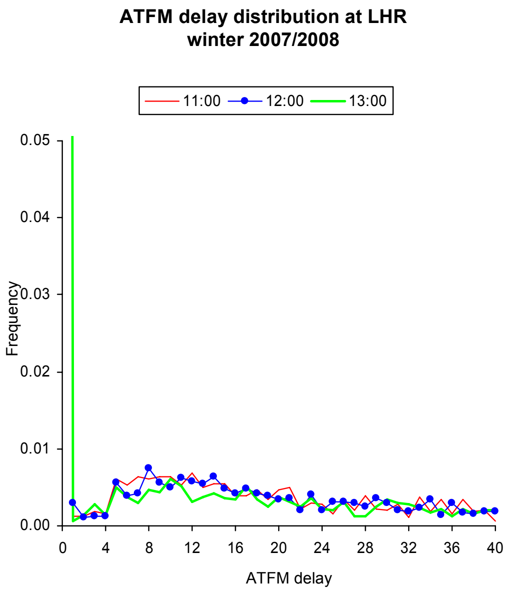
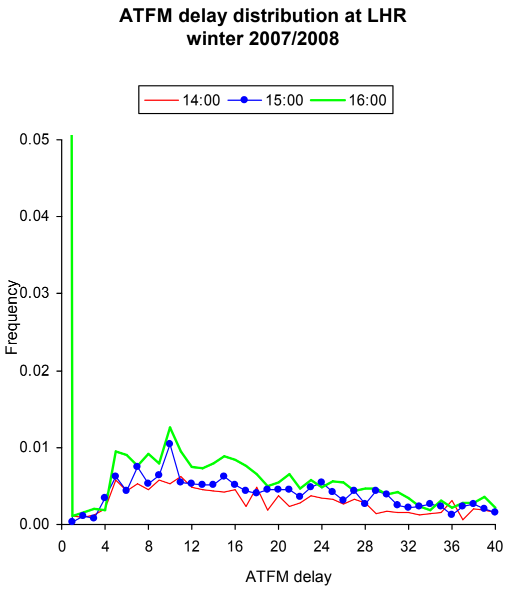
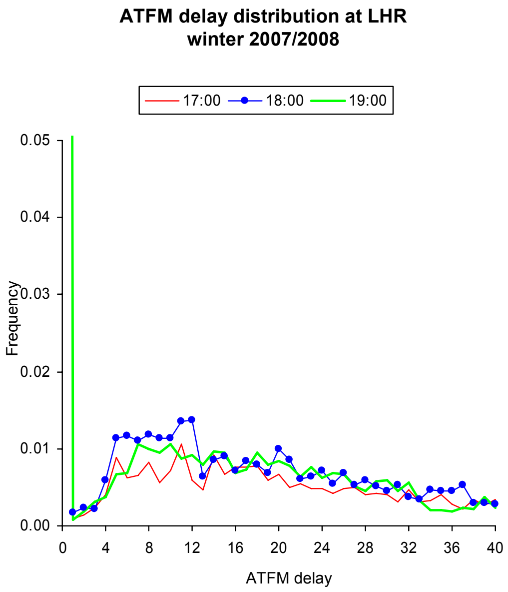


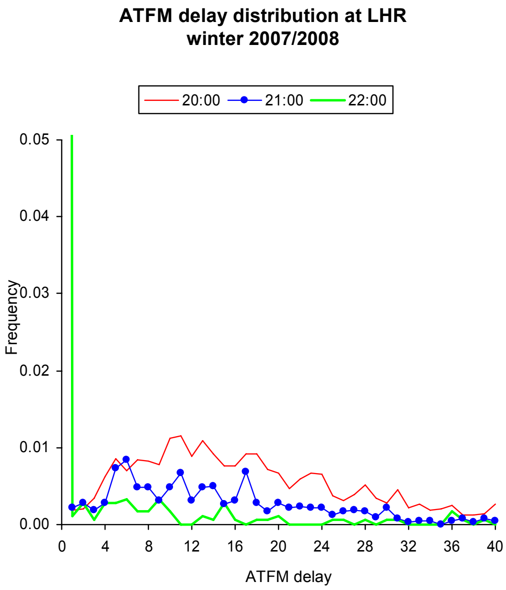
Exhibit D-9-14: ATFM Delay Distributions for Heathrow for Winter 2007/2008







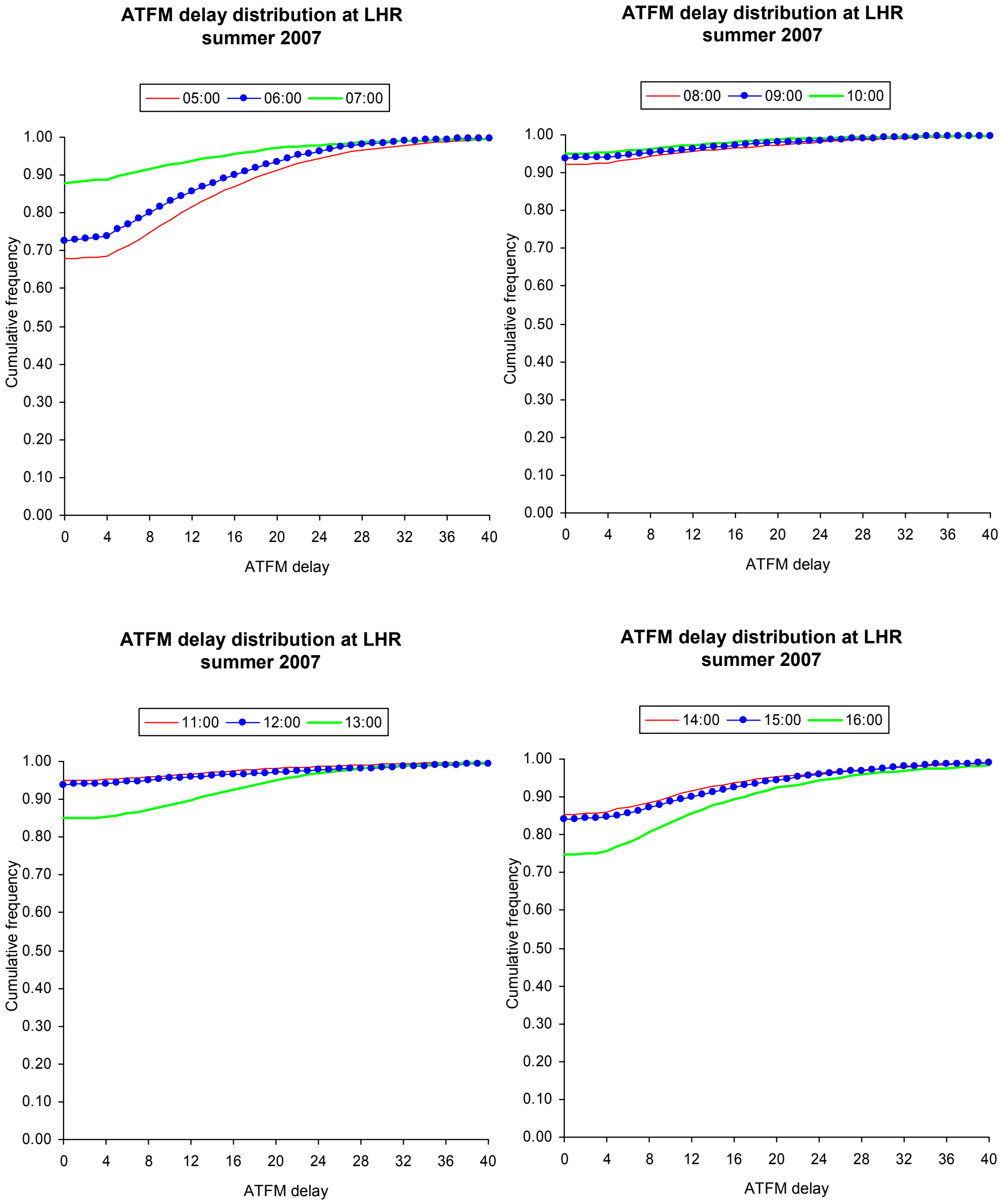




Cumulative distributions

9.50 The following exhibits show the cumulative distributions for Heathrow ATFM delays. The distributions generally increase monotonically and are fairly structureless.

Exhibit D-9-15: Cumulative ATFM Delay Distributions for Heathrow for Summer 2007



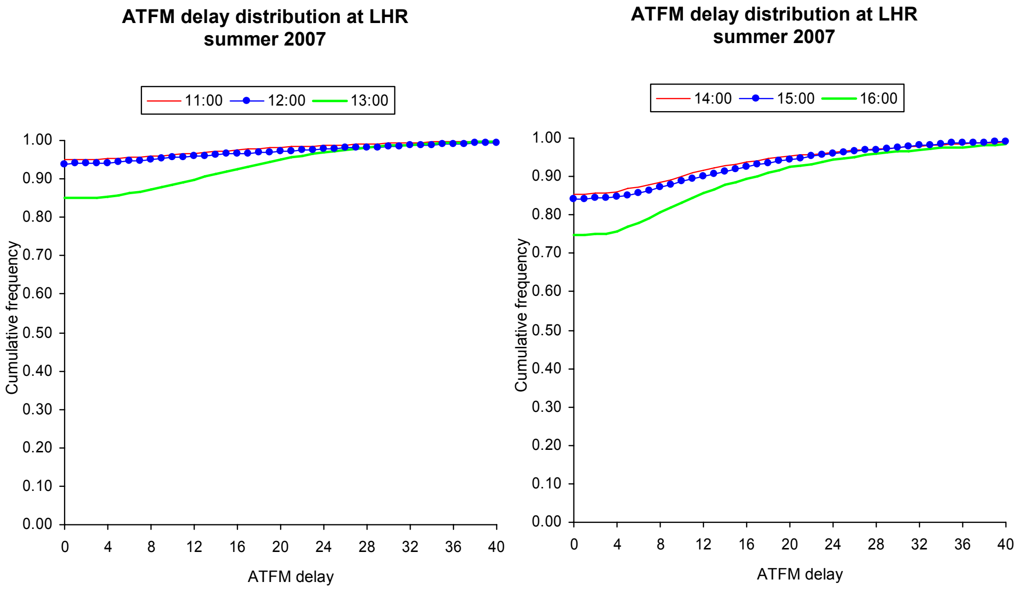
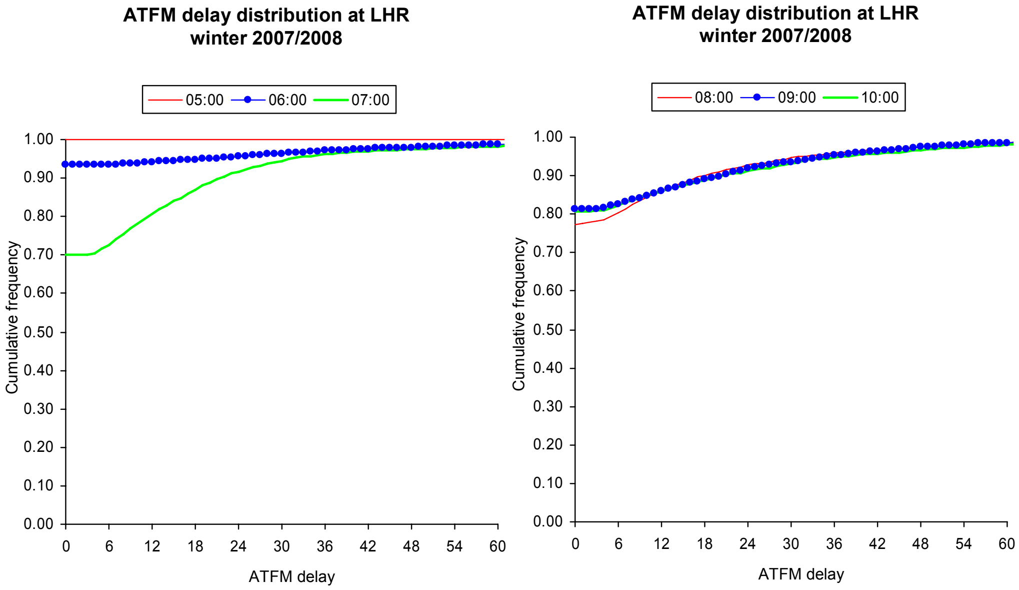
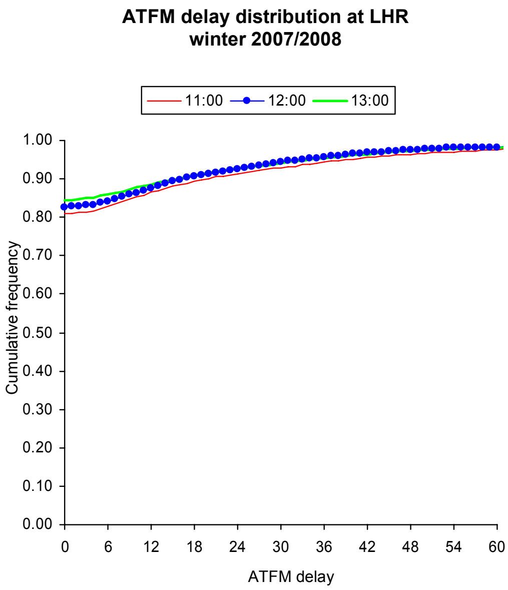
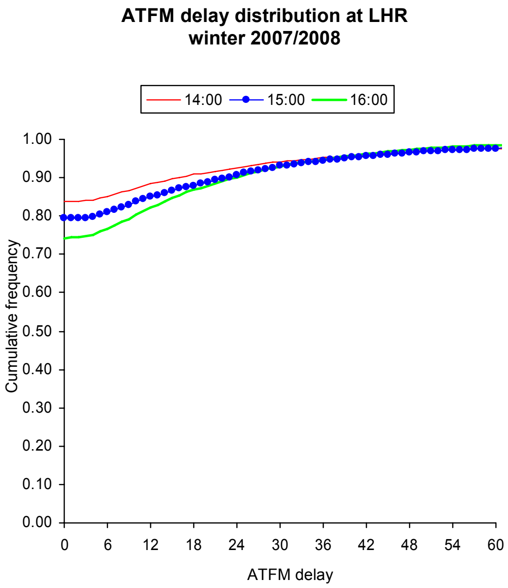
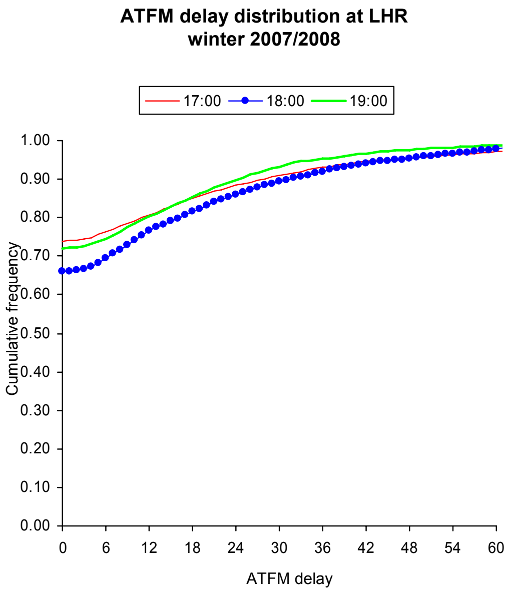


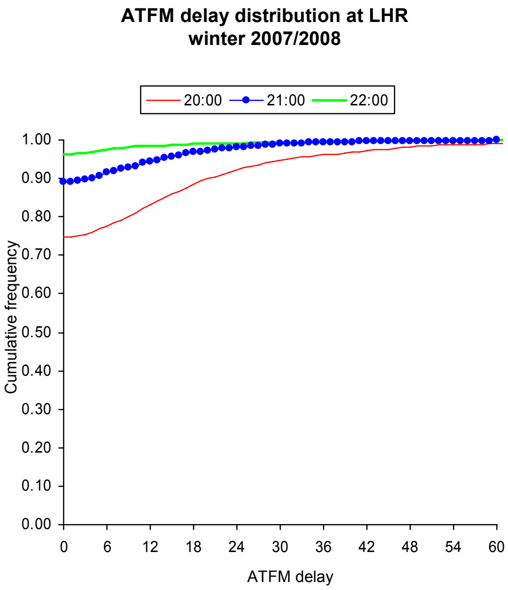
Exhibit D-9-16: Cumulative ATFM Delay Distributions for Heathrow for Winter 2007/2008











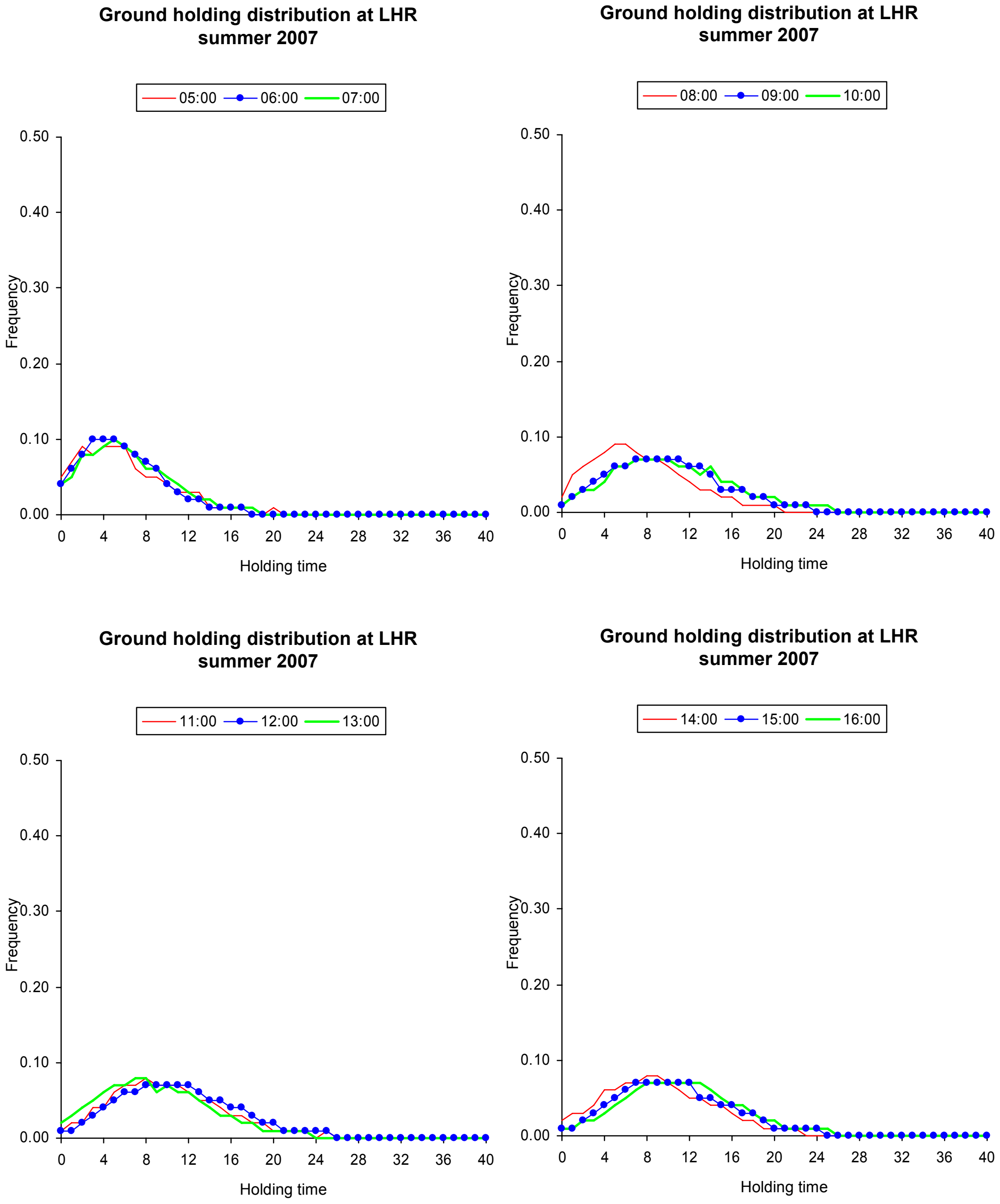
GROUND HOLDING DISTRIBUTIONS

Distributions

9.51 Exhibits D-9 and D-10 show the ground holding time distributions for departures from Heathrow for the summer 2007 and winter 2007/2008 seasons respectively. These distributions differ from the stack holding and ATFM delay distributions in that:

- they do not have a central peak but do have a well-structured side peak following an approximately normal distribution in all cases
- there are very few departures that are not subject to holding.

Exhibit D-9-17: Ground Holding Time Distributions for Heathrow for Summer 2007



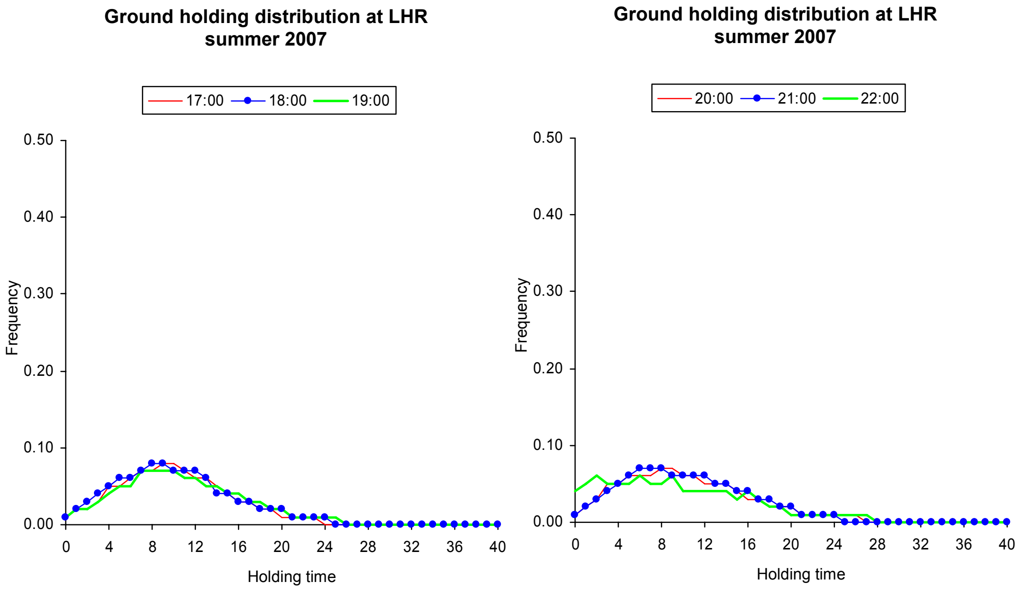
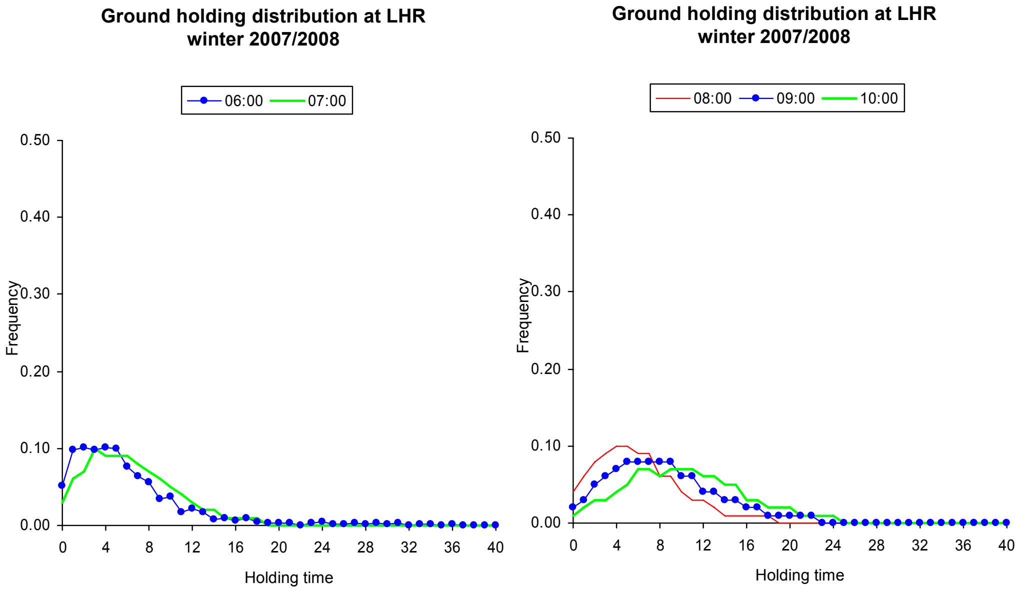
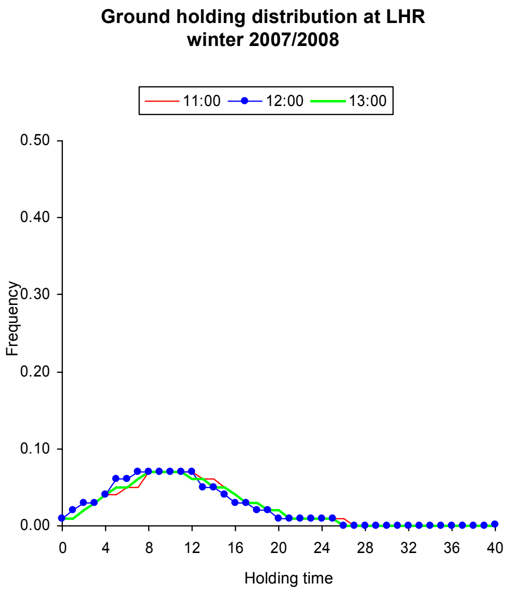
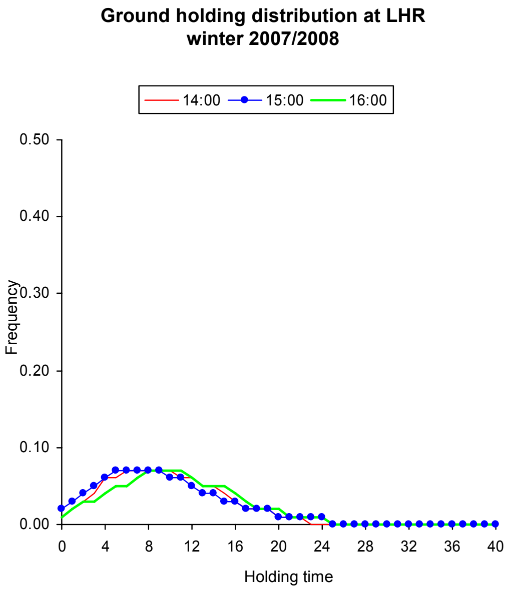
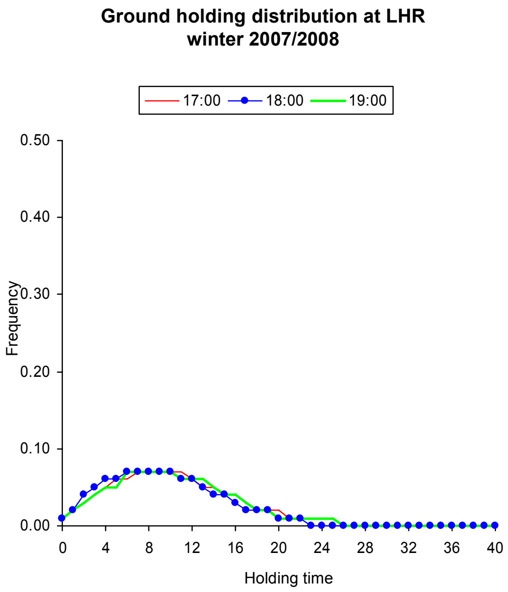


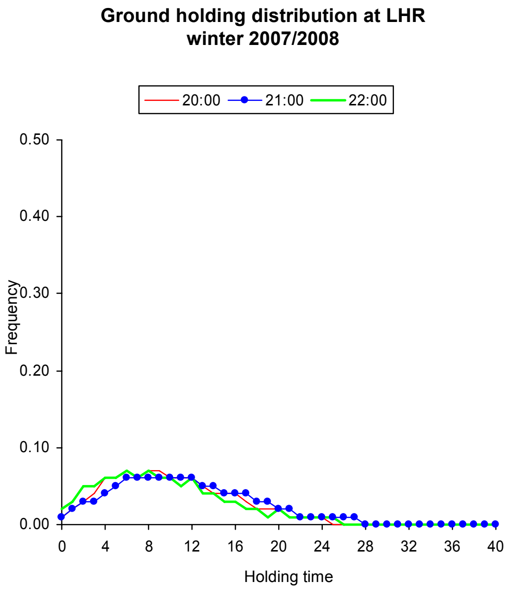
Exhibit D-9-18: Ground Holding Time Distributions for Heathrow for Winter 2007/2008







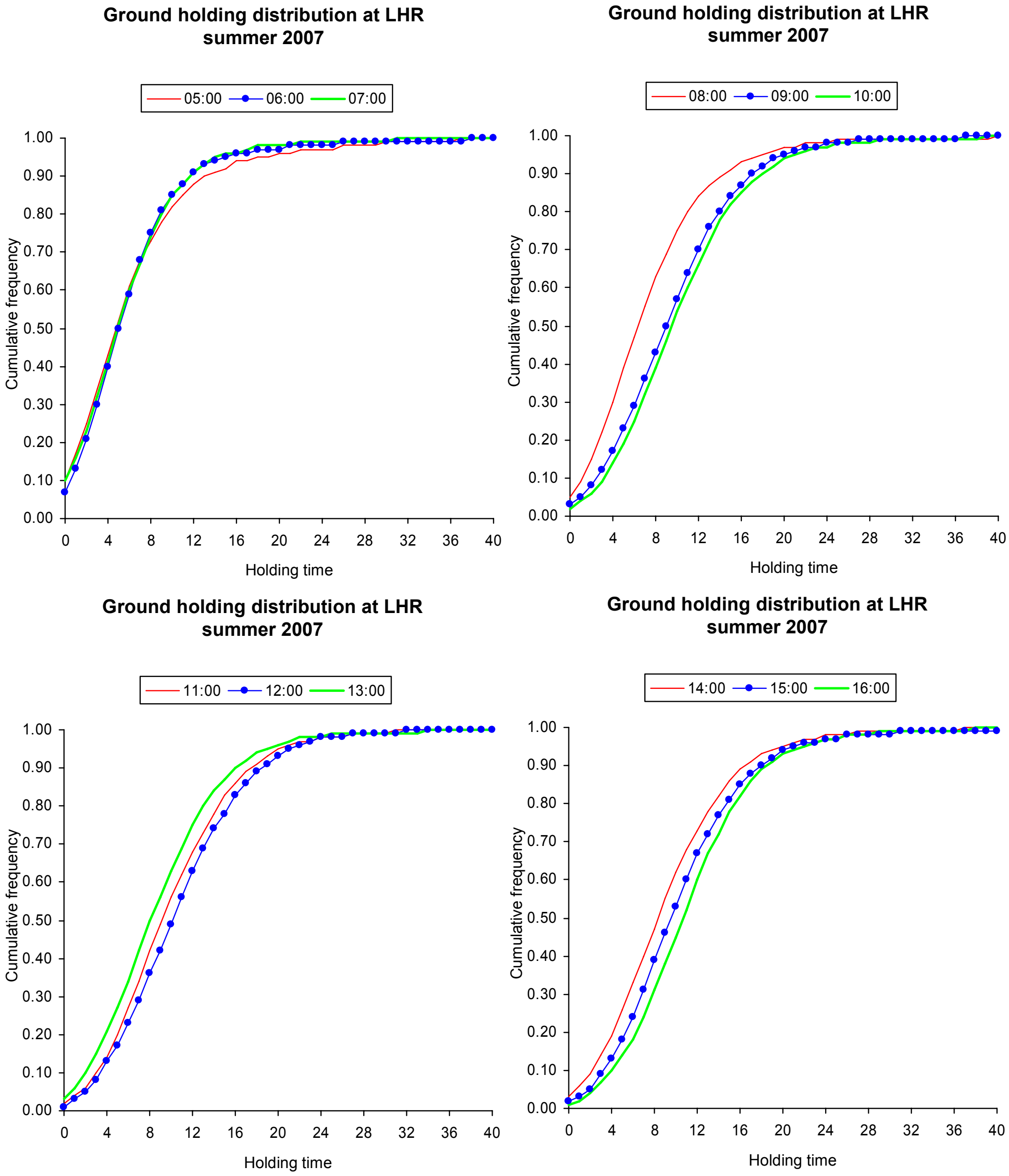




Cumulative distributions

9.52 Exhibits D-11 and D-12 show the ground holding time cumulative distributions for departures from Heathrow for the summer 2007 and winter 2007/2008 seasons respectively.

Exhibit D-9-19: Cumulative Ground Holding Time Distributions for Heathrow for Summer 2007



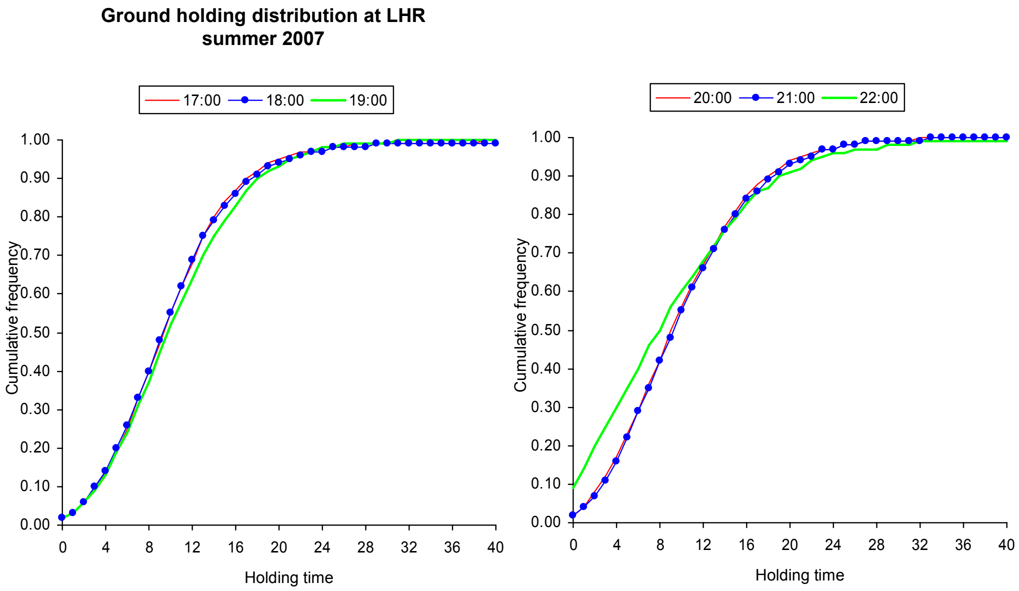
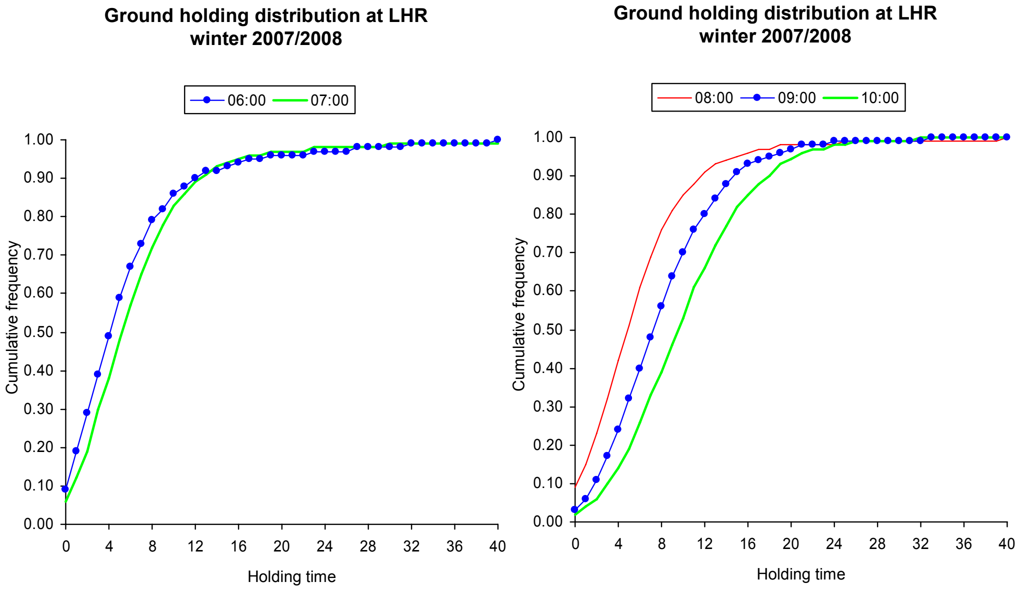
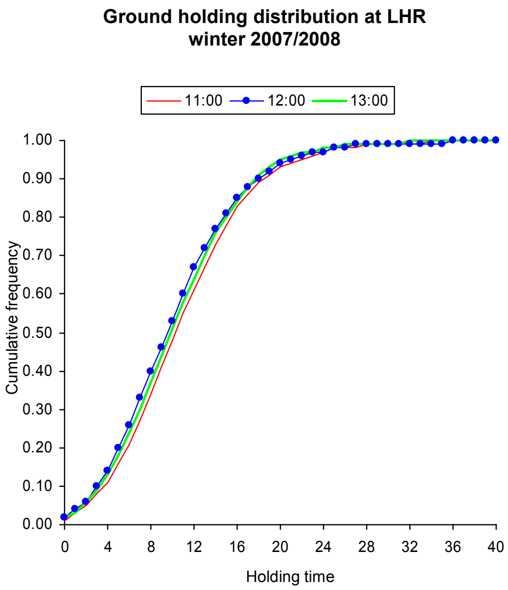
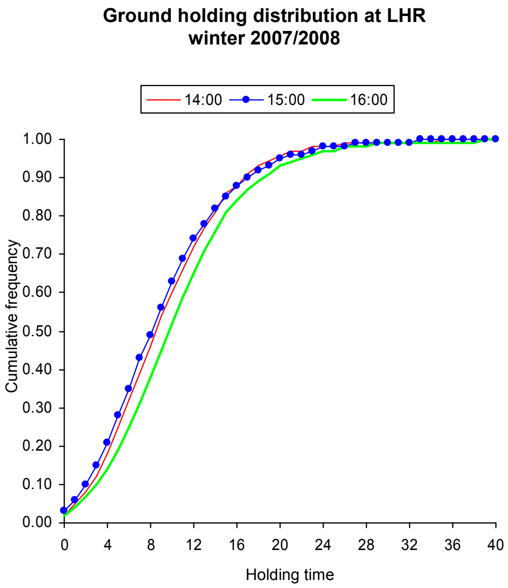
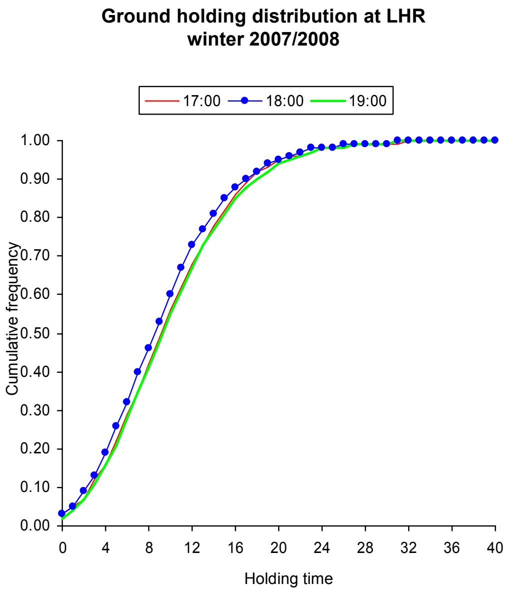


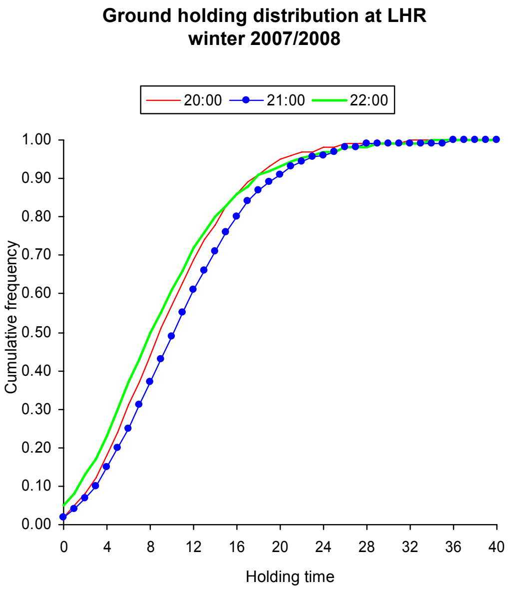
Exhibit D-9-20: Cumulative Ground Holding Time Distributions for Heathrow for Winter 2007/2008




Ground holding distribution at LHR
winter 2007/2008
11:00
12:00
13:00
Cumulative frequency
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
0
4
8
12
16
20
24
28
32
36
40
Holding time


Ground holding distribution at LHR
winter 2007/2008
14:00
15:00
16:00
Cumulative frequency
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
0
4
8
12
16
20
24
28
32
36
40
Holding time


Ground holding distribution at LHR
winter 2007/2008
17:00
18:00
19:00
Cumulative frequency
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
0
4
8
12
16
20
24
28
32
36
40
Holding time


Ground holding distribution at LHR
winter 2007/2008
20:00
21:00
22:00
Cumulative frequency
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
0
4
8
12
16
20
24
28
32
36
40
Holding time

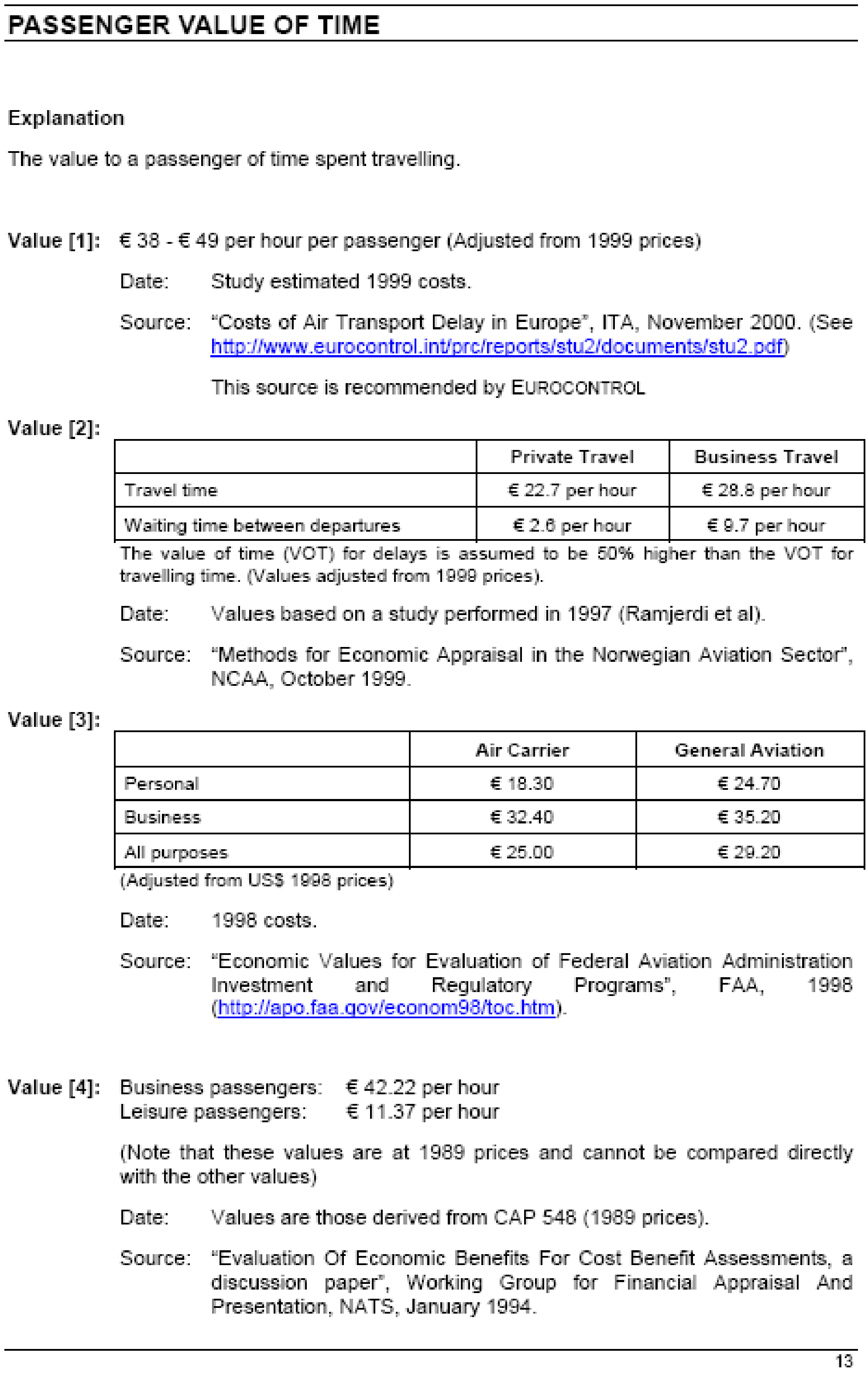
ICF INTERNATIONAL

SH&E
an ICF International Company

Appendix E:
PASSENGER VALUE OF TIME – EUROCONTROL FIGURES

The following extract is from the Eurocontrol “Standard inputs for Cost Benefit Analyses” which can be found at:

http://www.eurocontrol.int/cba/studies/standardinputs/standardvalues.doc



PASSENGER VALUE OF TIME

Explanation

The value to a passenger of time spent travelling.

Value [1]: € 38 - € 49 per hour per passenger (Adjusted from 1999 prices)

Date: Study estimated 1999 costs.

Source: “Costs of Air Transport Delay in Europe”, ITA, November 2000. (See http://www.eurocontrol.int/prc/reports/stu2/documents/stu2.pdf)

This source is recommended by EUROCONTROL

Value [2]:

	Private Travel	Business Travel
Travel time	€ 22.7 per hour	€ 28.8 per hour
Waiting time between departures	€ 2.6 per hour	€ 9.7 per hour

The value of time (VOT) for delays is assumed to be 50% higher than the VOT for travelling time. (Values adjusted from 1999 prices).

Date: Values based on a study performed in 1997 (Ramjerdi et al).

Source: “Methods for Economic Appraisal in the Norwegian Aviation Sector”, NCAA, October 1999.

Value [3]:

	Air Carrier	General Aviation
Personal	€ 18.30	€ 24.70
Business	€ 32.40	€ 35.20
All purposes	€ 25.00	€ 29.20

(Adjusted from US$ 1998 prices)

Date: 1998 costs.

Source: “Economic Values for Evaluation of Federal Aviation Administration Investment and Regulatory Programs”, FAA, 1998 (http://apo.faa.gov/econom98/toc.htm).

Value [4]: Business passengers: € 42.22 per hour
Leisure passengers: € 11.37 per hour

(Note that these values are at 1989 prices and cannot be compared directly with the other values)

Date: Values are those derived from CAP 548 (1989 prices).

Source: “Evaluation Of Economic Benefits For Cost Benefit Assessments, a discussion paper”, Working Group for Financial Appraisal And Presentation, NATS, January 1994.

13

Discussion

Source [1]:

The average value of time was estimated based on the estimated distribution of passengers according to travel purpose as defined in "PASSENGER DISTRIBUTION", page 18.

Purpose	VOT per hour (€)	
	Low	High
Business	47	63
Personal convenience	28	33
Tourism	20	23
Average	34	44

Note that the difference between "personal convenience" and "tourism" is not defined in the source document.

Values were then inflated to give 2004 prices.

Source [2]:

The value of travel time that might alternatively be spent working has been calculated by applying gross wage costs. For leisure travel, the approach has been to apply the net wage rate, since that is the amount the wage earner must sacrifice to have additional leisure time.

The values in the source document are assumed to have been adjusted to 1999 prices. These values were then inflated to give 2004 prices.

Source [3]:

The value of passenger time saved or lost as a result of investments in transportation facilities or regulatory actions. It is based upon guidance furnished by the Office of the Secretary of Transportation (OST) ("Departmental Guidance for the Valuation of Travel Time in Economic Analysis," Office of the Secretary of Transportation Memorandum, April 9, 1997).

For air carrier passengers, the time values are derived from the Air Transport Association of America Air Travel Survey, last conducted in 1993, escalated by the increase in median annual income to U.S. households from 1993 to 1995 as reported in Bureau of the Census, Current Population Reports, Money Income of Households, Families, and Persons in the United States, Series P-60. The value for personal travel is 70 percent of the weighted average of annual income categories in the survey for "visit friends," "sightseeing," and "other" travel divided by an assumed 2000 hours of work per year. The value for business travel is 100 percent of the annual income category in the survey for "business" divided by 2000 hours of work per year. When considering general aviation passengers as a separate category, a value of 70 percent of the median hourly income of AOPA members is established for personal travel and 100 percent of median hourly income for business travel.

The fractions of 70 percent and 100 percent were recommended by a panel of transportation economists. High and low values representing a plausible range of values based on variation in panel member opinions are provided for use in conducting sensitivity analysis.

	Air Carrier (cost per hour)	General Aviation (cost per hour)
Personal	$19.50	$26.30
Business	$34.50	$37.50
All purposes	$26.70	$31.10

Source [4]:

Values are derived from CAP 548.

Comparison with other industries

Values of time from several studies in Europe give varying values of transport times:

Mode	Value of time (1998 € per hour)
Bus	6 - 81.6
Car	2.8 - 53
Ferry	9.4 - 16.3
Train	0.3 - 18.4

Source: "TRACE, Costs of private road travel and their effects on demand, including short and long term elasticities", prepared for the European Commission Directorate-General for Transport.

The source provides full details of the value of time results.

Comments

Source [3] gives marginal values i.e. value of passenger time saved or lost. Source [2] gives separate values for time spent travelling and value of time for delays. It is unclear whether sources [1] and [4] give values which are marginal values or average values.

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Appendix F:
ROOT CAUSE ANALYSIS - IMPACT OF OPTIONAL IMPROVEMENT INITIATIVES

300 day scenario							50-60 day scenario	10-15 day scenario
	Pre-departure in-bound holds ("ATFM")	**Airborne in-bound holds ("Stack")**	**Ground holding outbounds**	**In-bound tactical flow-rate headroom**	**Out-bound tactical flow-rate headroom**	**Cancellations**	**Disrupted days**	**Seriously disrupted days**
Mixed Mode (3 scenarios)	Modelled in study			++ to +++ (for same traffic)	++	++	Recovery modelled in case studies	
Extension of TEAM	General - Modelled in study Detailed – specific opportunities for e.g. A380			++ +	Off-set on departures	+	Recovery modelled in case studies	
Demand reduction	General and some specifics - Modelled in study Other detailed opportunities in peaks			+ to ++ +	+	+	Recovery modelled in case studies	
Schedule smoothing (beyond current slot flexing)	++ Counters schedule demand peaks	++ Reduces required planned buffers	+	Does not change flow-rate capacity		+	+ When early morning flow restrictions	Probably overwhelmed
Revised planning parameters	++ Reduces capacity regulations	++ Parameters can be set to reduce holdings (may include changes to airline planning parameters and process)	++ Reduces MDIs	Does not change headroom unless capacity must be reduced to meet parameters		+ Reduced canx from capacity regulations	+ Plan should remain more resilient due to less bunching	Probably overwhelmed
Protocol for disruption								Mitigation and planned response

300 day scenario							50-60 day scenario	10-15 day scenario
	Pre-departure in-bound holds (“ATFM”)	**Airborne in-bound holds (“Stack”)**	**Ground holding outbounds**	**In-bound tactical flow-rate headroom**	**Out-bound tactical flow-rate headroom**	**Cancellations**	**Disrupted days**	**Seriously disrupted days**
Time-based separation	Resilience against wind-based flow regulation and stacking (assumed >38 flow-rate for 300 day scenario) Subject to further development and safety approval Consistent with SESAR objectives and programme			+ Maintain planned level for more hours		+ Reduced canx for wind-based flow restriction	++ Resilience against winds	Probably overwhelmed, esp non-wind
Separation reduction techniques e.g. AMAN, ROT reductions, MLS, Wake Vortex detection	Benefit of increased flow-rate headroom. Required to counter negative trends on aircraft mix. On-going development programme Consistent with SESAR objectives and programme Note: many techniques will require Safety Regulation and/or clearance			++ But some techniques not proven yet	+ But not proven yet	Marginal benefit	Main benefit in 300 – day scenario	
CFMU process improvement	+ Main benefit on disrupted days						+ Reduces spurious data within process	+ Reduces spurious data within process

300 day scenario							50-60 day scenario	10-15 day scenario
	Pre-departure in-bound holds (“ATFM”)	**Airborne in-bound holds (“Stack”)**	**Ground holding outbounds**	**In-bound tactical flow-rate headroom**	**Out-bound tactical flow-rate headroom**	**Cancellations**	**Disrupted days**	**Seriously disrupted days**
NATS regulation process evolution and decision support	+ Minimised regulation with some additional predictive support. Potentially faster relaxation					+ When canx would have been triggered by capacity regulations	Limited benefit if outside “normal” range	
Collaborative Decision Making	+ FUMs will support better information for decisions						Improved rotational performance due situational awareness	Improved response but limited outcome
Performance management system and process KPIs	Benefit from increased airline discipline in adhering to planned milestone timings. On-going target-setting, data quality improvement, root cause analysis and solution development							Track adherence to protocol and KPIs
Revised sequencing policy		Holding reduced for “compliant” operations (linked to AMAN)	Can effectively be managed within existing rulesets			+ For compliant operations	May be difficult to sustain under pressure	Will be difficult to sustain under pressure. Revert to disruption protocol

Notes:

Excludes

- Significant airspace redesign
- Network effects outside local stakeholder control or influence
- Airline contingency initiatives/provisions to protect or recover service
- Airline and airport process improvements aimed at punctuality improvement or other service quality measures
- Effects of infrastructure development
- Economic or environmental benefits linked to e.g. reduced holding and tighter 95th-ile distribution levels
- Business cases for individual pieces of development

Some options may not be independent e.g. Schedule Smoothing is of limited value if the Performance Management System does not track and motivate adherence to a revised schedule (beyond the fairly broad parameters of slot performance measures for 80% compliance)

Colour code for initiatives

🟩	Initiative in active development and implementation
🟨	Initiative under active research and development with limited implementation as yet
☐	No major active programme although may have stakeholder awareness as an issue and opportunity

Indicative scale of impact shown as range from “+” to “+++”

Appendix 6: Note providing commentary on the summary business model [Appendix F.1.5 to REP3-187]

1 Introduction

1.1 The Applicant's plan is for Manston Airport to be the UK's first cargo-focused airport. Whilst it has projected passenger traffic as a result of specific structural demand, its core business model is built on cargo. The plan will ensure that there are no slot restrictions for freighter aircraft.

1.2 Traffic forecasts were established using the forecasting method as detailed in Azimuth Volumes I-IV prepared by Dr. Sally Dixon [APP-085] and it is established therein that extrapolation from historic performance and comparison to passenger-focused airports is entirely inappropriate for the cargo activities planned for Manston.

1.3 A cargo operation at Manston is accessing demand that is either diverted elsewhere or not functioning due to the sub-economics of the severe capacity constraints currently existing in South East England. This exists at a general non-specific level and an idiosyncratic level pertinent to Manston itself. Therefore, Manston as a cargo operation is, within reason, a price-setter rather than a taker. The opposite is true in the world of passenger operations and certainly where the Manston passenger business would be concerned, as well as at any sizeable operation. Therefore, it is anticipated that profit margins across the board, whether at EBITDA or Net Income, are substantially higher in Manston's cargo business than in passenger.

2 Revenues

2.1 The assumptions used in the model are derived from a combination of operational experience, historical data, market comparisons and discussions with prospective carrier clients. The revenue model is built "Bottom up" from known inputs around carriers and demand and checked top-down for outlying outputs.

3 Aeronautical Revenues

3.1 Aeronautical Revenues in the Income Statement provided at Deadline Three [Appendix F.1.5 to REP3-187] are derived from cargo and passenger operations.

3.2 **Cargo Revenue** is generated from fees on:

(1) Movements based on the aircrafts IATA category and a surcharge for noise

(2) Freight handling based on a handling charge per tonne negotiated with carriers[1]

(3) Margins on the carrier purchase of fuel

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[1] This is not relevant for E-Commerce tonnage as those carriers would carry out handling operations on their own.

3.3 There is a combination of the above where an “E-Commerce” carrier becomes based at the airport. The airport swaps a higher margin and more volatile business for a lower margin higher volume and more stable income.

3.4 **Passenger Business Revenue** is generated from fees on:

(1) A fixed charge per passenger (arriving and departing)

(2) A passenger handling charge based on the service requirements (low cost carrier vs. full service)

(3) Margins on the carrier purchase of fuel

4 Commercial Income

4.1 Revenue is based around a passenger’s spending at the airport following through a turnover based rental contract with retailers.

5 Other Income

5.1 Revenue is based on airside warehouse rental income, ‘Northern Grass’ rental income, Fixed Base Operator (FBO) and Maintenance Repair and Overhaul (MRO)/ Recycling.

Warehouse (airside)

5.2 The assumption is that the airside warehousing space requirement will be driven by the forecast annual flown freight tonnages and so a ratio of annual flown freight tonnage to airside warehousing space required has been produced. Further, to recognize the increasing efficiency of space to tonnage that will arise as the tonnages grow, this ratio has been adjusted over the 20 year forecast period to start at what existed at a “quiet” airport (Prestwick has used as the example) and to end at what exists at a “busy” airport (East Midlands has been used as the example as the present flown tonnages there are similar to the flown tonnages forecast in year 20 at Manston).

5.3 The business model assumes that the airport operator will provide handling for all freight, aside from freight affiliated with “E-commerce” carriers. Thus, the requirement for airside warehouse space to rent is only supplied to the “E-Commerce” carriers who will occupy the space to handle the freight on their own. The remaining warehouse space, where the airport operator will employ workers, is owner occupied and there is no rental income affiliated with this occupancy of space.

5.4 The Applicant has assumed a conservative lease charge on the “E-Commerce” occupied space, which is based on previous experience of its advisors, commercially confidential conversations and comparable ‘property’ analysis.

Northern Grass:

5.5 At this point, it is difficult to ascertain who will be occupying a specific amount of space, and on what terms that tenant will be looking for. The Applicant has been in extensive conversations with potential end-users to occupy space on the Northern Grass for airport related purposes, however, these conversations remain commercially confidential.

5.6 The Applicant and its advisors have conducted industry research on comparable properties and ascribed conservative lease rates, terms and scenarios. The underlying scenarios vary, depending on the needs of the end-user. The Applicant has run pro-forma models which consider different scenarios of lease terms, characteristics and durations i.e., FRI, fee simple, ground lease, and variant lease scenarios at different lengths.

FBO and MRO

5.7 Both Fixed Base Operator & Maintenance Repair and Overhaul rental income are derived from the assumption that at each facility a single tenant will build, occupy, staff and maintain the facility and business. The underlying ground lease for the facilities are based on operational experience and comparable lease terms.

6 COSTS

Direct Costs

6.1 Costs are based on the operational cost of running the airport. Where appropriate, scalars have been attached to match the growth of the business. The negative correlation of costs to volume (WLU) match the economies of scale expected in a cargo business of this capacity. Examples of direct costs affiliated with the operation of the airport are Passenger, Cargo[2], ATS, RFFS, Operations, Maintenance, MT and Site and Freight Security.

Indirect Costs

6.2 Costs are based on the overhead costs of operating the airport. Where appropriate scalars have been attached to match the growth of the business. The negative correlation of costs to volume (WLU) match the economies of scale expected in a Cargo business of this capacity. Examples of indirect costs are Administration, Insurance, Rates, Promotions, Leasing and Utilities.

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[2] This is the highest cost considering the headcount implication of employing workers to handle cargo volumes.

APPENDIX 7: Note on airport ‘associated’ uses; the Northern Grass site

Note on airport ‘associated’ uses
The Northern Grass Site

1. The intensity of airport ‘associated’ uses proposed at Manston will be unusual at a UK airport, but has been pre-determined by the size of the core site, the location of the associated land and the nature of the airport business model being proposed. While many UK airports have examples of such associated development (some airside, some outside the fence), their scale and configuration depend on a range of individual circumstances. These include the size of airport, its environs, adjacent land uses, surface access links, planning policy constraints (e.g. green belt) and other local land use policies governing the location of business, industrial and logistics development. This means in many cases, associated uses will be mixed in with a wider range of airport related development, and sometimes even broader commercial development which is only indirectly airport related.

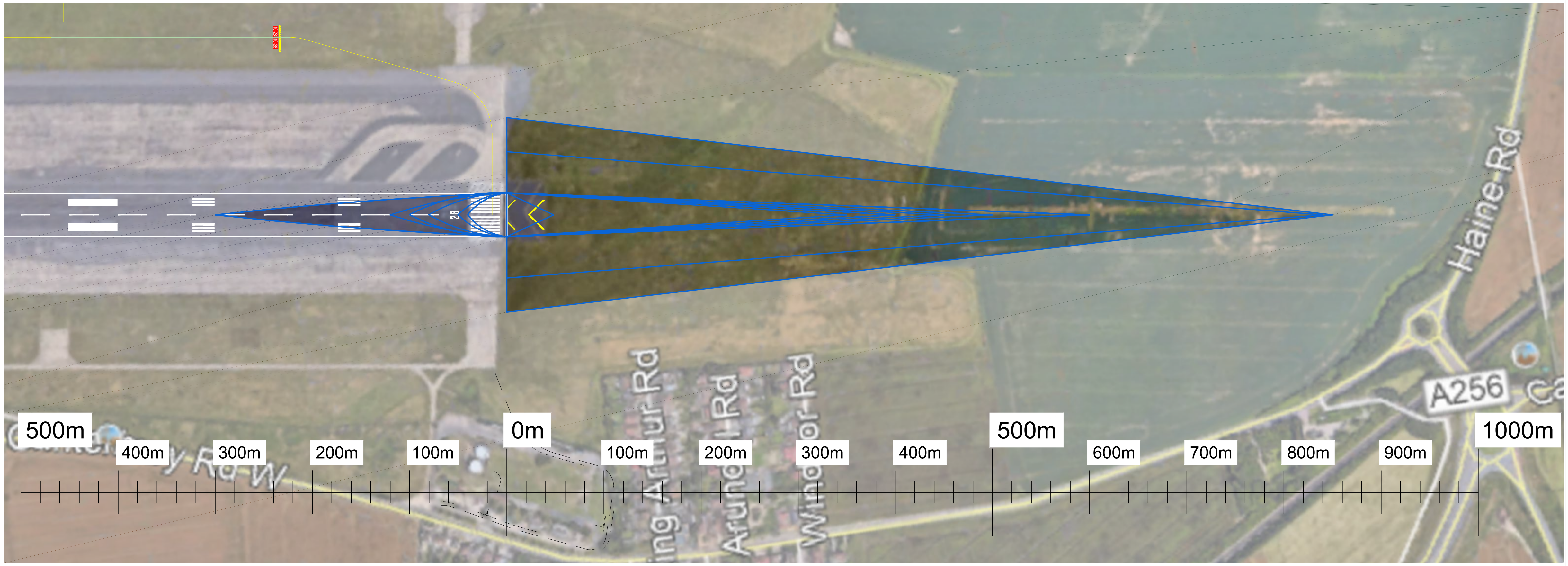
2. These kinds of airport ‘business park’ arrangements are typical at smaller airports like Newquay, Doncaster Sheffield, Gloucester Staverton, Biggin Hill, Prestwick and Bournemouth. They can also be found at medium sized airports like Aberdeen, Liverpool and East Midlands, and even at bigger airports like Manchester, Birmingham and Gatwick. However, it is difficult to find an equivalent to what is proposed at Manston because it is a new freighter-only led business model; and even East Midlands which currently has a similar scale of air freight activity, is focused heavily on the night-based ‘old’ integrator market which Manston will not serve. Moreover, Manston’s core site is smaller and therefore activities which might in other circumstances be located inside the fence will be housed on adjacent land at the Northern Grass so that core activities can remain airside, but other activities that don’t need to be are in close proximity, allowing access when needed.

3. For the reasons set out above, it has proved difficult to find a close equivalent for the Manston/Northern Grass relationship in the UK and we have turned our attention to airports in Europe and North America that provide, if not exact blueprints, then at least antecedents for a specialist freight airport such as is being proposed at Manston. Should this evidence be of interest to the Examining Authority, the Applicant will report on a number of relevant examples in time for Deadline 6.

Chris Cain
Northpoint Aviation
28 March 2019

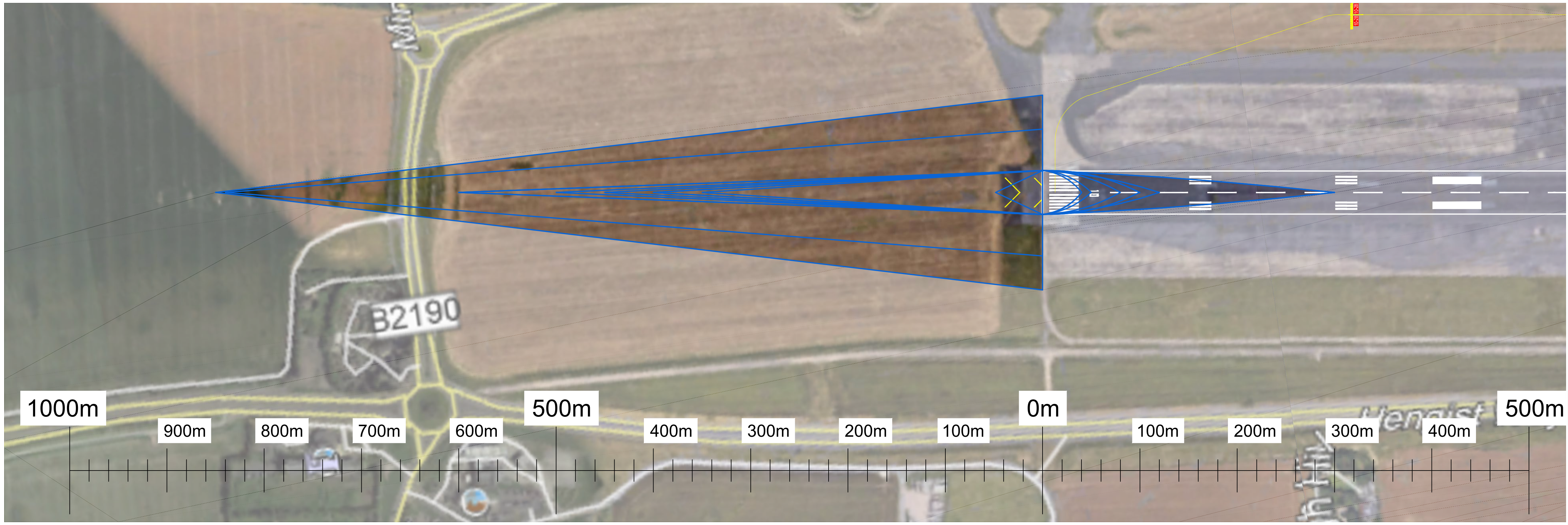
APPENDIX 8: Drawing of PSZs.

MANSTON AIRPORT MASTERPLAN DEVELOPMENT CONSENT ORDER
PUBLIC SAFETY ZONES (COMPARISON)
REGULATION 5 (2)(o)
THANET DISTRICT COUNCIL



Manston Predicted PSZ East Side

1:500



Manston Predicted PSZ West Side

1:500

10m

SCALE 1:500

RSP

Notes

1. Mapping data obtained from google earth

Airport PSZ	Source
Heathrow	Heathrow technical submission volume 2
Stanstead	-
Southend	Proposal to revise the public safety zones at Southend airport - Civil Aviation Authority
Bristol	Bristol international airport master plan 2006-2030
Norwich	Norwich Airport Draft Masterplan July 2017
East Midlands	-

Key

—	1:10,000 PSZ

Rev	Description	By	Ckd	Apr	Date
P01	First Issue	CM	CJ	GDD	27/03/19

Project MANSTON AIRPORT
DEVELOPMENT CONSENT ORDER

Title PUBLIC SAFETY ZONES
(COMPARISON)
REGULATION 5 (2)(o)
THANET DISTRICT COUNCIL

Document Number: NK019598 - RPS-MES-XX-DR-C-SK018
Revision: P01
Project Number | Originator - Zone - Level - Type - Role - Drawing Number

Application Number - TR02002

Scale	Sheet Size	Sheet No	Status
1:500	A3	1 of 1	S. 56