Ban on night flights at Heathrow Airport

A quick scan Social Cost Benefit Analysis

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Preface

This report has been commissioned by HACAN ClearSkies.
The authors are grateful to comments received from Hugo Gordijn (Netherlands Institute for Transport Policy Analysis) and Sabine A. Janssen (TNO Built Environment and Geosciences).
The views expressed in this report are those of CE Delft, as are possible errors.

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Contents

Summary

Night flights are often considered an essential element of airline networks. Long haul passengers who want to arrive in Europe at the beginning of the day often need to land during the night, especially when they arrive at a transfer airport such as Heathrow from where they take another flight to their final destination.

However, the noise they create is detrimental to human well-being as it causes sleep disturbance, increase in medicine use, stress and (environmental) insomnia. Around London Heathrow Airport, a large number of people are affected by aircraft noise during the night time.

As the UK Government reviews its limit on the number of night flights allowed at Heathrow, this report endeavours to quantify the costs and benefits to the UK of a ban on night flights at Heathrow before 6.00am. It uses social cost benefit analysis (SCBA) to do so. SCBA systematically identifies all the direct, indirect and external effects of a night flight ban and expresses them in monetary terms so that the net costs or benefits can be calculated. It uses the broad definition of welfare, in which all items that add to the well-being of the society are benefits, and all items that decrease well-being are costs. The boundaries of SCBA presented here are UK welfare effects. The presented SCBA is a quick scan SCBA, based on values from the literature.

We assess the costs and benefits of a night flight ban against a baseline scenario in which the current regime is continued. Airlines and passengers can respond in several ways to a night flight ban. We identify three extremes:
1. All flights and connections are rescheduled to daytime operations.
2. All flights are rescheduled to daytime operations but connections are lost, leading to a decrease in the number of transfer passengers.
3. All flights currently arriving or departing during the night are cancelled.

Most responses are likely to fall within these boundaries. Likewise, the costs and benefits of a night flight ban are likely to fall between the costs and benefits of these extremes.

This report finds that the impacts of a night flight ban on UK welfare are likely to range from an increase of £ 860 million to a decrease of £ 35 million over a period of ten years (2013-2023). The loss would occur if all current night time passengers stopped travelling to Heathrow once a night flight ban was introduced. That however is highly unlikely. The most likely scenario is that a proportion of them will continue to use the airport. If that is the case, a night flight ban before 6.00am will bring economic benefits to the overall economy. This is because there will be a significant decrease in the costs associated with sleep disturbance. The savings that will bring, in terms of improved health and well-being, are expected to offset the main costs of a ban - passengers' time and airline profits - by a wide margin. The results are sensitive, however, to the valuation of night noise, and we recommend studying the benefits of noise reductions in more detail. Other items that require more study are the impact on passenger choices, on airline networks and on tourism.

Our overall conclusion is that a ban on night flights at Heathrow is likely to be beneficial to the economy as the economic costs of the ban will be outweighed by the savings made by the reduced health costs of the sleep disturbance and stress caused by the noise of the night flights.

1 Introduction

1.1 Background

Night noise is detrimental to human well-being as it causes sleep disturbance, increase in medicine use, increase in stress and (environmental) insomnia. Around London Heathrow Airport, a large number of people are affected by aircraft noise during the night time.

The UK Government has restricted the number of night flights and the noise of night flights at Heathrow. Between 11.00pm and 7.00am, the noisiest aircrafts are not allowed to land or take-off. Between 11.30pm and 6.00am, the number of aircraft movements (landings or take-offs) is limited. Currently, the limit is set at approximately 16 movements per night (or more precisely, 2,550 flights in the winter season and 3,250 in the summer season)[1].

This regulation is up for a review and it is expected that the Department for Transport will start a consultation during 2011.

HACAN wants to use the consultation to plead again for a ban on flights between 11.30pm and 6.00am. It asked CE Delft to evaluate the costs and benefits of such a ban.

1.2 Aim and scope

The aim of this report is to analyse the social, environmental and economic effects of a ban on night flights at Heathrow Airport. It relates to effects such as local air quality, noise nuisance, profits of airline companies, etc.

In order to present these effects in a structured manner, we will set up a Social Cost Benefit Analysis (SCBA, also see Section 1.3). It aims to reveal all the effects of a ban on night flights in monetary terms, even those of a non-financial nature. Valuation methods are used to give the non-financial effects a price.

The SCBA has a national scale, which means that solely impacts on the UK are taken into account.

1.3 What is a SCBA?

A Social Cost Benefit Analysis (SCBA) is defined as 'an evaluation method that can be used to consider the impact of policy decisions'. Using SCBA will provide an overview of current and future pros and cons of a particular investment or policy project for society as a whole as objectively as possible. For this purpose, effects are denominated in pounds whenever possible and can be aggregated. The analysis then shows whether the project under evaluation leads to a desired increase in social welfare.

[1] The summer season is defined as the period of British Summer Time in any one year. The winter season is the remaining part of the year.

This means that SCBA differs fundamentally from a financial analysis (business case), which reveals the costs and benefits for a particular party. As SCBA assesses the overall public interest, certain financial costs and benefits that are included in a business case disappear as they are offset by benefits respectively costs of another party.

SCBA is based on a broad definition of the term ‘welfare’. Besides goods and services, SCBA takes into account intangible effects and expresses them in monetary terms. These include effects on the environment, landscape, nature and spatial quality. The value of those effects is calculated in monetary terms through specific valuation techniques, as no market prices are readily available. In the case of a night flight ban at Heathrow, important external effects are annoyance of night noise and the travelling time for passengers.

SCBA compares the costs and benefits of one or more project alternatives with a so-called baseline or business-as-usual scenario. The baseline scenario is the most likely development that will occur when no policy decision is taken. The difference between the project alternative and the baseline is the starting point for SCBA.

This SCBA has a national (UK) perspective. This has an important implication for the costs and benefits. Payments from UK citizens and/or companies to UK citizens and/or companies are neither a cost nor a benefit but a cash *transfer*, because, for the UK as a whole, the costs and benefits cancel out. One example is that the taxes which UK citizens pay to UK Governments are considered transfers and therefore not included in SCBA. From a political perspective, transfers *are* important because they define the distribution of costs and benefits over actors. However, they should be studied separately.

SCBAs are widely used in transport investment appraisals and other ex-ante policy evaluations both in the UK and in many other countries.

1.4 Structure of report

Chapter 2 identifies possible responses to a night flight ban. To that end, it analyses night flights at Heathrow and assesses options that airlines and passengers have to respond to a night flight ban. Chapter 3 lays out the framework of SCBA. It shows which effects are taken into account, the methodology of the calculation of physical impacts as well as valuations. It provides results per type of effect. Technical assumptions that underlie SCBA will also be provided here. Chapter 4 presents the results of the basic analysis. It reveals whether a ban would be cost-effective from a societal point of view. Two sensitivity analyses are also performed here. Chapter 5 concludes.

2 Responses to a night flight ban

2.1 Introduction

A total ban on aircraft movements at Heathrow between 11.30pm and 6.00am would be a significant change to the current situation. Airlines would no longer be able to land or take-off during the night and passengers could not arrive at night time. Both airlines and passengers could respond in several ways to a night flight ban. This chapter sets out to identify possible responses. It defines three responses that should be seen as extremes. This has the advantage that the most likely responses are likely to fall within the boundary set by the three extremes. Likewise, the costs and benefits of a night flight ban are likely to fall between the costs and benefits of these extremes.

This chapter first describes the current night flights at Heathrow in Section 2.2. Section 2.3 evaluates possible responses of airlines and passengers to a night flight ban. The response scenarios are summarised in Section 2.4.

2.2 Baseline alternative: current situation

The baseline scenario is defined as a continuation of the current situation, i.e. the current number of night flights, early morning flights (no autonomous growth is taken into account) and passengers.

2.2.1 Night flights

We have analysed flights scheduled to arrive between 11.30pm and 6.00am in one week, starting 29 August 2010, using information from FlightStats.Com[2]. Based on this weekly schedule and the winter/summer regulation on flights, we calculate the yearly number of flights. Under the current regime 2,550 flights are allowed in the winter season and 3,250 in the summer season. This means a maximum of 5,800 flights per year. It is assumed that this restriction is proportionally distributed among the various flights, so that the weekly flight pattern with respect to the number of departures, arrivals and the location of departures is the same as the yearly pattern.

Table 1 shows the arrivals performed by British and foreign airline companies and their geographical location of departure. It concerns a maximum of 5,250 arriving flights per year, with 62% of them (3,260) performed by British airlines[3].

[2] www.flightstats.com. The flights were retrieved and analysed for their scheduled time of arrival or departure. Code-sharing has been ignored: a flight that is operated in a code share arrangement between different airlines is only reported once under the airline that actually operates the flight. For each flight, data were retrieved on the origin or destination, flight number, airline and aircraft type.

[3] The following airlines operating night flights on Heathrow were considered British: BA, bmi, Virgin Atlantic.

Table 1 **Heathrow flight arrivals between 11.30pm and 6.00am**

Arrivals	Weekly summer schedule (based on week starting 29 August 2010)		Yearly schedule	
	Number of arrivals (% of B/f total)	Number of passengers (% of B/f total)	Number of arrivals	Number of passengers
All arrivals	124	33,076	5,250	1,400,286
Performed by British airlines	77	23,445	3,260	992,554
Location of departure:				
– Europe	0 (0%)	0 (0%)	0	0
– Africa	14 (18%)	4,284 (28%)	593	181,376
– North America	20 (26%)	6,646 (25%)	847	281,352
– Near East	14 (18%)	2,975 (13%)	593	125,966
– Indian subcontinent	18 (23%)	5,866(16%)	762	248,357
– Far East	11 (14%)	3,673 (18%)	466	155,503

Arrivals	Weekly summer schedule		Yearly schedule	
	Number of arrivals (% of B/f total)	Number of passengers (% of B/f total)	Number of arrivals	Number of passengers
Performed by foreign airlines	47	9,631	1,990	407,732
Location of departure:				
– Europe	1 (2%)	129 (1%)	42	5,453
– Africa	2 (4%)	329 (3%)	85	13,944
– North America	12 (26%)	2,760 (29%)	508	116,847
– Near East	2 (4%)	549 (6%)	85	23,236
– Indian subcontinent	6 (13%)	2,089 (22%)	254	88,430
– Far East	24 (51%)	3,775 (39%)	1,016	159,822

Note: The number of passengers was estimated using standard 2-class or 3-class seating arrangements for the aircraft concerned and average AEA passenger load factors for intercontinental routes.

Given the capacity of the types of aircraft used (CE, 2008a) and average passenger load factors per aircraft (PLFs) (AEA, 2010), it is estimated that those British flights carry over 23,000 passengers per week and nearly 1 million per year. It turns out that most arrivals originate from North America and the Indian subcontinent.

With respect to departures between 11.30pm and 6.00am, all 550 flights carry freight and their destination is Europe. The flights are performed by either Iberia airlines or British airlines (212, 38% of total), as Table 2 indicates.

Table 2 **Heathrow flight departures between 11.30pm and 6.00am: all freight transport**

Departures	Weekly summer schedule	Yearly schedule
	Number of departures	Number of departures
All departures	13	550
Performed by British airlines	5	212
Location of destination:		
– Europe	5	212

2.2.2 Type of passengers

The nationality of passengers on night flights, their destination and their travel purpose is not known. However, for passengers on all Heathrow flights (day and night), this information is available: of all the arriving passengers, nearly 65% have London Heathrow as their final destination. Slightly over 35% of the passengers solely use the airport to connect to other destinations (CAA, 2009). We assume that this overall pattern also holds during night time, due to a lack of more specific information. A sensitivity analysis on this assumption is performed, see Section 4.4.2.

For most of the terminating passengers at Heathrow Airport (63%), the purpose of the journey is leisure related, as Table 3 shows. Domestic leisure seems to be most important reason for travelling. Of the arriving and terminating passengers, 60% are of UK origin[4].

Table 3 Characteristics of passengers at Heathrow Airport

Purpose and origin	Share of *terminal* passengers (arrivals and departures)	Share of *terminating* passengers (arrivals)	Share of *non terminating* passengers (departures*)
Business	34%	37%	28%
- UK passengers	15%	21%	5%
- Foreign passengers	19%	16%	24%
Leisure	66%	63%	72%
- UK passengers	29%	39%	10%
- Foreign passenger	37%	24%	62%

Source: Own calculations based on CAA, 2009.
Note: * Including transferring passengers.

In the case of departing passengers, the proportion of business and leisure is similar but the share of UK passengers is much lower (15%). This indicates that a relatively high number of foreigner travellers depart from Heathrow, many using the airport as hub.

We assume that these general characteristics of travellers at Heathrow Airport apply to night flight passengers as well.

2.2.3 Early morning flights

Since 35% of the passengers do not have Heathrow as their final destination, this means that opportunities for transfer are relevant for 350,000 people per year arriving between 11.30pm and 6.00am. In that regard, it is relevant to look at early morning departures of passenger flights[5]. About 11,000 flights per year are scheduled between 6.00am and 7.00am, all with destinations in Europe, as shown in Table 4. Nearly half of them are British airlines, carrying half a million passengers per year. Flights between 7.00am and 8.00am, which can also offer transfer possibilities for passengers arriving in the night, are also predominantly (albeit not exclusively) destined for European airports.

4 21% plus 39%.

5 Freight flights are not relevant here.

Table 4 **Heathrow early morning departures between 6.00am and 7.00am**

Departures	Weekly schedule		Yearly schedule	
	Number of departures	Number of passengers	Number of departures	Number of passengers
All departures	210	23,483	10,920	1,221,131
Performed by British airline	94	10,259	4,888	533,487
Location of destination				
– Europe	94	10,259	4,888	533,487
Performed by foreign airline	116	13,224	6,032	687,644
Location of destination				
– Europe	116	13,224	6,032	687,644

2.3 Project alternative: night flight regulation

The project alternative is the situation when night flights are banned[6].
The question to be considered is what would happen to the flight schedules of Heathrow Airport and to the passengers who would have taken those flights that are no longer allowed. It depends on supply and demand factors.

With respect to the response of the airlines (the *supply* side), there are broadly two options:
- All flights that were originally scheduled between 11.30pm and 6.00am are rescheduled to earlier in the evening or later in the morning.
- All flights will not be executed, since Heathrow has insufficient capacity to reschedule these flights.

A third possibility could be a decision to reschedule (some of the) night flights by cancelling other flights that are less profitable. This possibility is not taken into account as it is not possible to provide a reliable estimate which flights would be substituted within the context of this study.

It is not impossible to reschedule night flights to daytime arrivals. Annex A shows that, for selected routes, both daytime and night time arrivals can be rescheduled. We assume that the flights currently arriving in daytime do not have the spare capacity to absorb the passengers from night time flights – in other words, if the number of flights is reduced, the number of passengers will also be reduced.

With respect to consumer response to the ban (the *demand* side), two options can be distinguished:
- Passengers opt for another arrival time.
- Passengers no longer fly to Heathrow as they:
  - Choose not to make the journey (in case of leisure passengers).
  - Opt for a different destination.
  - Decide to fly via another airport (in case of transfer).

Each of these choices would impact, to a certain extent, on the number of travellers, ticket revenues/airline profits, time associated with a particular trip and expenditure on hotel, catering et cetera (see Section 3.3). In order to evaluate the different potential consequences of a ban, we distinguish between the various scenarios in defining project alternatives. Please note that all project alternatives relate to a ban on night flights, but involve

[6] Assumption is that flights at 6.00am are allowed, so ban is till (and not up to an including) 6.00am.

different assumptions on the response of actors to this ban. This is, in our view, the most structured and transparent manner of presenting analysis and results.

Combining consistent demand and supply options, yields 3 response scenarios (R) that are evaluated:

1. All flights are rescheduled and passengers opt for other arrival times.
2. All flights are rescheduled, but only terminating business and leisure passengers (65%) will accept another arrival times; others, the transfer passengers (35%), will no longer fly via Heathrow[7].
3. All flights are cancelled and all passengers no longer travel to Heathrow.

The latter scenario is identical in effect to a situation in which air companies are able to reschedule flights, but passengers decide no longer to travel to Heathrow[8].

2.4 Response scenario summary

Table 5 provides a summary of scenarios that will be evaluated in this study.

Table 5 **Summary of scenarios evaluated in this research study**

Alternative	Description
Baseline scenario (B)	Continuation of current night flight regulation on Heathrow Airport
Project alternative	Total ban on night flights between 11.30pm and 6.00am on Heathrow Airport
– Response scenario 1 (R1)	– All flights are rescheduled and the original passengers opt for other arrival time
– Response scenario 2 (R2)	– All flights are rescheduled, but 65% of the original passengers accept other arrival time, the others no longer fly to Heathrow
– Response scenario 3 (R3)	– All flights are cancelled and passengers no longer travel to Heathrow

7 Example of a reasonable consumer response pattern, although others options are possible. Assumed here is that these passengers are distributed among all destinations, so that still all flights are rescheduled. Since demand can be assumed to be latent, no flights are cancelled.

8 This scenario is, therefore, not discussed separately. The scenario that none of the original 'night time' passengers come to Heathrow anymore is not a very realistic scenario, but is useful to include in the analysis, to indicate the boundaries of the results; the actual situation might well lie somewhere between the option 1, 2 and 3.

3 Social Cost Benefit Analysis framework

3.1 Introduction

This chapter lays out a framework for the social cost benefit analysis of a night flight ban at Heathrow. First, Section 3.2 identifies key assumptions and principles applied in SCBA. Section 3.3 identifies possible direct, indirect and external effects of a ban. Direct effects are analysed and quantified in Section 3.4; external effects in Section 3.5 and indirect effects in Section 3.6.

3.2 Technical principals SCBA

In this SCBA, the following principles are applied:
- The discount rate is 3.5%. This conforms with the UK green book (HM Treasury, 2003).
- Time horizon of SCBA is 10 years, covering the period from 2013 to 2023. This means that costs and benefits continue to the year 2023.
- The year 2010 is used as base year. We use constant prices and calculate net present values with a discount rate of 3.5%. Exchange rates published by the European Central Bank (2010) are used to convert Euro values to UK pounds.
- All prices have been converted to 2010 prices by correcting for inflation, based on British inflation figures published by British Office for National Statistics (2010).

3.3 Considered effects

In SCBA three types of effect can be distinguished:
- Direct effects.
- External effects.
- Indirect effects.

Table 6 provides an overview of effects that will be taken into account in this SCBA. A short explanation follows in Sections 3.4, 3.5 and 3.6.

Table 6 Overview direct, external and indirect effects in SCBA

Type effect	Effect	Taken into account in SCBA?
Direct (internal) effects	Impact on aviation revenues	Yes, quantitatively for passengers, not for freight
	Impact on non-aviation revenues	Yes, qualitatively
External effects	Impact on noise	Yes, quantitatively
	Impact on emissions	Yes, NO_x of LTO
	Impact on frequency and travel time	Yes, quantitatively
Indirect effects	Impact on tourism	Yes, quantitatively
	Impact on employment	Yes, qualitatively

3.4 Direct effects and valuation

Direct effects are impacts that are a direct consequence of the ban. They are also considered as internal effects, in the sense that they are reflected in markets and prices. In this SCBA we distinguish two types of direct (and internal) effects, following Gillen (2001):

- Aviation revenues.
- Non-aviation revenues.

3.4.1 Aviation revenues

Aviation or airside revenues are obtained from ticket revenues, aircraft landing charges, parking and gate fees and passenger handling charges. In this SCBA we will focus on the profits of airline companies (related to ticket prices see below). It is self-evident that these revenues and subsequent profits will change when a ban is introduced. These relate to the original night flights and early morning flights.

Night flights

The impact on night flight ticket revenues is either directly due to the cancellation of night flights (R3) or when flights are rescheduled and some of the passengers no longer choose to travel to Heathrow (R2). Table 7 shows the impact on the number of passengers.

Table 7 Number of passengers on (rescheduled) night flights

	Number of passengers per year			
Scenario	**Baseline**	**R1**	**R2**	**R3**
Percentage of original number of passengers on these flights	100%	100%	65%	0%
Foreign passengers on night flights performed by British airlines				
Departure from:				
– North America (average)	281,352	281,352	182,879	0
– Indian subcontinent	248,357	248,357	161,432	0
– Near East	125,966	125,966	81,878	0
– Far East	155,503	155,503	101,077	0
– Africa	181,376	181,376	117,894	0
Total	992,554	992,554	645,160	0
UK passengers on night flights performed by foreign airlines				
Departure from:				
– Europe	5,453	5,453	3,940	0
– North America (average)	116,847	116,847	75,951	0
– Indian subcontinent	88,430	88,430	57,480	0
– Near East	23,236	23,236	15,104	0
– Far East	159,822	159,822	103,884	0
– Africa	13,944	13,944	9,064	0
Total	407,732	407,732	265,026	0

From a national perspective, payments of UK passengers to a British airline are simply a question of distribution of welfare not an increase in welfare. Only when foreign passengers pay ticket prices to British airlines is it considered as a benefit for the UK (see the Table below). Likewise, ticket payments of UK passengers to foreign airlines are considered as a loss for the UK.

Airline\passenger	UK	Foreign
UK	Transfer	Benefit
Foreign	Loss	Not relevant for SCBA

Therefore, in this SCBA:
- Only a loss of ticket revenue for British airlines that used to be obtained from international travellers is considered to be a welfare loss.
- A loss of ticket revenue for foreign airlines that used to be obtained from UK passengers is considered as a welfare benefit.

Please also note the following:
- Since we look at the impact of a night flight ban, we assume that ticket revenue from those passengers no longer travelling is lost, i.e. the seats are not taken by other people. Thus, only when all flights are rescheduled and all passengers accept this (R1), no impact is expected ceteris paribus on ticket revenues and profits. This is a conservative assumption because we do not take into account that the costs of airlines and airports will also decrease.
- Impact on revenues is solely related to passenger flights. Changes in revenues of freight transport cannot be included, due to a lack of data, and will be referred to as PM (Pro Memory).
- As mentioned in Section 2.2.2, foreign passengers cover 40% of the total arrivals shown in Table 7. If passengers do not arrive at Heathrow, they will not depart from this airport either. Therefore, round-trip revenues are considered, instead of one-way tickets. This also holds for transfers from Heathrow to other destinations in Europe.
- If UK travellers no longer travel with foreign airline companies, they might spend the saved money elsewhere. Strictly speaking we must compare the welfare of the original night flights and the alternative spending in order to calculate the effect on national UK welfare. Since we do not have sufficient information on the behaviour change of UK passengers, this is not possible and we solely consider saved ticket expenses as a benefit. This implies an implicit assumption that alternative spending takes place within the UK (financial transfer).
- There might be a negative effect on airline profits due to the fact that the deployment of aircraft might be less efficient when operating times are more regulated by the Government (i.e. aircraft spend more time on the ground and less in the air). This effect is not included in the analysis, as no rough estimates exist on the order of magnitude.

Early morning flights
Under all project scenarios there is an additional impact on the passenger load of early morning flights to be expected:
- Under R1, 35% of the ‘night time’ travellers are still willing to transfer at Heathrow Airport. As the night flights are rescheduled, the question is whether flights are postponed to (early) morning, afternoon or the evening before. A reasonable assumption is that passengers would want to minimise their travel time and in general would not want to have a stopover in their schedule. Currently, stopovers are rare except for very long haul flights such as between Europe and Australia. Hence, airlines can reschedule their flights to arrive late in the afternoon or early in the evening the day before and still allow for a transfer to another flight on the same day, or reschedule to arrive early in the morning on the same day. The question is whether airport capacity allows this. We assume in this SCBA that the arrival time of half (50%) of the total executed flights

from each departure location is brought forward and half (50%) is delayed. So, for example, of the 1,040 night flights currently arriving from North America, 520 will be rescheduled to the evening before and 520 to the day after. Subsequently, some of the passengers will not be able to take the early morning flights. In that case they are expected to choose a later moment of departure. Eventually, all original passengers will travel to or via Heathrow.

- Under R2, only terminating passengers will continue to fly to Heathrow, so none of the original ‘night time’ passengers will actually transfer (note that 35% of the passengers currently arriving on daytime flights will still transfer to other flights).
- Under R3, night flights are cancelled so none of the passengers will transfer.

Table 8 shows the resulting number of departing passengers. As indicated in Section 2.2.2, about 85% of these passengers are foreign travellers and only 15% are expected to be of UK origin. This is relevant for the calculation of ticket revenue losses for British airlines from fares paid by international travellers and savings of ticket expenses for UK passengers who flew with foreign airline companies on early morning flights.

Table 8 Number of passengers early morning flights

Scenario	Number of passengers per year			
	Baseline	R1	R2	R3
British early morning flights				
Percentage of original number of passengers on those flights	100%	67%/ 100%*	34%**	34%**
Destination:				
– Europe	533,487	358,273/ 533,487	183,059	183,059
Foreign early morning flights				
Percentage of original number of passengers on those flights	100%	75%/ 100%*	49%**	49%**
Destination:				
– Europe	687,644	512,430/ 687,644	337,215	337,215

Notes: * First figure shows the percentage of the original number of passengers on early morning flights, taking into account that 50% of the transferring passengers would be expected to arrive too late. Since all transferring passengers will eventually take other flights during daytime, 100% is finally reached. Latter figure is used in the impact calculation.

** No transfers from night flight passengers any more.

Valuation
The estimated impact on airline profits is based on the expectation in the AERO model that net operating margins are 2.4% of the ticket revenue for EU airlines in 2012 (CE, 2007)[9]. Since we know the destination/origin of the flights that currently operate during night and early morning, we are able to estimate ticket revenues based on AEA (2007), which provides the passenger yield on European and long haul flights:
– 13.2 €cent/km on European flights.
– 6.7 €cent/km on long haul flights.
Average distances are determined by choosing a reference destination within the region, calculating corresponding travel kilometres via ICAO (2010) and rounding these off. Table 9 shows the results.

Table 9 Average distances

Location of departure/destination	Distance (km, one-way)
Europe	700
North America (average East and West Coast)	7,500
Far East	8,000
Near East	5,500
Indian subcontinent	9,000
Africa	6,500

Table 10 shows the loss there would be in British airline profits due to a night flight ban, taking into account round-trip revenues of non-UK passengers only[10]. It consists of the difference between the baseline profits and the profits under the project alternatives. Results range from no cost (R1) to £ 8.0 million per year (R3).

Table 10 Yearly profits of British airlines under the baseline and project alternative (round-trip, non-UK passengers)

Scenario	Ticket revenue per year (million GBP_{2010})	Profits per year (million GBP_{2010})	Cost of night flight ban per year (million GBP_{2010})
Baseline:	**356**	**8.5**	-
– Night flights	294	7.0	
– Early morning flights	62	1.5	
R1:	**356**	**8.5**	**0**
– Night flights	294	7.0	
– Early morning flights	62	1.5	
R2:	**213**	**5.1**	**3.4**
– Night flights	192	4.6	
– Early morning flights	21	0.5	
R3:	**21**	**0.5**	**8.0**
– Night flights	0	0	
– Early morning flights	21	0.5	

9 Since we consider the current situation to reflect the ticket sales etc. under the Business-as-Usual scenario from 2013 up to 2023, we will use this profit margin throughout the whole period up to 2022 even though estimates are that it increases to 3.1% in 2020.

10 40% of total arriving passengers on (rescheduled) night flights, 15% of total number of departing passengers, see Section 2.2.2 and 2.4.1.

Please note that the analysis is based on passenger yield, which exclude taxes such as Air Passenger Duty (APD) which is paid by both UK and international citizens when they board a domestic or international flight in the UK, except when they are transferring onto another flight. It is not paid by passengers arriving on a flight into the UK. Since this SCBA concerns impacts on arriving and transferring passengers, who do not have to pay APD, this duty is not relevant.

With respect to UK passengers originally travelling with foreign airline companies, the benefits of a night flight ban follow are shown in Table 11.

Table 11 **Yearly profits of non British airlines under the baseline and project alternative (round-trip, UK passengers)**

Scenario	Ticket revenue per year (million GBP_{2010})	Profits per year (million GBP_{2010})	Benefit of night flight ban per year (million GBP_{2010})
Baseline:	**203**	**4.9**	-
– Night flights	190	4.5	
– Early morning flights	14	0.3	
R1:	**203**	**4.9**	**0**
– Night flights	190	4.5	
– Early morning flights	14	0.3	
R2:	**89**	**2.1**	**2.8**
– Night flights	82	2.0	
– Early morning flights	7	0.2	
R3:	**7**	**0.2**	**4.7**
– Night flights	0	0	
– Early morning flights	7	0.2	

3.4.2 Non-aviation revenues

Non-aviation revenues at Heathrow are generated from parking, concessions (food, shops, car rental, etc.), leases and terminal rentals to airlines and associated aviation-related activity. Additional money brought into the UK economy, such as the spending of foreign passengers in hotels and restaurants, also needs to be considered.

Since there is no estimate of the non-air revenues in the baseline scenario, we are not able to make a quantitative assessment of the impact of a night flight ban. We can only indicate that revenues are expected to decline due to the cancelling and rescheduling of flights, which under R2 and R3 leads to a reduction in the number of passengers flying to Heathrow. It will be included as a Pro Memory (PM) issue.

3.5 External effects and valuation

External effects relate to unintended changes in the welfare of third parties due to a certain action or change in policy for which no compensation is received. These often concern the environmental impact, such as the effects on human health or the nature of the landscape. Since these impacts are not incorporated in market prices, they are denoted as external effects. In this research the following external effects can be distinguished:

- Noise.
- Emissions.
- Frequency and travel time.

3.5.1 Noise

Noise can be defined as the unwanted sound or sounds of duration, intensity, or other quality that causes physiological or psychological harm to humans (CE, 2008b). In general, two types of negative impacts of transport noise can be distinguished:

- Health effects:
  They relate to the long term exposure to noise and are often stress related, such as hypertension and myocardial infarction. Hearing damage can be caused by noise levels above 85 dB(A). The negative impact of noise on human health results in various types of costs - medical, the impact of lost productivity, and the costs of increased mortality.
- Annoyance effects:
  They reflect the cost of the disturbance which individuals experience when exposed to noise, ranging from pain suffering and discomfort to inconvenience and restrictions on enjoyment of desired leisure activities.

In HEATCO (2006) it is assumed that these two effects are independent, i.e. the potential long term health risk is not taken into account in people's perceived noise annoyance.

At present there are two main indicators of noise, prescribed by the European Commission: L_{den} (day-evening-night indicator) covers the overall annoyance of people, whereas L_{night} indicates the noise during the night and reflects sleep disturbance. In this SCBA, L_{night} is the most relevant parameter to look at, as the main impact of any ban would be that aircraft noise was avoided during the night. The Heathrow definition of night (11.30pm–6.00am) is applied. Estimates of L_{night} are provided by CAA (2007), indicating the number of people who are affected at different noise levels, as indicated in Table 12.

Table 12 Number of people affected at different noise levels under different scenarios

L_{night} noise level (dB)	Number of people affected	
	Baseline	Project alternative (R1, R2 and R3)
50-54.9	145,300	0
55-59.9	45,700	0
60-64.9	14,600	0
65-69.9	1,700	0
>70	100	0

When night flights are completely banned, as under R3, the noise is no longer present. To the extent that flights which were originally scheduled for the night are rescheduled to day-of evening-time, as under R1 and R2, changes in L_{day} and/or $L_{evening}$ can be expected. However, we assume these changes to be negligible as the impact of an additional flight during the day or evening is much smaller in dB terms than an additional flight at night. Under R3 night flights are cancelled, so all the noise related to these flights will disappear.

Valuation

With respect to the valuation of noise, there are several methods to estimate the value people attach to the reduction in noise from air traffic.
Broadly three approaches can be distinguished:

- Hedonic pricing: impact on property values, reflecting health and annoyance impacts.
- Stated preferences: asking people Willingness to Pay (WTP) to avoid noise.

– Direct valuation of health impact: looking at physical impact of noise and attaching a value on disability adjusted life years (DALY).

There are some pros and cons related to each approach. The advantage of hedonic pricing is that it is based on revealed behaviour, actual price differences that can be observed in the market. The difficulty, however, is to isolate a particular cause-effect relationship between, in this case, noise and property values. Other aspects might be present as well.

The main value of the stated preference method is that it allows the researcher to ask people the value they place on the specific issue under consideration. However, there can be a difference between people putting a value on something and it affecting their actual behaviour. Besides, a lack of knowledge of the impacts of the subject, like the noise and health impacts of night flights, might distort the value respondents put on it.

Direct valuation of health impacts has the advantage that it is based on academic research: the dose-effect relations between noise and health impacts. Yet, the valuation of human life (and thus DALYs) is not without controversy (although frequently used).

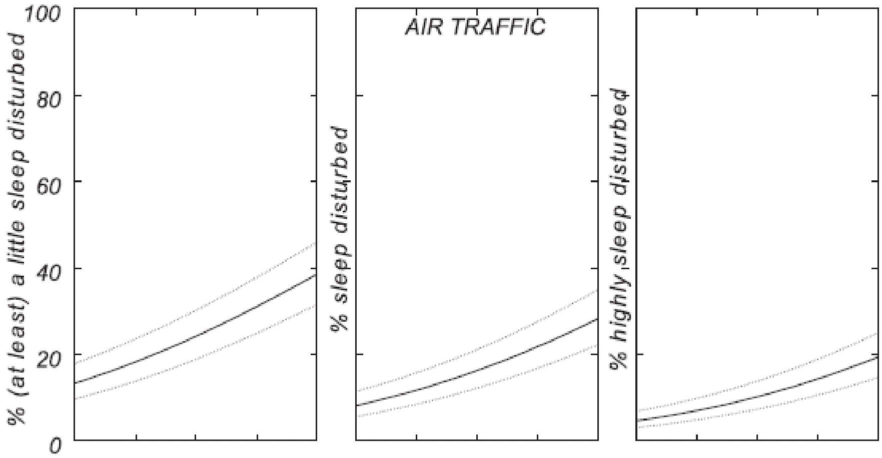
In addition, there is the practical issue that we were specifically looking for value of *night* noise caused by airplanes. With hedonic pricing only the total noise impact is considered, both in terms of time and source. With stated preference, most valuation studies have delivered values for L_{den}, so all impacts of noise are included, not specifically that at night. As Navrud (2002) indicated, there is a lack of knowledge and research on L_{night} valuation.

In this study, we therefore approach night noise valuation from three different angels:

1. Use L_{den} valuation.
   It means the translation of the available L_{den} valuation to L_{night} valuation, using the weight of night noise in the metric for average noise
2. Highly annoyed people and DALY.
   Here we consider the relationship between night noise and highly annoyed people; between highly annoyed people and DALYs and use the valuation of DALYs.
3. Blood pressure and DALY.
   We look at the identified relation between night noise and blood pressure and the relation between blood pressure and DALYs. Subsequently, DALY valuation is applied.

Section 4.4.1 covers a sensitivity analysis, as well as a discussion on the weaknesses of the various approaches. Calculations based on option 1 and 3 are included, but it is the second method we adopt in our basic SCBA because this is probably the most accepted one. It is based on Miedema (2007). Miedema has provided some estimates for the exposure-effect relationship between air traffic and sleep disturbance. Given the number of people exposed to night noise, we apply the results of Miedema, which are shown in Figure 1.

Figure 1 Sleep disturbance in relation to night noise



Source: Miedema, 2007.

About 18.13% of the exposed people are highly disturbed, as Figure 1 reveals. Combining this share with a severity weight of 0.089 (following WHO, 2007; 2009), yields a DALY impact per year per exposed person of 0.016.

To put a monetary value on DALY, we propose to use 40,000 Euro in prices of 2000 (NEEDS, 2006)[11] as starting point. This is an estimate for the whole EU-27 area, but, checking the results for individual countries, we found that the value for Great Britain was approximately the same[12]. We have converted this to British pounds and updated it to take account of British inflation and increases in the level of income. The latter adjustment is needed as valuation in Stated Preferences methods, which is used for Daly valuation, is related to income level - the higher the income of the respondents, the more the respondents are willing to pay for increase in environmental quality.
The NEEDS methodology is adopted here. Ultimately, the DALY value amounts to £ 29,524 in 2010 prices.

This means that the yearly benefit of avoidance of noise exposure during the night amounts to £ 476.40 per person. Combined with the total number of people currently exposed to night time aircraft noise at Heathrow (207,400 people, see Table 12), this yields an overall benefit of nearly £ 99 million if a night flight ban is introduced. Table 13 summarizes these results.

11 Which is the last stage of the ExternE series of project.

12 The value for Great Britain can be estimated on the basis of NEEDS (2006) as equal to 39,600 Euro, which would be an average of two slightly different methodological approaches. However in the paper using the values estimated for separate countries is not recommended because of not sufficient number of observations.

Table 13 **Highly annoyed people per year and valuation**

	Baseline	R1, R2, R3
DALY impact per person exposed to noise	0.016	0
Annual health benefits night ban		
In DALYs		3,318
In GBP		98,805,069

3.5.2 Emissions

Several emissions are related to air transport. In this study we choose to focus solely on NO_x emissions during the landing and taking off (LTO) events, as it is the most important one. CO_2 emissions are not included in the analysis. Although the UK carbon budget includes carbon, signalling a national aim to reduce those emissions, we consider them captured under the EU ETS scheme[13]. With respect to PM10, the precise amount emitted is quite difficult to estimate[14] and, moreover, the impact is expected to be relatively small.

For determining the impact on LTO-NO_x emissions in the UK, we divided figures of NO_x emission per LTO (CE, 2008a) into NO_x per landing and NO_x per take-off with a share of 21-79%. On average, NO_x emissions during the landing cover 21% of total emissions during LTO (based on ICAO engine emissions databank 15B). Table 14 shows the results.

Table 14 **NO_x emissions under different scenarios**

Scenario	NO_x emissions (kg)
Baseline, R1 and R2:	54,377
– Arrivals (landing)	42,198
– Departures (take-off)	12,179
R3	0

Note: For scenario R2 it is assumed that the remaining passengers are distributed among all the various aircrafts, so that still all flights are rescheduled.

Since the lifetime of aircraft is 30 to 40 years, any improvement in NO_x emissions due to Research & Development, etc. will fall outside the scope of the SCBA. Therefore, we use the same emission parameter for the whole period of time.

With respect to the valuation of the occurring emissions, there are several methods available to determine how much people are willing to pay for certain external effects. Since there is no market available for environmental quality, from which prices can be derived, shadow prices of emissions must be used. The NO_x price included in this SCBA is a damage costs value derived from CE (2010) and subsequently translated to the British situation by using the exchange rate and CPI indicators (see Section 3.2). It amounts to 5.23 GBP/kg NO_x.

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13 Since there are no reliable figures on CO_2 emissions of air transport, no sensitivity analysis is performed.

14 Since the exact relation between smoke and PM is quite complex.

During landing and take-off emissions can occur up to 914 metres (nearly 3,000 feet), with emissions below 100 m (328 feet) being generally considered more damaging to human health. Since both emissions higher and lower to the ground occur, we use a general price for NO_x.

Table 15 provides the results, revealing that there arises only a yearly benefit of lower NO_x emission of £ 284.5 million if all night flights are banned.

Table 15 Yearly cost of NO_x emissions under the baseline and project alternative

Scenario	Cost of NO_x emissions per year (million GBP_{2010})	Benefit of night flight ban per year (million GBP_{2010})
Baseline, R1, R2:	**284.4**	**-**
– Landing	220.7	
– Take-off	63.7	
R3:	**0**	**284.4**
– Landing	0	220.7
– Take-off	0	63.7

3.5.3 Frequency and travel time

With respect to passengers' travel time, two issues need to be considered:

1. Change in the frequency of flights.
2. Change in the duration of passengers' journey (travel time).

In this SCBA these considerations are only applied to arriving passengers of UK origin (60% of total), given the national perspective of the analysis.
The welfare effect on non-UK passengers falls outside its scope.

Frequency of flights

When night flights are banned, passengers are more restricted in their choice of arrival and (in case of a transfer) departure times. They face a lower frequency of flights or at least the option to fly at night[15].

It is assumed that, due to limited airport capacity (see Section 3.4.1), a rescheduling of flights (R1, R2) means that the arrival time of half (50%) of the total executed night flights from each departure location is brought forward whereas the other half of flights is delayed. Since the exact timing is uncertain, we assume that flights will depart on average 12 hours earlier and 12 hours later. This yields the results provided in Table 16.

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15 Although it could be argued that this effect is a direct effect, which induced a change in ticket prices, it is also reasonable to assume that prices are not very responsive and that impact on travel time of people is can be considered as an external effect. The latter approach is taken in the SCBA.

Table 16 **Number of UK passengers facing earlier/later arrival times or no arrival, compared to baseline**

Scenario		Number of people
R1:		
–	Arriving 12 hours later	298,815
–	Arriving 12 hours earlier	298,815
R2:		
–	Arriving 12 hours later	193,316
–	Arriving 12 hours earlier	193,316
–	Not arriving at all (transfers, 35% of total)	210,998
R3:		
–	not arriving at all (100% of total)	597,630
	of which transfers (35%)	210,998

Passenger travel time

In theory, transferring passengers might have to deal with a longer travel time due to longer waiting hours at Heathrow Airport or due to the need or wish to choose another hub. Under R1, however, it is expected that rescheduling of flights will take into account transfers, so no additional waiting time is expected. For people who no longer transfer at Heathrow (under R2 or R3), likely and satisfactory alternative airports seem to be Amsterdam, Paris and Frankfurt. In practice, additional travel time is unlikely there.

Valuation

Since people have preferences on time of arrival, rescheduling of flights has an impact on their welfare. According to Lijesen (2006), people negatively value deviations from their desired times of arriving. Arriving one hour earlier yields a disutility of 23 Euro (2006)[16], but, since people dislike arriving later even more, one hour later yields an average hour value of 34 Euro[17].

For terminating leisure passengers the preferred arrival time is the afternoon[18]. For them, therefore, current night flights are actually a deviation from their desired arrival time. This means that rescheduling 12 hours earlier/later would actually yield a benefit compared to the baseline scenario. Table 17 shows the valuation figures used.

For transferring leisure passengers and business passengers, the situation is different as night flights might have been the preferred way of travelling. We value the disutility of not being able to take these flights anymore with DfT figures (2009) regarding working and non-working time (4.46 respectively 26.73 GBP_{2002})[19]. These values would also have been used to value longer travel times, but transferring passengers are not expected to face longer duration of their journey.

16 Unweighted average of 19 Euro for low income travellers and 27 Euro for high income travellers.

17 Values range from 21 to 49 Euro.

18 Passengers would have desired arrival times between 2.49 and 6.36pm (Leijsen, 2006).

19 These values are not specifically for air travellers, but rather averages for other modes of transport. No better estimates are available to date. A comparison of ticket prices on the various journeys of different lengths (same route with or without transfer, for instance) could be used to determine the time value. This is however a very time-consuming exercise and cannot be executed within this research project.

Table 17 Valuation of frequency and travel time

Type of passenger	Type of effect (compared to baseline)	Value (GBP_{2010} per person per hour)
Leisure-terminating 12 hour earlier	Benefit	24.9
Leisure-terminating 12 hour later	Benefit	17.0
Leisure-transferring 12 hours earlier/later	Loss	5.2
Business-all arriving	Loss	31.0

Finally, there are passengers who no longer will travel to Heathrow. Under R2, these are travellers who choose another hub. It is reasonable to assume that there is no disutility here. Passengers who are not able to travel to Heathrow, even if they wish to, (R3)[20] might experience disutility. However, this cannot be taken into account quantitatively (PM issue). The reason for this is that we cannot reasonably assume what the alternative destination would be. This insight is needed in order to compare peoples' utilities under the baseline and new situation.

The analysis yields the impact shown in Table 18. It reveals that under R1 there are benefits for terminating leisure passengers, but these do not outweigh the costs for all business travellers and transferring tourists. Since under R2, the original 'night time' transferring passengers no longer visit Heathrow but choose another hub without facing disutility, the net effect is a benefit (= a negative cost). As mentioned above, no impact for scenario R3 can be quantified.

Table 18 Yearly costs regarding frequency and travel time under different scenarios

Scenario	Yearly cost (million GBP)
R1:	**30.07**
Leisure terminating 12 hours later	-24.73
Leisure terminating 12 hours earlier	-36.29
Leisure transferring	8.23
Business	82.87
R2:	**-4.80**
Leisure terminating 12 hours later	-16.00
Leisure terminating 12 hours earlier	-23.48
Leisure transferring	0.00
Business terminate	34.68
Business transferring	0.00
R3	PM

3.6 Indirect effects

Besides direct and external effects, there might be indirect effects of a ban on night flights. These effects occur due to a ban, but are not a direct consequence, rather a carry-over effect from other impacts. In R3, fewer people will visit the UK and this has an impact on tourism. In R2 and R3, fewer

20 Please note that this is a different situation as under R2, where some people choose not to travel to Heathrow. In that case the benefits of changing travel plans to exclude Heathrow outweigh the benefits of accepting the rescheduling. Under R3 people do not have a choice.

passengers will transfer, arrive at or depart from Heathrow. This may have an effect on the local economy, such as employment.

3.6.1 Impacts on tourism

In R1 and R2, the same number of people will arrive at Heathrow so the number of tourists will not be affected. In response scenario 3, however, 1.4 million fewer people will arrive at Heathrow. Of these, we assume that 24% (0.34 million) are foreign leisure passengers, most of which are tourists (see Table 3).

Conversely, 39% of the passengers are assumed to be British leisure passengers. Some of them would choose to go to other destinations, not served by night flights, or served by surface transport. Some of them would choose to spend their holidays in the UK, leading to an improvement of the tourism trade balance. We have conservatively assumed that the additional spending in the UK will be negligible.

In order to estimate what these tourists add to the UK economy, one should estimate the gross value added that their expenditures generate (estimating just expenditures ignores for example the fact that a share of what tourists consume is imported into the UK). Such information is available from so-called Tourist Satellite Accounts, of which we know one UK example relating to the year 2000 (Jones et al., 2004).

Jones et al. (2004) finds that in 2000 the total tourism consumption in the UK amounted to £89.6 billion, of which £16.1 billion (18%) was consumed by in-bound foreign tourists (the remainder was either consumed on day trips by UK citizens, on domestic holidays or spent in the UK on foreign holidays). They also found that the total tourism consumption generated £ 32.0 billion value added – i.e. each pound spent on tourism in the UK added 35.7 pence value to the UK economy. Combining these figures we estimate that the inbound tourists in 2000 added £ 2.05 billion to the UK economy (18% * 35.7% * GBP 32.0).

In 2000, there were 9.1 million non-European inbound tourists in the UK (Office for National Statistics, 2010). This has decreased to 7.8 million in 2009, the latest year for which figures are available. We assume that the number of inbound tourists in the future will be the average 2000–2009: 8.5 million. Hence, in response scenario 3, a night flight ban at Heathrow would reduce the number of foreign tourists by 4%. We assume that the value added would also decrease by 4%, or GBP_{2000} 0.08 billion.

Due to inflation, the value of a pound in 2000 equates to the value of 1.23 pound in 2010. Combining these figures, we estimate that in response scenario 3, the UK economy would lose GBP_{2010} 0.1 billion due to lower tourism receipts.

3.6.2 Employment effects

In general, employment effects can only be taken into account when the accompanying welfare effect is additional. When employment markets are functioning well, an additional job will lead to a loss of job in another region and vice versa, meaning that only a redistribution effect would occur. Only in cases of structural unemployment of specific groups of people, for instance relatively low educated personnel, might an additional effect occur[21].

[21] In that case, a series of welfare effects and transfers would occur.

In the Heathrow night flight ban case, it is reasonable to expect that employment at airlines and at Heathrow will be lower in the response scenarios where fewer passengers arrive at and depart from Heathrow. As a rule of thumb, it is often assumed that 950 jobs are needed per one million passengers (see e.g. MPD 2005). Hence, the 1.4 million passengers on night flights would sustain 1,330 jobs.

It should be noted that it is false to assume that 1,330 jobs would be lost in case of a night flight ban and R3 (cancellation of all flights). In a well-functioning job market, employees would find other jobs. Moreover, in R3, the money that UK citizens would not spend on aviation would most probably be spent elsewhere in the economy. If it is spent in sectors that are more labour intensive than aviation – of which there are many – employment could increase. How many jobs could be lost or added to the UK economy can only be determined by model calculations.

If jobs would be lost – which is unlikely - a series of welfare effects and financial effects would occur:

- The *employer* loses labour productivity but at the same time pays less wages and employer's contribution. In the margin these can be expected to be equal.
- The *employee* loses net wages, but will earn unemployment benefits and leisure time. On balance this is expected to be a welfare loss, which is quite logical (otherwise the person wouldn't have worked). In both situations, the employee paid income tax and social fees.
- The *government* pays unemployment benefit and loses income taxes on the difference between unemployment benefit and former gross wages. Also less social fees are paid.

These effects and transfers are also shown in Table 19.
In sum, the net welfare loss is the welfare loss due to one additional unemployed person is the gross wages minus worth of leisure time.

Table 19 Effects when one job would be lost

Party	Baseline: Employee has a job	Project alternative: Employee is unemployed	Effect
Employer	+ Labour productivity - Gross wage - Social contributions employer	None	- Labour productivity + Gross wage + Social contributions employer
Government (-institutes)	No unemployment benefit expenses + Tax revenues wage + Social contributions wage	- Unemployment benefit expenses + Tax revenue unemployment benefit + Social contributions unemployment benefit	- Unemployment benefit expenses - Δ Tax revenue and social contributions
Employee	+ Gross wage - Taxation wage - Social contribution employee - Leisure time	+ Unemployment benefit - Taxation unemployment benefit - Social contributions unemployment benefit	- Gross wage + Unemployment benefit + Δ Taxes and social contributions + Leisure time
Balance			- Labour productivity + leisure time

Note: - = cost, + = benefit.

If jobs are relocated from the aviation sector to other sectors, the welfare loss or gain would be the additional or lower value added.

4 SCBA results

4.1 Introduction

In this chapter we will present the results of the SCBA. In addition, outcomes of sensitivity analyses will be provided.

4.2 Presentation of results

Results of SCBA are expressed in terms of Net Present Value for the year 2010. This means that future costs and benefits are translated to the current period by discounting them. Costs are lower aviation revenues. Among the benefits are lower noise and NO_x emissions. Both are expressed in GBPs.

Finally, the total NPV value is presented for the project alternative; the NPV of expected costs are subtracted from the NPV of the expected benefits. If the NPV is positive, it would be desirable from an economic perspective to carry out the proposed ban.

4.3 Net present value of a ban on night flights

4.3.1 Project alternative 1 (R1)

Table 20 provides overview of costs and benefits of the project alternative with response scenario 1. This means that all night flights are rescheduled and all passengers continue to fly to Heathrow.

The effects sum up to a NPV of nearly £ 572 million. It means that, based on the evaluated effects, a ban on night flights at Heathrow Airport is cost-effective from a societal point of view. The benefits account for more than 300% of the costs. This result is mainly due to the valuation of noise. On the cost side, the costs of frequency of flights and travel times for passengers are relevant; most people are not able to fly on their desired time. When the current PM items are also being taken into account quantitatively, the outcome would probably become somewhat less positive but we do not expect costs to outweigh the benefits.

Table 20 Cost and benefits of ban on night flights under alternative R1, in million GBP_{2010}, NPV in 2010

Costs	Million GBP	Benefits	Million GBP
Freq and travel time	250.1	Noise reduction	821.7
Profits	0	NO_x emission reduction	0
APD and freight profits	PM	Saving travel expenses	0
Non-air revenues	PM		
Indirect effects-employment	PM		
Indirect effects-tourism	0		
Total	250.1	Total	821.7
		Balance	**571.6**
		Benefit/Cost ratio	329%

4.3.2 Project alternative 2 (R2)

Table 21 provides an overview of costs and benefits of the project alternative with response scenario 2 where all night flights are rescheduled but only terminating passengers continue to fly to Heathrow.

The effects add up to a NPV of nearly £ 860 million, which means that a ban on night flights at Heathrow Airport, is cost-effective from a societal point of view. Given the size of the net benefits, it is not to be expected that quantification of the current PM items would lead to negative net benefits, only to a slightly lower positive outcome.

Table 21 Cost and benefits of ban on night flights under alternative R2, in million GBP_{2010}, NPV in 2010

Costs	Million GBP	Benefits	Million GBP
Profits	28.5	Noise	821.7
APD and freight profits	PM	NO_x	0
Non-air revenues	PM	Frequency and travel time	39.9
Indirect effects-employment	PM	Saving travel expenses	22.9
Indirect effects-tourism	0		
Total	28.5	Total	884.5
		Balance	**856.0**
		Benefit/Cost ratio	3109%

4.3.3 Project alternative 3 (R3)

Table 22 provides an overview of costs and benefits of the project alternative with response scenario 3 where all night flights are cancelled so that passengers are no longer able to fly to Heathrow.

The effects add up to a NPV of about -£ 35 million. It means that a ban on night flights at Heathrow Airport is not cost-effective from a societal point of view if we consider the quantified effects. The benefits do not outweigh the costs (B/C ratio is less than 100%).

The main entry on the benefit side is noise reduction, which is lower than the loss in tourism revenues. On the cost side there is also a relatively large loss in airline profits (compared to the other project alternatives). Since none of the original 'night time' passengers is able to fly to Heathrow, it means a loss of ticket revenue and profits. Since the PM entry 'frequency and travel time' is also expected to be a cost, quantifying this (and other PM issues) would yield a more negative outcome.

Table 22 Cost and benefits of ban on night flights under alternative R3, in GBP_{2010}, NPV in 2010

Costs	Million GBP	Benefits	Million GBP
Freq and travel time	PM	Noise	821.7
Profits	66.8	NO_x	2.4
APD and freight profits	PM	Saving travel expenses	39.2
Non-air revenues	PM		
Indirect effects-employment	PM		
Indirect effects-tourism	831.7		
Total	898.4	Total	863.3
		Balance	**-35.2**
		Benefit/Cost ratio	96%

Note: * included in sensitivity analysis.

4.4 Sensitivity analyses

In every SCBA there exists a certain degree of uncertainty due to the assumptions made. A change in assumptions will, to a greater or lesser extent, have an impact on the final results of the SCBA. Therefore, we have considered the consequences:
- Other valuation of night noise hindrance.
- Other distinctions between transferring and terminating passengers.

4.4.1 Noise valuation

As mentioned, there is no valuation of night noise specifically in (academic) literature. Therefore, it is important to consider several options to see what effect our assumptions have on the final result. In the basic SCBA, we have used the direct valuation of DALYs based on highly annoyed persons. The two other approaches, i.e. valuation of L_{den} to calculate L_{night} values respectively and the direct valuation of DALYs based on blood pressure impacts are outlined here, after which the results and weaknesses of the approaches are discussed.

L_{night} valuation based on L_{den}

We derive a value for L_{night} directly from the L_{den} estimates for the UK of HEATCO (2006), based on the formula of L_{den}:

$$L_{\text{den}} = 10 \cdot {}^{10}\log \frac{12 \cdot 10^{\frac{L_{\text{day}}}{10}} + 4 \cdot 10^{\frac{L_{\text{evening}}+5}{10}} + 8 \cdot 10^{\frac{L_{\text{night}}+10}{10}}}{24}$$

The assumption here is that the value changes linearly to changes in dB(A), so when the noise measurement, L_{night}, has a higher weight in the formula of L_{den}, its value also has that higher share in the total value of L_{den}. Table 23 shows the resulting values for L_{night}.

Table 23 **Number of people affected at different noise levels under different scenarios**

L_{night} noise level (dB)	Value per person (GBP_{2010})
50-54.9	23.17
55-59.9	64.65
60-64.9	110.77
65-69.9	157.00
>70	284.18

Combining these values with the number of people affected (see Table 12), yields a negative noise impact of £ 8.2 million under the baseline scenario. Under the project alternatives, night flights are forbidden and a benefit of £ 8.2 million will result[22].

Blood pressure and DALY

The impact of aircraft noise on hypertension has been investigated in some empirical studies. Jarup et al. investigate the relation of hypertension and aircraft noise; also specifically for night time aircraft noise. They define hypertension as systolic blood pressure at the level above 140 mmHg and diastolic blood pressure at the level above 90 mmHg. They report the impact factor in terms of odds ratio (OR): a 10-dB increase in night noise related to an aircraft was associated with OR equal to 1.14 (with 95% confidence interval of 1.01–1.29).

The odds ratio is the ratio of the odds of an event occurring in one group to the odds of the same event occurring in another (control) group[23]. If the probabilities of the event in each of the groups are p_1 (first group) and p_2 (second, control group), then the odds ratio is:

$$\frac{p_1/(1-p_1)}{p_2/(1-p_2)} = \frac{p_1/q_1}{p_2/q_2} = \frac{p_1 q_2}{p_2 q_1},$$

where $q_x = 1 - p_x$. An odds ratio of 1 indicates that the condition or event under study is equally likely to occur in both groups. An odds ratio greater than 1 indicates that the condition or event is more likely to occur in the first group.

We are interested in the increase in the risk of hypertension due to noise exposure, and we will try to estimate relative risk (the ratio of risk of developing hypertension compared with the noise factor to the risk of developing hypertension without the noise factor). If the absolute risk in the control group is available, conversion between the two is calculated by:

$$RR = \frac{OR}{1 - R_C + (R_C \times OR)}$$

where:
RR = relative risk
OR = odds ratio
R_C = absolute risk in the control group

22 Noise during day- and evening hours are considered negligible.

23 Based on Wikipedia.

Jarup et al. report their estimates on the basis of empirical studies carried out in six European countries, including Great Britain (and specifically, the population around London Heathrow). They report that hypertension shows the lowest prevalence in Great Britain (48.8%) and the highest in Greece (57%). It seems a plausible assumption to take the absolute risk in the control group at the level of the average of these two values, i.e. 52.9%. With this assumption, relative risk can be estimated as:

RR = 1.14/ ((1 – 0.529) + (0.529 * 1.14)) = 1.06

This number can be interpreted in such a way that, with each increase of night aircraft noise by 10 dB (above 50 dB), the amount of people with hypertension in the population exposed to night aircraft noise increases by 6%.

Based on these findings, we have calculated the increase in cases of hypertension for the population exposed to aircraft noise around Heathrow. Table 24 shows the results. It reveals that, with a night flight ban, the number of people with hypertension decreases with 6,646. If we apply the disability weight factor for hypertension based on Stassen et al. (2008), which is equal to 0.352, the reduction in DALY is 23.4 annually. Subsequently, this change in DALYs can be combined with the valuation of DALY of £ 29.524 in 2010 prices (based on NEEDS, see above). It indicates that a yearly benefit of roughly £ 690,000 could be obtained by introducing a night flight ban. The discounted benefit for the years 2013-2023 equals £ 5.7 million.

Table 24 Number of high blood pressure cases per year and valuation

	Baseline	R1, R2, R3	
Occurrence high blood pressure	101,211	107,857	
Annual health benefits night ban			
In DALYs			23.4
In GBP			690,676

Discussion

The results of the three different approaches for night noise valuation are presented in Table 25, which shows that there are a large range of outcomes. The benefit of less noise hindrance is 12 times higher with direct valuation of annoyance than in a SCBA where we used valuation of L_{den} to calculate L_{night} values. Subsequently, the impact on the final result is considerable.

Table 25 Overview of noise valuation estimates using three alternative approaches

Results/Approach	1. Valuation L_{den} (£)	2. Annoyance and DALY (£)	3. Blood pressure and DALY (£)
Yearly benefit of ban	8.2 million	98.8 million	0.7 million
Discounted benefit, period 2013-2022	68.5 million	821.7 million	5.7 million
Total Net Present value of night flight ban-R1	**-181,6 million**	**571.6 million**	**-244.4 million**
Total Net Present value of night flight ban-R2	**102.8 million**	**856.0 million**	**40.1 million**
Total Net Present value of night flight ban-R3	**-788.4 million**	**-35.2 million**	**-851.1 million**

It is difficult to choose one approach to rely on in this SCBA as all approaches have their strengths and weaknesses. A weakness of the valuation based on L_{den} is that we rely on a formula of L_{den} in which the weight of L_{night} is debatable.

The direct valuation of DALYs based on highly-annoyed persons has difficulty of determining the number of people with severe sleep disturbance due to aviation. Estimates on road and rail traffic are much more common. The relationship between air traffic and sleep disturbance curves of Miedema is highly uncertain[24]. These curves are only indicative and involve much more uncertainty than the curves for road and rail traffic-related sleep disturbance (see Knol, 2005[25]).

With respect to the direct valuation of DALYs related to blood pressure, an important drawback is that only part of the total health impact is covered. Air noise can cause other effects as well. This means that our estimate is quite conservative and needs to be completed with additional research for other heath impacts. It is a minimal value.

Finally, L_{den} valuation has the advantage that it is based on a formula that is widely used in the EU. At the same time, however, deriving L_{night} from L_{den} valuation has not been done before. Therefore, we were not sure that it would be widely accepted.

We have chosen to use the direct valuation of DALYs related to annoyance as it is probably the least controversial method. In interpreting the results of the SCBA, however, one should bear in mind the great uncertainty of noise valuation and the substantial impact it has on the final outcome of the analysis.

4.4.2 Type of passengers

With respect to the type of passengers (see Section 2.2.2) it is assumed in the basic analysis that the general characteristics of Heathrow Airport, 65% terminating and 35% transferring passengers, also holds for night time in particular. No other data is available. In practice, the share transferring passengers might be higher, as it is reasonable to assume that people arrive at night at Heathrow in order to terminate elsewhere in Europe in the early morning.

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24 In 2002 it was not proposed by Miedema because of the large variance in outcomes.

25 For that reason, Knol (2005) did not use the curves for their study.

In order to outline the sensitivity of the final results to the assumption about the type of passenger, we now assume that 15% more passengers are transferring. So, the analysis is based on 50% terminating passengers and 50% transferring passengers during night time. This has an impact on:

– The value of frequency and travel time for passengers.
  These issues are expected to be relatively more important to transferring passengers, so the cost of a night flight ban on this issue would become higher (under R1), i.e. benefits are lower (under R2).
– The profits of UK airlines.
  Profit losses will be somewhat higher since fewer passengers are transferring at Heathrow Airport (under R2 and R3) compared to the basic analysis.
– Ticket savings of UK passengers.
  Since more passengers would be transferring, travel savings of those UK passengers no longer travelling via Heathrow are higher.

Table 26 shows the results.

Table 26 **Overview of change in costs and benefits when using another share terminating-transferring passengers**

Results/Approach Alternative R1	65% terminating, 35% transferring (£)	50% terminating, 50% transferring (£)
Yearly costs frequency and travel time	30.1 million	47.4 million
Discounted cost frequency and travel time, period 2013-2022	250.1 million	393.9 million
Total Net Present value of night flight ban	**571.6 million**	**427.8 million**

Results/Approach Alternative R2	65% terminating, 35% transferring (£)	50% terminating, 50% transferring (£)
Yearly *benefit* frequency and travel time	4.8 million	2.9 million
Discounted benefit frequency and travel time, period 2013-2022	39.9 million	23.8 million
Yearly profit loss	3.4 million	3.8 million
Discounted profit loss, period 2013-2022	28.5 million	31.8 million
Yearly savings travel expenses	2.7 million	2.8 million
Discounted savings travel expenses, period 2013-2022	22.9 million	23.5 million
Total Net Present value of night flight ban	**856.0 million**	**837.2 million**

Results/Approach Alternative R3	65% terminating, 35% transferring (£)	50% terminating, 50% transferring (£)
Yearly profit loss	8.0 million	8.4 million
Discounted profit loss, period 2013-2022	66.8 million	70.2 million
Yearly savings travel expenses	4.7 million	4.8 million
Discounted savings travel expenses, period 2013-2022	39.2 million	39.8 million
Total Net Present value of night flight ban	**-35.2 million**	**-38,0 million**

It turns out that a higher share of transferring passengers during the night at Heathrow means that the net benefits of a night flight ban are somewhat lower under all project alternatives. Differences are not substantial, though. Final results are less sensitive to the assumption we made on the share of transferring/terminating passengers than to our assumption on noise valuation.

5 Conclusions

Our overall conclusion is that a ban on night flights at Heathrow is likely to be beneficial to the economy as the economic costs of the ban will be outweighed by the savings made by the reduced health costs of the sleep disturbance and stress caused by the noise of the night flights.

The cost of a night flight ban is likely to range from a saving to the UK economy of almost £ 860 million per year to a loss of £ 35 million.
A loss would only occur if all current night time passengers stopped travelling to Heathrow once a night flight ban was introduced. That however is highly unlikely.

The most likely scenario is that a proportion of them will continue to use the airport. If that is the case, a night flight ban before 6.00am will bring economic benefits to the overall economy. This is because there will be a significant decrease in the costs associated with sleep disturbance, together with a smaller decrease in the costs of air pollution. The savings, in terms of improved health and well-being, are expected to offset the main costs of a ban – inconvenience to passengers' journeys and airline profits - by a wide margin. Finally we conclude that job losses from a ban would be small as the number of jobs directly dependent on night flights is not high and employees would find other jobs in a well-functioning labour market.

A summary is presented in Table 27.

Table 27 Summary of costs and benefits of a night time ban at London Heathrow

Costs	Million GBP	Benefits	Million GBP
Freq and travel time	250.1 - +39.9	Noise reduction	821.7
Profits	0-66.8	NO_x emission reduction	0-2.4
APD and freight profits	PM	Saving travel expenses	0-39.2
Non-air revenues	PM		
Indirect effects - employment	PM		
Indirect effects - tourism	0-831.7		
Total	28.5-898.4	Total	821.7-884.5
		Balance	**-35.2-856.0**

Source: This report.

The results are sensitive, however, to the valuation of night noise, and we recommend studying the benefits of noise reductions in more detail. Other items that require more study are the impact on passenger choices and on airline networks.

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Annex A Day and night flights on selected routes

It is possible to reschedule night flights to daytime arrivals.
This is demonstrated by the fact that each airport from which night flights arrive at Heathrow, is also served with a connection arriving in daytime. Table 28, Table 29, Table 30 and Table 31 below show four examples.

Table 28 Flights from Hong Kong (HKG) to Heathrow (LHR) on Monday, 8 November 2010

Time of departure (HKG)	Time of arrival (LHR)	Airline
1.05 am	6.20 am	Cathay Pacific
8.00 am	1.30 pm	Qantas Airways
9.20 am	3.00 pm	Cathay Pacific
2.55 pm	8.10 pm	Cathay Pacific
11.25 pm	4.50 am	British Airways
11.30 pm	4.50 am	Virgin Atlantic
11.45 pm	5.00 am	British Airways

Source: expedia.com

Table 29 Flights from Singapore (SIN) to Heathrow (LHR) on Wednesday, 10 November 2010

Time of departure (SIN)	Time of arrival (LHR)	Airline
9.05 am	3.05 pm	Singapore Airlines
12.55 pm	6.55 pm	Singapore Airlines
10.55 pm	4.50 am	British Airways
11.20 pm	5.25 am	Qantas Airways
11.45 pm	5.45 am	Singapore Airlines
11.59 pm	6.20 am	Qantas Airways

Source: expedia.com

Table 30 Flights from Riyadh (RUH) to Heathrow (LHR) on Tuesday, 9 November 2010

Time of departure (RUH)	Time of arrival (LHR)	Airline
1.45 am	5.55 am	bmi
8.30 am	12.35 pm	British Airways

Source: expedia.com

Table 31 Flights from Boston (BOS) to Heathrow (LHR) on Thursday, 11 November 2010

Time of departure (ORD)	Time of arrival (LHR)	Airline
6.10 pm	5.25 am	British Airways
6.20 pm	5.55 am	American Airlines
7.45 pm	7.25 am	Virgin Atlantic
8.20 pm	7.40 am	British Airways
8.15 am	7.30 pm	British Airways
9.05 am	8.40 pm	American Airlines

Source: expedia.com