Policy Programmes Team

Definition of overflight

CAP 1498

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Executive summary

1. Through this study, we have developed and presented our thinking around the definition and metric for assessing aircraft overflights primarily in the context of evaluating airspace change proposals. We propose the following definitions:

2. Definition of overflight
    An aircraft in flight passing an observer at an elevation angle (approximately the angle between the horizon and the aircraft) that is greater than an agreed threshold, and at an altitude below 7,000 ft.

3. Overflight metric
    The number of overflights experienced by a ground-borne observer over a given period of time.

4. We hope that providing a clear definition of what is an overflight will help conversations about airspace matters. It aims to reduce the confusion that arises when the term is used by people who have different understandings of what is an overflight.

5. The overflight metric enables the number of overflights experienced at locations on the ground to be calculated according to the agreed definition. Quantifying the number of overflights will help airspace change sponsors to present the possible effect of proposals on local communities that are exposed to noise from aircraft up to 7,000 feet. It will also help inform debates between industry and local community stakeholders about proposals, and will help us make decisions on such proposals.

Chapter 1

Introduction

Background

1.1   One of our functions is overseeing trials of new aircraft operating procedures and airspace change proposals at various UK airports. Through this work, we have identified the need for information on numbers of aircraft overflights, both for assessing airspace change, and also for our duty to publish information on aviation and the environment.

1.2   There is no internationally agreed definition of an aircraft 'over-flight', and over the past few years, we have discovered that overflight means different things to different people. There is a need for greater clarity over its definition.

1.3   In collaboration with the Department for Transport (DfT) we are revising our guidance on the airspace change process[1]. The outcome of our consultation on a revised airspace change process is documented in CAP1465[2]. Through what we have already learnt by listening to industry and local community stakeholders during the development of this guidance, we are proposing to bring the concept of overflight into the assessment of airspace options. This concept therefore needs a clear definition so that we can set criteria and options can be measured against them.

1.4   Also through listening to stakeholders, we know that local communities situated outside the standard noise contours used for assessing airspace changes[3] as well as the contour which marks the approximate onset of significant community annoyance, as given in paragraph 3.17 of the

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[1]   Existing guidance is given in CAP725: Airspace Change Process Guidance Document, Civil Aviation Authority, March 2016.

[2]   CAP1465: CAA response following consultation on proposals for a revised airspace change process, Civil Aviation Authority, October 2016.

[3]   CAP725, 57 dB L_{Aeq} and 90 dB(A) SEL contours.

Aviation Policy Framework (APF)[4], can also be adversely affected by passing aircraft. To represent people/communities affected in this way, we wish to propose a metric to quantify overflight both inside and outside of the standard noise contours.

Aim

1.5   This report documents a study which aims to:

- define overflight as it relates to airspace regulation, ensuring that affected community stakeholders living outside the traditionally used noise contours are represented; and
- define an overflight metric which may be used to quantitatively compare different airspace options.

1.6   The expectation is that these will form supplemental information required for the airspace change process. We will address these two aims simultaneously in the following chapters.

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[4]   Aviation Policy Framework, Cm 8584, Department for Transport, March 2013.

Chapter 2

How 'overflight' has been used to date

Overflight in policy

2.1   The Air Navigation Guidance[5] (ANG) is a DfT document which provides the CAA with guidance on how it should exercise its air navigation functions. This document is undergoing revision, and the DfT would like to consider the concept of overflight for inclusion in the revised guidance.

2.2   The current guidance will only be valid until the revised guidance is published. However, we mention some aspects of the current guidance here to show how the concept of overflight has already been used.

2.3   Chapter 7 of the ANG refers to overflight principally in the context of concentration versus dispersal of flight paths[5]. In summary, improving safety and efficiency has given rise to technologies which concentrate the paths of departing aircraft along a relatively small number of routes. The Government's current policy (which is under review) is to concentrate departures on the least number of practical routes designed to avoid densely populated areas. The aim has therefore been to minimise the number of people over-flown at low altitudes. Tools have therefore been developed to illustrate where aircraft fly with respect to residential areas in the vicinity of airports.

2.4   Section 8.2 of the ANG also refers to overflight in the context of the protection of landscapes and scenic beauty. It states that:
'Flights over National Parks and AONB are not prohibited by legislation as a general prohibition against over-flights would be impractical. Government policy will continue to focus on minimising the over-flight of more densely populated areas below 7,000 feet (amsl[6]), but balanced with

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[5]   Guidance to the Civil Aviation Authority on Environmental Objectives Relating to the Exercise of its Air Navigation Functions, Department for Transport, 2014.

[6]   Above mean sea level.

emissions between 4,000 and 7,000 feet (amsl), as set out in the altitude-based priorities in Chapter 4.1 of this Guidance. However, where it is practical to avoid over-flight of National Parks and AONB below 7,000 feet (amsl), the CAA should encourage this'.

2.5   This refers to the altitude-based priorities, i.e. which environmental effects should be addressed first depending on the altitude of the aircraft, which are set out in earlier in Chapter 4.1 of the ANG. These are copied below for convenience:

> *a.   in the airspace from the ground to 4,000 feet (amsl) the Government's environmental priority is to minimise the noise impact of aircraft and the number of people on the ground significantly affected by it;*
>
> *b.   where options for route design below 4,000 feet (amsl) are similar in terms of impact on densely populated areas the value of maintaining legacy arrangements should be taken into consideration;*
>
> *c.   in the airspace from 4,000 feet (amsl) to 7,000 feet (amsl), the focus should continue to be minimising the impact of aviation noise on densely populated areas, but the CAA may also balance this requirement by taking into account the need for an efficient and expeditious flow of traffic that minimises emissions;*
>
> *d.   in the airspace above 7,000 feet (amsl), the CAA should promote the most efficient use of airspace with a view to minimising aircraft emissions and mitigating the impact of noise is no longer a priority;*
>
> *e.   where practicable, and without a significant detrimental impact on efficient aircraft operations or noise impact on populated areas, airspace routes below 7,000 feet (amsl) should, where possible, be avoided over Areas of Outstanding Natural Beauty (AONB) and National Parks as per Chapter 8.1 of this Guidance; and*
>
> *f.   all changes below 7,000 feet (amsl) should take into account local circumstances in the development of airspace structures.*

2.6   These priorities, or criteria, are relevant in setting an overflight metric that extends beyond standard noise contours but reflects the relative environmental impact of aircraft passing over residential areas.

Overflight in assessments

2.7   After we receive a request for an airspace change from a Change Sponsor (the proposer of the change), we follow a particular process to reach a decision on whether to make the change. The process is set out in our guidance document, CAP725[7]. It is this document that we are revising.

2.8   The existing (March 2016) version of CAP725 sets out the requirements for assessing an airspace change proposal; the Environmental Requirements are given in Appendix B of CAP725:

- Section 4 of this appendix sets out the Standard Techniques, listing what information Change Sponsors must provide in order for us to assess the noise effects of proposals.

- Section 5 sets out the Supplementary Methods, i.e. additional information which Change Sponsors can choose to provide if they think it will help us to make the decision. Overflight is addressed in this section, under the 'Population Count Methodology', which is a *'simple count of either the population residing or the residential area beneath the proposed affected airspace'*.

2.9   Although this simple population count method is easy to understand and gives an indication of populations and areas overflown, including those outside the standard noise contours, the metric has limitations, as set out in CAP725 and summarised here:

- The overflown areas are considered to be those within a swathe extending 1.5 km either side of a departure track. This is a historic definition based on the navigational capability of aircraft using

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[7]   CAP725: Airspace Change Process Guidance Document, Civil Aviation Authority, March 2016.

outdated navigational technology; current technology enables an aircraft to follow a track much more accurately. The method does not necessarily correlate with noise impacts experienced on the ground, nor paint a reasonable picture of areas overflown by aircraft.

- Air Traffic Control (ATC) directs arriving aircraft to fly within wide swathes to help get the aircraft at the right separating distances as they line up with the runway. These swathes are presented by Change Sponsors as areas that may be overflown. Relative to the narrower departure swathes, however, there will be a lower probability of being overflown beneath the wider arrival swathes which is not usually reliably quantified in assessments.

- Not all individuals within the swathe are affected to the same extent. Individuals further from the airport where aircraft are at higher altitudes will be less affected by noise than those closer to the airport where aircraft are lower and create more noise on the ground. The population count method does not differentiate between these.

- The population count method does not take account of route usage. Some swathes will be used more frequently than others, but the method does not take this into account.

- Calculating the overflown built-up areas relies on definitions of built-up areas, usually taken from GIS (Geographical Information System) mapping.

2.10   The Population Count Methodology can be built upon for developing an overflight metric, but we will need to overcome these limitations for it to be effective. We address these in the following chapter.

2.11   The swathes that have been used to define overflight areas were originally conceived for airports, airlines and air navigation service providers to measure and monitor track-keeping performance (referring to the first bullet point in paragraph 2.9 above). This is a very objective exercise, to identify whether an aircraft path is within a certain perpendicular distance of a particular track. Overflight, from the perspective of a person on the ground, brings an element of subjectivity. Two people may have different views of whether an aircraft passing

nearby is an overflight, depending on its altitude and lateral distance from the observer.

2.12   Using a single metric to assess both track-keeping performance and overflight therefore presents a potential source of conflict. We think that the distinction should be made between these analyses, and that the definition of overflight and metric should not be used in assessing track-keeping performance.

Representation of overflight

2.13   Aircraft flights are typically represented on maps as lines showing the tracks flown by aircraft (see Figure 1), or as track density diagrams (see Figure 2) where the darker shaded areas represent areas that have been overflown a greater number of times than the lighter shaded areas. These diagrams have been used for ad-hoc studies to indicate where aircraft have flown, or to indicate the intensity of flights over a particular region.

Figure 1: Flight track diagram for a typical summer day at Heathrow Airport – departures only
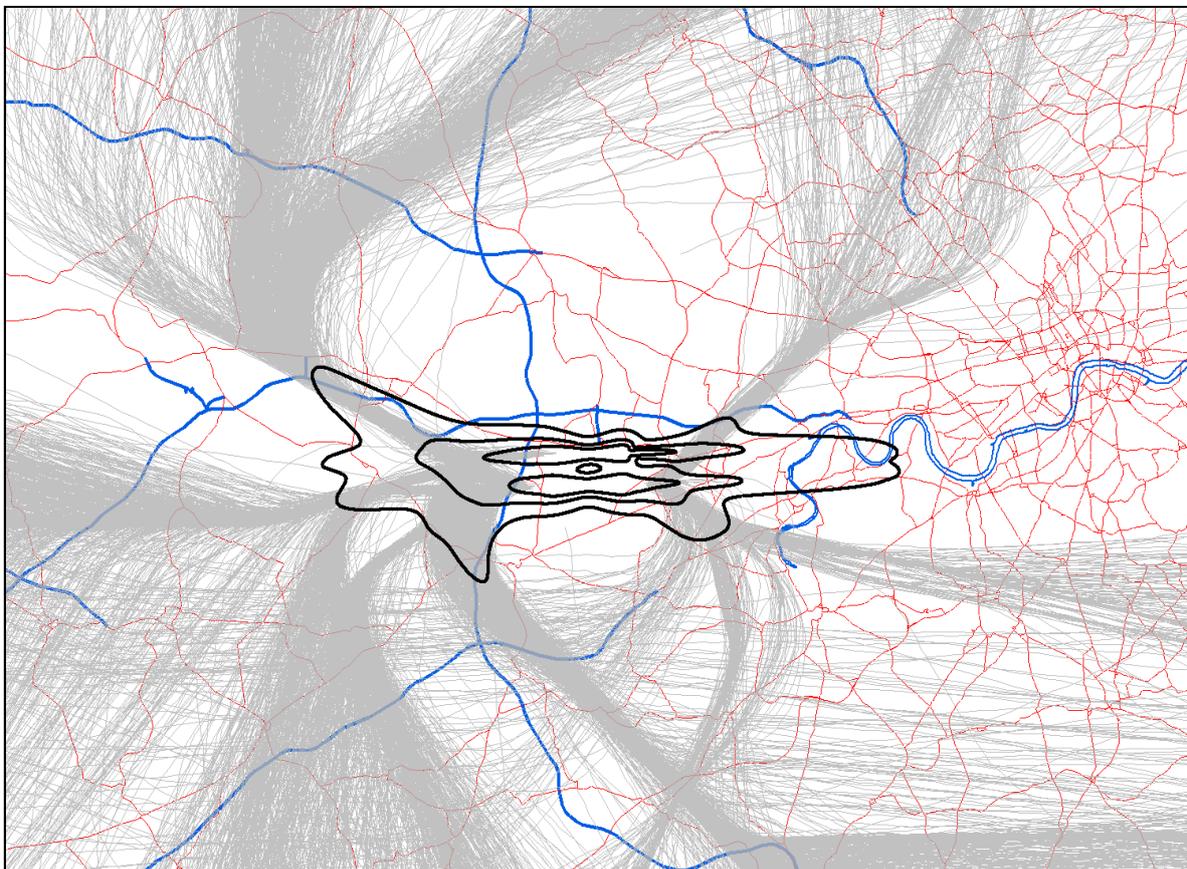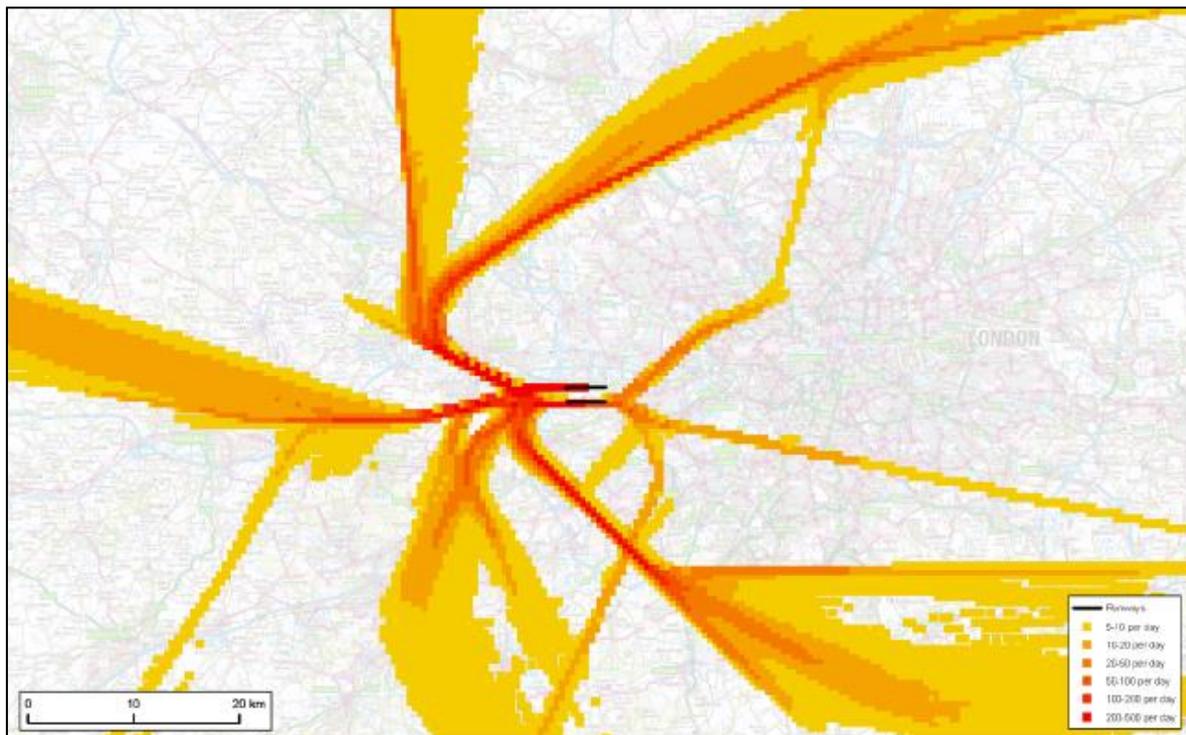
**Figure 2: Track density diagram for a typical summer day at Heathrow Airport – departures only**

2.14   The flight track diagram clearly shows where individual aircraft flew in the period, but where the tracks overlap it is impossible to know how many overflights a particular area on the ground has experienced. It is useful for illustrating track-keeping performance but is of limited use as a means of illustrating or quantifying overflights.

2.15   By contrast, the track density diagram does show how many overflights have been experienced by locations on the ground. However, the main limitation of track density representation is the method used to calculate it. This is done by dividing the ground into a grid of squares and for each square counting the number of times an aircraft passes directly above any part of it.

2.16   Depending on the geometry of the flight path and the size of the grid squares, a ground track could be located relatively close to a point on the ground but still not be counted as overhead, whereas other points further away would be counted as being overflown, see Figure 3. Larger grid squares can be used to overcome this issue but the diagrams then become less effective at indicating the overall pattern of flight paths.

Figure 3: Illustrative flight track passing through grid squares

> Flight track is closer to point A than point B, but not counted as overhead of point A.
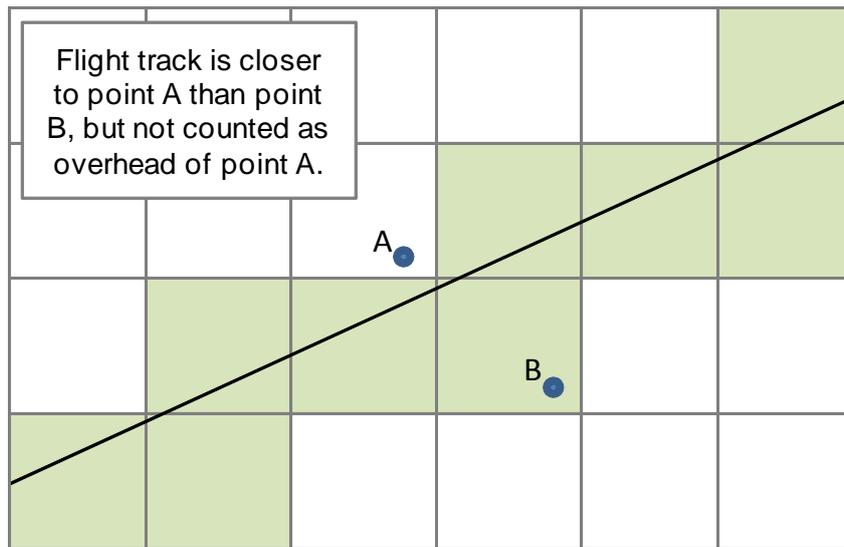
2.17   Another problem is that the areas of ground affected by an aircraft passing overhead depend on the size of the squares. A coarse grid of large squares will result in larger affected areas than a fine grid of small squares. Figure 4 shows this, where for the same sample of five flight tracks, the total area overflown is 115 km^2 for the fine grid, and 160 km^2 for the coarse grid. Furthermore, the coarse grid gives a poorer indication of the overall pattern of flight paths, as mentioned in paragraph 2.16.

Figure 4: Coarser grids (larger squares) result in larger affected areas than fine grids (small squares)

Fine grid
Area overflown = 115 km²

Coarse grid
Area overflown = 160 km²

Legend: ☐ 1 km²   ▨ 1 km² overflown
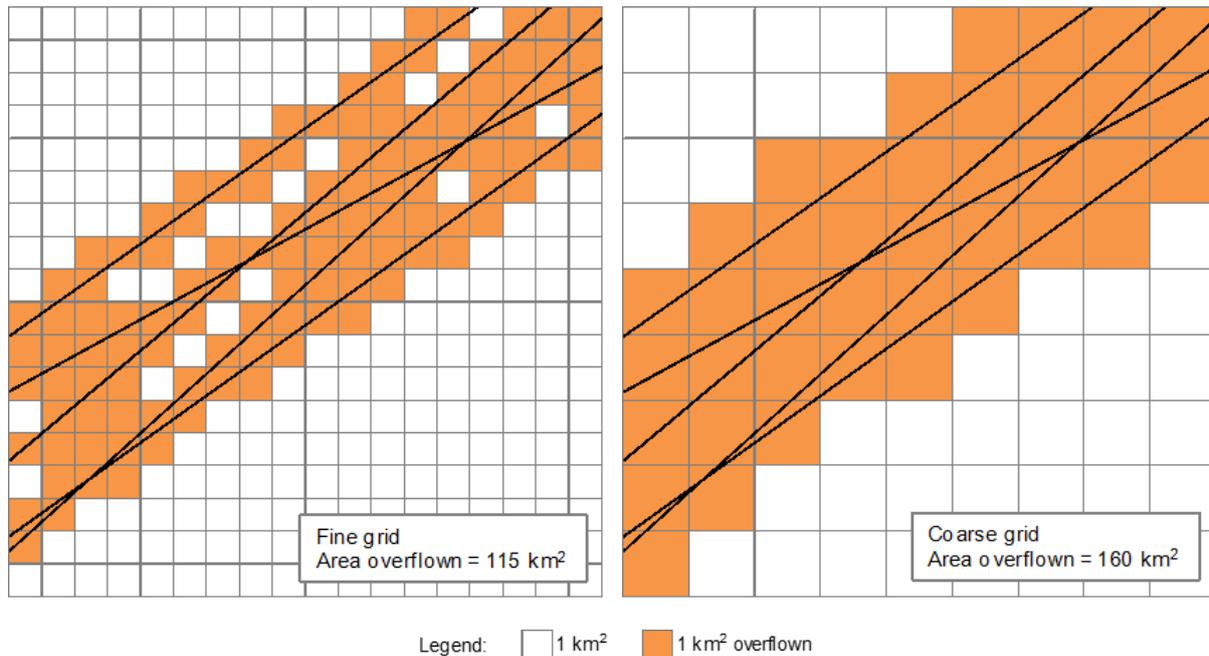
2.18   Additionally, a larger square will have a higher probability of being overflown. Therefore, for a given set of flight tracks, a coarser grid of larger squares will result in higher numbers of overflights, and therefore higher densities. Figure 5 illustrates this, showing that the fine grid reports densities of up to 2 overflights and the course grid reports densities of up to 3 overflights for same sample of five flight tracks. When scaled up to typical numbers of overflights, the differences in densities becomes very significant.

Figure 5: Coarser grids (larger squares) result in more reported overflights than fine grids (small squares)

Fine grid
Track density ≤ 2

Coarse grid
Track density ≤ 3

Legend (overflights):   1   2   3
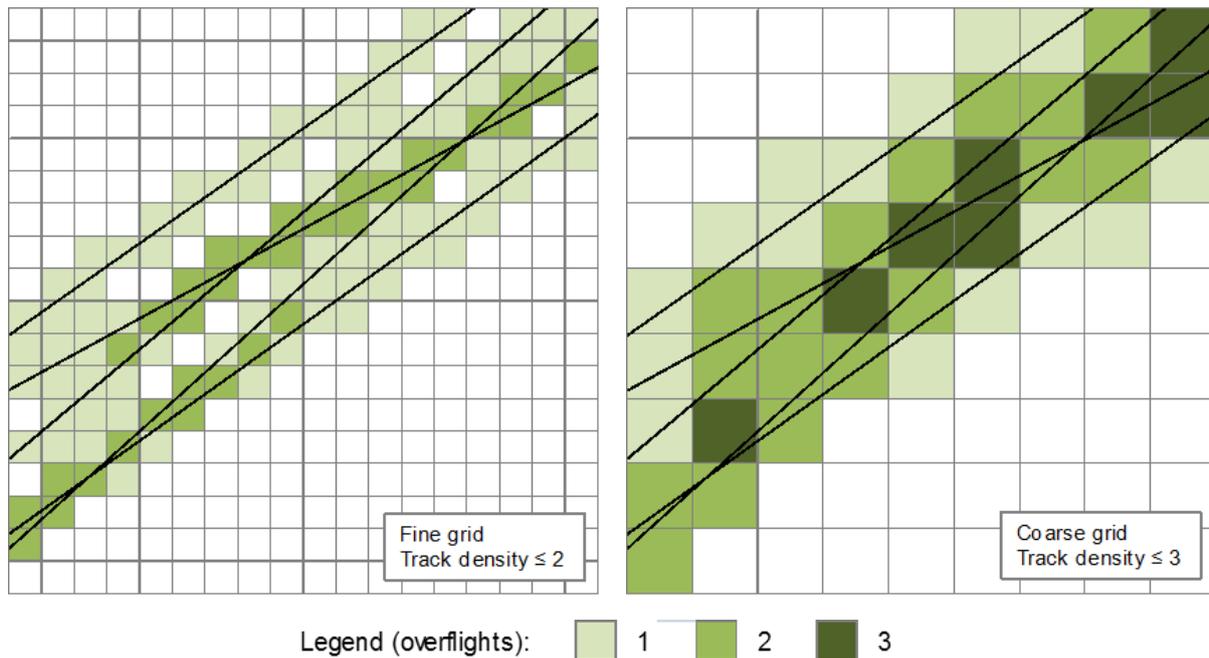
2.19   If the metric were to be used for making comparisons between airspace layouts, we would need to standardise the size of the squares, which brings further problems. A fine grid may be needed to show localised differences between quite similar airspace layouts, whereas a coarse grid may be more appropriate to portray a whole airport (each square is calculated separately, so a fine grid for a whole airport would take a disproportionate amount of time to calculate).

2.20   We will need to address this for any new overflight metric.

Chapter 3

Developing the definition and metric

3.1   In this chapter we will consider the elements needed for the definition to be meaningful and the metric to be effective, and address the limitations highlighted in the previous chapter.

Criteria for the definition and metric

3.2   We propose that the overflight definition and metric should:

- Be clear and unambiguous, i.e. be understood by all without any further explanation and offer no scope for misinterpretation
- Represent the experience of residents affected by noise from aircraft flying nearby
- Relate to aircraft noise levels
- Represent the interests of those affected by overflying aircraft whether they live inside or outside of the standard noise contours
- Illustrate and quantify overflight for existing airspace layouts
- Be unaffected by mapping or computational factors
- Be able to show the difference between two different airspace layouts
- Be able to show the difference between concentrated and dispersed flight tracks
- Meet the above criteria for proposed (as well as existing) airspace layouts
- Be used only when appropriate

3.3   The above criteria will be addressed in this chapter, where we set out our thinking leading to our proposal for a new definition of overflight and overflight metric.

Development

Definition based on perception

3.4   To date, overflight has been assessed to be when an aircraft passes directly over the observer, see Figure 6. This has been calculated using the grid method described in Chapter 2.

Figure 6: Overflight assessed as aircraft passing directly over the observer
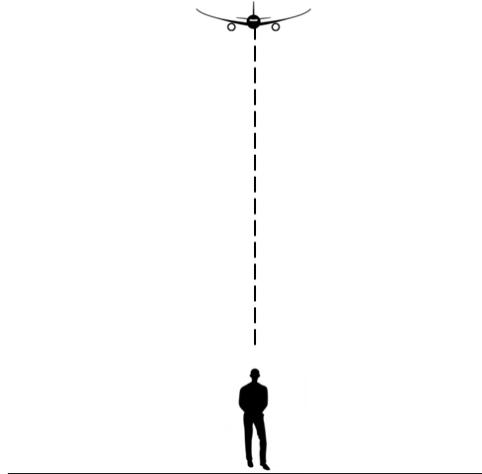
3.5   However, we understand that an aircraft does not have to be directly overhead to be considered an overflight by a person on the ground, see Figure 7. Feedback from residents affected by recent SID trials at the London airports has highlighted the difficulties in determining whether an aircraft is considered to be overhead or to the side of its expected flight path.

Figure 7: An aircraft not directly overhead still being considered an overflight
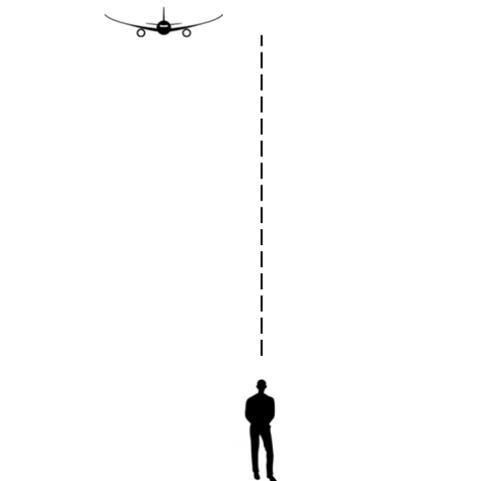
3.6   An illustrative example arose during helicopter monitoring for the Greater
           London Council (GLC) in the 1980's and refers to monitoring of routine
           helicopter flights in central London that were required to navigate along
           the river, as today. Analysis of logs showed that observers on both the
           north and south banks of the river reported the same aircraft had
           overflown them, but the aircraft could not have been directly above both
           banks at the same time.

3.7   To accommodate this, we propose to define overflight so as to include
           aircraft that pass above and to the side of an observer. The distance that
           an aircraft can be to the side and still be considered an overflight will be
           set using a threshold on the elevation angle of the aircraft. Figure 8 below
           illustrates this. The elevation angle is the angle between the ground and
           the aircraft as seen from the observer at ground level. An aircraft flying
           directly overhead would be at an elevation angle of 90°, and an aircraft on
           the ground would be at an elevation angle of 0°.

Figure 8: Overflight when an aircraft passes an observer above an elevation angle threshold
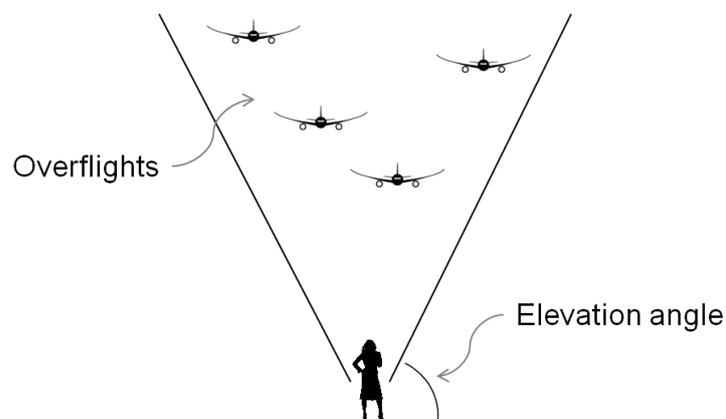

3.8   This accommodates the perception that an aircraft is overhead even when
           it is above and to the side (lateral) of an observer. Anecdotal evidence
           (see paragraph 3.6) suggests that the visual location of an aircraft in the
           sky is a part of how an observer decides whether an aircraft is overflying
           them. By basing the threshold on an elevation angle, aircraft at higher
           altitudes may be at greater lateral distances and still be considered
           overflights. This meets the second criterion listed earlier, that the metric

represents the experience of residents affected by noise from aircraft flying nearby.

3.9   The third criterion is that the definition should **relate to aircraft noise levels**. To meet this, our view is that for an observer on the ground, the noise produced by an overflight should be within a known range.

3.10   The distance between the aircraft and the observer is called the propagation distance. The greater the propagation distance, the further the sound has to travel, getting weaker in the process. For an aircraft overflying an observer at a given altitude, say 1,000 m (3,280 feet), the shortest propagation distance between the aircraft and the observer (known as the slant distance) occurs when the aircraft is directly overhead, i.e. 1,000 m. If the aircraft is 500 m to the side of the observer, the distance between the aircraft and the observer increases to 1,118 m. The extra 118 m (12%) added to the propagation distance results in a reduction in the maximum sound level of 1.3 dB. This is illustrated in Figure 9 below.

Figure 9: Illustrating effect of lateral distance on slant distance and noise level at the observer
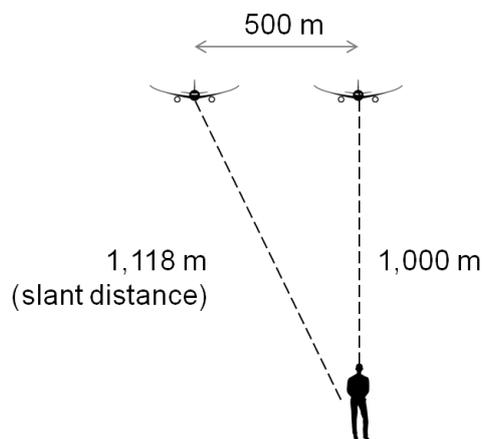
3.11   In the example above, the elevation angle of the aircraft at 1,000 m altitude and 500 m lateral distance is 63°. If the aircraft was at 2,000 m altitude and 1,000 m lateral distance, the elevation angle would also be 63°, and again, the noise level at the observer aircraft would be 1.3 dB less than if the aircraft was directly overhead at 2,000 m altitude. In other words, compared to an aircraft flying directly overhead, the reduction in

noise at the observer is constant for a constant elevation angle, no matter the altitude of the aircraft.

3.12   This means that we can define overflight to be when an aircraft passes by an observer at an elevation angle above a threshold angle. This definition relates to aircraft noise levels, and we think that this will better represent the experience of residents affected by noise from aircraft flying nearby than the metrics currently in use.
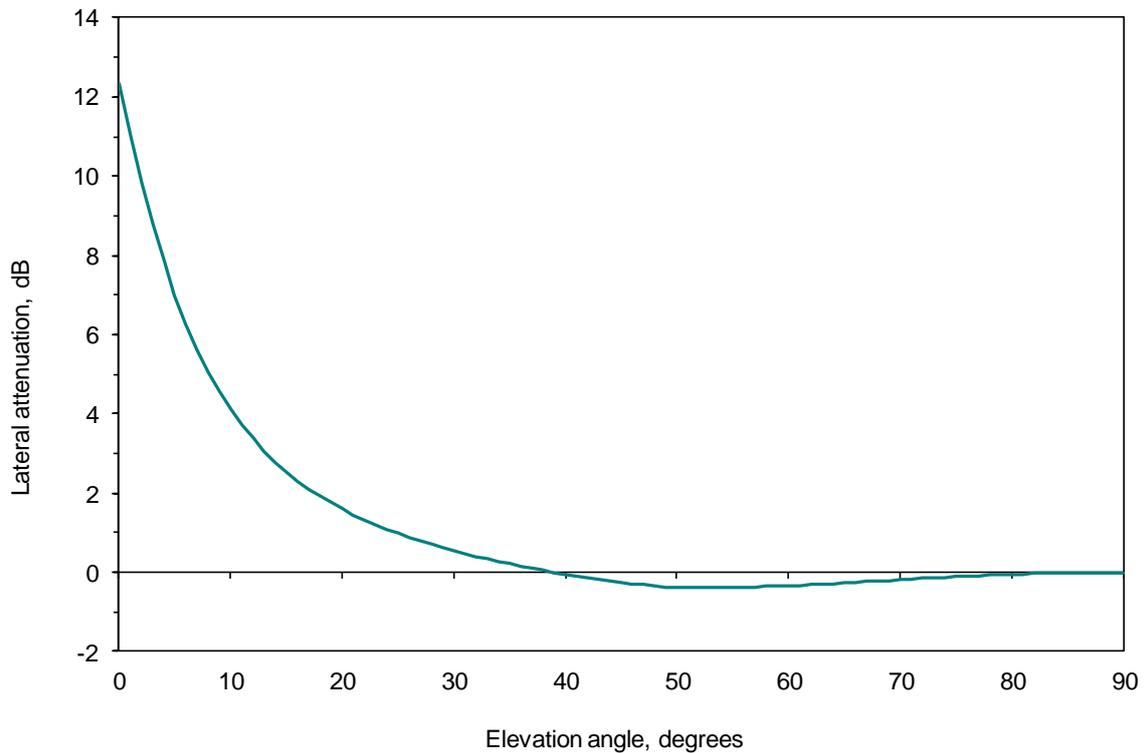
Elevation angle threshold

3.13   Having established that elevation angle is an appropriate parameter for the threshold, we now need to determine a suitable threshold elevation angle. In our recent work[8] to revise our guidance on the airspace change process, we have started using this concept with two trial elevation angle thresholds: 60° and 48.5°. These are discussed below.

3.14   Above elevation angles of 60°, aircraft sound is influenced by the propagation distance, the amount of sound generated by the aircraft and, for some noise metrics[9], the duration of the sound.

3.15   Below elevation angles of 60° the sound propagation begins to be influenced by additional factors such as atmospheric scattering effects, engine shielding (which is also influenced by engine type/location) and, at lower elevation angles, ground absorption. All these effects are collectively known as lateral attenuation.

3.16   Figure 10 shows the effect of lateral attenuation for aircraft with wing mounted engines. At elevation angles below approximately 60°, lateral attenuation starts to become important; noise attenuation is reduced (i.e. observer noise levels increase) by up to around 0.5 dB between 40° and 60°. Below about 35°, lateral attenuation increases dramatically, reducing noise levels at a given observer location.

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8   CAP1378: Airspace Design Guidance: Noise Mitigation Considerations when Designing PBN Departure and Arrival Procedures, Civil Aviation Authority, April 2016.

9   Exposure noise metrics such as SEL and L_{eq} depend on not just the level of the noise, but also how long the noise is heard for by an observer.

Figure 10: Attenuation of noise from aircraft with wing-mounted engines vs elevation angle (source, SAE International AIR-5662)

3.17   By using a threshold elevation angle of 60° we can avoid the added complications of these effects. More information is given in a study we reported in 2003[10].

3.18   Following our explanation in paragraph 3.11, an aircraft flying through the boundary of the 60° elevation angle threshold at any given height above the ground would give a noise level approximately 1.5 dB lower than if it had flown directly overhead at the same height.

3.19   It is widely accepted in the environmental acoustics profession that 3 dB is the smallest difference between two noise levels that the average person can perceive when the noises are not heard one immediately after the other. This is stated in former planning policy guidance[11] which set quantified guidelines on the acceptability for residential development of sites exposed to noise from existing sources. A threshold based on the

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[10]   ERCD Report 0207, 'Departure Noise Limits and Monitoring Arrangements at Heathrow, Gatwick and Stansted Airports', March 2003.

[11]   Planning Policy Guidance 24: Planning and Noise, Department for Communities and Local Government, ISBN 9780117529243, October 1994.

smallest perceptible difference between noise levels is attractive from a noise perspective. For an aircraft to give a noise level approximately 3 dB lower than if it had directly overflown the centre at the same height, it would need to be at an elevation angle of 48.5°.

3.20   The 60° and 48.5° thresholds are illustrated in Figure 11. For a 60° elevation angle threshold, an aircraft at a height of 2,000 ft and located, for example, 400 m laterally would not be considered overhead. However, at the same lateral distance an aircraft flying at 3,000 ft would be considered overhead. Using a 48.5° threshold, the aircraft would be considered overhead in both the above examples. However, if it were at a height of 1,000 ft at the same lateral distance, it would not be considered overhead.

Figure 11: Lateral distance and altitude of aircraft on 60° and 48.5° elevation angle thresholds
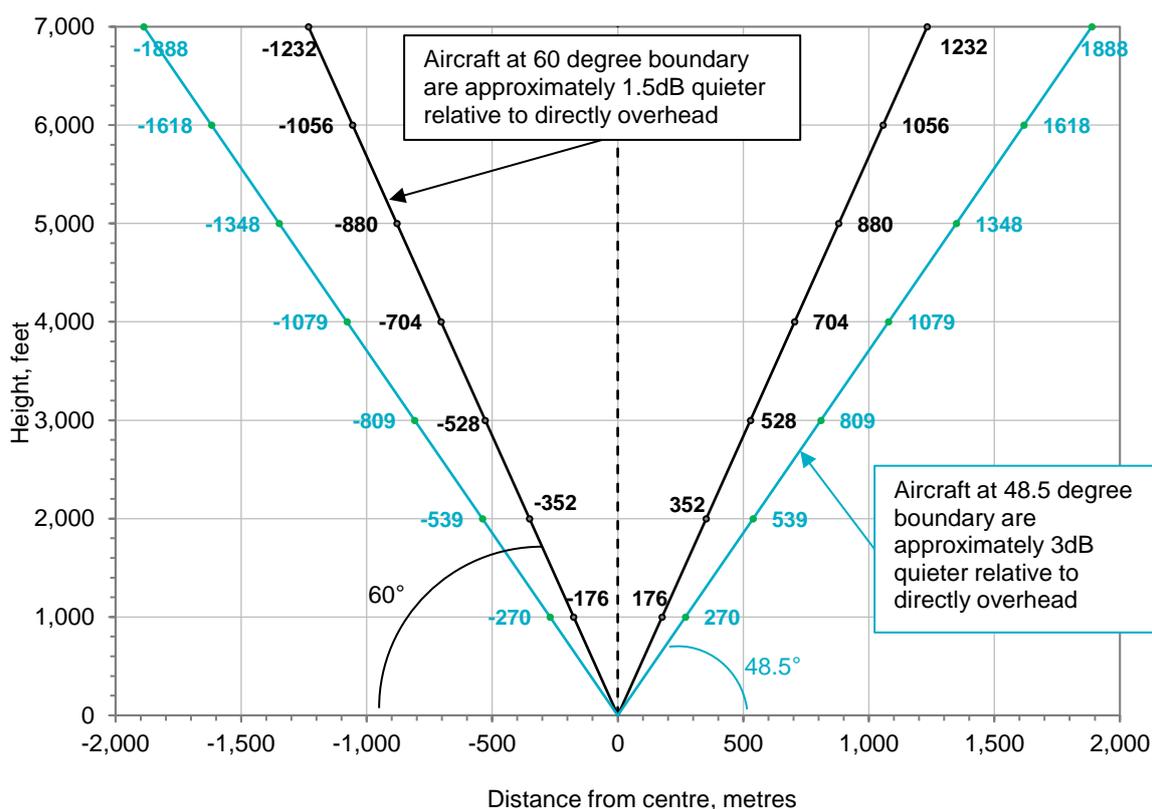
3.21   This concept could be used for aircraft at any altitude. As the standard noise contours for assessing airspace change are affected by aircraft at

altitudes of only a few thousand feet, this concept could be applied to aircraft and, importantly, locations outside the standard noise contours. This way, the definition meets the fourth criterion to **represent the interests of those affected by overflying aircraft whether they live inside or outside of the standard noise contours**.

3.22   Figure 11 shows this concept being used for aircraft at altitudes up to 7,000 ft. According to the ANG[12], this is the highest altitude for which noise management is prioritised above or equal to greenhouse gas emissions. At the same time, noise takes ultimate priority over emissions up to 4,000 ft, so this may may also be used as a threshold.

3.23   We will therefore take the elevation angle threshold concept forward using threshold angles of 60° and 48.5° and altitude cut-offs of 4,000 and 7,000 ft.

Illustration and quantification of overflights

3.24   Anyone with access to radar data who wishes to illustrate numbers of overflights on a map would need to be able to use computer modelling to consistently and reliably simulate what happens in the real world. In this section we develop the elevation angle concept to enable a computer programmer to write software to calculate numbers of overflights and illustrate these on a map.

3.25   So far we have discussed the elevation angle thresholds in two-dimensions. Since we live in a three-dimensional world, we need to adapt the concept to also work in three-dimensions. We therefore turn the flat triangular boundaries shown in Figure 11 into a cone, see Figure 12 below.

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[12]   Guidance to the Civil Aviation Authority on Environmental Objectives Relating to the Exercise of its Air Navigation Functions, Department for Transport, 2014.

Figure 12: Cone marking 60° elevation angle threshold

Aircraft passing
through circle are
overflights

Flight path
of aircraft

60°
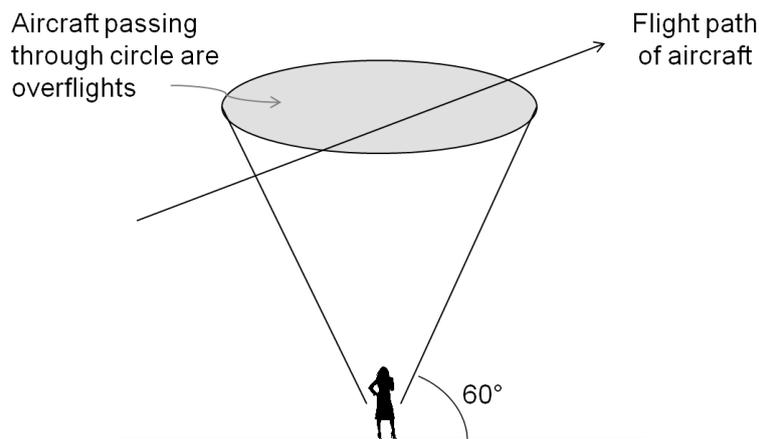
3.26   From the point of view of an observer, an aircraft passing through any part of the circle, formed by slicing through the cone at the altitude the aircraft is flying at, will be considered to be an overflight.

3.27   Alternatively, from the aircraft's perspective, Figure 3.8 shows an equivalent 60°cone turned upside down and below the aircraft. All observer locations enclosed by the circle are overflown by the aircraft (because for every location the aircraft is at an elevation angle of 60° or more).

Figure 13: Cone marking 60° elevation angle threshold from the aircraft's perspective

Flight path
of aircraft

Ground track
of aircraft

Observers in circle
are overflown
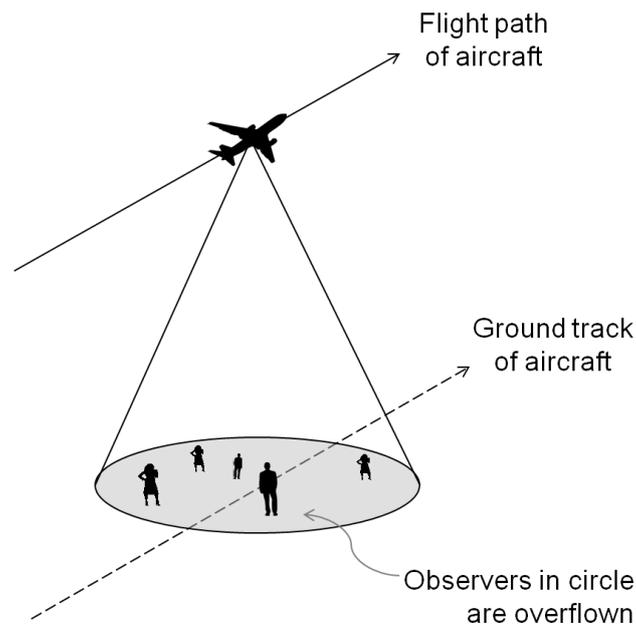
3.28   This three-dimensional cone concept can now be coded into a computer model. With this, we can calculate the numbers of overflights at any point on the ground. This means, for a set of flight tracks, we can calculate the number of overflights experienced by individual observers.

3.29   We can repeat the calculation across a grid of points, like we do to calculate noise contours, and draw lines between points having the same number of overflights (using interpolation) to generate overflight contours. The difference between noise contours and overflight contours, therefore, is that noise contours show geographical areas exposed to different noise levels, whereas overflight contours show geographical areas which experience different numbers of overflights.

3.30   Figure 13 shows overflight contours calculated using 60° and 48.5° cones respectively for the same flight track data as that used to produce Figure 2, up to an altitude of 4,000 ft. We have presented the contours at 1, 5, 10, 20, 50, 100 and 200 overflights per day, similar to the levels used to present 'number above' contours, e.g. N70 and N60 (the 1 and 5 levels are not typically presented due to the uncertainty in the predictions at these low levels, but included here for information only).

Figure 14: Overflight contours for a typical summer day at Heathrow Airport, to 4,000 feet – departures only (60° and 48.5° cones respectively)
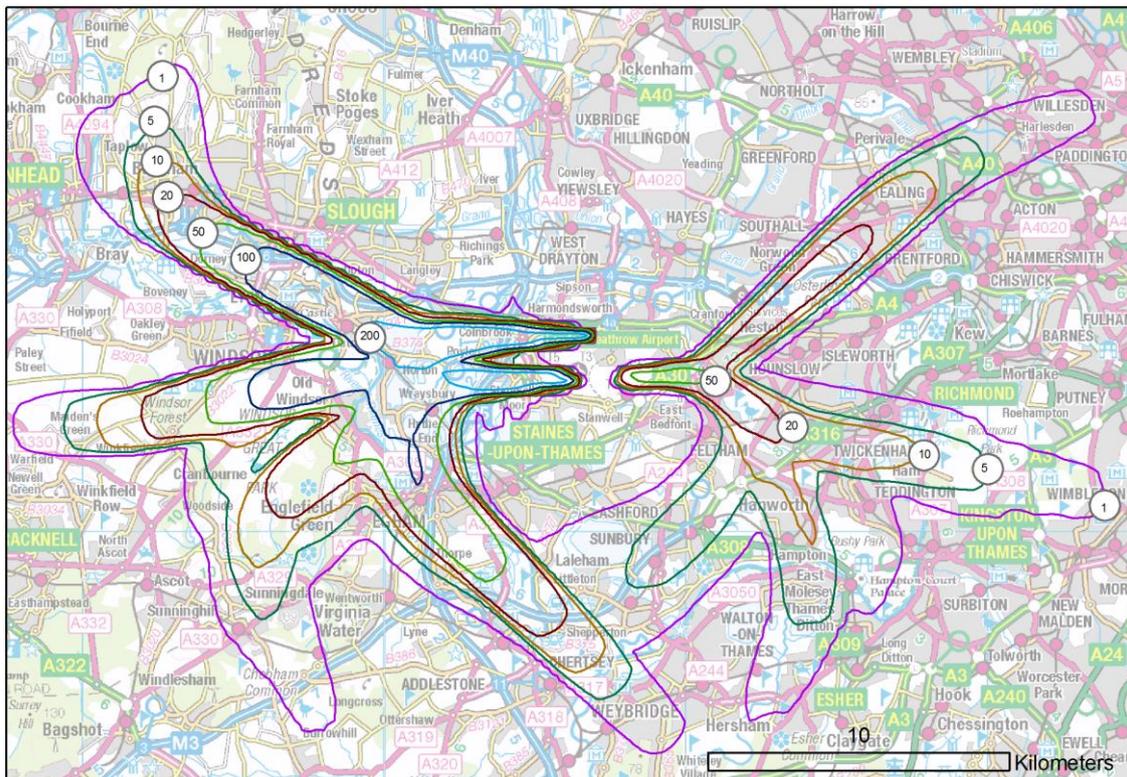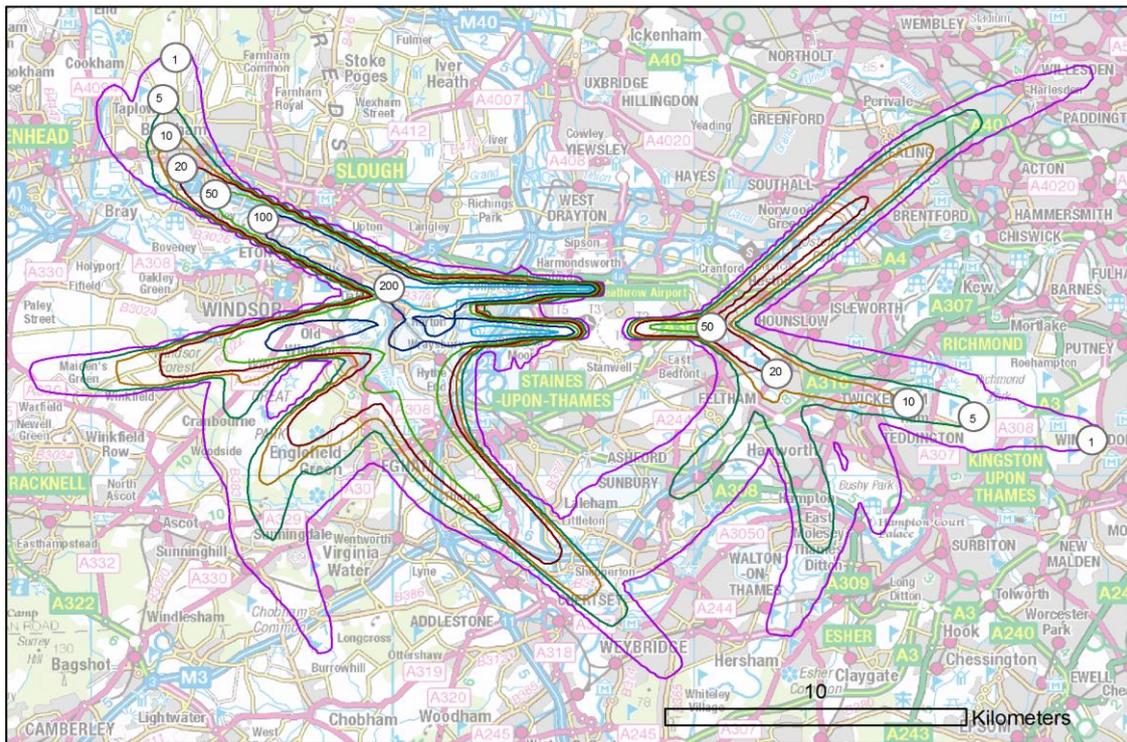
3.31   Like for noise contours, we can calculate the areas, populations and numbers of households enclosed by the contours, see Table 1. This

meets part of the fifth criterion, i.e. the definition and metric can **illustrate and quantify overflight for existing airspace layouts**.

3.32   The data shows that the areas enclosed by the 48.5° cone contours are around 50% larger than the areas enclosed for 60° cone contours. The differences are greater for the highest level contours. The populations and households enclosed by the 48.5° cone contours are approaching double those for the 60° cone contours.

Table 1: Areas, populations and households of overflight contours generated using 60° and 48.5° cones, to 4,000 feet – departures only

No. daily overflights	60° cone			48.5° cone		
	Area (km²)	Population	Households	Area (km²)	Population	Households
1	229.9	430,500	178,700	297.2	572,600	237,200
5	122.4	218,800	91,000	177.4	336,100	140,500
10	84.8	124,900	51,900	125.2	215,900	89,100
20	58.9	50,700	20,600	86.7	96,400	38,700
50	34.8	24,900	10,400	51.7	43,900	18,300
100	15.5	8,300	3,200	28.6	17,400	6,700
200	3.2	800	400	7.2	3,100	1,500

3.33   Since the cone concept counts overflights that meet the elevation angle criterion, and is calculated for single points (rather than grid squares), the problems explained in paragraphs 2.15 to 2.20 do not apply to this method. The contour diagram and the calculated areas, populations and households are **unaffected by mapping or computational factors**, i.e. meeting the sixth criterion.

3.34 Additionally, we can calculate an overflight density diagram equivalent to that shown in Figure 2. This may help to illustrate areas being overflown. Unlike the squares method used to calculate Figure 2, the density values are unaffected by grid size. The resolution of the image is affected, however; the finer the grid, the more accurate the result but the longer the computer processing time. Track density plots equivalent to the contours shown in Figure 14 are presented in Figure 15.

Figure 15: Overflight density plots for a typical summer day at Heathrow Airport, to 4,000 feet - departures only (60° and 48.5° cones respectively)
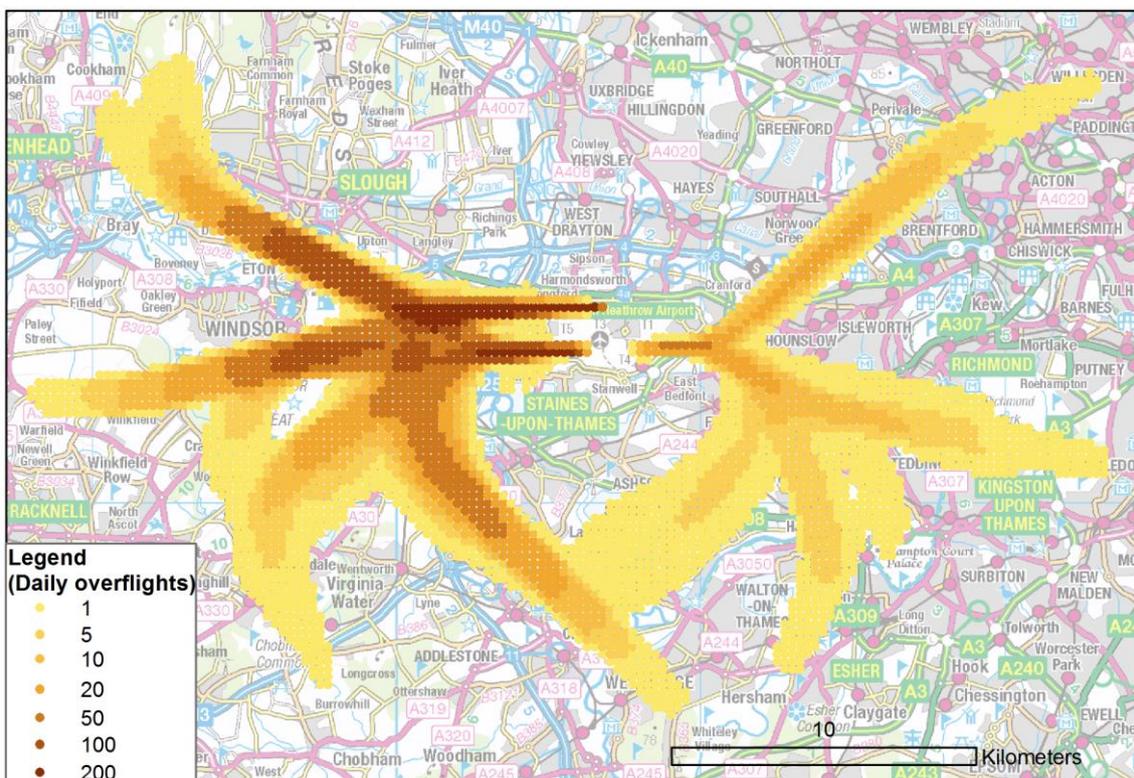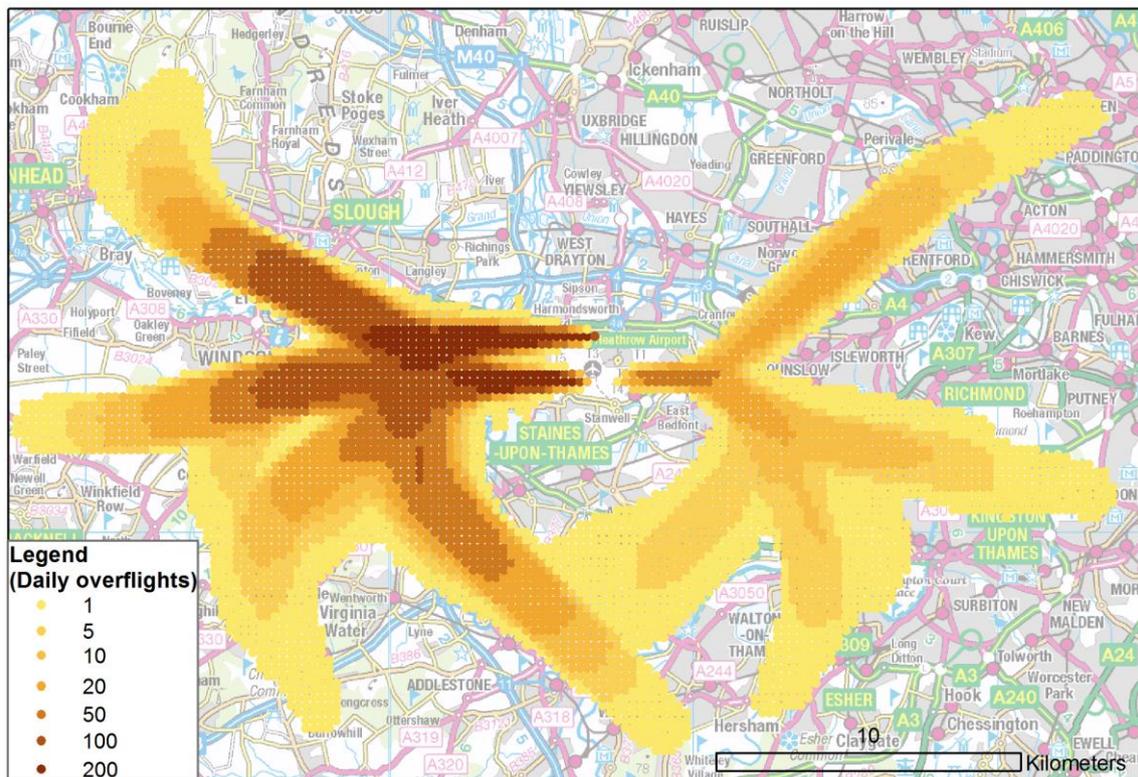
Comparing airspace scenarios using overflights

3.35   The seventh and eighth criteria relate to the ability of the metric to show a) the difference between two different airspace layouts, and b) the difference between concentrated and dispersed flight tracks. Theoretically these are possible, and we have produced some examples to demonstrate this using actual radar tracks.

3.36   Figure 16 shows two sets of real aircraft tracks. The tracks of Case A follow a slightly tighter turn with quite a wide spread either side of the intended route. The tracks of Case B take a wider turn but with less spread, or lateral 'dispersion'. They include tracks taken over periods of 116 and 121 days respectively.

Figure 16: Example flight tracks
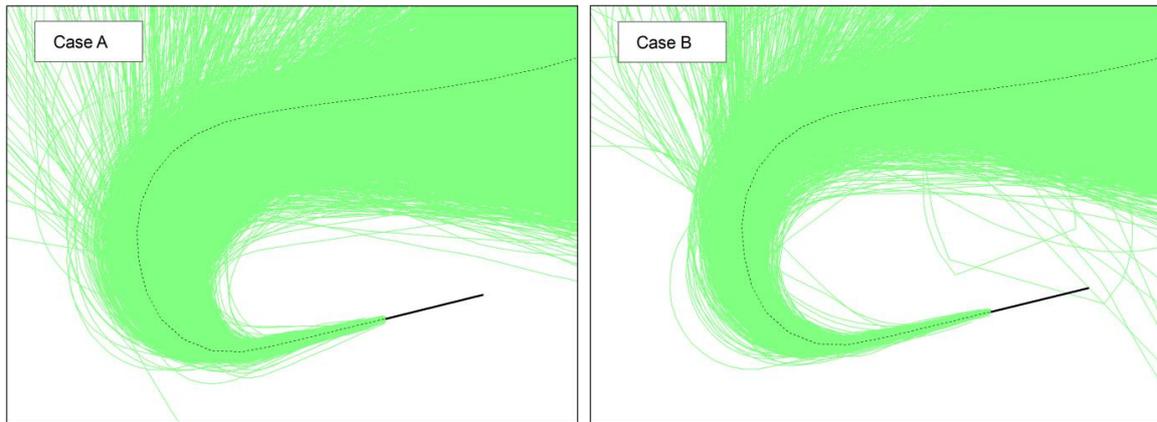
3.37   We have generated overflight contours for both of these sets of data up to 4,000 ft altitude, using the 60° cone for those shown in Figure 17, and the 48.5° cone for the contours shown in Figure 18. They are given in levels of 1, 5, 10, 20, 50 and 100 daily overflights as indicated on the figures.

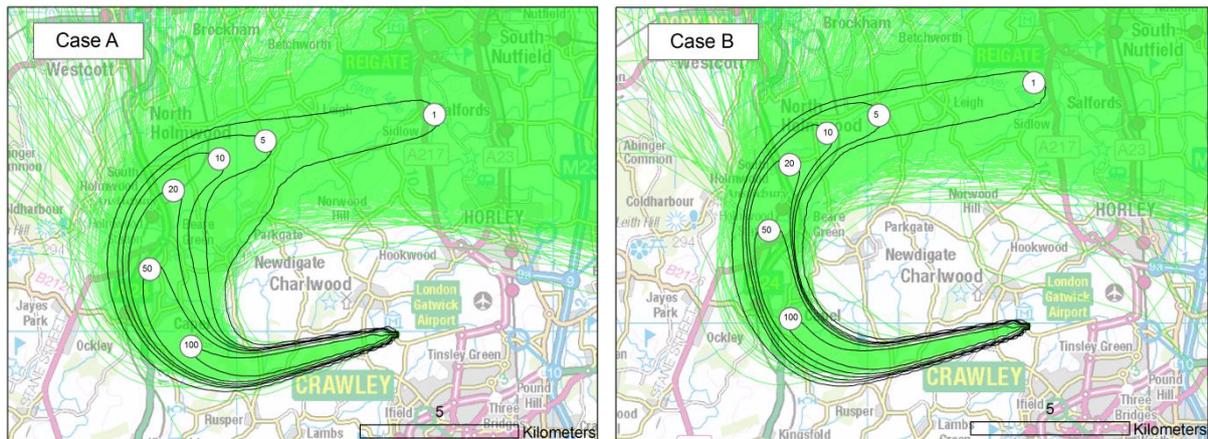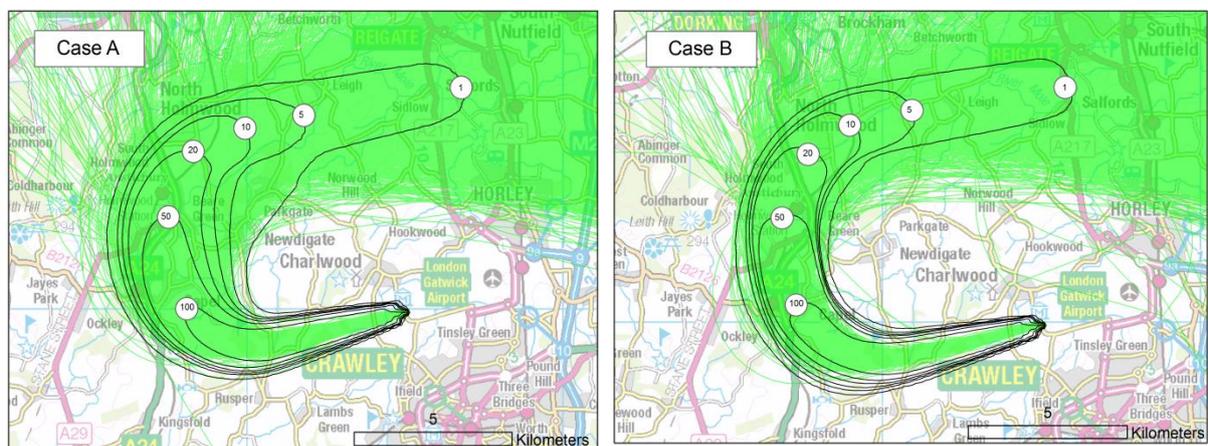**Figure 17: Overflight contours, 60° cone, to 4,000 feet**

Figure 18: Overflight contours, 48.5° cone (up to 4,000 ft altitude)

3.38   Figure 3.12 clearly shows the difference in overflights caused by the two sets of tracks. The contours for Case A, calculated using the 60° cone, are wider than those for Case B except at the ends furthest from the runway, which are more pointed. The Case B contours have more parallel sides and rounded ends, as we would expect for more concentrated flight paths. The Case A contour for 1 daily overflight is much wider on the inside of the curve, reflecting the aircraft which would have been directed by air traffic control to move off the line of the curve.

3.39   The contours calculated using the 48.5° look similar, except they are wider and slightly longer than those calculated using the 60° cone.

3.40   Area, population and household data for these contours is given in Tables 2 and 3.

Table 2: Areas, populations and households of overflight contours generated using the 60° cone, to 4,000 feet – departures only

No. daily overflights	Case A			Case B		
	Area (km²)	Population	Households	Area (km²)	Population	Households
1	42.8	5,700	2,400	34.1	5,200	2,300
5	24.6	3,600	1,600	21.3	3,700	1,600
10	18.7	3,500	1,500	17.2	3,300	1,400
20	13.6	3,000	1,300	13.7	2,600	1,100
50	7.7	900	400	9.1	1,400	600
100	2.8	0	0	3.5	0	0

Table 3: Areas, populations and households of overflight contours generated using the 48.5° cone, to 4,000 feet – departures only

No. daily overflights	Case A			Case B		
	Area (km²)	Population	Households	Area (km²)	Population	Households
1	42.8	5,700	2,400	34.1	5,200	2,300
5	24.6	3,600	1,600	21.3	3,700	1,600
10	18.7	3,500	1,500	17.2	3,300	1,400
20	13.6	3,000	1,300	13.7	2,600	1,100

| 50 | 7.7 | 900 | 400 | 9.1 | 1,400 | 600 |
| 100 | 2.8 | 0 | 0 | 3.5 | 0 | 0 |

3.41   Using either cone, we can see clear differences in the areas, populations and households exposed to daily overflights at certain levels between the two flight track scenarios. Like for Table 1, the contours calculated using the 48.5° cone are about 50% larger than those calculated using the 60° cone. This time, however, due to the difference in the way the residential landuse is distributed, the population and household numbers are generally 10-60% larger for the 48.5° cone.

3.42   This information shows that by using either cone, we are able to use this approach **to show the difference between two different airspace layouts and to show the difference between concentrated and dispersed flight tracks**, both illustratively and quantitatively, meeting the seventh and eighth criteria.

Assessing proposed airspace layouts

3.43   The nineth criterion is that the criteria are met **for proposed (as well as existing) airspace layouts**. The difference between proposed and existing airspace layouts is that for existing layouts, flight track data already exists, whereas for proposed layouts, it does not.

3.44   We have methods for simulating radar tracks, as needed to calculate noise contours for future scenarios. To model future scenarios we make assumptions on how tracks are dispersed either side of a mean track, and then undertake the same overflight calculations as done for the existing radar track data.

3.45   Therefore, this definition and metric meets the ninth criterion.

Appropriate use

3.46   The final criterion is that the definition and metric should **be used only when appropriate**. Our view is that their use should be limited to

circumstances where people's perception of being overflown is under consideration.

3.47   The definition and metric should not be used for assessing flight track keeping performance and other such parameters that are concerned with the position of an aircraft in flight. A typical example is checking that aircraft have remained within the corridor of a noise preferential route (see Chapter 5 of the current ANG).

Other considerations

3.48   A metric quantifying the number of overflights requires a time period over which the overflights are assessed. Clearly, the number of overflights occuring over a 1-hour period would be less than that occuring over a whole day.

3.49   Standard noise exposure metrics (such as L_{eq}) use periods such as a 16-hour day (07:00-23:00), 8-hour night (23:00-07:00), 24-hour day, and other variations on these. They are also typically assessed for an average annual day or a summer average day (across the 92-day period from 16th June to 15th September inclusive). We consider it appropriate to assess the number of overflights using the same time periods and averaging approaches as those used for noise exposure metrics.

3.50   Due to uncertainties in modelling aircraft tracks at larger distances from airports, we consider it inappropriate and potentially misleading to present overflight contours and associated results below a certain level, e.g. 5 daily overflights.

3.51   Finally, as mentioned in paragraph 2.5, the ANG defines altitude-based priority levels for addressing environmental effects of aviation. So far, we have looked at overflight contours for aircraft at altitudes up to 4,000 feet, where noise management is the priority. Between 4,000 and 7,000 feet both noise and emissions are important, and in paragraph 3.23 we stated that we would take forward altitude thresholds of both 4,000 and 7,000 ft.

3.52   Figures 19, 20 and 21 below show the equivalent contours for Figures 14, 17 and 18 but calculated up to 7,000 feet, rather than 4,000 feet.

Figure 19: Overflight contours for a typical summer day at Heathrow Airport, to 7,000 feet - departures only (60° and 48.5° cones respectively)
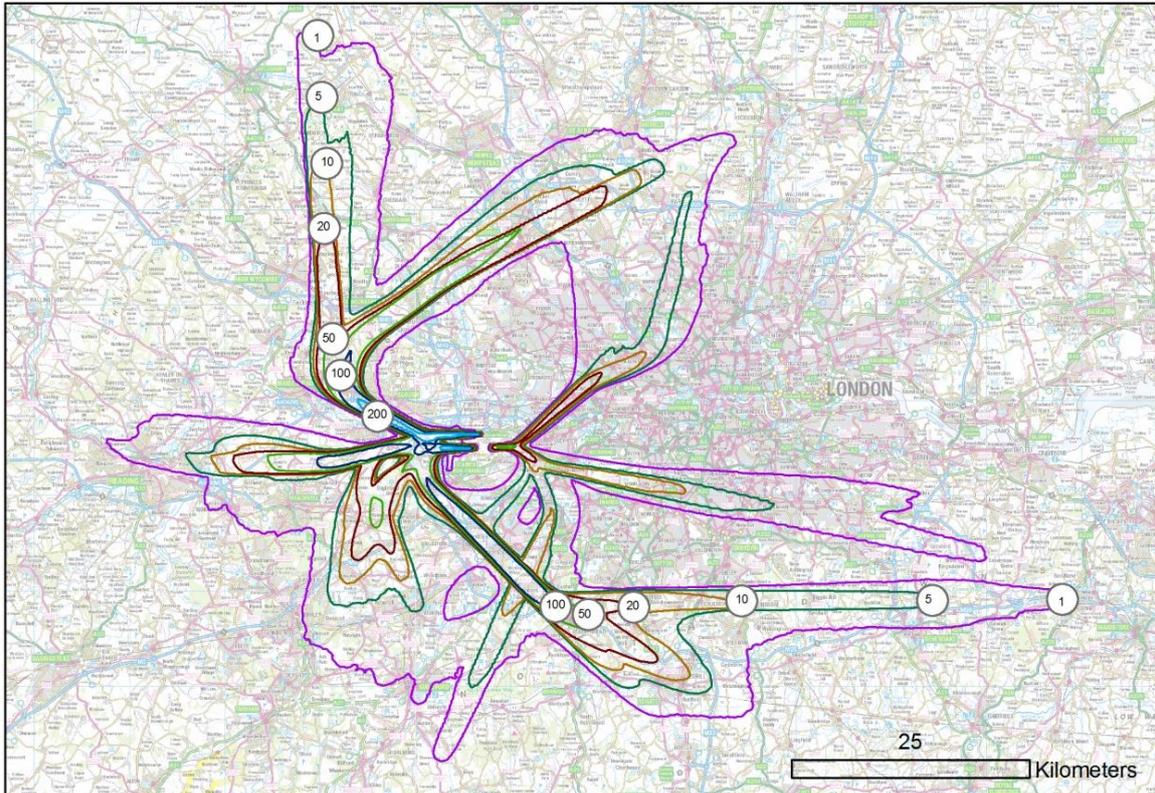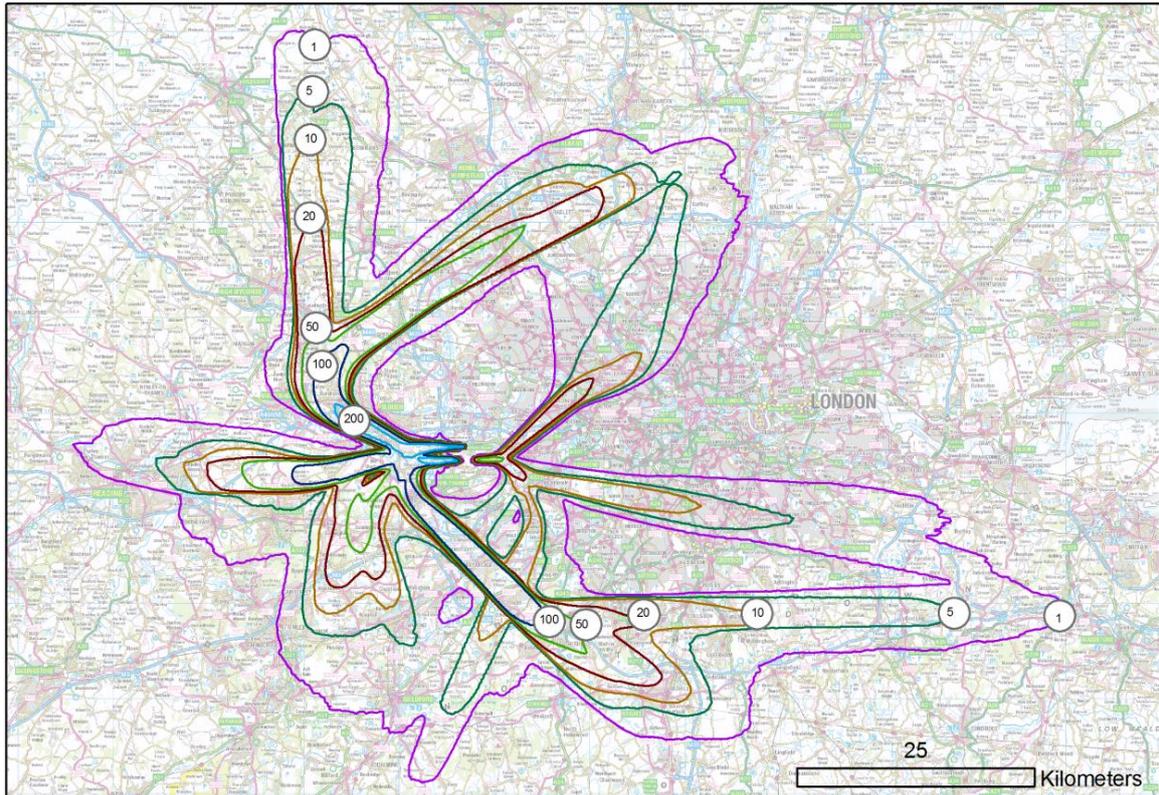
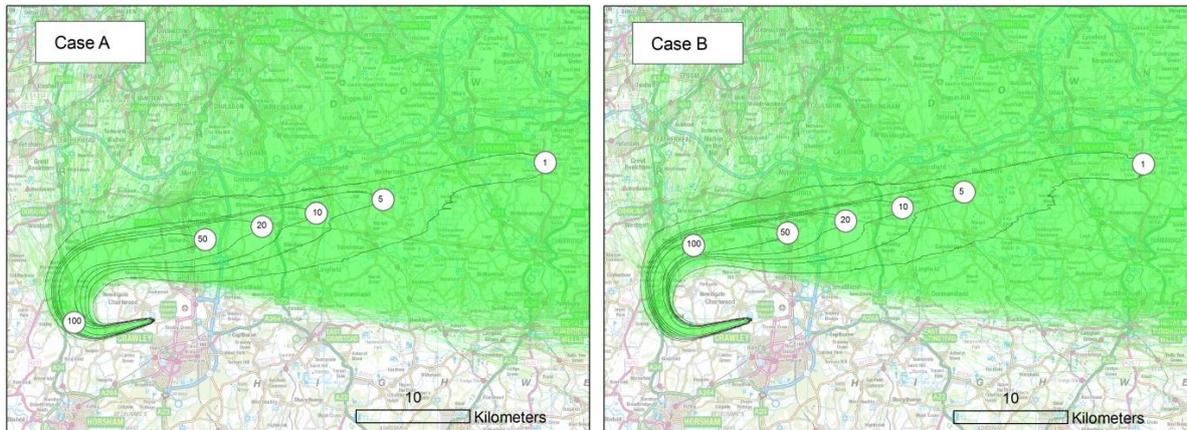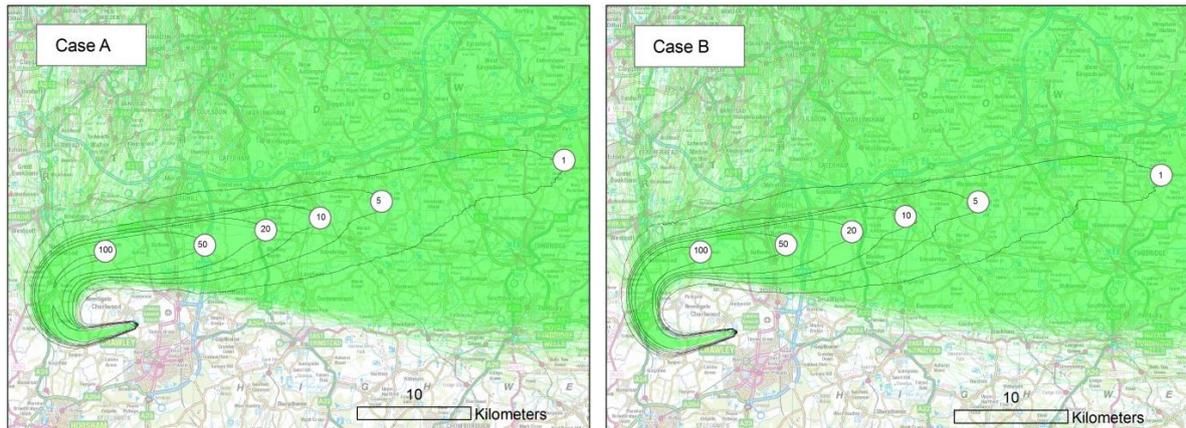**Figure 20: Overflight contours, 60° cone, to 7,000 feet**

Figure 21: Overflight contours, 48.5° cone, to 7,000 feet

3.53   These figures show that by including aircraft up to 7,000 feet, communities outside the standard noise contours (which extend to around 10 km from the airport) are represented, which meets the fourth criterion. They also show the difference between different airspace layouts, meeting the seventh and eigth criteria.

3.54   This is supported by Tables 4 and 5 which provide the area, population and households data for the contours shown in Figures 20 and 21. There are clear differences between the numerical results for Case A and Case B.

Table 4: Areas, populations and households of overflight contours generated using the 60° cone, up to 7,000 feet – departures only

No. daily overflights	Case A			Case B		
	Area (km²)	Population	Households	Area (km²)	Population	Households
1	256.5	84,000	34,700	254.5	87,500	36,200
5	120.2	26,000	10,700	112.6	32,700	13,500
10	83.8	15,400	6,400	78.3	19,200	7,900
20	56.7	11,700	4,900	53.3	16,500	6,800
50	30.3	5,300	2,300	30.3	5,700	2,400
100	2.9	0	0	10.3	1,700	700

Table 5: Areas, populations and households of overflight contours generated using the 48.5° cone, up to 7,000 feet – departures only

No. daily overflights	Case A			Case B		
	Area (km²)	Population	Households	Area (km²)	Population	Households
1	344.2	119,800	49,400	348.0	134,500	55,300
5	170.7	48,900	20,200	165.3	53,300	22,000
10	122.8	28,700	11,900	118.9	34,600	14,300
20	87.1	17,400	7,200	84.5	26,100	10,900
50	50.7	11,300	4,700	50.6	14,600	6,200
100	8.9	600	200	21.7	3,700	1,600

3.55   Like for the previous results tables, the contours calculated using the 48.5° cone are about 50% larger than those calculated using the 60° cone. The population and household numbers are generally 50-90% larger for the 48.5° cone.

3.56   Comparing these results with those shown in Tables 3.2 and 3.3 highlights that the contours including aircraft overflights up to 7,000 feet give results around 4-8 times larger for all parameters compared to the contours including overflights up to 4,000 feet.

3.57   The ratios between the contour levels are similar regardless of the altitude threshold or the elevation angle threshold (cone), except for at the lowest

contour levels (1 and 5 daily overflights). This again illustrates the greater uncertainty in the modelling and calculation at these levels and confirms that these levels should not be presented.

3.58   People overflown by aircraft at higher altitudes will experience less noise than those who are overflown at lower altitudes, i.e. up to 4,000 feet. Including all aircraft overflights up to 7,000 feet does not account for the lower impact, but does significantly increase the populations enclosed by the contours. This lower impact at higher altitudes should be addressed when applying the overflight metric, possibly by applying different weightings to overflights occuring at different altitudes.

Chapter 4

Conclusions

Through this study, we have developed and presented our thinking around the definition and metric for assessing overflights primarily in the context of evaluating airspace change proposals. We can draw this together as follows:

Definition of overflight

An aircraft in flight passing an observer at an elevation angle that is greater than an agreed threshold and at an altitude below 7,000 ft.

We advocate using either 60° or 48.5° as an elevation angle threshold on the grounds of noise attenuation.

Overflight metric

The number of overflights experienced by a ground-borne observer over a given period of time.

Pending any Governmental decision to set firm elevation angle and altitude thresholds, metric results must be presented with information on the elevation angle and altitude thresholds used.

The metric results can be provided for individual observer locations, or overflight contours can be calculated and presented overlaid on maps. From these contours numerical results can be calculated for the areas, populations and households enclosed by the overflight contours. In other words, for a given set of aircraft flight tracks or for a given scenario of airspace use, the area, population and households overflown can be quantified and compared.

The definition and metric meet the criteria we set out for these in paragraph 3.2.