SLIGHTLY STEEPER APPROACHES
FULL OPTIONS APPRAISAL

FINAL

Heathrow

DOCUMENT CONTROL

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CONTENTS

1. INTRODUCTION

1.1.1 Heathrow is consulting on the permanent adoption of Slightly Steeper Approaches (SSA) for some of the aircraft arriving at the airport. SSA increase the angle of aircraft on final approach from 3.0° to 3.2° which enables aircraft to stay higher for longer and therefore helps to reduce noise on the ground.

1.1.2 Between 17 September 2015 and 16 March 2016 and between 25 May 2017 and 11 October 2017, Heathrow ran two live trials to investigate the effect of a slightly steeper 3.2° Area Navigation (RNAV)[1] approach on a number of factors, covering safety, the airport's operation and the environment.

1.1.3 The 3.2° area navigation (RNAV) slightly steeper approaches (SSA) are currently in operation at Heathrow and have been since the second trial, as the Civil Aviation Authority (CAA) permitted this on a temporary basis whilst Heathrow submits this Airspace Change Proposal (ACP) for their permanent adoption. Heathrow is now seeking permission from the CAA to keep SSA as a permanent feature.

1.1.4 We have now reached Stage 3 (Consult) in the CAA's Airspace Change Process and as part of this stage, we are required to undertake a Full Options Appraisal (FOA) of the remaining options.

1.1.5 The FOA is a vigorous technical and environmental appraisal of the shortlisted options that form the SSA Airspace Change Proposal. These are to either permanently adopt 3.2° RNAV SSA (applicable to 0.6% of aircraft in 2019) or to revert to all aircraft operating 3.0° ILS and RNAV approaches.

1.1.6 This FOA document will provide stakeholders and the CAA with detailed information on the costs and benefits of permanently adopting SSA and allow comparison against the baseline of reverting to all aircraft operating 3.0° ILS and RNAV approaches.

1.2 CAP1616 Process

Where we are in the CAP1616 process

1.2.1 Changes to flight paths are submitted to and approved by the CAA following the Airspace Design Guidance provided in its document known as 'CAP 1616'. This guidance sets out a process framework following a 7-stage approach to implement a permanent airspace change.

1.2.2 The figure below displays the full ACP process as defined in CAP1616. We have completed Stage 1 and 2 of the process and we are now at Stage 3: Consult.

[1] This document refers to 'RNAV (GNSS) approaches' as we have used that term throughout the live trials, engagement and reports to-date and we will remain with this term for this process. The new and correct term is now 'RNP Approach'. When we refer to RNAV approaches we are specifically referring to LNAV and LNAV/VNAV. LPV200 approaches have been excluded from this ACP due to low aircraft equipage within the Heathrow fleet.

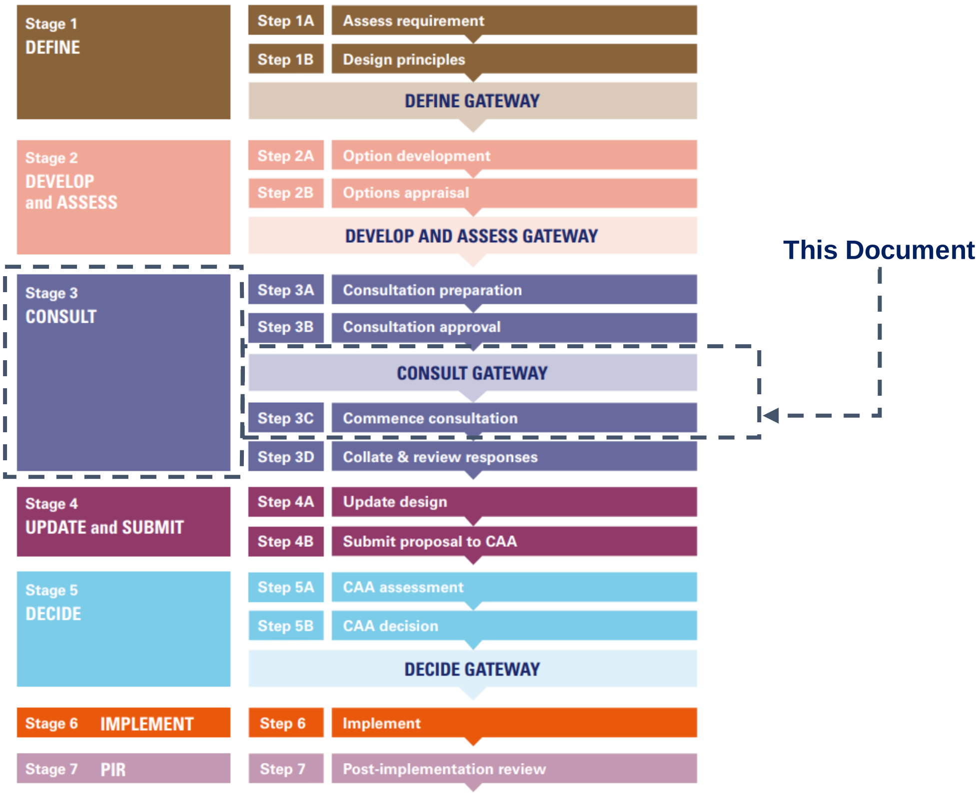


Figure 1 CAP1616 ACP Stages

1.2.3 At Stage 3 of the CAP1616 process, we are required to undertake a FOA of the option(s) under consideration and prepare consultation documents. Following the Consult gateway planned for 26 Feb 2021 we will be at Stage 3C and ready to commence consultation on SSA. This is where we are now.

1.3 This Full Options Appraisal Document

1.3.1 Step 3A requires the change sponsor to develop a FOA as evidence to analyse its remaining option(s), compared with a ‘do nothing’ option.

1.3.2 The main objective of this FOA document is to provide detailed technical and environmental information about SSA, enabling stakeholders to compare the proposal to permanently adopt 3.2° RNAV SSA, against reverting to all RNAV aircraft operating 3.0° approaches (in both cases, ILS approaches remain unchanged at 3°).

1.3.3 Alongside this FOA document, there are two further documents which support the overall consultation for SSA:

Table 1 SSA Consultation Documents

Document	Content
Overview/Summary Document	2-page summary, aimed to be a quick read and easy to understand document with diagrams.
Main Consultation Document	Summary of the ACP so far, including links to documents on the portal. Describing the SSA procedure in more detail and how Heathrow have reached the final option they are requesting to implement.
Full Options Appraisal (This document)	This FOA document provides detailed technical and environmental analysis for consultees who wish to read the technical data.

1.4 Consultation Options

1.4.1 The CAP1616 process requires airspace change sponsors to develop flight path options and then appraise these at three stages in the process. At Stage 2B we developed an Initial Options Appraisal (IOA) for the proposed flight path options.

1.4.2 A single viable option (B2: Increase RNAV Vertical Path Angle (VPA) to 3.2°, maintain ILS Vertical Path Angle (VPA) at 3.0°) was appraised at Stage 2B and compared against the Baseline (B1: RNAV and ILS VPA at 3.0˚).

1.4.3 To find out further information about how we developed and refined the SSA options throughout each stage of the change process, please see the Consultation Document here.

1.4.4 The initial options appraisal involved a qualitative assessment of Option B2 against B1 and the outcome concluded that Option B2 delivers a net benefit compared to the Baseline B1. Option B2 therefore proceeded to this Stage 3 of the ACP.

Table 2 Stage 3 Option Description

Option	Reference used within this document	Description
B2	3.2° RNAV SSA	Maintain RNAV Vertical Path Angle (VPA) at 3.2°, maintain ILS VPA at 3.0°
B1 (Baseline)	3.0° RNAV and ILS approaches	Decrease RNAV VPA to 3.0° and maintain ILS VPA at 3.0°

1.4.5 As only a single viable option (Option B2 3.2° RNAV SSA) and the baseline B1 (Option B1: 3.0° RNAV and ILS approaches) was progressed from Stage 2B, this FOA has directly assessed that one option against the Baseline.

1.4.6 This aligns with our Consultation question 'Do you support the permanent adoption of slightly steeper approaches at Heathrow airport?' as it enables all stakeholders to directly compare the benefits and impacts of permanently adopting 3.2° RNAV SSA (B2) or reverting to all aircraft operating 3.0° RNAV and ILS approaches (B1).

1.5 Instrument Flight Procedures

1.5.1 As above, the 3.2° RNAV SSA are currently operated at Heathrow and have been since the second trial in 2017. The CAA permitted the continuation of the procedures on a temporary basis whilst Heathrow follows this ACP process for the permanent adoption of the procedures.

1.5.2 3.2° RNAV SSA are therefore published in the UK Aeronautical Information Publication (AIP). Alongside this, there are published procedures for 3.0° RNAV approaches[2], and 3.0° ILS approaches into Heathrow.

1.5.3 Full details and charts of the procedures can be viewed on the eAIP under Part 3 AD2 Aerodromes EGLL AD 2.24.

1.5.4 This ACP does not propose to make any changes to the existing procedures that are published and operated today. Depending on the outcome of this ACP, either the 3.2° RNAV approach procedures will be made permanent or withdrawn.

[2] Although 3.0° RNAV procedures are currently published, they are not allocated by ATC.

2. HOW WE ASSESS SSA: CRITERIA AND METHODOLOGY

2.1 Baseline and Forecasts

2.1.1 CAP1616 requires the change sponsor to define a baseline 'do nothing' option, against which the cost and benefits of an airspace change can be assessed. For the purpose of the FOA, **the baseline is Option B1** (Decrease RNAV VPA to 3.0° and maintain ILS VPA at 3.0°).

2.1.2 The following assumptions have been made when defining the baseline:

- **The assessment period under consideration is between 2019 and 2031.** The assessment is considered up to 2031 as per CAP1616 requirements (see baseline and future forecast year section below).
- **SSA is considered a standalone ACP.** No other ACPs shall be considered in this Full Options Appraisal.
- **Traffic levels shall remain constant at 2019 levels throughout the assessment period.** This assumes the present 480,000 movements per annum cap remains in place and the permanent adoption of 3.2° RNAV SSA has no impact on the number of Heathrow ATMs.
- **RNAV usage rates remain constant throughout the assessment period.** RNAV approaches need to be requested by pilots and approved by ATC. The standard approach is to use the ILS approach which is unaffected by this airspace change proposal. RNAV approaches result in a higher ATC and pilot workload. In 2019, 0.6% of arrivals operated 3.2° RNAV SSA (the remainder land using the 3.0° approaches). During the trials, an average of 2% of aircraft operated SSA. Due to the higher ATC and pilot workload, even if more crews (above 2% of arrivals) elected to fly RNAV approaches, ATC might not be able to accommodate and could decline pilot requests. This FOA analysis is based on 2019 data (see baseline section below) and therefore a 0.6% 3.2° RNAV usage has been applied, with 99.4% of flights operating a 3.0° approach.

2.2 Baseline and future forecast year

2.2.1 Owing to the significant decline in traffic due to COVID-19, 2019 was selected as the most representative and recent baseline assessment year for the environmental analysis in this FOA.

2.2.2 CAP1616 requires change sponsors to also provide forecast data 10 years in future from the planned implementation date of the ACP. In the case of this ACP, which is planned for implementation in 2021, this involves creating a future forecast for 2031. As Heathrow was operating close to its capped traffic movements of 480,000 in 2019, the future forecast has not considered an increase in the number of movements in 2031 but has considered aircraft fleet turnover and retirements, and future aircraft types predicted to be in operation in that year along with how routes may be used to reflect departure destinations.

2.2.3 For the FOA analysis, recorded number of movements from ANOMS data (Heathrow's Noise Track Keeping Database) summarised in table 3 below, have been used to determine the number of 3.2° RNAV approaches undertaken in 2019.

Table 3 2019 ANOMS Arrivals Data

Approach Type	Number of arrivals	Percentage of arrivals
SSA 3.2° Approaches	1378	0.6%
3.0° Approaches	236,732	99.4%
Total	238,110	

2.2.4 For the purposes of the FOA noise and environmental analysis, 2019's actual figures of 0.6% of arrivals using SSA have been used. As outlined in the section above, during the trials an average of 2% of aircraft operated SSA, therefore it is possible that the benefits of SSA, outlined in the following sections of the document, could be slightly improved compared to the FOA analysis if more than 0.6% of aircraft fly SSA in future.

2.3 Full Options Appraisal Methodology

2.3.1 Stage 3 requires Heathrow as the change sponsor to carry out a 'full' appraisal of the impacts of each option progressed from Stage 2B. This is the second of three iterative phases of options appraisal.

2.3.2 The Full Options Appraisal should build upon the qualitative assessments undertaken as part of the Initial Options Appraisal at Stage 2B and introduce quantitative and monetisation assessment where applicable using the Department for Transport (DfT) WebTAG[3]. This highlights to change sponsors, stakeholders, and the CAA the relative difference between the impacts, both positive and negative, of each option.

2.3.3 As only a single viable option (Option B2: 3.2° RNAV SSA) was progressed from Stage 2B, this full options appraisal has directly assessed that against the Baseline (Option B1: 3.0° RNAV and ILS Approaches). This aligns with the Consultation question 'Do you support the permanent adoption of slightly steeper approaches at Heathrow airport?' as it enables all stakeholders to directly compare the benefits and impacts of permanently adopting SSA or reverting to all aircraft operating 3.0° approaches.

2.3.4 The criteria for assessment have been developed to reflect the requirements of:

[3] Transport analysis guidance (TAG): https://www.gov.uk/guidance/transport-analysis-guidance-webtag

- Air Navigation Guidance 2017
- CAP1616;
- CAP1616a;
- WebTAG[2];
- Transport Act 2000.

2.3.5 Following the example set out in CAP1616 Appendix E, the assessment criteria have been categorised using the following groups:

- Communities;
- Wider Society;
- General Aviation;
- General Aviation/Commercial Airlines;
- Commercial Airlines;
- Airports / Air Navigation Service Providers (ANSP).

2.3.6 Section 3 of this document presents each group of assessment criteria and the assessment performed. Where categories do not need to be considered further in this assessment, e.g. because they may not provide any distinction between the options, justification is provided. Further detail regarding the methodology used for the assessments of categories that do require consideration is outlined in the sections below.

Noise Assessments

2.3.7 The noise assessment work has been undertaken using the Aviation Environmental Design Tool (AEDT) version 3b. The modelling has been supported by the OnTrack software system developed by Noise Consultants Limited. All modelling undertaken with AEDT has been subject to a validation complying with the 'Category A' requirements of the recent CAA consultation 'CAP1875 – Consultation on CAA Minimum Requirement for Noise Modelling'. To this end, all models developed for the ACP have been subject to:

2.3.8 Development of customised flight profiles to reflect altitudes, air speeds and associated climb and departure rates. This has included the preparation of flight profiles reflecting different Noise Abatement Departure Procedures (NADP).

2.3.9 Modified Noise Power Distance (NPD) information for aircraft L_{Amax} and SEL using measured data at each of Heathrow's fixed Noise Monitoring Terminals (NMTs) and temporary monitors.

2.3.10 Analysis of track keeping data to determine arrival and departure routes and associated dispersion around these.

2.3.11 All analysis as described above has been achieved through analysis of Heathrow's ANOMS data for the 92-day summer average period between 16 June to 15

September 2019. This data has been processed to determine the number and type of aircraft arriving and departing Heathrow, the respective use of runways, departure routes and approaches, along with the proportion of aircraft using various NADP procedures. The assessed modal split (80% westerly operations and 20% easterly operations) is therefore the summer 2019 modal split.

2.3.12 This analysis has been used to help inform the forecast modelling for an assessment year of 2031. A schedule has been prepared reflecting the scheduled 2019 operation, however having regard to fleet modernisation along with how routes may be used to reflect departure destinations. This has been informed by a forecast schedule. All other operational conditions have been taken directly from the 2019 operation.

2.3.13 To consider the noise implications of SSA, the flight profiles used within the modelling have been modified whereby final approaches have been increased to 3.2° to reflect the RNAV approaches with a proportion of aircraft using these approaches considered with the rest assumed to be using the 3.0° ILS approach. For all scenarios presented using the 3.0° ILS, the final approach has been fixed at 3.0°.

2.3.14 Having regard to CAP2091 (The CAA Policy on Minimum Standards for Noise Modelling), it is considered that the modelling undertaken meets the requirements of ‘Category A’ as described within the CAA document.

2.3.15 To facilitate the assessment, noise contours and exposure levels at post code centroids reporting the number of households and populations based on census data and forecast population growth. This data has been obtained from CACI[4]. All population counts for 2019 are based on 2019 population and household estimates with data for the forecast year of 2031 reflecting CACI forecast populations and households in 2031. All other non-residential noise sensitive receptors have been obtained from the Point X data product[5] which presents the location and addresses of receptors such as schools, hospitals and places of worship. This data product has been used to calculate noise exposure at such receptors as is required by the CAP1616 guidance.

CAP1616 Noise Metrics

2.3.16 The following CAP1616 noise metrics have been produced within the calculation study area:

- **$L_{Aeq, 16hr.}$** Equivalent sound level of aircraft noise in dBA, often called equivalent continuous sound level. This is based on the daily average movements that take place in the 16 hour period (07:00-23:00 local time) during the 92 day period 16 June to 15 September inclusive. This metric is the measure of noise exposure adopted by Government for the purposes of considering aircraft noise annoyance. It forms the basis of the Government’s policies in relation to daytime aircraft noise.

- **$L_{Aeq, 8hr.}$** Equivalent sound level of aircraft noise in dBA, often called equivalent continuous sound level. This is based on the nightly average movements that take place in the 8 hour period (23:00-07:00 local time) during the 92 day period

[4] CACI Ltd. | Marketing, Technology & Data Specialists
[5] Description available here: https://www.pointx.co.uk/products

16 June to 15 September inclusive. This metric is the measure of noise exposure adopted by Government for the purposes of considering sleep disturbance arising from aircraft noise. It forms the basis of the Government's policies in relation to night-time aircraft noise.

- **N65.** The number of noise events greater than 65dBA L_{max} during the day (07:00 – 23:00)
- **N60.** The number of noise events greater than 60dBA L_{max} during the night (23:00 – 07:00).

The N65 and N60 metrics are a measure used as part of the Airspace Change Process to help communicate airspace changes. These are required by the CAA to help with engagement on noise and airspace change, and to further differentiate between airspace options which have a similar impact with respect to the L_{Aeq} metrics.

2.3.17 These metrics and associated noise contours have been produced for an average mode of 80% Westerly and 20% Easterly operations for daytime and night-time periods. To help further understand and articulate the proposals impacts for noise, contours representing 100% easterly and 100% westerly operations have also been produced.

100% SSA contours and data tables

2.3.18 Due to the small percentage of aircraft that operate 3.2° RNAV SSA (0.6% in 2019), and knowing the outcome of the trials in 2015-2017, the results of the noise calculations were expected to be difficult to distinguish on a standard noise contour as requested by the process. We have therefore also undertaken analysis with 100% of flights operating RNAV SSA arrivals.

2.3.19 It is very important to note that due to the higher ATC and pilot workload, even if more crews elected to fly RNAV approaches, ATC might not be able to accommodate and could decline pilot requests. The 100% contours are therefore only available to visually demonstrate the benefits of SSA in the results; at present it is not operationally feasible for 100% of arrivals to operate 3.2° RNAV SSA.

Calculation Extents

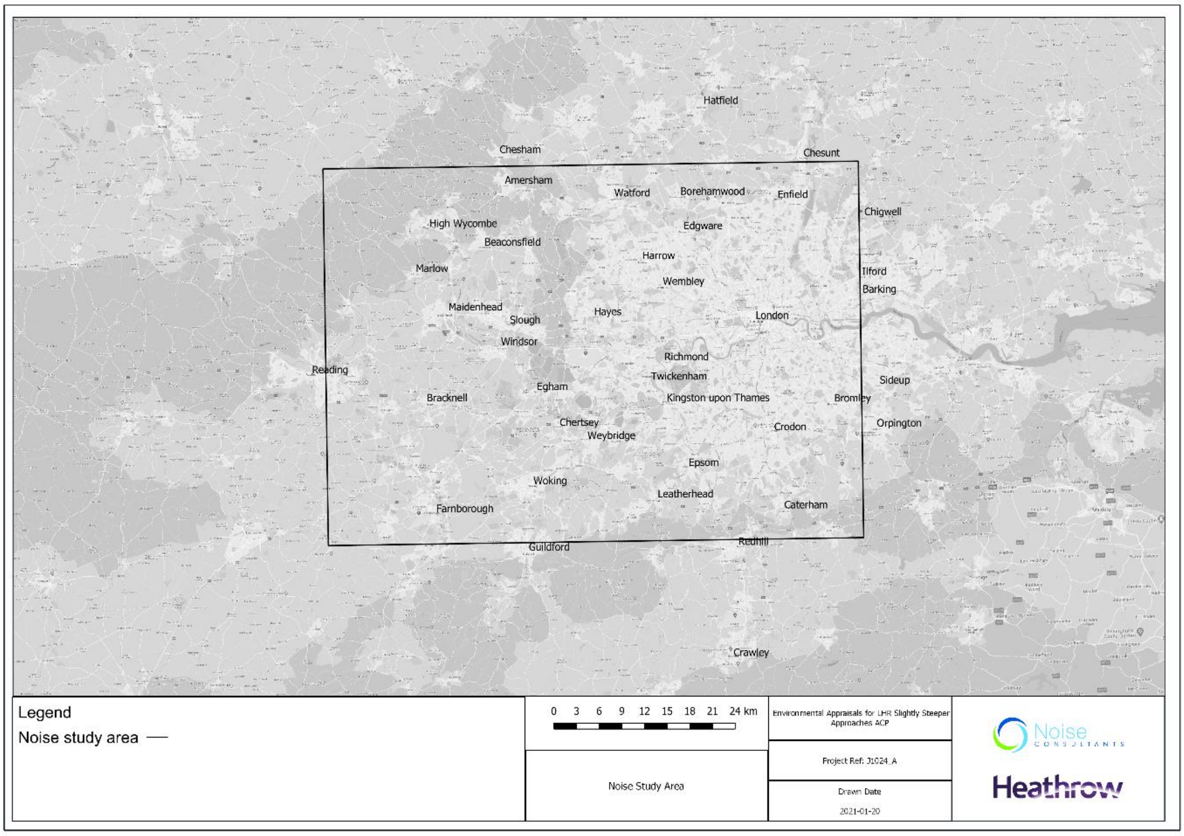


Figure 2 Noise Calculation Extents

2.3.20 All noise calculations have been undertaken for the study area presented in figure 2. This study area has been defined based on the location of the daytime and night-time LOAEL contours. All contours and associated noise exposure analysis has been carried out within this study area. This has resulted in some contours being truncated by the study area extents. For this ACP this is considered satisfactory, as the main changes associated with SSA occur where aircraft are on final approach which are areas within the daytime and night-time LOAELs.

WebTAG

2.3.21 A WebTAG assessment has been undertaken using the 2019 and 2031 forecast average daytime and night-time noise exposure data.

2.3.22 The monetary valuation used in the TAG Noise Workbook is based on the recommendations of the study: **Environmental noise: Valuing impacts on: sleep disturbance, annoyance, hypertension, productivity and quiet (Defra, 2014) (referred to as the Defra Study).**

2.3.23 TAG Noise Workbook[6] (referred to as workbook from now on) uses the annual value of the impact of a 1dB change in aircraft noise levels from 45 to 81 dB $L_{Aeq,\ 16hr}$ and $L_{Aeq,\ 8hr}$. The workbook responds to the Defra study by providing a template from which

[6] 'Noise workbook - aviation - sensitivity testing' as available here: www.gov.uk/government/publications/tag-environmental-impacts-worksheets.

the valuation of the impacts on sleep disturbance, annoyance, hypertension, productivity and quiet as reported within the Defra Study. The calculations made within the workbook provide the WebTAG outputs required under Government aviation noise policy for airspace changes as described within the Air Navigation Guidance 2017 and as required for airspace changes following the process set out in CAP1616.

2.3.24 The Workbook accepts noise exposure data in terms of the households' or population's exposure to different levels of noise and applies this against evidence of how people respond differently to aircraft noise. This is then used to calculate changes in health outcomes associated with the forecast changes in aircraft noise exposure.

2.3.25 The Workbook applies these values to proposed airspace changes running into the future. Therefore, the Workbook accounts for growth factors in line with real GDP per capita. By default, the Present Value Base Year (PVBY) used as part of the valuation in WebTAG are set at 2010 prices. The example used within CAP1616a to demonstrate the use of WebTAG[7] has used a 2010 PVBY. As such a 2010 value has been used for the basis of the WebTAG calculation for SSA.

2.3.26 The outputs and impacts related to the airspace change are then interpolated over the years between the opening year and the forecast year of the airspace change and then extrapolated over the appraisal period which is set by default as 60 years from the opening year within the WebTAG template. This is then discounted to the Department's standard base year.

2.3.27 As such, any monetary outcome presented in the Workbooks and the FOA for SSA is the monetary outcome of the airspace change over an appraisal period of 60 years.

Trial Noise Data

2.3.28 Alongside the noise assessment work undertaken by the AEDT tool, the SSA trials (2015 and 2017) collected noise data which was used for the Initial Options Appraisal at Stage 2B and has been used as part of this FOA.

Trial Study area

2.3.29 The study area is defined by the locations used by Heathrow's SSA trials (2015 and 2017) which evaluated amongst other things, the potential noise improvements owing to the 3.2° steeper approach. During these flight trials measurements of aircraft noise event levels were taken below 27L approaches into Heathrow, specifically at Heathrow's fixed noise monitoring terminals at Mogden Sewage Works (NMT129), Mid-Surrey Golf Course (NMT130), and Roehampton Golf Club (NMT131).

[7] CAP1616a, Figure 6 'Illustrative example of the webTAG input and workbook monetisation results for changes in population noise exposure when assessing a relevant PPR'

Methodology

2.3.30 Sound Exposure Levels (SEL) of aircraft using the 3.2° RNAV SSA have been compared against those using the 3.0° conventional ILS approach. This comparison is taken from both steeper approach trials. From this comparison, the average change in aircraft SEL has been determined and provides an indication in the improvements in aircraft noise event levels as a result of aircraft operating the 3.2° RNAV SSA.

Reasoning

2.3.31 The use of data obtained from trials to support the FOA provides actual measured data of the performance of the 3.2° RNAV SSA compared to the existing conventional 3.0° ILS approach. This evidence therefore provides a strong indication of the noise improvements that would remain with the permanent implementation of 3.2º RNAV SSA.

2.3.32 The use of information taken from the trial reports also confirms that there will be no change to ground tracks as a result of permanently adopting 3.2° RNAV SSA. This therefore confirms that the permanent adoption of SSA, or the reversion to all aircraft operating 3.0° approaches, will not result in a redistribution of noise.

2.3.33 The SEL measure is used in the modelling and assessment of noise exposure (in terms of LAeq) as required by WebTAG. As such, any improvement in SEL is indicative of the potential of 3.2° RNAV SSA to contribute towards the Government's aviation noise policy objective to "limit and, where possible, reduce the number of people in the UK significantly affected by adverse impacts from aircraft noise" as measured by WebTAG.

Criteria

2.3.34 The criteria used as part of this appraisal of noise as part of the trials is:

1. Differences in average measured aircraft SEL at NMT129, NMT130 and NMT131 between approaches using the 3.2° RNAV SSA compared to the existing 3.0° ILS approach; and

2. Ground track comparisons of aircraft arrivals using the SSA compared to the existing 3.0° ILS approach.

2.3.35 These criteria are representative of the measures used to evaluate potential noise benefits during the trials.

2.3.36 All data provided has been taken from published 2015 and 2017 trial reports which are based on data obtained from Heathrow's Airport Noise Monitoring and Management (ANOMS) Noise and Track Keeping System.

Tranquillity and Biodiversity

2.3.37 Given the nature of the SSA ACP, consideration of any potential impacts on tranquillity and biodiversity have been made with reference to change in noise contours, particularly the N65 and N60. Consideration has been given to the 100% easterly and 100% westerly conditions presented in Appendix A along with the outcomes from the trials held in 2015-2017, which demonstrated that there is no change to lateral flight tracks as a result of SSA.

2.3.38 For other airspace changes where there are associated changes in lateral tracks, additional metrics and assessment approaches would be required. However, given the small changes associated with SSA, the methodology adopted is considered proportionate.

Greenhouse impact / CO_2 Emissions / Fuel Burn

2.3.39 The assessment of 3.2° RNAV SSA on greenhouse gases and CO_2 emissions has considered changes in fuel burn for approaches made using the 3.2° RNAV SSA as opposed to the 3.0° ILS. The AEDT modelling used to inform the noise appraisal has been used to quantify changes in fuel burn. To support this, an approach to Heathrow airport from an altitude of 10,000ft has been simulated for the Airbus A320 using the EUROCONTROL BADA Aircraft Performance Model. Using this information, the impact of SSA on greenhouse gas and CO_2 has been considered by extrapolating the fuel burn results from the AEDT model along with information available from other relevant studies.

Cost Benefit Analysis

2.3.40 Due to the nature of the SSA ACP, where there are no changes to lateral flight paths and therefore only very marginal benefits to most assessment criteria categories, it was not considered proportionate to undertake monetised assessments other than for noise. Subsequently a cost benefit analysis table has not been included in this FOA however details of the monetised assessment for noise are included within the Communities section, and we have provided an FOA summary to allow stakeholders side by side comparison of the benefits of keeping SSA or reverting to all aircraft operating 3.0° approaches.

3. FULL OPTIONS APPRAISAL

To read the full FOA, please scroll to the next stage. For quick navigation, please use the links below.

3.1 Communities

<table>
<tr><th>Impact</th><th>Level of Analysis</th><th>Permanently adopt Option B2
Slightly Steeper 3.2º RNAV Approaches</th><th>Revert to Option B1
All aircraft operate 3.0º approaches</th></tr>
<tr><td>Noise impact on health and quality of life</td><td>Monetise and quantify</td><td colspan="2">

Description: CAP1616 Appendix B sets out detailed guidance on the assessment of noise, carbon, air quality and other environmental impacts.

Assessment: The noise assessment work undertaken for this Stage 3 FOA has considered information gathered from Heathrow's steeper approach trials, and data gathered during the ongoing operation of SSA on a temporary basis. This data has informed the noise modelling and noise exposure data requirements as per the CAP1616 process.

Trial Outcomes
The table below presents the results reported in Heathrow's two SSA trials in 2015 and 2017. The table presents the average aircraft SEL differences between 3.2° RNAV SSA and 3.0° ILS approaches.

<table>
<tr><th>Trial</th><th>NMT129

Mogden Sewage Works

c. 3.7nm from touchdown

c 78ft higher with SSA</th><th>NMT130

Mid-Surrey Golf Club

c.4.7nm from touchdown

c 100ft higher with SSA</th><th>NMT131

Roehampton Golf Club

C7.2nm from touchdown

c. 153ft higher with SSA</th></tr>
<tr><td colspan="4">Average Differences in Aircraft Noise Events, Sound Exposure level (SEL dBA)</td></tr>
<tr><td>First Trial</td><td>- 0.25 dB</td><td>-0.49 dB</td><td>- 0.74 dB</td></tr>
<tr><td>Second Trial</td><td>- 0.32dB</td><td>-0.55 dB</td><td>- 0.68 dB</td></tr>
</table>

The trials demonstrated that there was an **Average SEL reduction of 0.51 dBA per aircraft on a 3.2° RNAV SSA**. An average reduction of 0.51 dBA results in a change in SEL that is unlikely to be perceptible from the ground however the permanent adoption of 3.2° RNAV SSA approaches is an incremental step to reducing the impact of Heathrow airport's noise footprint on health and quality of life.

</td></tr>
</table>

Impact	Level of Analysis	Permanently adopt Option B2 Slightly Steeper 3.2º RNAV Approaches	Revert to Option B1 All aircraft operate 3.0º approaches

Noise Modelling Outcomes

WebTAG

When evaluating the option of permanently adopting 3.2° RNAV SSA against the baseline, the outcome of the WebTAG assessment is an overall net benefit:

	WebTAG assessment	Sensitivity test excluding impacts below 51 dB (for aviation proposals only)
Net present value of change in noise (£, 2010 prices):	£27,632,143	£10,544,020
	*positive value reflects a **net benefit** (i.e. a reduction in noise)	
Net present value of impact on sleep disturbance (£, 2010 prices):	£10,122,037	£1,825,547
Net present value of impact on amenity (£, 2010 prices):	£14,917,345	£6,125,713
Net present value of impact on AMI (£, 2010 prices):	£51,097	£51,097
Net present value of impact on stroke (£, 2010 prices):	£1,013,021	£1,013,021
Net present value of impact on dementia (£, 2010 prices):	£1,528,642	£1,528,642

<u>Quantitative results</u>

households experiencing increased daytime noise in forecast year:	12408
households experiencing reduced daytime noise in forecast year:	41825
households experiencing increased night time noise in forecast year:	1008
households experiencing reduced night time noise in forecast year:	12170

Noise Metrics

The full details of the noise exposure data, including the contours, data tables and webTAG assessments can be found in Appendix A.

The noise appraisal shows that overall the effects of 3.2° RNAV SSA whilst positive will be minimal due to the number of aircraft using SSA (In 2019, 0.6% of all approaches). This is reflected in the noise exposure data which shows small reductions in the numbers of people exposed above the daytime and night-time LOAELs and is reflected in the WebTAG assessment outputting a net benefit of £27,632,143 with a sensitivity test outcome of £10,544,020. These net benefits are calculated for the 60 year appraisal period set by default within the Workbook.

Impact	Level of Analysis	Permanently adopt Option B2 Slightly Steeper 3.2º RNAV Approaches	Revert to Option B1 All aircraft operate 3.0º approaches
		The FOA analysis is based on 2019 actual data where 0.6% of aircraft operated 3.2º RNAV SSA. During the trials, an average of 2% of aircraft operated SSA and therefore it is possible that the benefits of SSA could be slightly improved compared to the FOA analysis if more than 0.6% of aircraft fly SSA in future.	
		Summary Option B2: 3.2° RNAV SSA (Option B2) have been shown to provide a small noise benefit. The permanent adoption of SSA would mean that the average noise reduction of 0.51dBA would remain for the 0.6% of flights that operate 3.2° RNAV approaches. An average reduction of 0.51 dBA results in a change in SEL that is difficult to perceive from the ground, however the permanent adoption of 3.2° RNAV approaches is an incremental step to reducing the impact of Heathrow airport's noise footprint on health and quality of life. This noise reduction is reflected in the noise exposure data which shows a small reduction in the number of people exposed above the daytime and night-time LOAELs. It is also reflected in the WebTAG assessment which associates a net benefit of £27,632,143 (with a sensitivity test outcome of £10,544,020) with the permanent adoption of 3.2° RNAV SSA.	**Summary Baseline B1:** As 3.2º RNAV SSA (Option B2) are already in operation at Heathrow reverting to Option B1, where all aircraft operate 3.0° approaches, will result in a small noise disbenefit. The reversion to all aircraft operating 3.0° approaches would mean that the average noise reduction of 0.51dBA for the 0.6% of flights that operate SSA would be lost. Whilst a change of 0.51dBA SEL is small, removing SSA would have a negative impact on Heathrow airport's noise footprint on heath and quality of life. The noise exposure data shows that there would be a small increase in the number of people exposed above the daytime and night-time LOAELs; this is reflected in the WebTAG assessments which shows a net disbenefit of £27,632,143 (with a sensitivity test outcome of £10,544,020) as a result of the removal of SSA.

Impact	Level of Analysis	Permanently adopt Option B2 Slightly Steeper 3.2º RNAV Approaches	Revert to Option B1 All aircraft operate 3.0º approaches
Air quality	Qualitative or monetise and quantify, depending on the scope of the proposal	**Description:** CAP 1616 Appendix B sets out detailed guidance on the assessment of noise, carbon, air quality and other environmental impacts. A full assessment of air quality impacts is set out in WebTAG unit A3. **Assessment:** Heathrow is within the Hillingdon Air Quality Management Area (AQMA) and adjacent to other AQMAs, however, changes in emissions below 1,000ft as a result of 3.2° RNAV SSA are considered minimal as there are no changes to the current lateral flight paths of arriving aircraft to Heathrow, and SSA will not change the number of air traffic movements which are capped at 480,000. In terms of Air Quality, the implications of use of a steeper VPA of 3.2° relate to the relative fuel burn of aircraft compared to using a shallower 3.0° VPA. The differences in fuel burn are dictated by differences in engine thrust required to help stabilise the aircraft whilst on approach. On a steeper VPA, the level of thrust required by an aircraft on final approach is slightly lower. The lower thrust requirement for a 3.2° VPA vs a 3.0° VPA has been evidenced in other studies (e.g. Koenig and Schubert, 2011)[8]. To provide an example of this, an approach to Heathrow airport has been simulated for the Airbus A320 using the EUROCONTROL BADA Aircraft Performance Model[9] as Implemented within the Aviation Environmental Design Tool version 3b. The A320 is the most common aircraft variant in operation at Heathrow Airport. The BADA Aircraft Performance model used is based on the same validated aircraft approach profiles used to support the noise assessment work. The model predicts that for a simulated approach there is a 1.3% reduction in average engine thrust between 10,000ft and touchdown for an aircraft on a 3.2° VPA compared to using a 3.0º VPA. Although the modelling focuses upon a single common aircraft variant, the effect of the steeper 3.2° VPA on engine thrust and fuel burn is likely to be similar for other aircraft variants on approach to Heathrow airport. In terms of air quality, the use of a 3.2° VPA in favour of a 3.0º VPA has two minor benefits: - the reduction in thrust and fuel flow required for the 3.2° approach will result in lower overall emissions of NOx, PM and hydrocarbons; and	

[8] Koenig R. and Schubert E., (2011) AIAC14 Fourteenth Australian International Aerospace Congress On the Influences of an Increased ILS Glide Slope on Noise Impact, Fuel Consumption and Landing Approach Operation.
[9] EUROCONTROL, (2011) Base of Aircraft Data Aircraft Performance Model version 3.9.

Impact	Level of Analysis	Permanently adopt Option B2 Slightly Steeper 3.2° RNAV Approaches	Revert to Option B1 All aircraft operate 3.0° approaches
		- the steeper VPA maintains the aircraft at a slightly higher altitude above ground for longer, thus reducing the contribution of emissions to ground level air quality. The FOA analysis is based on 2019 actual data where 0.6% of aircraft operated 3.2° RNAV SSA. It is possible for closer to 2% of aircraft to operate SSA as per frequencies during the trial period, therefore it is possible that the benefits of SSA could be slightly improved compared to the FOA analysis if more than 0.6% of aircraft operate SSA in future.	
		Summary Option B2: There are overall air quality benefits associated with Option B2 3.2° RNAV SSA; however, due to the small percentage of aircraft that operate SSA (0.6% in 2019), the overall benefits are marginal.	**Summary Baseline B1:** As 3.2° RNAV SSA are already in operation, reverting to all aircraft operating 3.0° approaches would result in a very small disbenefit in air quality; however, due to the small percentage of aircraft that operate SSA (0.6% in 2019), the overall disbenefits are marginal.

3.2 Wider Society

<table>
<tr><th>Impact</th><th>Level of Analysis</th><th>Permanently adopt Option B2
Slightly Steeper 3.2° RNAV Approaches</th><th>Revert to Option B1
All aircraft operate 3.0° approaches</th></tr>
<tr><td>Greenhouse gas impact</td><td>Monetise and quantify</td><td colspan="2">Description: CAP1616 Appendix B sets out detailed guidance on the assessment of noise, carbon, air quality and other environmental impacts. The greatest effect on climate change from aviation is emissions of carbon dioxide (CO_2).
Assessment: Emissions of greenhouse gases arise from the combustion of aviation fuel. Rate of aviation fuel combustion is influenced by track length, lateral tracks, the number of air traffic movements, landing rate, aircraft holding and thrust. The SSA ACP will not involve any changes to the track length or lateral flight paths of aircraft arriving at Heathrow (as evidenced by the flight trials conducted between 2015 and 2017), nor will it involve any increase in the number of air traffic movements. It was further reported that during the flight trials 3.2° RNAV SSA had ‘no adverse impact on the daily operation’ and ‘no impact’ on Heathrow airport’s landing rate, indicating that no increase in aircraft holding will arise as a result of the implementation of 3.2° RNAV SAA arrivals.

In terms of carbon emissions, the implications of use of a steeper VPA of 3.2° relate to the relative fuel burn of aircraft compared to using a shallower 3.0° VPA. The differences in fuel burn are dictated by differences in engine thrust required to help stabilise the aircraft whilst on approach.

With a steeper VPA, the level of thrust required by an aircraft on final approach is slightly lower, which in turn leads to reduced fuel burn and reduced carbon emissions. The lower thrust requirement for a 3.2° VPA vs a 3.0° VPA has been evidenced in other studies (e.g. Koenig and Schubert, 2011)[10].

To provide an example of this, an approach to Heathrow airport has been simulated for the Airbus A320 using the EUROCONTROL BADA Aircraft Performance Model[11] as Implemented within the Aviation Environmental Design Tool version 3b. The A320 is the most common aircraft variant in operation at Heathrow Airport. The BADA Aircraft Performance model used is based on the same validated aircraft approach profiles used to support the noise assessment work.

The model predicts that for a simulated approach that there is a 1.3% reduction in average engine thrust between 10,000ft and touchdown for an aircraft on a 3.2° VPA compared to using a 3.0° VPA. This results in a 3% reduction in fuel burn and therefore a 3% reduction in carbon emissions. Although the modelling focuses upon a single common aircraft variant, the effect of the steeper 3.2° VPA on engine thrust and fuel burn is likely to be similar for other aircraft variants on approach to Heathrow airport.</td></tr>
</table>

[10] Koenig R. and Schubert E., (2011) AIAC14 Fourteenth Australian International Aerospace Congress On the Influences of an Increased ILS Glide Slope on Noise Impact, Fuel Consumption and Landing Approach Operation.
[11] EUROCONTROL, (2011) Base of Aircraft Data Aircraft Performance Model version 3.9.

<table>
<tr><th>Impact</th><th>Level of Analysis</th><th>Permanently adopt Option B2
Slightly Steeper 3.2° RNAV Approaches</th><th>Revert to Option B1
All aircraft operate 3.0° approaches</th></tr>
<tr><td rowspan="2"></td><td rowspan="2"></td><td colspan="2">Detailed analysis shows that the majority of the reduced thrust and fuel burn occurs in the final approach from 4,500 ft to touchdown, where the BADA model simulates a 9.8% reduction in thrust on a 3.2° VPA, resulting in a 7.4% reduction in fuel burn and carbon emissions in that phase of flight.

The FOA analysis is based on 2019 actual data where 0.6% of aircraft operated 3.2° RNAV SSA. It is possible for up to 2% of aircraft to operate SSA before ATC and pilot workload becomes the limiting factor, therefore it is possible that the benefits of SSA could be slightly improved compared to the FOA analysis if more than 0.6% of aircraft operate SSA.</td></tr>
<tr><td>Summary Option B2: Overall, the use of a 3.2° RNAV SSA will lead to a reduction in carbon emissions compared to use of a 3.0° VPA. However, given the use of 3.2° RNAV SSA (0.6% of all arrivals in 2019) the influence of the approach on carbon will overall be negligible.</td><td>Summary Baseline B1: Overall, reverting to all aircraft operating a 3.0° approach will lead to a small increase in carbon emissions, however given the use of the of the 3.2° RNAV SSA (0.6% of all arrivals in 2019), the influence of the approach on carbon will overall be negligible.</td></tr>
</table>

Impact	Level of Analysis	Permanently adopt Option B2 Slightly Steeper 3.2° RNAV Approaches	Revert to Option B1 All aircraft operate 3.0° approaches
Capacity /resilience	Qualitative	**Description:** CAP1616 Appendix E: 'Sponsors should qualitatively assess the effect of the proposal on the overall UK airspace infrastructure'. **Assessment:** The introduction of 3.2° RNAV SSA will not impact the present movement cap on Heathrow Airport and there are no impacts on existing controlled airspace boundaries or airspace classifications. As such the introduction of 3.2° RNAV SSA arrivals is expected to have a neutral impact on system capacity/resilience with the levels of uptake observed in the trials and current operations. **Summary:** Capacity/resilience impacts will not be a differentiator between the Baseline and Option B2.	
Social Impact	Qualitative	**Description:** WebTAG unit A4.1: 'Social impacts cover the human experience of the transport system and its impact on social factors, not considered as part of economic or environmental impacts'. Social impacts include accidents, physical activity, security severance, journey quality, option and non-use values, accessibility and personal affordability. **Assessment:** Following a review of TAG unit A4.1, all eight of the social impacts considered in WebTAG are scoped out and no assessment will be undertaken. Social impacts cover the impact of transport on social factors. Of the eight social impacts – accidents, physical activity, security, severance, journey quality, options and non-use values, accessibility, and personal affordability – none are applicable to this airspace change as these are relevant to ground transportation and would not be affected by airspace change of any kind. The Social Impact assessment is scoped out for all stages of the CAP 1616 process for this SSA ACP. **Summary:** Social Impact will not be a differentiator between the Baseline and Option B2	
Distributional Impact	Qualitative	**Description:** WebTAG unit A4.2: 'Distributional impacts (DIs) consider the variance of transport intervention impacts across different social groups. The analysis of DIs is mandatory in the appraisal process and is a constituent of the Appraisal Summary Table (AST). Both beneficial and /or adverse DIs of transport interventions need to be considered, along with the identification of social groups likely to be affected'. **Assessment:** Following a review of TAG unit A4.2, all eight of the distributional impacts considered in WebTAG are scoped out and no assessment will be undertaken. Distributional impacts cover the variance of transport intervention impacts across different social groups. As with social impacts, these are applicable to ground transportation and of the eight distributional impacts – user benefits, noise, air quality, accidents, security, severance, accessibility, and personal affordability – only noise and air quality have applicability to an airspace change. For the SSA ACP, the distributional impact of noise and air quality has been considered within the respective noise and air quality assessment. **Summary:** Distributional impact will not be a differentiator between the Baseline and Option B2.	

Impact	Level of Analysis	Permanently adopt Option B2 Slightly Steeper 3.2° RNAV Approaches	Revert to Option B1 All aircraft operate 3.0° approaches
Tranquillity	Qualitative	**Description:** WebTAG unit A3: Tranquillity 'means the remoteness and sense of isolation, or lack of it, within the landscape. This can be affected and often determined by noise levels and visual amenity resulting from the absence of built development and intrusion from traffic'. **Assessment:** CAP1616 sets out that an assessment of tranquillity impacts should be undertaken in accordance with the WebTAG guidance on 'Landscape'. Tranquillity is often determined by noise levels and visual amenity. For a tranquillity assessment, the potential implications for the tranquillity of nationally protected landscapes (National Parks and AONBs) and other areas identified through community engagement are to be considered in terms of potential overflight. The main purpose of the proposal to use 3.2° RNAV SSA is to reduce the levels of noise associated with arriving aircraft at the Airport, particularly under final approaches. For the SSA ACP, given the limited changes to existing airspace movements, no change in adverse effects are expected in terms of noise and visual impact. There will be no change to the lateral flight paths of aircraft arriving at Heathrow, which is evidenced by the flight trials conducted between 2015 and 2017. There will be no increase in the number of air traffic movements through the SSA ACP. Lateral fight paths and the number of air traffic movements influence visual amenity and noise levels for sensitive receptors and thus the tranquillity experienced in these areas. As there will be no change to existing lateral flight paths and no increase in the number of air traffic movements, the nationally protected landscapes of National Parks and AONBs as sensitive receptors will not be affected by the SSA airspace change. The noise assessment has shown that when an aircraft operates 3.2° RNAV SSA noise levels do decrease, albeit only very little and, at a level which is imperceptible on the ground having regard to the total operation. Therefore, it is considered that there is no potential for any negative effect to arise as a result of the proposals on areas of tranquillity. Furthermore, as the decrease in noise levels are considered to be imperceptible, it is considered that any positive effects arising as a result of the proposals on the same sensitive biodiversity or tranquillity receptors, would on the whole be negligible. **Summary:** Tranquillity will not be a differentiator between the Baseline and Option B2.	

<table>
<tr><th>Impact</th><th>Level of Analysis</th><th>Permanently adopt Option B2
Slightly Steeper 3.2° RNAV Approaches</th><th>Revert to Option B1
All aircraft operate 3.0° approaches</th></tr>
<tr><td>Biodiversity</td><td>Qualitative</td><td colspan="2">Description: Guidance on assessing impacts on Biodiversity are included in WebTAG unit A3, following advice provided by Natural England. WebTAG unit A3 provides advice on how to appraise the costs and benefits of transport schemes in terms of their effects on both biodiversity and earth heritage (geological) interests.

Assessment: The WebTAG approach is designed to correspond to general terrestrial/aquatic transport projects where land take and other associated effects would be considered as a matter of course.

For the SSA ACP, the potential effects on biodiversity are restricted to those associated with disturbance created (noise or visual disturbance) by aircraft landing at the airport and to potential effects of air quality on habitats. Research shows disturbance effects associated with aircraft typically occur during the landing and take-off cycle when an aircraft is flying at or below 500m (1,640 feet)[1].

As the SSA ACP would not require any changes to the current lateral flight paths arriving aircraft fly on approach to Heathrow, and there would be no increase in the number of aircraft arriving at Heathrow, there is not potential for disturbance of biodiversity to increase.

In terms of air quality, analysis shows that when aircraft operate 3.2° RNAV SSA fuel burn and NOx emissions are marginally reduced when compared to a 3.0° approach. In addition, aircraft remain at a greater height above ground on approach in 3.2° RNAV SSA than approach at 3.0° and as such the contribution of aircraft engine emissions to ground-based biodiversity receptors will be lower when aircraft operate 3.2° RNAV SSA. Overall, these changes will result in reductions in NOx concentrations (and associated nitrogen deposition) at biodiversity receptors (i.e. a beneficial impact), as a result of 3.2º RNAV SSA, however the decrease in concentrations will be imperceptible and therefore the effects will be negligible.

The noise assessment has shown that when an aircraft operates 3.2° RNAV SSA noise levels do decrease, albeit only very little and at a level which is imperceptible on the ground having regard to the total operation.

Therefore, it is considered that there is no potential for any negative effect to arise as a result of the proposals on sensitive biodiversity receptors. Furthermore, as the decrease in noise levels are considered to be imperceptible, it is considered that any positive effects arising as a result of the proposals on the same sensitive biodiversity receptors, would on the whole be negligible.

Summary: Biodiversity will not be a differentiator between the Baseline and Option B2.</td></tr>
</table>

[1] Drewitt, A. (1999) Disturbance effects of aircraft on birds. English Nature Birds Network Information Note

Impact	Level of Analysis	Permanently adopt Option B2 Slightly Steeper 3.2° RNAV Approaches	Revert to Option B1 All aircraft operate 3.0° approaches
Historic environment	Qualitative	**Description:** WebTAG unit A3: ‘The man-made historic environment (‘heritage’, or heritage resource, heritage assets) comprises: • buildings (individually or in association) of architectural or historic significance; • areas, such as parks, gardens, other designed landscapes or public spaces, remnant historic landscapes and archaeological complexes; and • sites (e.g. ancient monuments, places with historical associations such as battlefields, preserved evidence of human effects on the landscape, archaeological sites and so on). The historic environment also includes the sense of identity and place which the combination of these features provides’. **Assessment:** The assessment of impacts on the historic environment is not one of the five environmental aspects identified by CAP1616, however an assessment is suggested in paragraph B10 of CAP 1616 via WebTAG. For the SSA ACP, an assessment of the historic environment is not required because the effects on heritage assets is considered to be negligible. There will be no change to the lateral flight paths of aircraft arriving at Heathrow, which is evidenced by the flight trials conducted between 2015 and 2017. There will be no increase in the number of air traffic movements through the SSA ACP. It is also important to note that in 2019, SSA was flown by 0.6% arrivals, and in the trial 2% of arrivals flew the RNAV approaches (the remainder flying on 3.0° approaches). It is considered that the SSA noise improvements will not affect noise thresholds enough to significantly alter the contribution of setting to the significance of heritage assets. This is based on evidence from the trial reports and the noise analysis undertaken as part of this FOA. Therefore, the Historic Environment assessment is scoped out for all Stages of the CAP 1616 process for this SSA ACP. **Summary:** Historic environment will not be a differentiator between the Baseline and Option B2.	
Landscape	Qualitative	**Description:** WebTAG unit A3: ‘Landscape means more than just ‘the view’. It is both the physical and cultural characteristics of the land itself (i.e. its use and management) and the way in which we perceive those characteristics. It is this mix of characteristics and perceptions that make up and contribute to landscape character and give a “sense of place”. **Assessment:** As set out in CAP 1616, the WebTAG guidance for landscape (which is consistent with that for townscape, where relevant to airspace change) is applied to a tranquillity assessment. Landscape/townscape is therefore inherently taken into account in an assessment of tranquillity for airspace change. If the criteria were to be additionally applied to landscape and townscape topics there would be duplication of assessment, which would not be appropriate. The tranquillity assessment concluded that due to the very minimal differences in noise, tranquillity will not be a differentiator between the Baseline Option B1 and Option B2 and therefore landscape will also not be a differentiator. **Summary:** Landscape will not be a differentiator between the Baseline and Option B2.	

Impact	Level of Analysis	Permanently adopt Option B2 Slightly Steeper 3.2° RNAV Approaches	Revert to Option B1 All aircraft operate 3.0° approaches
Townscape	Qualitative	**Description**: WebTAG unit A3: 'Townscape is the physical and social characteristics of the built and non-built urban environment and the way in which we perceive those characteristics. It is this mix of characteristics and perceptions that make up and contribute to townscape character and give a 'sense of place' or identity'. **Assessment:** As set out in CAP1616, the WebTAG guidance for townscape (which is consistent with that for landscape, where relevant to airspace change) is applied to a tranquillity assessment. Landscape/townscape is therefore inherently taken into account in an assessment of tranquillity for airspace change. If the criteria were to be additionally applied to landscape and townscape topics there would be duplication of assessment, which would not be appropriate. The tranquility assessment concluded that due to the very minimal differences in noise, tranquillity will not be a differentiator between the Baseline Option B1 and Option B2 and therefore townscape will also not be a differentiator. **Summary:** Townscape will not be a differentiator between the Baseline and Option B2.	
Safety	Qualitative	**Description:** Consider existing hazards and new hazards including mitigation strategies. **Assessment:** A successful outcome of the flight trials was defined by Heathrow as to have 'gathered sufficient data with no adverse impact to safety or operational performance', considering 'Continuous descent approach performance, speed adherence on final approach, landing rates, runway occupancy time, numbers of go-arounds, landing gear deployment, aircraft tracks over the ground and to quantify the re-distribution of noise'. Feedback was gathered from Air Traffic Control (ATC) and Airlines, including safety observations. Two safety observations were raised during the first trial, neither attributable to the 3.2° RNAV approach, and none during the second trial. Flight trials conducted between 2015 and 2017 concluded that the trial 'met all objectives with no adverse impact on the daily operation', thus meeting the objective of 'no adverse impact to safety'. Following the trials, 3.2˚ RNAV SSA have continued to operate on a temporary basis and, to date (January 2021), NATS have confirmed no safety reports have been made regarding SSA. **Summary:** Safety will not be a differentiator between the Baseline and the Option B2.	

Impact	Level of Analysis	Permanently adopt Option B2 Slightly Steeper 3.2° RNAV Approaches	Revert to Option B1 All aircraft operate 3.0° approaches
Water environment	Qualitative	**Description:** Guidance on assessing impacts on the water environment is included in WebTAG unit A3, which provides advice on how to appraise the costs and benefits of transport schemes in terms of their effects. **Assessment:** Following a review of TAG unit A3, impacts on the water environment are scoped out and no assessment will be undertaken. The WebTAG guidance distinguishes between impacts arising from the construction of new transport infrastructure, and changes in the use pattern of existing infrastructure and states any transport scheme should fit into one, or both, categories. An assessment of the impact on the water environment is not considered relevant for the SSA ACP as the airspace change will not result in any measurable effects on water receptors. This is because the SSA ACP would not require any changes to the current lateral flight paths arriving aircraft fly on approach to Heathrow, nor would it seek to increase the number of aircraft arriving at Heathrow. The water environment assessment is scoped out for all Stages of the CAP1616 process for SSA. **Summary:** Water environment will not be a differentiator between the Baseline and the Option B2.	

3.3 General Aviation

Impact	Level of Analysis	Permanently adopt Option B2 Slightly Steeper 3.2° RNAV Approaches	Revert to Option B1 All aircraft operate 3.0° approaches
Access	Qualitative	**Description:** CAP1616 Appendix E: 'Sponsors should qualitatively assess the effect of the proposal on the access to airspace for General Aviation'. Also considered was the impact of the proposed airspace change on access to adjacent airspace. Including but not limited to; Gatwick, London City, Stansted, Luton, Farnborough, NATS en-route, Ministry of Defence, impact on London Airspace Management Programme (LAMP) / Future Airspace Strategy (FAS) / overall UK airspace infrastructure, and General Aviation (GA). **Assessment:** There are no impacts on existing controlled airspace boundaries or airspace classifications or on traffic numbers with the introduction of 3.2° RNAV SSA. As such Option B2 will not change the current impact on GA access. **Summary:** Access will not be a differentiator between the Baseline and Option B2.	

3.4 General Aviation & Commercial Airlines

Impact	Level of Analysis	Permanently adopt Option B2 Slightly Steeper 3.2° RNAV Approaches	Revert to Option B1 All aircraft operate 3.0° approaches
Economic impact from increased effective capacity	Quantify	**Description:** CAP1616 Appendix E: 'Forecast increase in air transport movements and estimated passenger numbers or cargo tonnage carried'. **Assessment:** There will be no change in traffic numbers due to the introduction of 3.2° RNAV SSA; the present traffic cap of 480,000 movements per annum remains. Flight trials conducted between 2015 and 2017 reported 'no adverse impact on the daily operation' and 'no impact' on Heathrow airport's landing rate so long as the numbers of RNAV approaches are limited to what is operationally acceptable. As such there is no change in effective capacity between the baseline and Option B2. **Summary:** Economic impact will not be a differentiator between the Baseline and Option B2.	

Impact	Level of Analysis	Permanently adopt Option B2 Slightly Steeper 3.2° RNAV Approaches	Revert to Option B1 All aircraft operate 3.0° approaches
Fuel burn	Monetise and quantify	**Description:** CAP1616 Appendix E: ‘Fuel costs and the relative efficiency of aircraft are readily obtainable from market data. The change sponsor must seek to quantify and monetise these costs based on its assumptions of the fleets in operation’. **Assessment:** Flight trials conducted between 2015 and 2017 demonstrated ‘no noticeable difference in tracks over the ground between the 3.0° and 3.2° arrivals or between the 1st and 2nd trial’. It was further reported that 3.2° RNAV SSA had ‘no adverse impact on the daily operation’ and ‘no impact’ on Heathrow airport’s landing rate. This indicates that no increase in aircraft holding will arise from the option. In terms of fuel burn, the implications of use of a steeper vertical path angle (VPA) of 3.2º relate to the relative fuel burn of aircraft compared to using a shallower 3.0° VPA. The differences in fuel burn are dictated by differences in engine thrust required to help stabilise the aircraft whilst on approach. With a steeper VPA, the level of thrust required by an aircraft on final approach is slightly lower, which in turn leads to reduced fuel burn and reduced carbon emissions. The lower thrust requirement for a 3.2° VPA vs a 3.0° VPA has been evidenced in other studies (e.g. Koenig and Schubert, 2011)[12]. To provide an example of this, an approach to Heathrow airport has been simulated for the Airbus A320 using the EUROCONTROL BADA Aircraft Performance Model[13] as Implemented within the Aviation Environmental Design Tool version 3b. The A320 is the most common aircraft variant in operation at Heathrow Airport. The model utilised is based on the validated profiles used to support the noise assessment work. The model predicts that for a simulated approach that there is a 1.3% reduction in average engine thrust between 10,000ft and touchdown for an aircraft on a 3.2° VPA compared to using a 3.0° VPA. This results in a 3% reduction in fuel burn. Detailed analysis shows that the majority of the reduced thrust and fuel burn occurs in the final approach from 4,500 ft to touchdown, where the BADA model simulates a 9.8% reduction in thrust on a 3.2° VPA, resulting in a 7.4% reduction in fuel burn in that phase of flight. The FOA analysis is based on 2019 actual data where 0.6% of aircraft operated 3.2° RNAV SSA. It is possible for up to 2% of aircraft to operate SSA before ATC and pilot workload becomes the limiting factor, therefore it is possible that the benefits of SSA could be slightly improved compared to the FOA analysis if more than 0.6% of aircraft operate SSA.	

[12] Koenig R. and Schubert E., (2011) AIAC14 Fourteenth Australian International Aerospace Congress On the Influences of an Increased ILS Glide Slope on Noise Impact, Fuel Consumption and Landing Approach Operation.
[13] EUROCONTROL, (2011) Base of Aircraft Data Aircraft Performance Model version 3.9.

Impact	Level of Analysis	Permanently adopt Option B2 Slightly Steeper 3.2° RNAV Approaches	Revert to Option B1 All aircraft operate 3.0° approaches
		Summary Option B2: Overall, the use of a 3.2° RNAV SSA will lead to a reduction in fuel burn for commercial aircraft compared to use of a 3.0° VPA. However given the use of the of the 3.2° slope (0.6% of all arrivals in 2019) the influence of the approach on fuel burn will overall be negligible.	**Summary Baseline B1:** Overall, reverting to all aircraft operating a 3.0° approach will lead to a small increase in fuel burn, however given the use of the of the 3.2° RNAV SSA (0.6% of all arrivals in 2019), the influence of the approach on fuel burn will overall be negligible.

3.5 Commercial Airlines

Impact	Level of Analysis	Permanently adopt Option B2 Slightly Steeper 3.2° RNAV Approaches	Revert to Option B1 All aircraft operate 3.0° approaches
Training costs	Monetise and quantify	**Description:** CAP1616 Appendix E: 'Where a proposal would lead to a need for retraining, this should be quantified and where possible monetised'. **Assessment:** 3.2° RNAV SSA are presently operational. Flight trials conducted between 2015 and 2017 reported airlines have 'No issues with 3.2° approach angle' and 'No detrimental impact due to 3.2º approach' to ATC. No training costs are applicable as the 3.2° approach has been in use for two flight trials, conducted between September 2015 – March 2016 and May – October 2017. No special permissions are required for use of a 3.2° RNAV VPA. **Summary:** Training costs will not be a differentiator between the Baseline and Option B2.	
Other costs	Monetise and quantify	**Description:** CAP1616 Appendix E: 'Where there are likely to be other costs imposed on commercial aviation, these should be described. Where these costs are quantifiable, an assessment should be made'. **Assessment:** No other costs have been identified. 3.2° RNAV SSA are presently operational and RNAV fleet equipage rates are high (in 2016 the equipage rate was 95%). Furthermore, the use of RNAV approaches remains optional with other 3.0° approach options available, therefore operators of unequipped aircraft face no mandatory equipage costs. **Summary:** Other costs will not be a differentiator between the Baseline and Option B2.	

3.6 Airport / Air Navigation Service Provider

<table>
<tr><th>Impact</th><th>Level of Analysis</th><th>Permanently adopt Option B2
Slightly Steeper 3.2º RNAV Approaches</th><th>Revert to Option B1
All aircraft operate 3.0º approaches</th></tr>
<tr><td>Infrastructure costs</td><td>Monetise and quantify</td><td colspan="2">Description: CAP1616 Appendix E: ‘Where the proposal requires a change in the infrastructure, this should be monetised’.

Assessment: RNAV approaches do not rely on ground-based equipment to determine the final approach vertical and lateral path. No change in infrastructure is required for the implementation of either option and thus no infrastructure costs are incurred by Heathrow airport or NATS as the ANSP.

Summary: Infrastructure costs will not be a differentiator between the Baseline and Option B2.</td></tr>
<tr><td>Operational costs</td><td>Monetise and quantify</td><td colspan="2">Description: CAP1616 Appendix E: ‘Where a proposal will lead to changes in operational costs, these should be monetised’.

Assessment: IFP design, validation, AIP promulgation and ATC operational instructions and training have already been completed for 3.2° RNAV SSA as part of the flight trials conducted in 2015 and 2017.

Flight trials conducted between 2015 and 2017 reported ‘No detrimental impact due to 3.2° approach’ to ATC and ‘no impact’ on Airport landing rate. No further operational costs are applicable to Heathrow airport or ANSP for the permanent adoption of 3.2° RNAV approaches.

It is anticipated that if the decision was made to remove SSA and revert to all aircraft operating 3.0° approaches, the 3.0° RNAV Approach procedures would require a review by a UK Approved Procedure Design Organisation to ensure there still exists a safe obstacle environment for their use. At present the RNAV procedures are published by Heathrow in the AIP; however, they are not allocated by ATC. The cost of the APDO review of the procedures to Heathrow is estimated to be £8,000.

Summary: Whilst there is a small cost associated with Option B1 (Reverting to 3.0° RNAV approaches) this is minimal and therefore operational costs will not be a differentiator between the Baseline and Option B2.</td></tr>
<tr><td>Deployment costs</td><td>Monetise and quantify</td><td colspan="2">Description: CAP1616 Appendix E: ‘Where a proposal would lead to a need for retraining and other deployment, this should be quantified and where possible monetised’.

Assessment: Instrument Flight Procedure (IFP) design, validation, AIP promulgation and ATC operational instructions and training are already completed. No further deployment costs applicable to Airport or NATS as the ANSP for the permanent adoption of 3.2° RNAV SSA.

Summary: Deployment costs will not be a differentiator between the Baseline and Option B2.</td></tr>
</table>

3.7 Full Options Appraisal Summary

3.7.1 The outcome from the Full Options Appraisal has been summarised in table 4 below:

Table 4 Full Options Appraisal Summary

Group	Impact	Permanently adopt Option B2 Slightly Steeper 3.2° Approaches	Revert to Option B1 All aircraft operate 3.0° approaches
Communities	Noise impact on health and quality of life	Positive impact	Negative impact
Communities	Air quality	Positive impact (marginal)	Negative impact (marginal)
Wider society	Greenhouse gas impact	Positive impact (marginal)	Negative impact (marginal)
Wider society	Capacity / resilience	Neutral impact	Neutral impact
Wider society	Social Impact	Neutral impact	Neutral impact
Wider Society	Distributional Impact	Neutral impact	Neutral impact
Wider Society	Tranquillity	Neutral impact	Neutral impact
Wider Society	Biodiversity	Neutral impact	Neutral impact
Wider Society	Historic Environment	Neutral impact	Neutral impact
Wider Society	Landscape / Townscape	Neutral impact	Neutral impact
Wider Society	Safety	Neutral impact	Neutral impact
Wider Society	Water Environment	Neutral impact	Neutral impact
General Aviation	Access	Neutral impact	Neutral impact
General Aviation / commercial airlines	Economic impact from increased effective capacity	Neutral impact	Neutral impact
General Aviation / commercial airlines	Fuel burn	Positive impact (marginal)	Negative impact (marginal)
Commercial airlines	Training costs	Neutral impact	Neutral impact
Commercial airlines	Other costs	Neutral impact	Neutral impact
Airport / Air navigation service provider	Infrastructure costs	Neutral impact	Neutral impact
Airport / Air navigation service provider	Operational costs	Neutral impact	Negative impact (marginal)
Airport / Air navigation service provider	Deployment costs	Neutral impact	Neutral impact

4. CONCLUSION

4.1.1 Our Slightly Steeper Approaches consultation is asking the question:

'Do you support the permanent adoption of slightly steeper approaches at Heathrow airport?'

4.1.2 As part of the CAP1616 process, Heathrow is required to state its preferred option for this ACP. Our conclusion is that Option B2, to permanently introduce 3.2° RNAV Slightly Steeper Approaches, is our preferred option for the following reasons:

- Keeping slightly steeper approaches reduces the average SEL of aircraft on RNAV approach by on average 0.51dB compared to the baseline. Whilst the change in SEL is small, the introduction of 3.2° RNAV approaches is an incremental step to reducing the impact of Heathrow airport's noise footprint on health and quality of life.
- Our noise exposure analysis has shown that maintaining RNAV SSA leads to a small reduction in the number of people exposed above the daytime and night-time LOAELs.
- The WebTAG assessment of SSA gives an overall net benefit of £27,632,143 with a sensitivity test outcome of £10,544,020 over the 60 year appraisal period.
- Our environmental analysis of Air Quality and Greenhouse Gas (Carbon Emissions) shows a marginal net benefit of SSA. There is no adverse environmental impact of permanently implementing SSA.
- No stakeholder groups are identified who are adversely affected as a result of retaining SSA.
- There are no other construction or other works required in order to permanently implement SSA; the current temporary procedure would simply become permanent.
- Reverting to Option B1 3.0° ILS and RNAV Approach procedures would result in a small negative impact to the current noise environment, air quality and carbon emissions and would also require the published procedures to be reviewed by a UK Approved Procedure Design Organisation which is an additional cost to Heathrow.

4.1.3 We therefore support the permanent implementation of SSA at Heathrow airport.

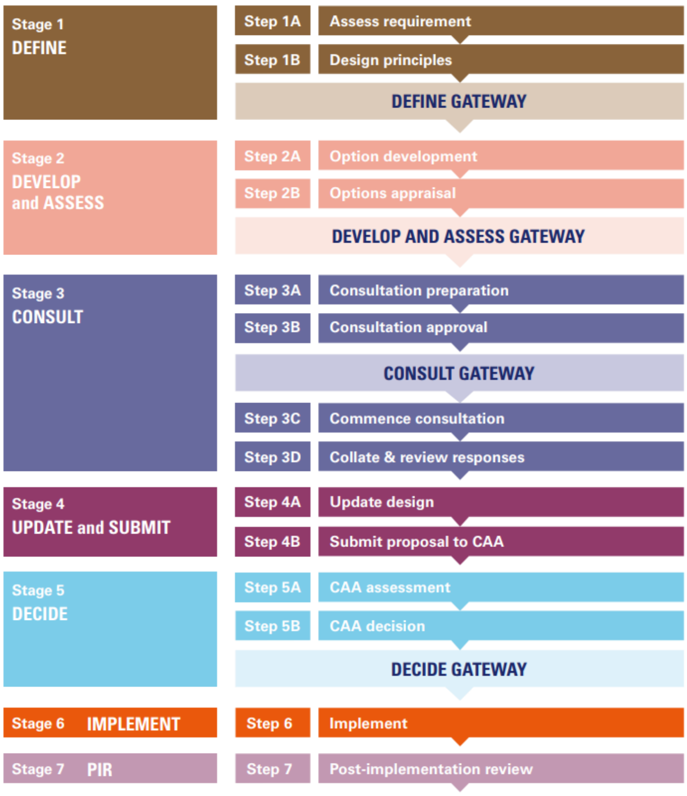
4.2 Next steps

4.2.1 To read our Consultation Document and to respond to the consultation, please use the link below to the SSA Consultation site:

Slightly Steeper Approaches Consultation Site

4.2.2 After the consultation has closed, we will collate, review, and categorise consultation responses on the portal. Our categorisation will be reviewed by the CAA. This forms Step 3D of the Airspace Change Process.

4.2.3 At Stage 4, we will consider the consultation responses and finalise our options appraisal. This will be published on the CAA airspace change portal.



5. APPENDIX A NOISE CONTOURS AND DATA

Please see Appendix A PDF document.

6. APPENDIX B ABBREVIATIONS

ACP	Airspace Change Proposal
AIP	Aeronautical Information Publication
ANSP	Air Navigation Service Provider
ANOMS	Airport Noise Monitoring and Management
ATC	Air Traffic Control
AQMA	Air Quality Management Area
CAA	Civil Aviation Authority
CAP	Civil Aviation Publication
CDA	Continuous Descent Arrival
dB	Decibels – unit to measure sound level
FOA	Full Options Appraisal
GA	General Aviation
GNSS	Global Navigation Satellite System
ICCAN	Independent Commission on Civil Aviation Noise
IFP	Instrument Flight Procedures
ILS	Instrument Landing System
IOA	Initial Options Appraisal
LNAV	Lateral Navigation
LPV	Localiser Performance with Vertical Guidance
MoD	Ministry of Defence
NATS	Primary UK Air Navigation Service Provider
NMR	National Monuments Record
Nx Contours	Nx contours show the locations where the number of events (i.e. flights) exceeds a pre-determined noise level, expressed in dB LAmax.
PBN	Performance Based Navigation
RMT	Remote Monitoring Terminal (Noise)
RNAV Area Navigation:	A method of instrument flight rules navigation that allows an aircraft to choose any course within a network of navigation beacons.
RNP	Required Navigation Performance
SEL	Sound Exposure Level: numerically equivalent to the total

	sound energy.
SSA	Slightly Steeper Approaches
VNAV	Vertical Navigation
VPA	Vertical Path Angle
WebTAG	UK Government Online Transport Analysis Guidance Tool