



RESPIRE FROM AIRCRAFT NOISE SUMMARY OF RESEARCH JOURNEY

PREPARED FOR HEATHROW AIRPORT LTD

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RESPITE FROM AIRCRAFT NOISE

SUMMARY OF RESEARCH JOURNEY

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1 INTRODUCTION

The body of research that has been conducted over several decades leaves little doubt that there are health effects associated with transportation noise exposure. However, there is little research into the overall impacts of aviation on quality of life (QoL) and wellbeing and there is a need for a more holistic assessment of the impacts of aviation. Over recent years Heathrow Airport Ltd (HAL) has been working with other airports, in partnership with ACI-Europe,¹ to develop a co-ordinated research programme delivering a better understanding of airports impact on QoL and, to better understand the effectiveness and value to local communities of interventions airports make in terms of noise reduction and health outcomes (including those aimed at delivering respite). The research roadmap from that work is shown in Figure 1.

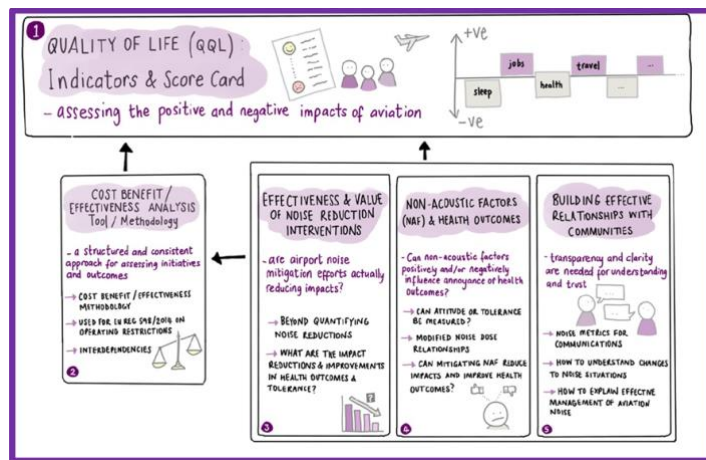


Figure 1: Research Roadmap and QoL

Furthermore, there are broader considerations for policy makers as they balance the impacts of noise policy within a wider social, economic, and environmental context. This is highlighted within EU Regulation 598² (EU598) which sets out that the key objective of transport policy is sustainable development, stating that *'this requires an integrated approach aimed at ensuring both the effective functioning of transport systems and protection of the environment'*. In this context, EU598 requires that measures aimed at reducing the impact of aircraft noise are considered within the framework of the ICAO 'Balanced Approach'³ to noise management and that they are cost-effective. Interventions that deliver respite therefore need to be considered in this light.

HAL is committed to airspace modernisation and keeping pace with the wider UK programme. HAL had initially proposed to undertake airspace modernisation through its Airspace Change Proposal (ACP) for the Heathrow

¹ N Porter, R Norman, X Oh, Research Roadmap for Aircraft Noise, Proceedings of Internoise 2018, Chicago, USA.

² Regulation (EU) No 598/2014 of the European Parliament and of the Council of 16 April 2014 on the establishment of rules and procedures with regard to the introduction of noise-related operating restrictions at Union airports within a Balanced Approach and repealing Directive 2002/30/EC, Amended under The Aviation Noise (Amendment)(EU Exit) Regulations 2019 <https://www.legislation.gov.uk/eur/2014/598>

³ ICAO 9829, 2nd Edition, 2008 - Guidance on the Balanced Approach to Aircraft Noise Management

Expansion Project (HEP), but that is now on pause. Consequently, HAL began a new ACP to make the necessary changes to flight paths. HAL wishes to take the opportunities that the airspace modernisation programme brings to improve operational efficiency and minimise the consequences of aircraft operations on health and QoL for local communities, whilst being committed to broader global climate change and carbon emission concerns. This includes how to potentially design airspace with consideration of providing respite, which requires definitions and measures against which designs can be tested and assessed.

Since 2014 HAL has undertaken a programme of work to develop a better understanding of respite, partly as HAL funded research but also investigated as part of the HEP and associated ACP; the timeline of this work is summarised in Figure 2. The current ACP is considering how respite can be incorporated into the airspace design and so to support this work, HAL has asked Anderson Acoustics to produce a summary of activities of its respite work programme.



Figure 2: Respite Journey to date

This paper builds on the previous reviews⁴ and includes additional further HAL funded research, the supporting work for HEP, its associated ACP; and consultation feedback. Sections 2-8 provide short summaries of each activity and the high-level outcomes; with conclusions provided in Section 9.

The summary aims to consolidate current understanding of respite and its effective implementation, to bring together more parts of the puzzle forming a more holistic understanding of delivering meaningful respite.



⁴ <https://www.heathrow.com/company/local-community/noise/making-heathrow-quieter/respite-research>

2 2014-2016 RESPITE WORKING GROUP (RWG) AND ‘STATE OF THE ART’ REPORT ON RESPITE

In October 2014, the Respite Working Group (RWG) was set up to review current state of the art on respite from aircraft noise and included representatives of UK Government, regulator, aviation industry stakeholder and community groups. In 2016 the group published its report⁵ that provided an analysis of the ‘state of the art’ in understanding and implementing “respite” from aircraft noise as part of a noise management strategy, and proposed areas of future research. For the purposes of their project the RWG developed and agreed the working definitions presented in Table 1.

Working Definitions used by the RWG for the purposes of their 2014/15 work

Relief can be defined as a break from or a reduction in aircraft noise.

Respite can be defined as a scheduled relief from aircraft noise for a period of time.

Table 1: Working Definitions used by RWG

In developing these definitions, the group members recognised that there are many factors affecting the perception of respite and there would be additional work required to further define 'a period of time', 'break' and 'reduction' in terms of community perception.

The RWG concluded that, in general, the provision of some form of noise respite was perceived by communities affected by aircraft noise to be beneficial. However, there appeared to be no consensus on the best way to provide noise respite; or on the best way to define or measure it; and very little quantitative evidence of its value to neighbouring communities and impact on QoL or health outcomes. It was generally agreed that specially targeted research would be required at Heathrow to provide a scientific basis for any future development of a noise respite policy. Such research would help underpin and inform noise management at Heathrow Airport, rather than provide a specific solution. The RWG agreed that priority should be given to gaining a better understanding of how the community values respite, before considering operational feasibility, cost-effectiveness, and the development of assessment metrics. It set out 2 key initial questions to address.

1. By how far do you need to spatially change routes in terms of height and track, and for arrivals and departures) to make a perceived difference to the community (in terms of discernibility and, ultimately to be of perceived ‘benefit’)? For example, to provide effective respite through flight

⁵ N Porter et al, Respite Working Group Report: A Review on The State of The Art on Respite, Anderson Acoustics, June 2016, <https://www.heathrow.com/company/local-community/noise/making-heathrow-quieter/respites-research>.

path/route alternation, the routes must be spatially separated to a sufficient extent to make meaningful differences in sound levels as perceived on the ground. This was investigated through laboratory work.

2. What are the optimum temporal distribution patterns? In other words, are quieter periods resulting from managed flight path/ route alternation more/less beneficial at different times of day; and is alternation of flightpath more/less beneficial than a block of time when one flightpath is used, followed by a block of time when the other flightpath is used? This was investigated through fieldwork.

3 2017-2019 HAL FUNDED RESPITE RESEARCH

In 2017, HAL began a research programme aimed at addressing the questions raised in the RWG recommended research approach. A Peer Review Group was also set up to oversee the scientific robustness of the work and comment on the technical aspects of the research. Details for Phase 1 and 2 can be found in both the technical report and the overview report⁶.

3.1. Phase 1

First, a series of active-listening test comparisons with volunteer members of the public was carried out in the Arup SoundLab facility in central London using representative (recorded) aircraft flyovers. A second series of listening test comparisons (using the same recordings) was then carried out with residents in local venues in different locations around Heathrow Airport.



Photo 1 and 2: Listening Facility (Arup SoundLab), Local Venue Set Up

The active-listening experiments found that sound level differences between successive flyover events of at least 3 dB between maximum event levels (L_{Amax}) were necessary for the difference to be '**discriminable**'. In practical

⁶ N Porter et al, Report on Respite from Aircraft Noise: Overview of Recent Research Work, Anderson Acoustics, May 2017, <https://www.heathrow.com/company/local-community/noise/making-heathrow-quieter/respite-research>

terms, the results suggested that 5 to 6 dB L_{Amax} differences between successive aircraft noise events might be required for more reliable discrimination between the first and second sounds of a pair of sounds differing only in sound level, under active listening conditions.

In the second series of tests, listeners were asked to compare a series of aircraft events in a more realistic sequence, with representative random variation between flyover events (which occurs naturally without any attempt at respite management). These tests found that average differences in L_{Amax} of around 7-8 dB were necessary for these differences to be considered of 'value'. The researchers suggested that since the overall duration of the two sequences as heard in the SoundLab was only around 15 mins - and considering that, under real-life conditions, changes in aircraft noise sound levels mostly take place over very much longer time scales - it seems likely that even larger sound level differences would be required to be considered as 'valued' in the real world.

3.2. Phase 2

Phase 2 involved field studies and aimed to provide understanding of differences in sensitivity to aircraft sound levels in an area under real-life in-situ conditions (passive listening) than when actively comparing successive aircraft flyover events under laboratory conditions (active listening – Phase 1).

The field survey was carried out from September to early December 2017 in six carefully designed sampling areas differing in overall $L_{Aeq,16hr}$ and the difference in $L_{Aeq,8hr}$ (splitting the day into two 8h periods) arising from 'managed respite' afforded by the existing 'runway alternation' scheme for westerly arrivals. Noise exposure was calculated according to the overall daytime (0700-2300) level of aircraft noise ($L_{Aeq,16h}$; below and above 57 dB); and the average respite sound level difference was based on the average sound level difference between runway operations associated with the arrivals flight tracks for the managed respite mode ($L_{Aeq,8hr}$ differences) and categorised in bands 1-4 dB, 5-8 dB, and 9+ dB).⁷ A total of 461 interviews were conducted, with respondents selected randomly within each sampling area.

For this work, respite that was predictable by nature of planned/scheduled changes in operating pattern through the existing runway alternation scheme was termed 'managed respite'. Respite that came about because of unpredictable or unscheduled change in operating pattern due to a wind direction change causing a change of operating direction, was known as "E-W relief".

Each interview included a number of preliminary questions on the general topic of aircraft noise - including existing levels of awareness of 'managed respite'; and more specific questions about 'managed respite' after being given detailed explanations of the current runway alternation schedule. During this 'explanation', which used maps showing the north and south runways and flightpaths under westerly conditions, respondents were

⁷ It is worth noting that for this fieldwork which related to real-life in-situ conditions, differences in $L_{Aeq,T}$ measures were used to describe the managed respite noise level differences, as opposed to differences in single event maximum noise levels (L_{Amax}) used in the laboratory work.

asked to consider their own experiences, seeing and hearing aircraft in relation to their home, at different times of day.

The outcomes of Phase 2 of research generally showed that:

- After having been told about ‘*managed respite*’, and for areas with average aircraft noise levels above 57dB $L_{Aeq,16h}$ where respondents expressed benefit of respite, it was ‘valued’ with $L_{Aeq,8hr}$ differences of at least 9 dB and ‘noticed’ with differences between 4 and 9 dB $L_{Aeq,8hr}$.
- The research also highlighted that there could be considerable benefit to the airport, even if periods of respite achieved only modest reductions in noise (i.e., $L_{Aeq,8hr}$ differences of 2-3 dB), as the majority of respondents said they would feel more positive about the airport, even if it would not be particularly noticeable (although, a small minority would see it as a waste of resources).
- Residents may be unlikely to notice or appreciate small dB reductions in average sound level, particularly against the context of typical day-to-day or hour to hour variation, and if any such changes take place over long time scales.
- People largely value respite if they know it is being provided and hence the benefit of a future respite scheme will be dependent on community engagement as well as level and duration of respite provided;
- Further work was required to understand the different levels of annoyance against which any benefit of “managed respite” can be judged.

Phase 2 researchers suggested their work highlighted that there could be considerable benefit to the perception of the airport even if ‘*managed respite*’ provided relatively modest noise level differences (i.e., $L_{Aeq,8hr}$ differences of 2-3 dB) as respondents generally felt more positive. Although, they also noted that a small minority would see it as a waste of resources. This is an example of the many non-acoustic factors that may



have a significant influence on community attitudes and acceptability of changes in air-space management. For many residents, non-acoustic factors (NAF), such as the effectiveness of public engagement, trust and understanding could be at least as important as actual sound level differences in terms of their appreciation of noise respite policy. A number of the findings of Phase 2 were explored further in Phase 3 (see below).

3.3. Summary of Acoustic Outcomes from Phases 1 and 2

Difference Scenario	Description
<p>Between aircraft events in lab (Phase 1)</p> <p>- Based on L_{Amax} difference measures</p>	<p>Sound level differences between successive flyover events of at least 3 dB L_{Amax} were necessary for the difference to be 'discriminable'.</p> <p>In practical terms, the results suggest that 5 to 6 dB differences between L_{Amax} of successive aircraft events might be required for more reliable discrimination between the first and second sounds of a pair of sounds differing only in sound level, under active listening conditions.</p> <p>For a series of events, average differences in L_{Amax} of around 7-8 dB were necessary for these differences to be considered of 'value'.</p>
<p>Between 2 periods of time (manage respite modes) (Phase 2)</p> <p>- Based on L_{Aeq} difference measures</p>	<p>After having been told about <i>'managed respite'</i>, and for areas with average aircraft noise levels above 57dB $L_{Aeq,16h}$ where respondents expressed benefit of respite, it was 'valued' where $L_{Aeq,8hr}$ difference was at least 9 dB between managed respite modes; and 'noticed' where differences were between 4 and 9 dB $L_{Aeq,8hr}$. Differences of 2-3 dB $L_{Aeq,8hr}$ whilst not being particularly noticeable were considered worth having by many.</p>

3.4 Phase 3

Phase 3 of this programme investigated community perceptions of *'managed respite'* arising from the runway alternation pattern at Heathrow Airport and was divided into quantitative work and qualitative work:

- The main aim of the **quantitative work** was to explore further some of the key findings and indications arising from the Phase 2 quantitative research. Additional statistical methods were applied at an individual respondent level along with outcomes of more sophisticated acoustical modelling to the analysis database. The key issues investigated further included: the perceived value of *'managed*

respite’; the influence of non-acoustic factors on the perceived value of *‘managed respite’*; and the effect of *‘managed respite’* on reported annoyance, taking non-acoustic factors into account.

- The main aim of the **qualitative work** was to further investigate whether *‘managed respite’* is an effective intervention and to further explore the potential confounding influence of *E/W relief* caused by changing wind direction on the value of *‘managed respite’*. It also aimed to explore the extent to which individual differences in perceived benefit are affected by individual differences in non-acoustic factors and confirm which non-acoustic factors have the largest impact on the value residents place on *‘managed respite’*. The work required the collection of new data through the development of new questionnaire topic guides, and new sampling and recruitment of study respondents in selected sampling areas. Separate strands of discussion (focus groups or in-depth interviews) with residents were conducted in different proximities to the airport, specifically targeting areas with different levels of *‘managed respite’*, *E/W relief*, and overall noise exposure (as defined by long-term average L_{Aeq}).

The outcomes of Phase 3 of research generally showed that:

- *Respite is an effective intervention.* It could be concluded that predictable respite is effective as an intervention – it is (genuinely) valued by residents, when they are informed of it, and they certainly don’t want it removed. When told about periods of *‘predictable respite’*, these same residents tended to be generally positive about the concept. There were indications that the overall value of predictable respite to the communities around Heathrow Airport could be maximised by increasing individual awareness of the procedure through more effective public engagement (communication campaigns and education efforts). Providing effective respite to some communities who currently receive none, may mean spreading noise over areas not currently overflowed, or not overflowed as much, and might be referred to as a *‘newly overflowed community’*. In this instance what one side consider a positive outcome that has provided some respite, the other would consider a new noise issue and may then have a greater impact.
- *In general, residents do not differentiate between relief and ‘managed respite’ – ‘Managed respite’, and ‘E/W relief’* provided quite different patterns of noise and noise difference with considerable variation in different areas around the airport. Few residents differentiate between the two.
- *Effectiveness of ‘managed respite’ is maximised though effective communication campaigns and increased educational efforts* - Research demonstrated that increasing residents’ awareness of *‘managed respite’* could have a positive impact on community relations, but how HAL could best achieve this was not straightforward.
- *Night-time respite considered more beneficial than day-time-* Aircraft noise at night was considered by many to be more annoying and disruptive than daytime noise, particularly for those who experience

higher noise levels overall (as defined by L_{Aeq}). So, instinctively, most people thought that respite at night would be more beneficial than day-time respite.

- *No apparent evidence that sound level differences from ‘managed respite’ are effective for reducing reported annoyance.* The effect of ‘managed respite’ sound level differences on annoyance was not clear-cut, and indeed, in combination, non-acoustic factors were more highly correlated with reported annoyance than acoustic factors. There was no detailed evidence either from the previous research, or the additional analysis, that ‘managed respite’ was effective in reducing reported annoyance in the general, uninformed, residential population – more work was required. Whilst analysis suggested that there is no indication that providing respite reduces annoyance there is other evidence suggesting that people who are ‘newly overflown’ are more annoyed for the same noise level than those who have been overflown for some time. It is not clear whether the provision of respite as a mitigation would be received positively by people who become ‘newly overflown’.

3.5 Novel Dissemination Techniques

Throughout the research work, a number of alternative methods were used to help disseminate the research journey and outcomes. One example pulled the early stages of research respite journey into an animation (prepared by Anderson Acoustics Ltd) which was used for stakeholder and community engagement (on Heathrow Airport’s website and at noise fora) – see Figure 4. This journey was also presented as a visual storyboard (see Figure 5). Both used sketch drawings to assist in explaining more complex messages (see Figure 6). At that time, these were new initiatives from Anderson Acoustics and HAL that received very positive feedback in facilitating education and information dissemination.



Figure 4: Example of Animation

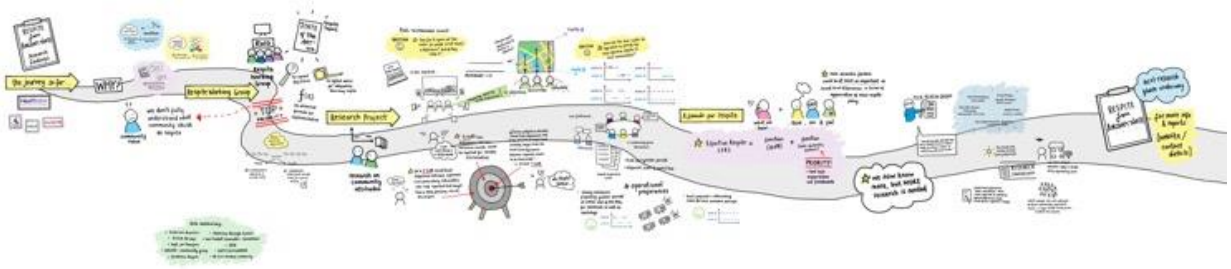


Figure 5: Storyboard of Journey

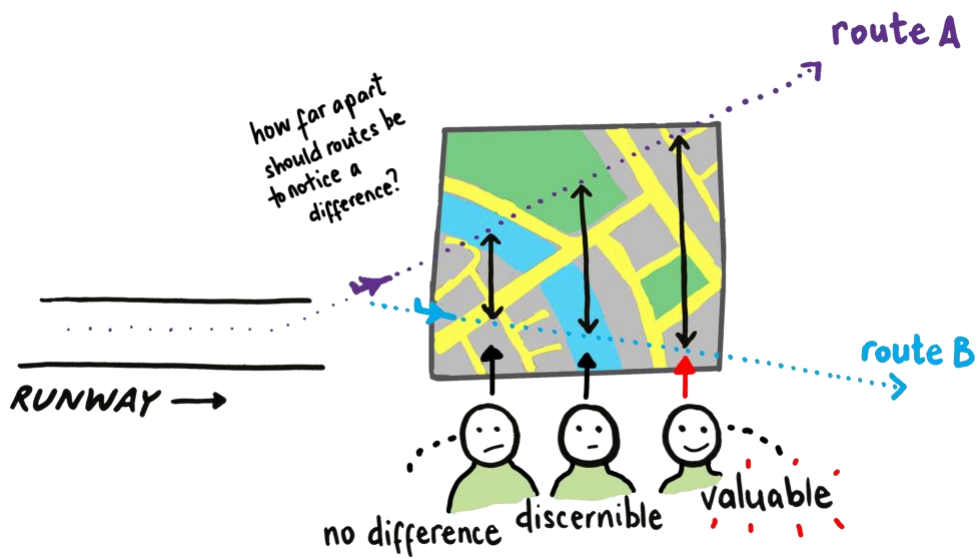


Figure 6: Example of Sketch

4 2018-2019 CONSULTATION ACTIVITIES

Although plans for expansion of Heathrow Airport were paused in 2020, the work that was conducted whilst developing its plans has contributed to the growing understanding of the delivery of effective respite. There were a series of consultations held in 2018 and 2019.

Airport Expansion Consultation One and Airspace Principles Consultation (January to March 2018) - During this first stage of consultation, HAL consulted on emerging proposals and options for the expansion of the airport. At the same time, HAL also consulted on the principles to apply when developing the new airspace design that will be needed for an expanded Heathrow Airport.

Airspace and Future Operations Consultation (January to March 2019) - During the second stage of consultation, HAL consulted on future operations and airspace changes for an expanded Heathrow Airport. This presented airspace design envelopes (the geographic areas where flight paths could be positioned in the future - not a 'Noise Envelope' which is a different concept). The idea being that there would be at least one flight path through each design envelope. In addition, it might be possible to put more flight paths through each design envelope. This could allow for the variation of the use of flight paths at different times, giving people greater respite from aircraft noise - known as flightpath alternation.

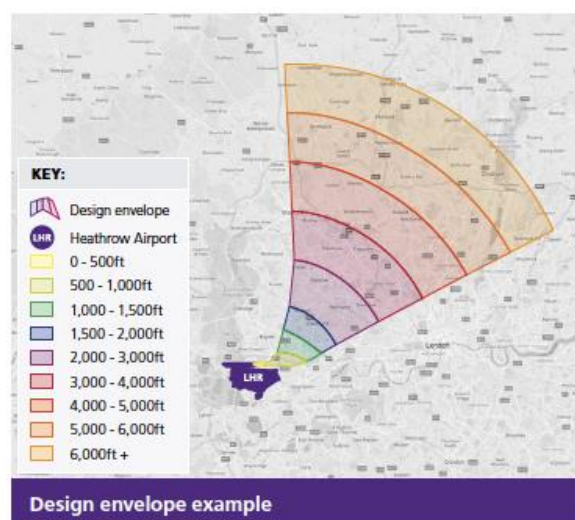


Figure 7: Illustrative geographic design envelope example

HAL also asked about the ways that it could operate the runways for an expanded Heathrow Airport, including how to provide breaks from aircraft noise through initial proposals for runway and airspace alternation⁸.

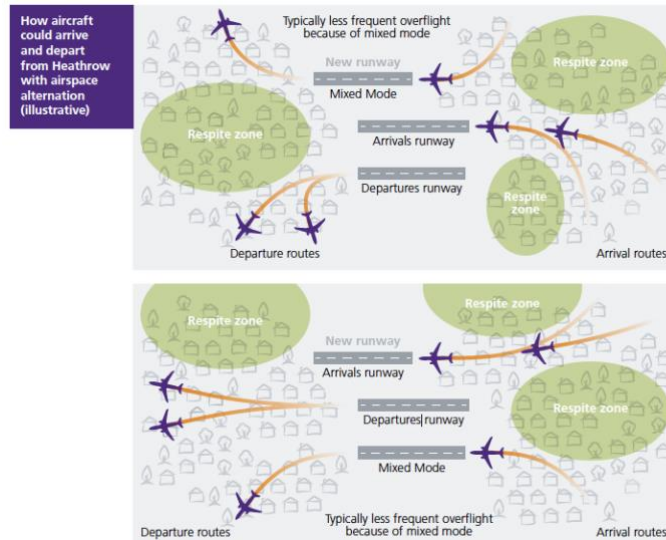


Figure 8: Illustrative example of ACP proposals for airspace alternation to offer respite zones

Airport Expansion Consultation Two (June to Sept 2019) - This consultation sought feedback on HAL’s preferred masterplan for expansion, plans for operating the future airport, the assessment of effects of airport’s growth and plans to manage the effects of expansion.

The Airports National Policy Statement (ANPS) required Heathrow Airport to develop the noise envelope approach with local communities and other stakeholders, and it set up independently chaired Noise Envelope Design Group (NEDG). The noise envelope formed part of the plans for Environmentally Managed Growth at Heathrow Airport, where increases in aircraft and passengers are only permitted if they are within strict environmental limits. The noise envelope was viewed as a set of legally binding and enforceable limits and controls to manage noise in the future while allowing the airport to grow. It was aimed towards providing certainty both now and in the future designed to protect communities while enabling the airport to operate efficiently and allow it to grow within these limits. The NEDG were reviewing how to tie respite provision into its work, but progress was halted when Expansion was paused.

The key lessons from these Consultation Activities (and therefore necessarily based on an expanded 3-runway Heathrow Airport and associated airspace design), of particular relevance to the provision of respite moving forward, at that time were:

⁸ Heathrow Airport, Airspace and Future Operations Consultation Document, January 2019 <https://www.heathrow.com/content/dam/heathrow/web/common/documents/company/about/consultation/Airspace%20and%20Future%20Operations%20Consultation%20Document.pdf>.

- The local community considered the provision of respite as an important mitigation for expansion.
- Alternating runways could provide respite closer to the airport, alternating airspace could provide respite for those living further away. By integrating both methods, respite could be provided over a much wider area than is currently offered.
- There was a general preference for provision of respite during the evenings, night-time, and early mornings.
- Earlier starts on one runway was preferred to later starts on two runways – which effectively would have provided longer periods of respite to more people.
- Providing geographic information such as geographical design envelopes and postcode checkers which are community centric, helps to open up conversations with the public.
- Combining day-time alternation modes and night-time restrictions could optimise respite periods.
- Consultation responses suggest that having some respite every day in a similar way to the current 2-runway alternation scheme is preferable to whole days of respite followed by full days of overflight.
- Reflective alternation, such that communities that are expecting predicted respite will receive it independent of the mode of operation due to wind direction, should be considered further .
- There are a range of media options to facilitate effective engagement and information dissemination – all potential routes should be explored in the future.
- If the concepts of adopting a noise envelope approach be further considered for future noise management, then tying in the provision of effective noise respite could be considered into the principles.

5 2018-2020 HEATHROW EXPANSION PROGRAMME (HEP)

There was relevant work associated with describing respite concepts during the now paused HEP. In the absence of a more proven alternative, and because of its association with other health effects such as annoyance and sleep disturbance, HEP analysis adopted overall $L_{Aeq,T}$ and $L_{Aeq,T}$ difference as measures to objectively describe respite where T was the period for which a particular operating pattern occurred. Potential ways for mapping respite differences were demonstrated, and candidate options for a ‘*respite index*’ to help communicate concepts and for optioneering were developed.

Candidate options for a ‘*Respite Index*’ were developed to combine the notions of noise change and time as experienced by population numbers into one metric. Whilst this work was in its infancy it was showing some promise in being able to objectively describe the degree to which respite was experienced by the population around Heathrow Airport and to compare the effectiveness of different options. For example, “the number of people-hours of valued respite” which could be derived from the number of hours of valued noise change for the population exposed to noise levels greater than LOAEL during a full rotation of operating patterns. These types of measures can be mapped but need further evaluation.

Aircraft noise can impact health in several ways including through sleep disturbance and annoyance. Analysis during HEP, using outputs from SoNA 2014 specifically associated with Heathrow Airport, indicated that the relationship between respite noise level differences and community annoyance was not clear-cut for this dataset. Community annoyance measured using the standard ISO annoyance scale was much too variable between individuals within common noise areas to be able to demonstrate any strong relationship with long term average sound level exposure.

6 2019-2020 HEP AIRSPACE CHANGE PROCESS (ACP)

There were some relevant respite related considerations in connection with the design and concepts for the original ACP programme⁹ (again based around operating a 3-runway rather than the existing 2-runway Heathrow Airport).

Whilst the noise related benefits associated with '*managed respite*' had been elucidated through the HEP and previous research, the ACP work recognised that providing respite may bring some dis-benefits, some non-acoustic. Providing respite means providing alternative airspace to use and means some areas of airspace are empty for a period of time. Further, alternate flightpaths may lead to new people being overflown and may be inefficient from a carbon perspective. The provision of respite could therefore have potential impacts on noise (potentially more and new people overflown), fuel, and ATC (Air Traffic Control) network efficiency. More work is required to understand trade-offs and Government priorities.

The operational methods for respite delivery include runway alternation, airspace alternation, flight path/route alternation. Flight/path dispersal (to provide unpredictable respite during a mode of operation by spreading flights from one runway across more than one flight path) could also form a future consideration.

⁹ At the time of writing, HAL's ACP programme has been restarted based on 2-runways.

7 2020 RESPITE SPRINT

In February 2020, a 'Respite Design Sprint' session was held to consider how best to use , then existing, information on respite for preparing the Heathrow Expansion's Environmental Statement and for associated Airspace Design and consider what else was needed moving forward (short and long term). Representatives in attendance were from different 'perspective areas': airport operations, research, airspace, planning and impact assessment and community. This sprint session could be considered as another step towards consolidating the cumulative knowledge on respite and understanding of the key issues.

Discussions indicated that the terms 'respite' and 'relief' meant the same thing to the community and consequently it was suggested that the language be simplified to reflect the predictability and scheduling nature of respite. In the main, the original definition of respite developed by the RWG has stood the test of time. However, in response to ongoing conversation the following amendments and additions were suggested to simplify and improve clarity:

- *Respite: 'A break from or a reduction in noise from aircraft overhead'*
- *Predictable Respite: 'Scheduled respite from aircraft noise for a period of time'; and*
- *Unpredictable Respite: 'Unscheduled respite from aircraft noise'.*

It should be noted that these definitions do not imply that a break from aircraft noise means aircraft are inaudible; nor that aircraft not considered overhead are inaudible, nor that aircraft noise is not disturbing to some people.

Key lessons from the Respite Sprint, of particular relevance to the provision of respite moving forward, were:

- Respite information and language should be seen through the lens of others and tested to capture 'user' experience. Although the respite language has been evolving, it is still not known how well this language meets the needs. It therefore requires further testing to make sure it is fit for purpose, and further developed where required.
- There was a sense that one block of respite time during the day (as current with the day split into 8h periods) is preferable to more blocks of shorter periods of time.
- It was considered important to bring everything together into a summary report.
- It is important to consider the role of non-acoustic factors in assessing effectiveness of respite (particularly the concept of fairness and sharing) and effective engagement and communication.
- Indicators and presentational methods need to be fit for purpose and should include some measure of flights overhead
- There are clear gaps in the evidence and there is a need to further develop knowledge and understanding of the value and effectiveness of respite to mitigate effects of aircraft noise.
- It is important to be clear about what is possible now, and in the future, and what is not.

8 2017-2020 ADDITIONAL WORK

The following additional pieces of work have been undertaken by others that are of note in the discussion on respite concepts:

1. CAA's theoretical analysis of respite differences and definitions of overflights¹⁰.
2. HACAN's joint work on suggestions for PBN (Performance Based Navigation) implementation options¹¹.
3. Heathrow Airport and ACI (Airports Council International) Europe development of a Research Roadmap for Aviation Noise¹².

Specifically in respect of respite, key take-aways from this additional work are:

- The CAA has developed empirical data on theoretically how far tracks should be separated at different aircraft heights to achieve different L_{max} differences related to established psychoacoustic loudness theory, with a 3 dB change in sound level 'just perceptible', 5 dB as clearly noticeable change, 10 dB to 'appear half or twice as loud' but this is based on laboratory conditions, not real-life listening conditions in the field.
- The CAA has presented a current objective definition for overflight as '*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*' with an Overflight metric as '*The number of overflights experienced by a ground-borne observer over a given period of time*'.
- Taken together, these CAA analyses suggest that for aircraft up to 4,000ft, noticeable noise level differences could be achieved for aircraft on adjacent routes by ensuring that the cone formed by an elevation angle of a maximum 48.5 degrees to the horizon under the centreline of each route should not overlap up to 4,000ft, the centrelines should be separated by at least 1,500m.
- Work was continued by the CAA (Civil Aviation Authority) on their recommended approach to evaluating respite from aircraft noise although only recently published.
- HACAN's joint work on PBN suggests a number of alternative methods for delivering respite and includes staggering the joining point for arrivals, consideration of how the coding of aircraft navigation systems differently could help to disperse aircraft on departure, varying the arrival paths of pre-6am

¹⁰ Civil Aviation Authority, UK, CAP 1498, Definition of overflight, 2017

¹¹ HACAN, Noise Relief: Some practical proposals to improve the noise climate for communities under the Heathrow flight paths.

¹² N Porter, R Norman, X Oh, Research Roadmap for Aircraft Noise, Proceedings of Internoise 2018, Chicago, USA.

flights, and to consider the airspace as a whole and not confined to operations to one (Heathrow) airport.

Heathrow and ACI have considered a research roadmap which includes aspects of respite. It is reported that when considering a research roadmap for aviation noise, the overall outcome should work towards a better understanding of airports impacts on Quality of Life. This should include work on the development of cost-benefit analysis methodology and tools, looking at the effectiveness of mitigation measures, better understanding the relationship between non-acoustic factors and health outcomes, and building better relationships with communities to build trust.

9 CONCLUSIONS

This paper has presented an overview of activities associated with improving HAL’s understanding of respite since this journey began in 2014. In concluding this summary, some key questions and responses based on current understanding are considered below.

What do we mean by respite? – The following definitions are proposed:

- *Respite* is ‘A break from or a reduction in noise from aircraft overhead’.
- *Predictable Respite* is ‘Scheduled respite from aircraft noise for a period of time’.
- *Respite noise change* is the difference in noise level between different operational modes, most commonly measured as $L_{Aeq,T}$ for each mode of operation. These changes could be classified into 3 bands; dB $L_{Aeq,T}$ changes of greater than 9 dB being “valued”, 4-9 dB being “noticeable”, and less than 4 dB being considered “worth having”.
- *Unpredictable Respite* - previously termed Relief – is ‘Unscheduled respite from aircraft noise’.

At present, these definitions only refer to aircraft in flight and not to ground operations. Although the respite language has been evolving, we still do not know how well this language meets the needs. It therefore requires further testing to make sure it is fit for purpose, and further developed where required.

How is respite subjectively perceived? - Predictable respite is generally viewed as of benefit and considered helpful as a mitigation measure to reduce the impacts of noise. It is concluded that ‘managed respite’ is perceived to be beneficial to local people – it is (genuinely) valued by residents, when they are informed of it – and they certainly don’t want it removed. Respite has both quality and quantity elements to it, and the overall appreciation of respite is dependent on both, and subjective perception of respite varies between individuals. The degree of its effectiveness is dependent on both acoustic and non-acoustic factors. However, many residents are not aware of the current respite provision, and the research suggests that non-acoustic factors

such as effectiveness of public engagement, trust and understanding could be at least as important as the respite noise level differences in terms of their appreciation of a noise respite intervention. The research indicated that residents value respite in blocks of time, rather than reducing overall average noise exposure by alternating aircraft between flight paths which increase the time between flights overhead but does not provide sustained blocks of time with respite. Route dispersion type approaches increase the spread of noise and reduce average levels of noise experienced by those overflown but increase the number of people overflown and are not perceived as providing respite. Time of day is important, and most people perceive respite at night to be more beneficial than during the day currently no quantitative data is available on the size of that benefit.

How is respite objectively measured? - It is important to describe the degree to which respite can potentially be delivered, along with where and when it can be delivered. At its simplest level, respite can be described using average noise level ($L_{Aeq,T}$) difference between two operating periods at a particular location and/or for a given population. Other event-based measures (e.g., N65) have shown promise, but have yet to be formally tested. The magnitude of noise change can be summarised as a set of tables or graphically giving respite noise change ranges by areas or population, over the different time periods using the noise change bands described above. Noise change information can also be presented on maps with contours or by postcode points. It is suggested that consideration be given to constraining analysis to defined levels of exposure such as the Lowest Observed Adverse Effect Level (LOAEL) or the Significant Observed Adverse Effect Level (SOAEL) used in Policy and planning. Supplementary information can be added on overall average noise levels or ‘newly overflown’ populations. The priority for providing respite is the population for which there are quantifiable adverse effects from noise. Therefore, in objectively describing respite it is important to provide population counts and communities that experience the respective noise level difference between operating patterns and GIS then used to present the geography of these noise level differences. Notwithstanding the complexities of the interaction between noise level, noise level difference, respite period and time of day there appears to be merit in future consideration of an index (or set of indices) to objectively describe the amount of respite provided and then used to compare respite options. Currently it is not clear how best to consider time in objectively describing respite. These measures require user testing to understand which are best for which purpose.

How is respite best reported and communicated? - People largely value respite if they know it is being provided and hence the benefit of any future respite scheme is dependent on community engagement as well as the quantity and quality of respite provided. Research demonstrates that increasing residents’ awareness of ‘managed respite’ could have a positive impact on community relations. The initial review work highlighted at the outset that a strong and effective communication strategy and good community engagement is essential for the successful implementation of respite. Furthermore, multi-stakeholder engagement is fundamental and more efforts in communication are needed. Information should be fit for purpose; community information should be community centric, providing geographic information potentially by postcode. Adopting meaningful and relevant metrics and indices are vital to meet specific purposes - which may vary between community and industry needs. Language and a common narrative are all important. There is a range of media options to facilitate

effective engagement, information dissemination and clear narratives, including adopting more novel approaches such as those based around animations and sketches – all potential routes should be explored moving forward. Additionally, care should be taken with promoting respite as a positive mitigation strategy for those ‘newly overflown’. If entirely new communities are to be overflown, then providing periods of respite could be viewed positively (eventually) but addressing the non-acoustic factors (understanding of scheme, communication, perception of fairness and sharing) will be absolutely critical to success.

How does the provision of respite relate to health and Quality of Life impacts? - Aircraft noise can impact health in a number of ways including through sleep disturbance and annoyance. The effect of respite on annoyance is not clear-cut, and indeed, in combination, non-acoustic factors can be more highly correlated with reported annoyance than acoustic factors. It could be that if respite is not provided when it was expected then annoyance has the potential to increase. Aircraft noise at night is considered by many to be more annoying and disruptive than daytime noise, particularly for those who experience higher noise levels overall. There is currently no clear indication that providing respite reduces annoyance although there is other evidence suggesting that people who are ‘newly overflown’ are more annoyed for the same noise level than those who have been overflown for some time. There is currently insufficient information on the benefits of respite to health, quality of life, and on the economic value of the effects of respite, and more work is needed.

There is a clear need to expand the evidence base recognising the gaps in knowledge and being transparent about what is possible now and, in the future, (and what is not). As with any journey of building our knowledge, this is a constantly evolving and iterative process of developing ideas through research, testing and review. For respite we need to better understand the benefits (or otherwise) that it can have on health and quality of life. We need to better understand the value (in terms of noise reduction and health outcomes to those directly affected by any changes) and effectiveness of providing respite as a valuable mitigation option. Furthermore, we need to consider how best to build stronger relationships with communities through effective engagement. This requires the development of metrics and communication tools to enhance transparency and clarity in explaining respite in a meaningful way.

What might be the general considerations for designing for respite?

In general, it is suggested that *in developing an airspace design* for respite the starting point should be to maximise the separation of adjacent routes - the further apart the routes the better for providing respite – and that priority should be for aircraft up to 4,000ft.

The CAA has developed generalised guidance for minimum lateral separation and cone angles for aircraft to be considered “overhead” and minimum separations with associated dB reductions. This suggests that for aircraft up to 4,000ft, noticeable noise level differences could be achieved between aircraft on adjacent routes by ensuring that the cone formed by an elevation angle of a maximum 48.5 degrees under the centreline of each route should not overlap up to 4,000ft; and centrelines should be separated by at least 1,500m.

For practical reasons it is suggested that *initial analysis* for assessing differences between routes for the purposes of providing respite should be based on event L_{Amax} differences. Route combinations that do not fit the “noticeable difference” principles above should be discarded; and then separations between routes maximised as far as possible (within the safety, physical and operational constraints, considering broader noise policy and other environmental, emissions and sustainability factors) to achieve the highest L_{Amax} differences possible between individual aircraft noise events on different routes (differences of average L_{Amax} of say >9 dB to be considered ‘of-value’¹³) i.e. the best available evidence at the time of writing this report. This approach can be used to understand the extent to which people will notice the difference between aircraft on different routes.

The *real-life in-situ exposure differences* in terms of the longer term average $L_{Aeq,T}$ will depend on the fleet mix, number of events, aircraft operational procedures, heights etc. So once combinations of routes for “managed respite modes” have been determined, $L_{Aeq,T}$ differences between 2 operational modes should be generated with anticipated use. The differences should be analysed and results at this stage used to refine the airspace design to maximise average ($L_{Aeq,T}$) sound level differences between modes where possible¹⁴.

So, what next?

We would recommend that a research roadmap for respite is developed. This requires a clear research objective, strategy and outcomes and be developed with the Respite Working Group and evolved through wider feedback via targeted presentation and discussion with other key stakeholders and researchers. The roadmap should also serve to seek funding and encourage others, both national and international, to join in the research programme.

¹³ Value of >9 dB considered here based on the findings that for a series of events, average differences in L_{Amax} of around 7-8 dB were necessary for these differences to be considered of ‘value’.

¹⁴ This should consider the Phase 2 research findings that after having been told about ‘*managed respite*’, and for areas with average aircraft noise levels above 57dB $L_{Aeq,16h}$ where respondents expressed benefit of respite, that it was ‘valued’ where $L_{Aeq,8hr}$ difference was at least 9 dB between managed respite modes.