



Respite from aircraft noise: high-level overview of journey on building our knowledge

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ABSTRACT

The need has been identified for an overall outcome of any co-ordinated airport research programme to work towards a better understanding of airports impact on QoL with a requirement to better understand the value (in terms of noise reduction and health outcomes) and effectiveness of the interventions airports make – this includes the provision of respite. Anderson Acoustics Ltd (funded by Heathrow Airport Ltd) has been consolidating current knowledge on respite, particularly in relation to airspace design. That work has essentially continued the journey towards understanding respite and its effective implementation, linking together past, current, and potentially future activities, providing timelines, signposting to other reports and work. This paper presents a high-level overview of HAL's journey to date on building knowledge on respite.

1. INTRODUCTION

Over recent years Heathrow Airport Ltd (HAL) has been working with other airports, in partnership with ACI-Europe, to consider how best to influence the international research agenda – ultimately aiming to enhance the Quality of Life (QoL) around airports (ref 1). The overall outcome of any co-ordinated research programme was agreed as working towards better understanding of airports' impact on QoL and the need to better understand the value (in terms of noise reduction and health outcomes) and effectiveness of the interventions airports make – this includes the provision of respite.

Furthermore, HAL remains committed to airspace modernisation and to keeping pace with the wider UK programme. HAL has begun a new Airspace Change Programme (ACP) to make the necessary changes to flight paths to and from its existing two runways. HAL wishes to take the opportunity to maximise operational efficiencies whilst continuing to manage the consequences of its operations on neighbouring communities.

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So, with this renewed focus on managing the impacts of aviation on health and quality of life and as part of the ACP programme development, HAL recognised the need to consolidate understanding to date of how the respite provided by different runway/airspace/flight path alternation schemes can potentially modify noise impacts. HAL asked Anderson Acoustics Ltd to consolidate HAL's activities and current respite knowledge, particularly in relation to airspace design. The purpose of this paper is to present a high-level overview of activities that have marked that journey.

The chronological order of HAL related activities that have been completed since 2014 in relation to expanding our knowledge on respite is depicted in **Figure 1** below. A summary of each element with some of the relevant outcomes are given in the Sections 2 to 8, followed by some concluding remarks in Section 10.



Figure 1: Respite Journey to date

2. 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. A report produced in 2016 (ref 2) providing an analysis of the, then current, state of the art in relation to implementing respite from aircraft noise as part of a noise management strategy, and proposed areas of future research.

The RWG agreed on working definitions for the purposes of their project. It recognized that there are many factors affecting the perception of respite and the additional work required to further define 'a period of time', 'break' and 'reduction' in terms of community perception.

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.

The outcomes of the RWG and State of the Art Report generally concluded that the provision of some form of noise respite appeared to be beneficial. However, there was no consensus on the best way to provide noise respite; no consensus on the best way to define or measure it; and very little quantitative evidence available to demonstrate its worth to neighbouring communities. 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

3. 2017-2019 HAL FUNDED RESPITE RESEARCH

In 2017, a research project programme was set up to start to address 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 report (ref 3).

3.1. Phase 1

First, a series of 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.

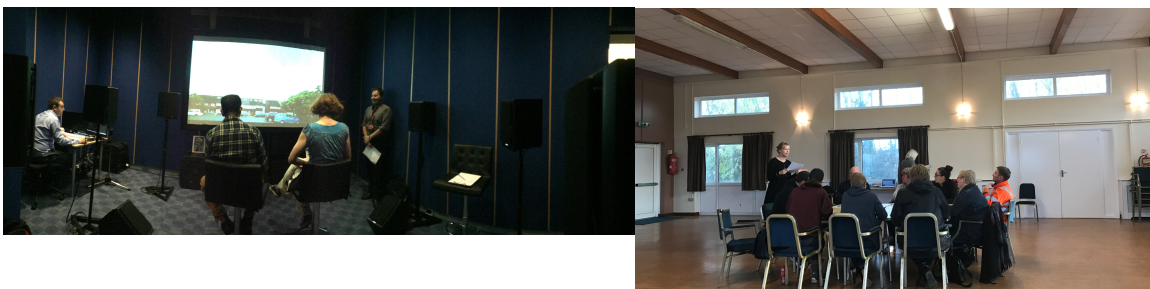


Photo 1 and 2: Listening Facility (ArupSound Lab), Local Venue Set Up.

The active listening experiments found that sound level differences between successive flyover events of at least 3 dB (between maximum event levels) were necessary for discriminability. When compared in a more realistic sequence, with representative random variation between flyover events (which occurs naturally without any attempt at respite management), average differences of around 7-8 dB (between maximum event levels) were necessary for these differences to be considered of value.

3.2. Phase 2

Phase 2 involved field studies to try and understand any differences in sensitivity to aircraft sound events under real-life in-situ conditions (passive listening) than when actively comparing successive aircraft flyover events under laboratory conditions (active listening).

The field survey was carried out from September to early December 2017 in six carefully designed sampling areas differing in overall L_{Aeq} and managed respite sound level differences under westerly arrivals. A total of 461 interviews were conducted, with respondents selected randomly within each sampling area according to matched quotas.

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’ above 9 dB and noticed between 4 and 9 dB (consistent with the findings of Phase 1 laboratory active listening tests);
- 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; and
- Further work was required to understand the different levels of annoyance against which any benefit of managed respite can be judged.

3.3. Phase 3

Phase 3 of the work was to carry out new primary research, and secondary analysis and modelling, into community perceptions of managed respite arising from the runway alternation pattern at Heathrow Airport.

Phase 3 was divided into the quantitative work - with further statistical analyses of Phase 2 existing data and additional noise modelling down to postcode level to inform new higher resolution statistical analyses of existing data, and qualitative work - requiring 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.

The outcomes of Phase 3 of research generally showed that:

- *Respite as an effective intervention*
It might 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).
- *Relief versus managed respite*
Predictable respite, and east-west unpredictable respite, provided quite different patterns of noise reduction with considerable variation in different areas around the airport; and only a few residents can differentiate between the two.
- *Maximizing effectiveness of respite through 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 trivial. However, achieved, it would seem that only fairly high-level messages need to, or can, be disseminated to neighbouring communities for greatest effect.
- *Night-time versus Day-time Respite*
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.
- *Managed Respite and 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. So, 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 is required.

4. 2018-19 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.

1. 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.

2. 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 was 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 flight path alternation.

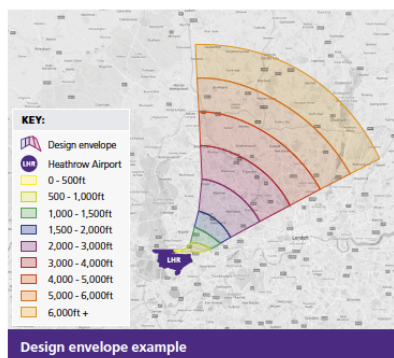


Figure 2: Illustrative geographic design envelope example

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 alternation (ref 4).

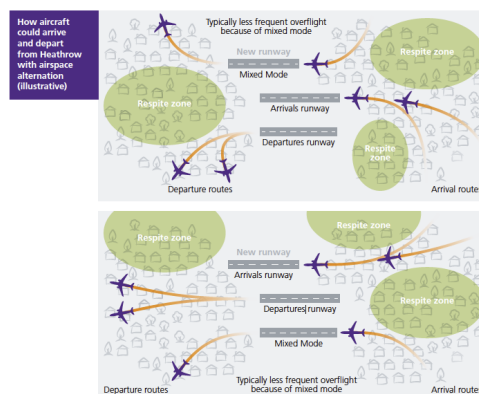


Figure 3: Illustrative example of ACP proposals for airspace alternation to offer respite zones

3. 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 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:

- Community considers the provision of respite in the future as extremely important.
- Alternating runways could provide respite closer to the airport, alternating airspace could provide respite for those living further away. Both together could potentially offer relief over a much wider area than is currently offered when considering a 3-runway airport.
- 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 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 can 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 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.

5. 2018-19 WORK TOWARDS HEATHROW EXPANSION PROGRAMME (HEP)

There was relevant work associated with respite concepts during the now paused HEP. The key lessons (again necessarily based on an expanded 3-runway Heathrow Airport and associated airspace design) of particular relevance to the provision of respite, suggested a number of candidate options for including respite in an overall impact analysis. Options that were mooted but required further evaluation included:

- assigning respite as an additional factor that would then reduce significant effects arising from a primary factor such as end state noise exposure.
- respite, provided by operating different modes could potentially be described objectively (quantitatively) by differences in overall average noise level, and have the potential to be translated into subjective definitions such as 'perceived', 'valued' etc.
- although convincing research evidence was lacking in this regard, one approach that was considered, and rejected, was a TAG type of cost analysis (a UK assessment tool). The relationship between respite level differences and community annoyance was (and still is) not clear-cut. Community annoyance measured using the standard ISO annoyance scale is much too variable across different individuals within common noise areas to be able to demonstrate any strong relationship with long time average sound levels. Indeed, there may not even be an underlying strong relationship.

The work demonstrated a number of potential ways of mapping respite differences, and candidate options for developing a respite index to help communicate concepts and for optioneering. These

options would have to be evaluated further but included percent of time with a given noise level difference, or the development of a respite quotient based on people-hours.

6. 2019-2020 WORK TOWARDS THE AIRSPACE CHANGE PROCESS

There were some relevant respite related considerations in connection with the design and concepts for the original ACP programme³ (again based around operating a 3-runway rather than the existing 2-runway Heathrow Airport).

The ACP work recognised that providing respite can have some disbenefits, some of which are non-acoustic. Providing respite means ensuring areas of airspace are empty for a period of time and may be inefficient from a carbon perspective. It can therefore have potential impacts on noise (more people overflown), fuel, carbon, and ATC network efficiency. Consequently, more work is required to understand trade-offs and Government priorities. The potential methods for respite delivery included runway alternation, airspace alternation and flight path/route alternation.

7. 2020 RESPITE SPRINT

In February 2020, there was a ‘Respite Design Sprint’ session 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, modelling, comms, and community. This sprint session could be considered as another step towards consolidating the cumulative knowledge on respite and understanding of the key issues. Shortly after this event, there was a halt on all work due to the pandemic.

The 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.
- It was considered important to bring everything together into a ‘single source’.
- The need for the use of non-acoustic factors in assessing effectiveness of respite (particularly the concept of fairness and sharing), and also consideration of their role in effective engagement and communication.
- The robustness of any currently developing approaches should be considered.
- Indicators and presentational methods need to be fit for purpose.
- A clear need to expand the evidence base recognising where there are gaps in knowledge and being honest and transparent about what is possible now and, in the future, (and what is not).

8. 2017-20 Additional Work

There has been some additional work which is worth highlighting for the sake of completeness.

1. CAA’s theoretical analysis of respite differences and definitions of overflights (ref 5).
2. HACAN’s joint work on suggestions for PBN implementation options (ref 6).
3. Heathrow Airport and ACI Europe development of a Research Roadmap for Aviation Noise (ref 1).

³ HAL’s ACP programme has been restarted based on 2-runways.

The key take-aways from this additional work suggest:

- There is empirical data on theoretically how far tracks should be separated at different heights to achieve different L_{Max} differences, which can be 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.
- There is a current objective definition for overflight and an associated overflight metric, although the details of the observation angle are not agreed.
- Work is continuing by the CAA on their recommended approach to evaluating respite from aircraft noise although nothing is, at the time of writing, yet published.
- Some alternatives for delivering respite (from a community-led publication) which have included staggering joining points on arrivals, consideration of how the coding of aircraft differently could help to disperse departure routes, varying the arrival paths of pre-6am flights, and to consider the airspace as a whole and not confined to operations to one (Heathrow) airport.
- 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

Given the above body of work, let us consider some key questions and how we might answer them at this juncture.

What do we mean by respite?

Respite is ‘A break from or a reduction in aircraft noise’. *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 can be classified into 3 bands; dB changes of greater than 9 dB, 4-9 dB, and less than 4 dB. *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.

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 might be concluded that managed respite is effective – it is (genuinely) valued by residents, when they are informed of it – and they certainly don’t want it removed. 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 research has suggested 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.

How is respite objectively measured?

It is important to describe what levels of respite can potentially be delivered, where and when these 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. 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 LOAEL/SOAEL). Supplementary information can be added on overall average noise levels or ‘newly overflown’ populations. These measures require user testing to understand which are best for which purpose.

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.

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. Information should be fit for purpose; community information should be community centric, providing geographic information potentially by postcode. Language and a common narrative are all important. There is a range of media options to facilitate effective engagement and information dissemination – all potential routes should be explored moving forward.

There is a clear need to expand the evidence base recognising the gaps in knowledge and being honest and 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 process of developing ideas through research, testing, reviewing and so on.

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 the 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.

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 nationally and international to join in the research programme.

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research consortium, the Peer Review Group, the Respite Working Group, the attendees at the Respite Sprint.

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