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Simulating Changes in Aircraft Noise at Heathrow Airport during the 2020 Covid-19 Lockdown

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ABSTRACT

Global restrictions on domestic and international travel introduced in March 2020 as a result of the Covid-19 pandemic resulted in a significant reduction in air traffic movements around the world. This paper presents the findings of research carried out at London Heathrow Airport exploring the day-by-day changes in aircraft noise exposure and event levels over the period March 2020 to June 2020. The research was carried out using validated modelling of aircraft procedures and noise profiles alongside radar data obtained from the airport. This allowed trends in metrics such as LAeq, N65, and overflight to be considered in the form of contours, and at community locations. This was facilitated using geospatial databases and interactive dynamic reporting toolkits. The research has allowed estimates to be made of the point where aircraft noise at Heathrow Airport reached a minimum. It also provides some helpful insight as to the potential of generating daily noise exposure data and the advantages, and disadvantages of modelling using radar data.

1. INTRODUCTION

The Covid-19 pandemic led to an unprecedented decline in global commercial aviation. Working with Heathrow Airport, the authors identified an opportunity to track the impact of the reduced aircraft movements through modelling and analysis techniques. This paper presents the techniques adopted the by authors, the outcome of daily noise modelling from 1 March 2020 to 31 July 2020 and estimates in the reduction in aircraft noise experienced at Heathrow Airport due to national and international travel restrictions.

2. CONTEXT

London Heathrow Airport is the largest and busiest airport in the United Kingdom. In 2019, Heathrow was the second busiest airport in the world by passenger traffic providing transport for

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approximately 81 million passengers with a total of 478,059 aircraft movements [1]. Through the airport's two runways and its airspace arrangements, the declared hourly runway capacity at Heathrow Airport is for 45 arrivals and 46 departures [2].

In line with policy and relevant legislation, noise modelling and the generation of noise exposure data for airports is typically generated so to represent a long-term average of several months to a year [3]. Noise exposure data is produced for Heathrow Airport each year by the UK Civil Aviation Authority (CAA). In the UK, aviation noise policy is based on an assessment period which covers an 'average summer day' from 16 June to 15 September inclusive [3]. For daytime periods, assessment is undertaken for traffic in the busiest 16 hours of the day, between 0700 and 2300 local time [3]. For night-time periods, the busiest 8-hours of the night, between 2300 and 0700 local time are considered [3].

UK aviation noise policy is underpinned by the L_{Aeq} metric however additional metrics are used to describe impacts, namely the N65 and N60 metrics which illustrate the number of aircraft events above 65 dB L_{Amax} and 60 dB L_{Amax} respectively for the daytime and night-time periods [4,5]. UK noise policy and aviation noise policy adopts established concepts from toxicology in form of 'effect levels'. UK aviation noise policy defines a 'Lowest Observed Adverse Effect Level' (LOAEL) of 51 dB $L_{Aeq,\ 16hr}$ and 45 dB $L_{Aeq,\ 8hr}$ as measured for the average summer day [4,5,6]. These thresholds can be used to describe areas and populations exposed to levels of aircraft noise where adverse effects begin to be observed. An 'overflight metric' can also be used to describe the degree to which locations are 'overflown' by aircraft [7]. The metric relies on establishing whether an aircraft event occurs at or below 7,000ft above the ground, and whether the aircraft is above a defined elevation angle from the receiver [7]. The metric is not an acoustic measure but was developed in a manner which relates to perception [7].

The authors have previously investigated the potential of adopting an 'event based' approach to aircraft noise modelling [8]. The approach works by modelling each discrete aircraft event and storing the calculated noise levels so to assemble noise metrics for discrete periods. Figure 1 presents a process flow for an 'event-based' approach. This is approach has been utilized in support of this work. An event-based approach generates significant volumes of data. As illustrated in Figure 1, this requires analysis techniques to be employed so to generate noise exposure metrics.

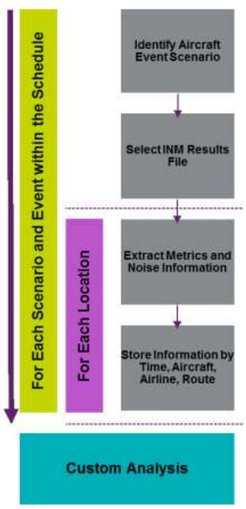

Figure 1: Event-Based Approach Process Flow

The focus of this paper is on evaluating and presenting changes in aircraft noise around Heathrow Airport due to national and international travel restrictions imposed as part of Government interventions to manage the spread of Covid-19. The analysis commences on 1 March 2020. In the UK, advice to stop non-essential travel was issued on 16 March 2020, with a national lockdown ordering people to stay at home announced on 23 March 2020 [9].

3. PURPOSE AND OBJECTIVES

Using an event-based approach, the authors investigated the impact of global travel restrictions on noise exposures around Heathrow Airport. The analysis considered two periods:

- 01/03/2020 to 31/03/2020; and
- 06/04/2020 to 31/07/2020.

The objectives of the study were as follows:

- Track daily changes in noise exposure as a result of Covid-19 restrictions;
- Identify how localised noise exposure data can be communicated;
- Investigate how airport operational and noise exposure data can be more interactive; and
- Demonstrate how airport noise characteristics can be tracked in the short-term.

The final two objectives are not considered directly in this paper but the outputs with respect to the figures presented are taken from interactive web-based dynamic reporting tools which were designed to present the data generated from the event-based analysis.

3. MODELLING TECHNIQUES

All modelling adopted an event-based approach with AEDT Version 3.0b used to calculate aircraft noise events. The model was validated in accordance with UK CAA guidance as set out in CAP2091 [10]. This entailed the development of custom flight profiles using analysis of radar data alongside a validation of each aircraft's Noise-Power-Distance (NPD) through statistical comparisons to measured noise levels at Heathrow's noise monitoring terminals [11].

As part of long-term noise modelling, it is typical for the modelling to utilize a representation of the airspace by modelling the centerline for each flight path with a series of sub-tracks [3,12]. This approach relies on an analysis of the statistical distribution of flight paths. When modelling short-term events, such a method does not adequately reflect the location and occurrence of aircraft noise events. The event-based modelling adopted by the authors therefore utilized the actual flight tracks for each aircraft event taken directly from Heathrow's ANOMS system. ANOMS is used by many airports internationally and is software system for aircraft noise monitoring, noise reporting and flight tracking. The software stores a multitude of information including flight numbers, aircraft types, 3-dimensional tracks, and associated correlated noise events measured at the airports noise monitoring terminals. To facilitate the noise modelling, a CSV output from ANOMS over the period of interest was obtained and cleaned to allow flight tracks and noise events to be written directly into AEDT through the software's standard input file (ASIF). An example is shown in Figure 2 below and has formed the basis of generating noise event data for this study.

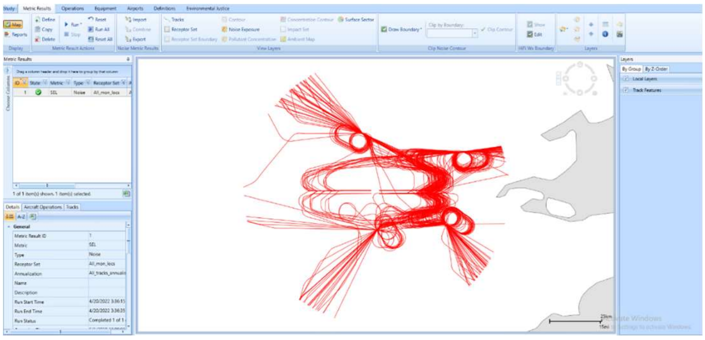

Figure 2: Radar Arrival Flight Tracks taken from ANOMS and reproduced in AEDT

For each operation and flight track, noise levels were calculated on a 50m x 50m grid, and at receptors located in the center of places and communities around the airport. In addition to calculating noise levels, software was used to calculate overflights.

3. OPERATIONAL IMPACT OF COVID-19

3.1. Impact on Movements

Over the first week of March, air traffic movements at Heathrow were relatively unaffected, however, by 10th March movements began to reduce. Five days later, from the 15 March 2020, the data shows that aircraft traffic movements began to reduce significantly. This coincides with most other European countries closing land borders around 15 - 20th March 2020 [13]. UK lockdown measures commenced on 23rd March, and the data obtained from Heathrow's ANOMS system showed that by the end of March, air traffic was operating at levels at least 85% lower than at the beginning of month as illustrated in Figure 3.

Over the first two weeks of April 2020, traffic movements reduced further to around 10% of the activity seen at the beginning of March 2020. For comparison, at the beginning of March 2020 aircraft movements were consistently above 70 per hour during the operational day with peaks of over 80 movements. In contrast during the first two weeks of April this was well below 10 movements per hour. Over the period April through end-May 2020 there was a slow increase in flights however by the summer of 2020 there was still few than half the number of movements.

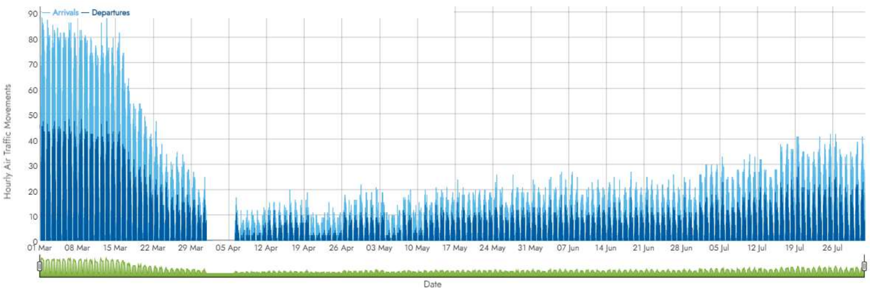

Figure 3: Hourly Movements at Heathrow Airport between 1 March 2020 to 1 July 2020

3.2. Changes in Runway Operations

During March 2020, Heathrow operated both of its runways, using one for arrivals and one for departures. During westerly operation, the airport maintained its runway alternation program providing communities living beneath the flight paths used by arriving aircraft, predictable periods of noise relief by switching runways at 1500 each day.

On 3 April 2020, Heathrow announced that it would be moving to single runway operations from Monday 6 April 2020. This means instead of operating one runway for departures and one runway for arrivals a single runway is used for both departures and arrivals. This was communicated as a temporary measure due to *"the unprecedented impacts of the coronavirus (COVID-19) outbreak"* and for the Airport to provide *"greater resilience and safety for our colleagues, passengers and cargo"* owing to the significant reduction in aircraft movements [14].

Through Single Runway Operations (SRO), Heathrow began alternating which runway was used for its schedule on a weekly basis. SRO was made available during both westerly and easterly operations. This is illustrated in Figure 4 which shows respective runway use before and after SRO was introduced. It also shows the periods where the airport was operating in easterly (runways 09L and 09R) and westerly (runways 27L and 27R) directions.

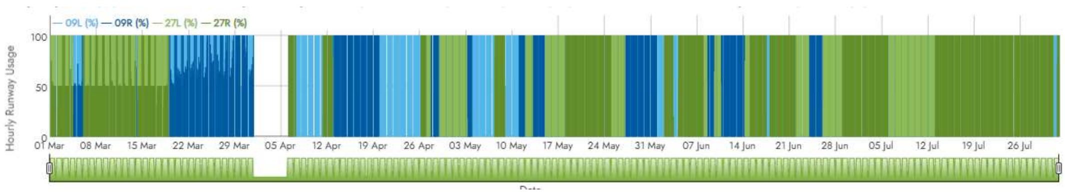

Figure 4: Illustration of Runway Usage at Heathrow Airport over the period 1 March 2020 to 31 July 2020

4. IMPACT ON NOISE

4.1. Reduction in Noise Output

Noise contours can be used as a measure of noise output. Figure 5 presents the calculated size in km^2 of daytime and night-time LOAEL contours over the period 1 March 2020 to 30 March 2020. As shown in Figure 6 and Figure 7, the area of the LOAEL contour reduced from 264km^2 on 1 March 2020 to 55 km^2 on 31 March 2020. This shows that over the period where air traffic had reduced by approximately 85% that daytime noise output had reduced by approximately 80% with noise exposure levels reducing by around 7 dB when standardised.

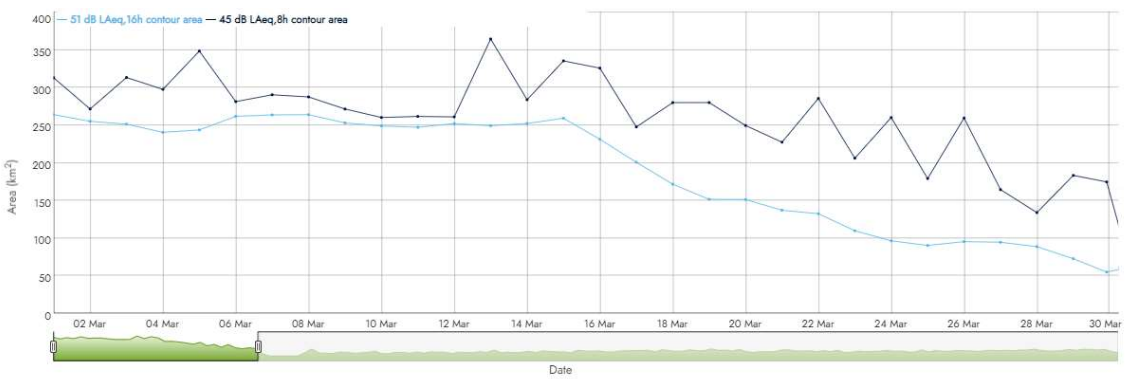

Figure 5: Daytime and Night-time LOAEL contours (km^2)

Figure 6: $L_{Aeq,16hr}$ noise contour for 1 March 2020 (with westerly operations)

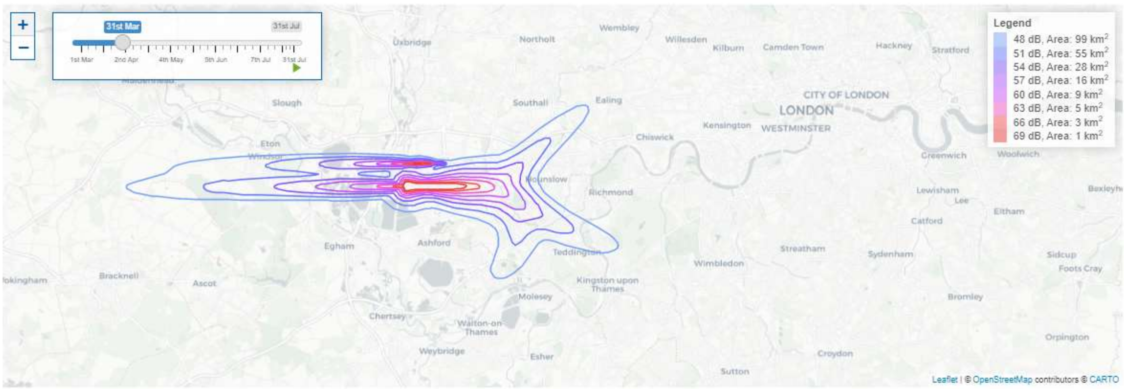

Figure 7: $L_{Aeq,16hr}$ noise contour for 31 March 2020 (with easterly operations)

Such trends were also observed with respect to the N65 metric. Significant contractions in the areas experiencing at least 100 and 200 65 dB L_{Amax} events per day we identified. However the contraction in the size of areas experiencing at least 20 and 50 events per days was less profound.

4.2. Changes to the pattern and distribution of aircraft noise

As outlined, prior to the pandemic Heathrow operated as a two-runway operation. Following the significant decline in traffic, single runway operations commenced. The SRO cycle employed by Heathrow weekly and as such, certain communities were potentially received week-long periods without overflight and/or significantly reduced noise exposure, the most significant of which occurring for communities located under the airport's final approaches and initial departures.

An example of this is shown is Worton Road, near Isleworth, which is affected by westerly arrivals onto Heathrow's 27L runway. It is not affected by the airport's departure routes. For example, between the week commencing 5 July 2020 and 12 July 2020, Worton Road saw a reduction of c150 events in N65 metric and a 13 dB reduction in noise exposure over a weeklong period due to runway patterns delivered through SRO as shown in Figure 8.

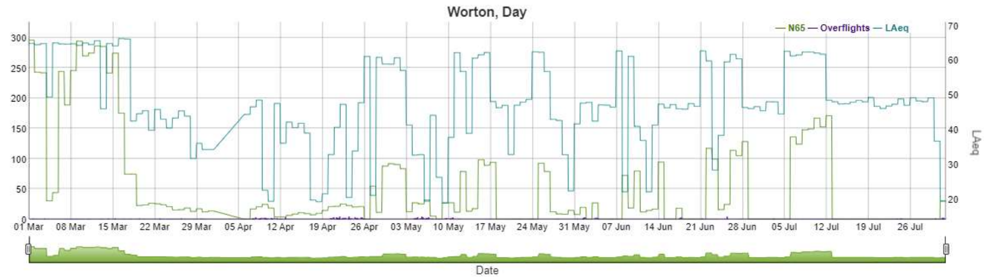

Figure 8: Daytime Noise Exposure and Event Metrics for Worton, Isleworth over the period 1 March 2020 to 31 July 2020

In communities located under departure routes, impact of SRO on the pattern of noise exposure was less profound. Egham, for example is located under Heathrow's DET departure route. It is not overflown by arriving aircraft and falls outside of the noise preferential route for easterly departures. When considering the pattern in noise exposure in Egham, the number of noise events, overflight and exposure is driven by the time of the day i.e. day or night, and whether the airport was operating in an easterly or westerly direction. As such, a communities such as Egham observed reduced noise during SRO as a result of the downturn in air traffic rather than changes in the pattern of the aircraft noise it experienced.

For a small number of locations around Heathrow, SRO resulted in noise exposure and event levels returning to levels more consistent with those observed in March 2020 even though air traffic remained significantly reduced. Cranford, for example, is located immediately to the east of Heathrow Airport and is routinely overflown by arriving aircraft onto Heathrow's 27R runway. During normal easterly operations, aircraft take off from Heathrow's southern runway (09R) and land on its northern runway (09L). SRO resulted in aircraft departing and landing on runway 09L resulting in direct overflight of Cranford. Due to prevailing wind directions this occurred mainly during April and May 2020. From 17 May 2020 most operations were westerly at Heathrow and periods SRO on runway 27L can be clearly seen. A 19 dB difference in noise exposure levels was observed in Cranford due to SRO operations.

5. REACTION ON SOCIAL MEDIA

No social surveys were in place over the period considered in the study and therefore correlating community reactions to the reduction in aircraft noise cannot be undertaken. However, to provide some insight, the authors undertook a basic data mining using the Twitter's API which entailed tracking the location of the tweets alongside the occurrence of key terms (i.e. 'noise', 'aircraft', 'Heathrow'). The data mining highlighted an increased pattern of positive comment with regards to reduced aviation noise in London around 26th March. Examples tweets over the 20 March to 1st April 2020 included:

- *"We are really noticing the absence of aircraft noise. It is so quiet. (We live between Gatwick and Heathrow)."*
- *"The days have been so quiet overhead; no aircraft turning for #Heathrow and now one crosses overhead. What a noise!!"*
- *"One thing that I'm really appreciating at this weird time is how quiet it is. Barely any noise from planes (we're on the Heathrow flight path) or traffic and it's so peaceful. With the window open tonight, all I can hear is birdsong."*

- *"Heathrow is so quiet that I've just watched a private plane (from Gloucester Airport) cruising past at 1500 ft just two miles from the end of the take- off runway. Never been known. See also - birdsong is unusually audible, no aircraft noise or constant rumble from M4."*

Over the period other sources of environmental noise would have reduced considerably. The UK Government's "stay at home" advice on the 16 March 2020 and subsequent lockdown of 23 March 2020 will have significantly reduced road traffic and ambient noise across London. However, on 19th March 2020 Heathrow Airport switched direction from westerly to easterly operations. This would have had the effect of significantly reducing the amount of noise distributed over London and this may have been a factor in prompting the comments submitted to social media.

6. CONCLUSIONS

The event-based techniques adopted by the authors successfully allowed a detailed dataset of aircraft noise exposure metrics to be created for hourly periods over a period of c4 months from March 2020 to July 2020. The methods adopted allowed for the changes in noise from Heathrow Airport during the imposition of national and international travel restrictions to be calculated and presented. The analysis showed significant reductions in aircraft operations with corresponding reductions in the areas exposed to certain thresholds of aircraft noise.

More broadly the techniques adopted in preparing this study could be used to support ongoing noise management and help provide researchers with a greater level of detail in the variation in the levels of aircraft noise exposure and events experienced by communities along with diurnal trends. Such information could be helpful in exploring attitudes and effects of aircraft noise.

7. ACKNOWLEDGEMENTS

We would like to acknowledge Heathrow Airport for providing the data which has underpinned this study.

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