AN ALTERNATIVE APPROACH TO PRESENTING AIRCRAFT NOISE IMPACTS THROUGH MODELLING

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1 INTRODUCTION

Aircraft noise is a complex environmental issue. The topic transcends fields such as technology, health and social sciences, and politics.

In recent years, there has been much debate and criticism of the metrics that have been traditionally used to assess and communicate aircraft noise impacts. The consultation responses to the Airport's Commission 2013 discussion paper *'Aviation Noise'*[1] highlighted the weight of argument around such metrics. The majority of the near 100 responses to this consultation provided much commentary and discussion on this subject.

The responses to the consultation highlighted not only the need to align aircraft noise metrics with scientific research on health and social effects such as annoyance and sleep disturbance, but also to consider how noise impacts can be described and presented in a way which can be clearly understood and trusted by community stakeholders.

A number of responses suggested the use of N-metrics, such as N65, which describe the number of aircraft events above a certain level of noise. Indeed these metrics have been used elsewhere such as in Australia to present noise management practices, and in the case of Brisbane Airport, the impact of a new parallel runway[2]. Other suggestions included time-above metrics and 'noise histograms' to allow people to understand how noise aircraft changes throughout the day at a particular location.

The general consensus amongst most of the consultation respondents was that the development, application and end-use of noise metrics requires cross-stakeholder involvement.

Based on the ideas and concepts highlighted in the consultation responses, the authors have developed a software-based approach that can facilitate, derive and help present a number of metrics. This paper describes the development of a software application, its general concept, and how its outputs can provide potential end-uses in communicating aircraft noise effects.

2 APPLICATION DEVELOPMENT

2.1 Basic Concept

The basic concept is to simulate aircraft events as they appear in an airport's schedule throughout the day using noise modeling techniques and other relevant information from technologies such as radar. The aim is to translate these simulated events into a profile of how they may be experienced by receptors on the ground.

At a fundamental level, each aircraft noise event comprises of a number of acoustic and non-acoustic metrics. Acoustic aircraft event metrics include indices such as the Sound Exposure Level (SEL) or L_{Amax}. Non-acoustic metrics include the event duration, the altitude of the aircraft at the point they overfly the receptor, and the time at which the events occur. Additionally, the type of aircraft may also be a consideration because of perception.

The application has been designed to correlate modeled aircraft events within an airport's schedule with the resultant acoustic and non-acoustic metrics at receptors. The concept therefore attempts to replicate what may be experienced by a receptor as a result of airport operations by generating a profile of how that receptor is overflown according to these acoustic and non-acoustic metrics in the same way a Noise and Track Keeping (NTK) system can capture similar information.

The concept and process is illustrated in Figure 1.

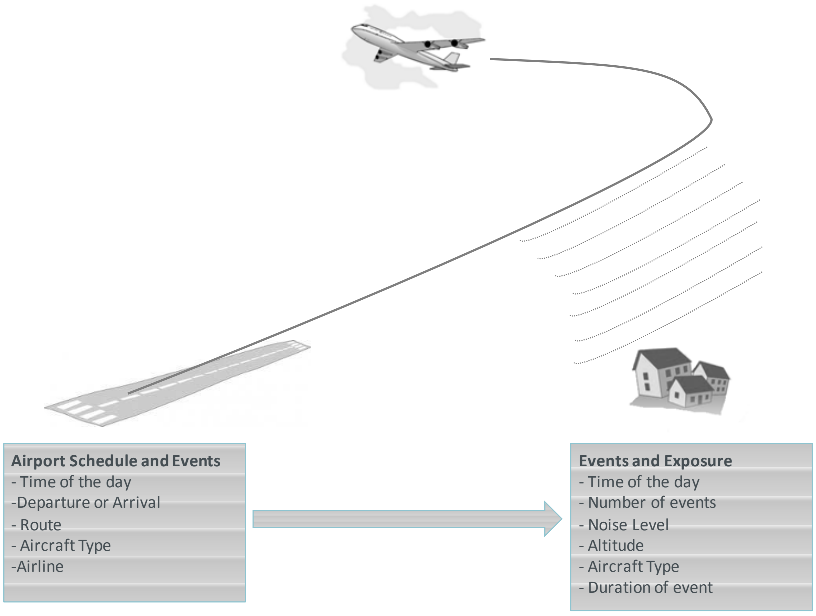

Figure 1 – Basic Concept

2.2 Development

The application has been developed around the Federal Aviation Administration's Integrated Noise Model (INM) version 7.0d using an open-source programming language. The application has been designed to control and configure INM and process its outputs. Using GIS integrations, other geo-spatial information can also be processed in a similar manner and incorporated into the analysis. The process comprises of a five-stage process as illustrated in Figure 2. These stages are described in the following sections.

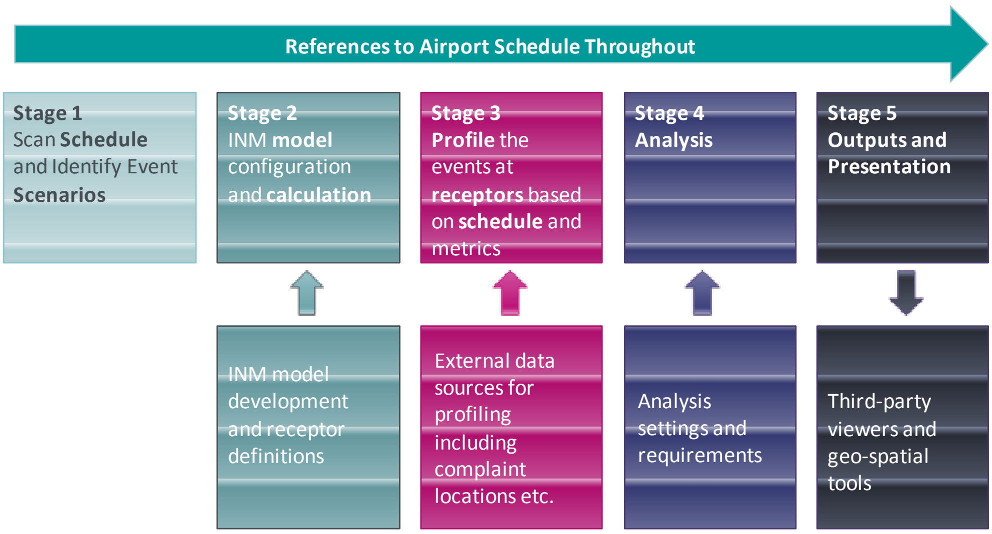

Figure 2 – Application Stages

2.2.1 Stage 1 – Schedule and Scenarios

Stage 1 of the application process is a preparation stage. The airport's schedule is analysed and all potential scenarios identified. The scenarios are event based, which means that an aircraft on a particular route either arriving at or departing from a particular runway is classified as a single scenario. Using this information, the tool automatically constructs these scenarios for a variety of event indicators within the INM modeling environment.

This is achieved through the use of a schedule input file which has been designed to work alongside the application. The schedule input file itself can be configured to represent a number of operating conditions to take into account single mode conditions and noise management practices such as runway alternation. It can also be configured to represent long-term averages or daily variations.

2.2.2 Stage 2 – Model and Calculation

Stage 2 of the application process involves the INM model and the calculation of the event metrics at location points. The location points are pre-defined. The proof of concept presented in Section 3 of this paper has used postcode centroids; however, in theory, any location can be used. The automation process includes the configuration of calculation settings and outputs to prescribed values so that each scenario and metric is calculated consistently.

2.2.3 Stage 3 – Event Profiling

Stage 3 of the application process follows the calculation of the event metrics. At this stage, other non-acoustic event metrics can also form part of the profiling. The application has built-in functions to capture other geo-spatial data such as aircraft altitude at the nearest point, and other relevant proximities.

A high level illustration of the process behind the event profiling is shown in Figure 3.

Using the schedule, the application identifies the corresponding scenario and results file from INM. Using a handler, the application can also cross-check other data sources for information relating to the event. For example, if a certain event or activity has resulted in noise complaints, this information can be identified and fed into the profiling. Likewise, other non-acoustic information such as aircraft altitudes can also be inserted into the profile using GIS techniques.

Once the event scenario is identified the application cycles through each location storing information about the event in a series of arrays. These arrays are configured and ordered to reflect the temporal order of the schedule. The information can be binned into discrete analysis periods such as hourly or half-hourly intervals.

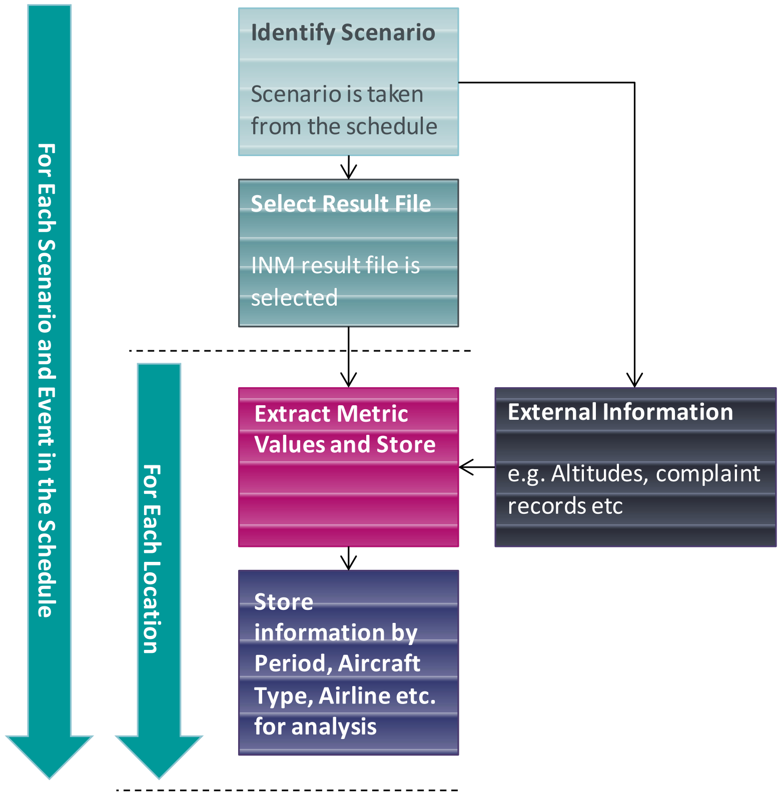

Figure 3 – Event Profiling

2.2.4 Stage 4 – Analysis

The analysis stage uses the profile information to produce statistics based on the metrics and events. The analysis considers the acoustic and non-acoustic metrics to produce the statistics for each of the analysis periods across the whole day. Using long-term schedules, the analysis can be configured to consider a week or a whole year. Likewise, the analysis can consider single and average mode conditions and runway and airspace usage patterns. The type of indicators that can be derived from the analysis include, N-metrics throughout the day, the number of a particular aircraft or airline overflying a particular location, and short-term average noise levels such as $L_{Aeq, 1hr}$. Using the event profiles, metrics such as the Average Individual Exposure (AIE) and Person's Event Index (PEI) can also be derived for each location over short and long-term periods. Other non-acoustic metrics that the analysis can perform includes the average altitude of over-flight throughout the day. The analysis can be customised to the end-user's requirements and data interactions prepared to highlight any correlations.

2.2.5 Stage 5 – Output and Presentation

The outputs deposited from the application reflect the required analysis and can be configured in a number of formats. The outputs are flexible, which enables the use of third-party software tools to present and display the results or further processing for correlation with other information such as the findings of social surveys.

In their basic format the outputs can be loaded into geospatial data systems to present the profiles and metrics as discrete locations. In its standard form the application has been designed to work with proprietary GIS software, depositing formats such as ESRI shapefiles.

2.3 Limitations

There are a number of limitations in the approach to the concept however, these are not insurmountable.

The first key limitation is the accuracy of the noise levels and event information calculated by INM. In order to best replicate real-world events, the noise model must be prepared to a good level of confidence. This means that all departure and arrival profiles must be as realistic as possible. This is however best practice. The application should therefore only be used where detailed noise models have been verified.

The second key limitation is aircraft dispersion. Conventional aircraft navigation means that aircraft can be dispersed by up to several nautical miles about their tracks. Although it is possible to model a number of routes about a track, it is not possible to predict exactly what course an aircraft will take in any given event, only that it will more or less follow its allocated track. Applying the application and concept to current day operations makes it somewhat indicative. However, in the future, and with technological advances and adoption of air navigation aids and systems such as Precision-Area Navigation (P-RNAV), aircraft will be capable of flying to within 1 nautical mile of an allocated track. In reality this will be within a couple of hundred metres of track. An illustration of this is provided in Figure 4.

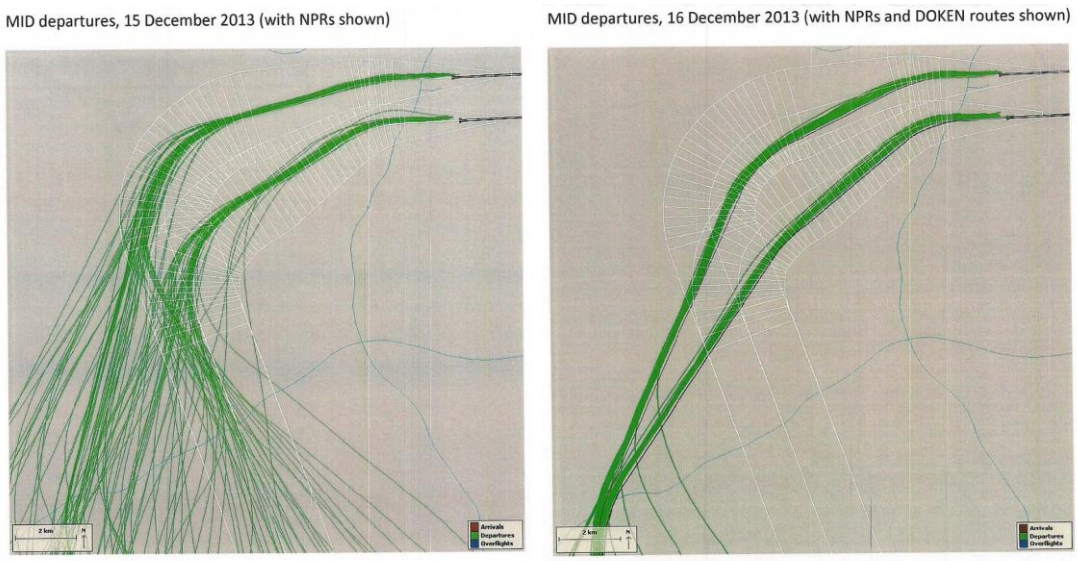

Figure 4 – P-RNAV Illustration (source: NATS)

3 PROOF OF CONCEPT

3.1 Concept Scenario

A proof of concept scenario was developed to test the potential end-uses of the application. A dummy two-runway airport was been modeled and configured to replicate around 135,000 air traffic movements and operating conditions similar to London Heathrow. This included runway alternation. The model was configured to include post-code centroids obtained from Ordnance Survey OpenData

3.2 Selecting an Analysis

The application can be configured in a number of ways. However, in proving the concept, the authors have decided to process the schedule and profile event information to produce statistics and metrics for each 30 minute daytime period of the day during easterly operations. The analysis has considered acoustic and non-acoustic metrics. In the analysis, the application was configured to illustrate the benefits of runway alternation by demonstrating event profiles throughout the day and producing statistics either side of the alternation period at a set time of 1500hrs.

3.3 Presentation

Although the application itself has no specific visual presentation, the outputs were used to create a geo-spatial visualisation using a third-party software tool. The third-party tool was configured to present the location of the postcodes and their natural boundaries and the profile information for each 30-minute period and overall statistics. The tool was also configured to facilitate comparisons of overflight profiles for various metrics between postcodes. For context, the runways and flight paths are presented on top of contextual background mapping obtained from a Web Mapping Service (WMS).

3.4 Examples

Figures 5 – 8 present some examples of how the outputs from the application can be presented. In all examples, an interactive map is presented with the various metrics selectable by the user. Postcodes can be searched, with flight tracks and runways overlaid on symbolised postcode boundary polygons.

Figure 5 presents a map showing the $L_{Aeq,\ 30min}$ noise level for a particular period symbolised against postcode boundaries. The bottom right corner of the display shows the $L_{Aeq,\ 30min}$ noise levels across the day. For the selected postcode, the display shows the reduction in noise level at 15:00hrs as the runways alternate. It is also possible to animate the symbolised postcode boundaries to show how the noise changes throughout the day.

Figure 6 presents an example where the number of N65 events per postcode is compared side by side for two 30-minute periods before and after runway alternation. The approach clearly shows the benefit of runway alternation on noise levels under the flight paths.

Figure 7 demonstrates how the number of N65 events can be presented for postcodes and how the number of N65 events can be illustrated and compared throughout the day. The example in Figure 7 shows that at the selected postcode (orange) there are no longer any N65 events from 1500hrs thus indicating respite. For the comparison postcode (blue), N65 events begin after 1500hrs whereas none occurred before alternation.

Figure 8 shows how a simple indicator can be used to illustrate the effectiveness of runway alternation. The indicator presents the average time between N65 events either side of the alternation period. For the selected post codes, the visualisation shows how the average number of minutes between N65 events swings between 480 minutes (i.e. 8 hours) and less than 3 minutes either side of alternation.

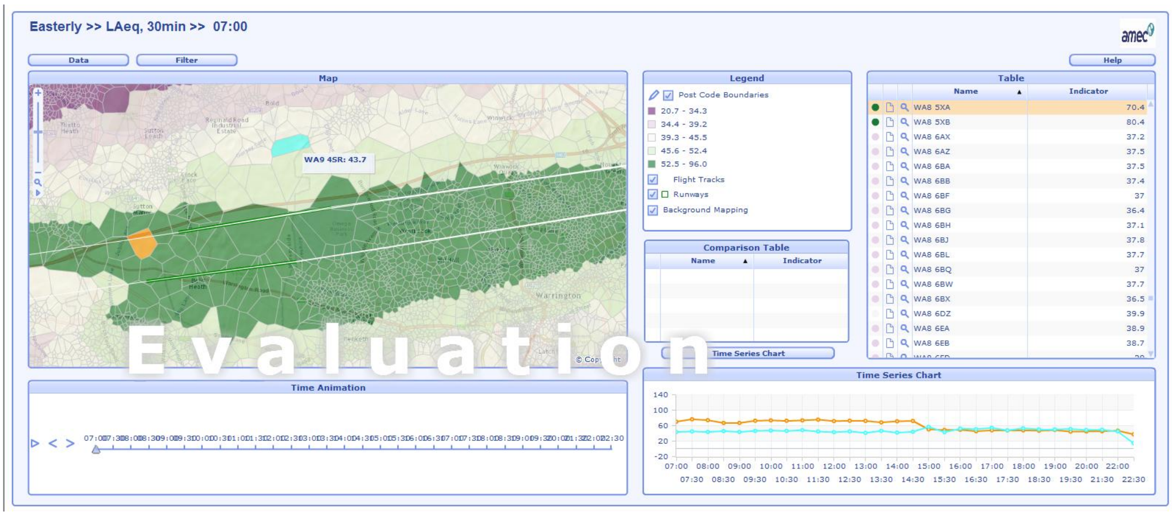

Figure 5 – Profile showing $L_{Aeq,\ 30min}$ noise levels at a selected postcode and comparison

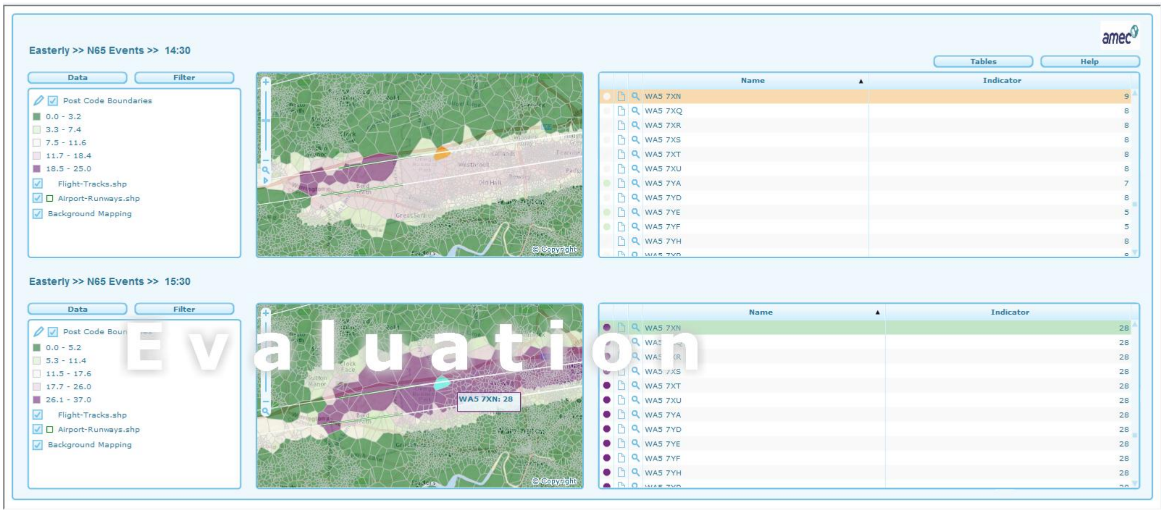

Figure 6 – N65 events in two 30-minute periods before and after alternation

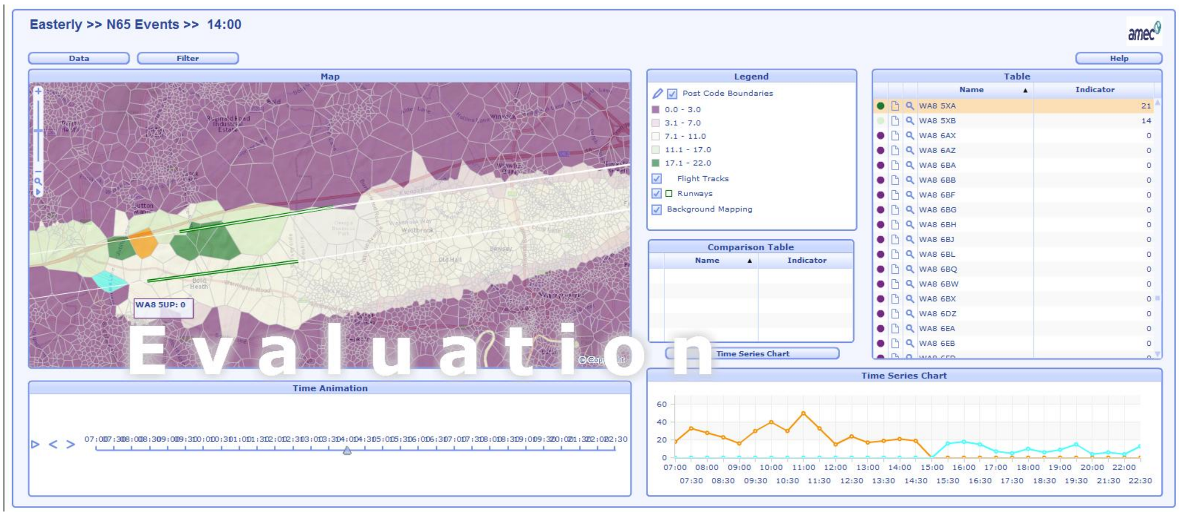

Figure 7 – Time-series profile and map of N65 events at a selected postcode

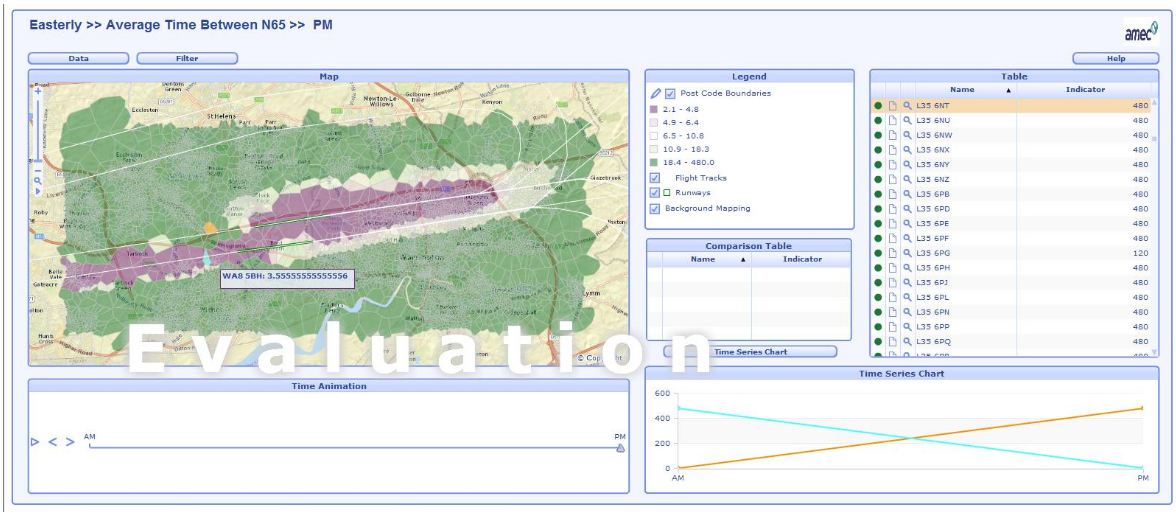

Figure 8 – Presentation of the average time between N65 events before and after alternation

4 FURTHER END-USES AND WORK

The basic concept and application has potentially significant end-uses in communicating and investigating the impacts of airport operations. The approach may also be used to aid research.

4.1 A Communication Tool

As demonstrated in Section 3, it is possible to use the application to demonstrate a range of airport noise impacts and operating characteristics. Using the internet and compatible WMS tools, this information could be published to provide noise stakeholders with an interactive and selectable set of metrics. The information could assist people in understanding how they are overflown and how it compares with locations around the airport. This information could be helpful in communicating how runway alternation and runway modes protect and provide outdoor amenity. The information could also be used to help people plan to use their gardens, for example.

The application does not necessarily have to communicate current impacts. It may also be used to communicate changes arising from, for example, airspace change or a new runway. The application and analysis could be configured to illustrate how a receptor is overflown now and how this would change in the future. Using the event profiles, it may even be possible to identify which locations currently have a similar pattern of overflight so that newly exposed receptors can visit these locations to understand the likely noise impacts when they are overflown in the future.

4.2 Supporting Research and Investigation

Given the number of metrics that can be stored, derived and interacted with each other, the application could be used to help support aircraft noise research through evaluating correlations with social survey data or complaints. Given that the profiling and analysis facilitates both short-term and long-term metrics, responses to aircraft noise can be evaluated in terms of ‘conditions’ rather than by just levels of noise exposure. For example, using social survey responses and the various metrics derived from the application, it could be possible to identify a set of conditions that translate to the perception of being overflown thus allowing a definition of noise respite.

4.3 Further Work

The authors plan to apply the approach to a real-world airport where wider information on community responses can form part of the analysis stage. The authors also plan to investigate the web-publishing aspects of the visualisations.

5 REFERENCES

1. Airport's Commission, Discussion Paper 05: Aviation Noise, (2013).
2. Details available at: http://www.bne.com.au/corporate/flight-paths/discovery-centre