An Introduction to Noise Metrics

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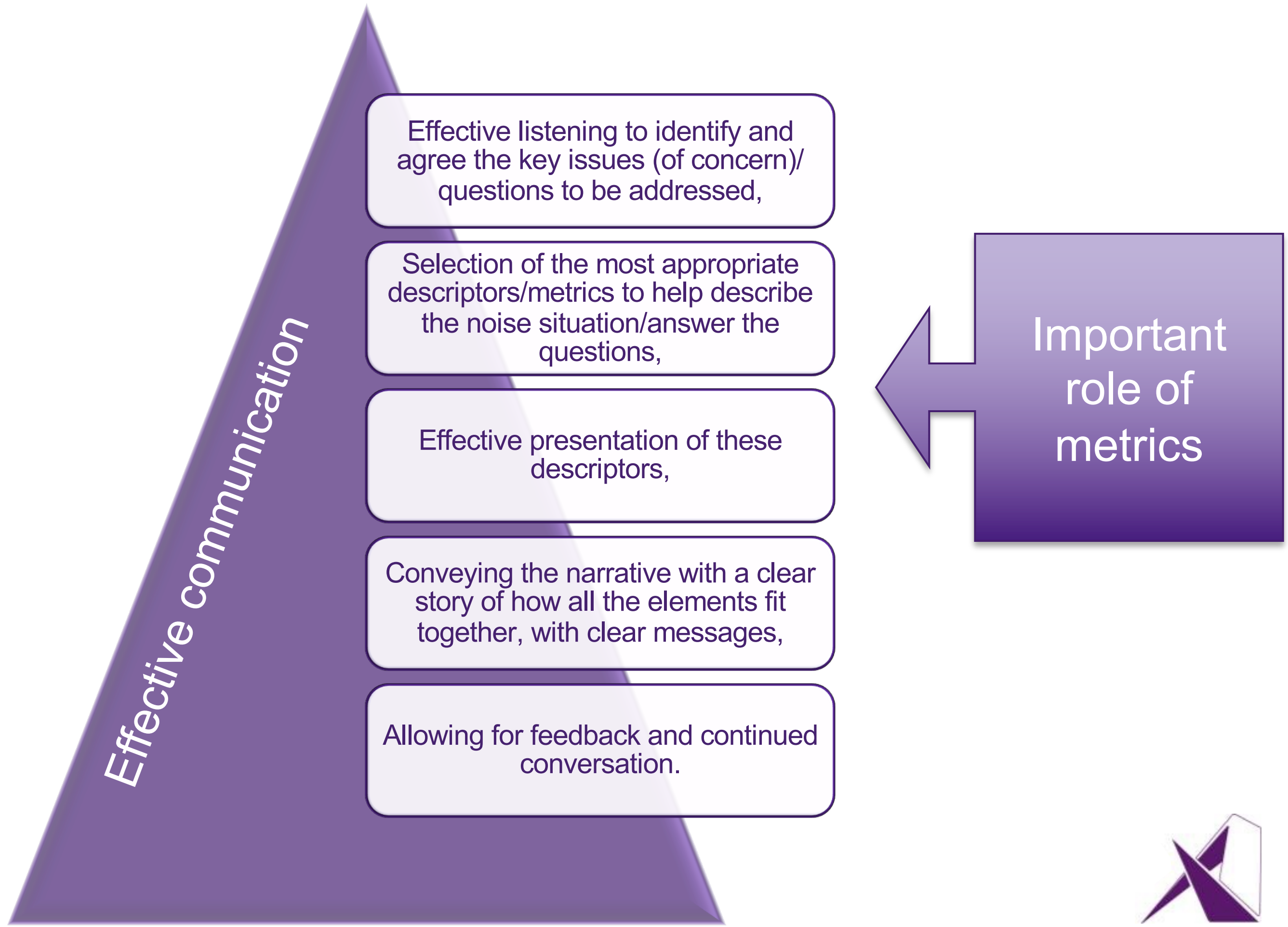
What I will cover

1. Why are metrics important?
2. Why does their use often lead to contention?
3. What you might see on a sound level meter as an aircraft flies over
4. Recap of key metrics used today
5. How metrics could be used to better reflect how people experience noise and exposure to aircraft - examples
6. Final cautionary note

Why are metrics important?

They are a tool for understanding of, and for effective communication about, the noise environment



Why does their use often lead to contention?

- They need to fit the need
- Policy makers have different needs to local community
- Metrics used in policy making often do not reflect the concerns and experience of the individual - leading to contention
- Policy - robust and objective – mainly based on long-term averages
- Community need to understand and have answers to questions like ….

How does the operating pattern of the airport affect the way in which I'm affected?

How am I affected at night – how does that change?

How will route changes affect me?

Why are some days worse than others?

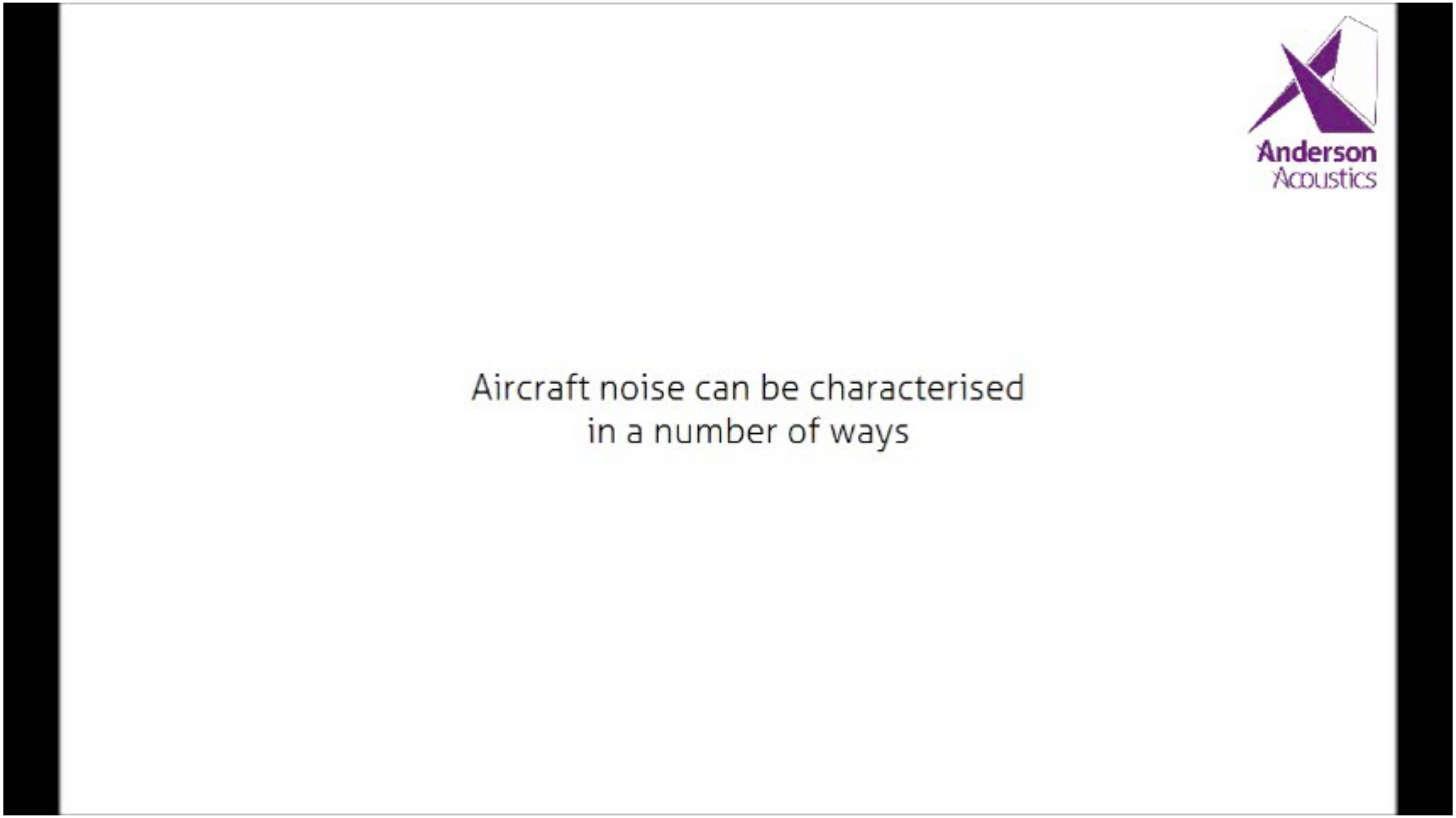
How does that average relate to what I perceive?

Lack of trust
Disconnection between policy & community
Lack of trust leads to annoyance
Annoyance on the pathway to many other effects

Why does their use often lead to contention?

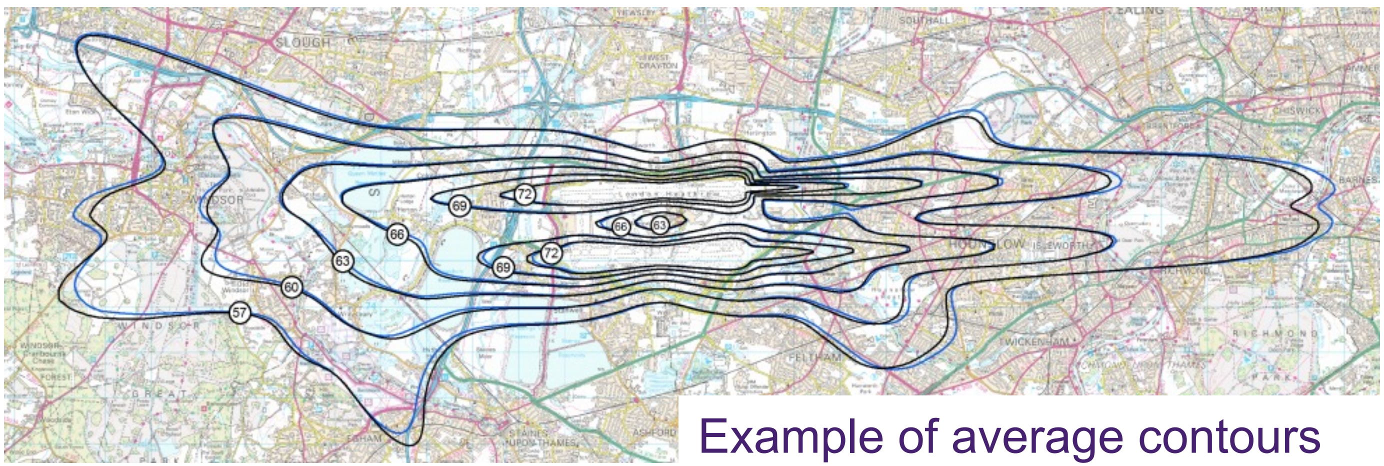
- Some indices are also too complex to understand by all……..
- I will now try and demystify some of these for you today, and
- look at some ways in which some of the metrics could better reflect the way people hear aircraft noise

So what happens if you are looking at your sound level meter as an aircraft flies over?



So for common understanding of key metrics….

- I have illustrated how noise levels from different aircraft events may vary
- I have illustrated how noise information on single events can be used to build average levels of specific time periods
- The average LAeq,T is used for commonly for showing noise level contours over specific time periods.



Example of average contours

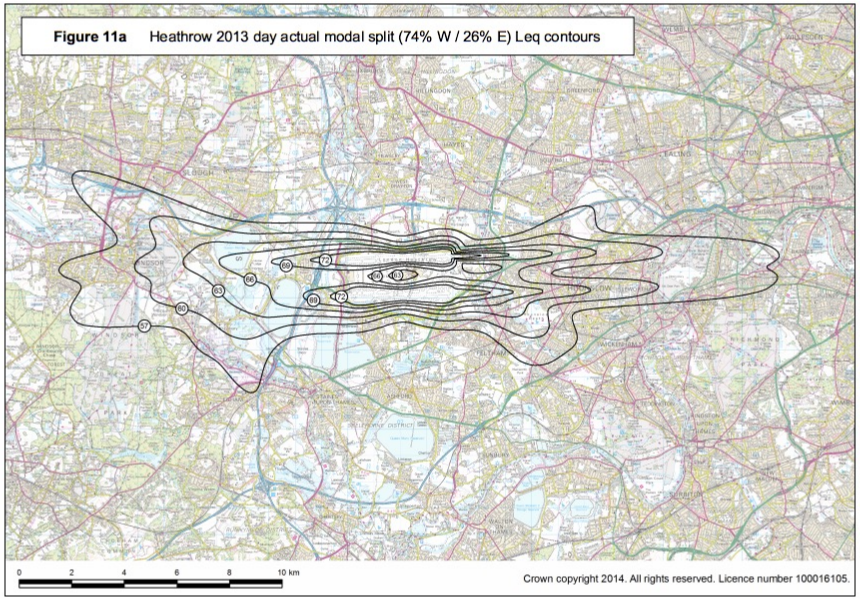
- Now I will recap the key metrics used today to describe aircraft noise

Standard noise metrics - average noise level descriptors

$L_{Aeq,T}$

What is it?

The equivalent continuous sound pressure level. This is the sound level that if continuous over time period T would give the same energy as the fluctuating level. It is essentially the average noise level over a time period T.



Other standard environmental noise $L_{Aeq,T}$ derivatives include:

- $L_{day(07:00-19:00)}$
- $L_{eve(19:00-23:00)}$
- $L_{night(23:00-07:00)}$

Comments:

- Useful for historic trends and as part of policy planning.
- Long term average contours are not understood or trusted by local community - not reflective of on-the-day experience..
- Can be refined and applied to any period or mode of operation.
- In the form presented for aviation, the $L_{Aeq,16hr,\ Summer}$ does NOT include night flights.

Standard noise metrics - average noise level descriptors

L_{den}

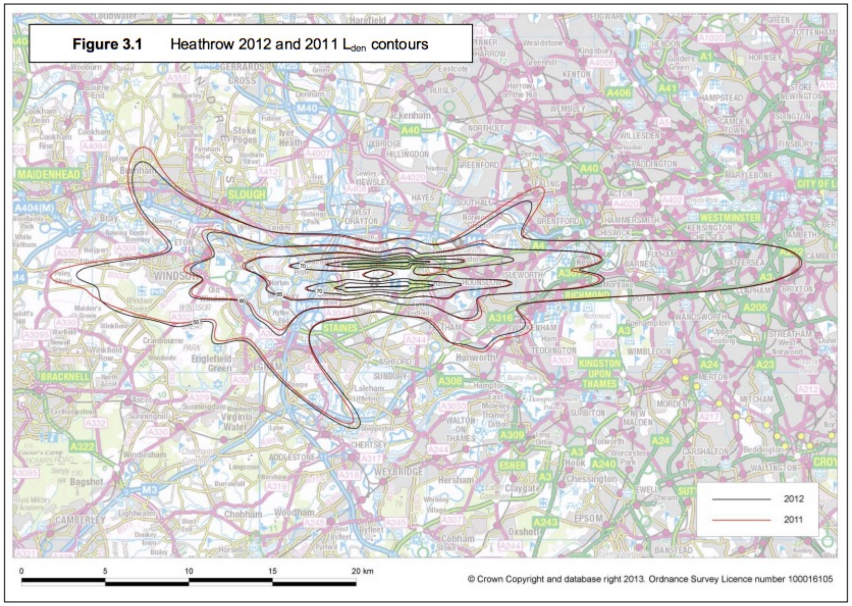
What is it?

The annual average day-evening-night level. This metric is derived from the $L_{Aeq,T}$ based $L_{day(07:00\text{-}19:00)}$, $L_{eve(19:00\text{-}23:00)}$ and $L_{night(23:00\text{-}07:00)}$ metrics with a 5 dB penalty applied to the evening period and a 10 dB penalty to the night period to "reflect" increased sensitivity to noise during these times.

Some examples of use:

This is **long term** average metric used in EU noise directive/noise action planning. It is also used EIA alongside other descriptors.

Typically presented as series of contours.



Comments:

- Since is essentially an $L_{Aeq,T}$ based metric the same criticisms apply.
- Useful for historic trends and as part of policy planning.
- Long term average contours are not understood or trusted by local community - not reflective of on-the-day experience.
- Not particularly responsive to airport operation.
- Whilst in principle there seems to be merit in weighting the evening and night period - there is no scientific basis for the weightings

Standard noise metrics – event specific

SEL

What is it?

The A weighted single event level or sound exposure level. It is the sound level that if it occurred for 1 second would have the same energy as the fluctuating noise event.

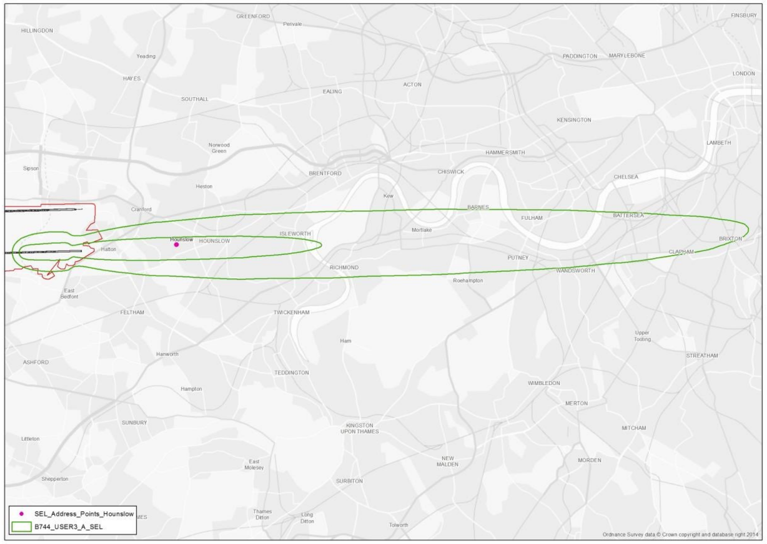
Some examples of use:

Impact studies, to provide indication of area of effect.
Night flights – sleep disturbance.

Comments:

- Pretty much impossible to understand by the lay person.
- Very useful for comparing the relative noisiness of aircraft types.
- Lmax probably a more understandable metric.

Typically presented as series of contours.



Supplementary metrics – noise related

N_{Above}

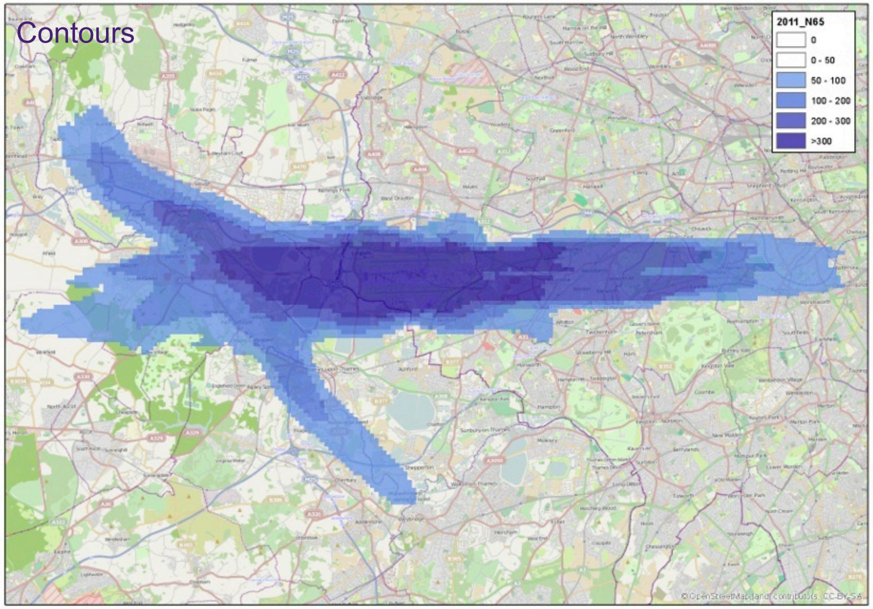
What is it?

This is the number of events where there is a maximum noise level above a stated value. Commonly used values are N70, N65 and N60. It is typically stated with a time period that it applies to.

The N_{above} can be applied to any period and can be applied to the same period as the long term average metrics.

Recent research indicates a good correlation between individual annoyance and the N65 which could be seen as describing number of "noticeable" events.

Can be presented as:



Comments:

- Provides a link between noise and number of events.
- It is an easy concept to understand and if applied to the right period appears to be reflective of community perception.
- It is a linear metric – 2x number of flights -> Nabove 2x.
- Balances the issues of frequency and noise, but doesn't provide an indication of magnitude, just that it's over a value.

Some examples of use:

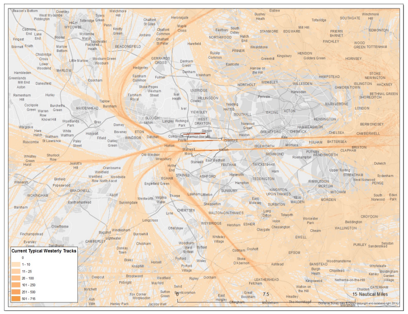
In Australia, TNIP uses the $N_{above.}$ it was developed as part of the Sydney Airport expansion Long term Operating Plan. They typically use the N70 during the day and N60 at night.

Vienna Airport uses N65 metrics as one of the agreed controls (*Results of the mediation process*, 2005). In Sweden, Swedavia proposed to adopt the N70 and N80 as formal legislative tools for aircraft noise management (*New environmental permit for Arlanda*, 2010).

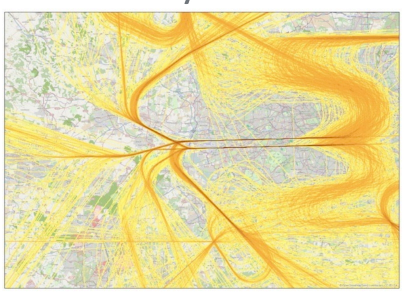
N65 has been used in previous Heathrow trials analysis.

Supplementary metrics – what about the metrics that do not provide noise data but describe the exposure to aircraft events? E.g. flight track based or movement related

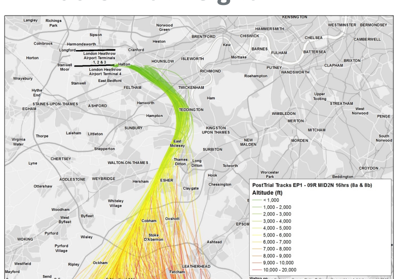
Flight track visualisation



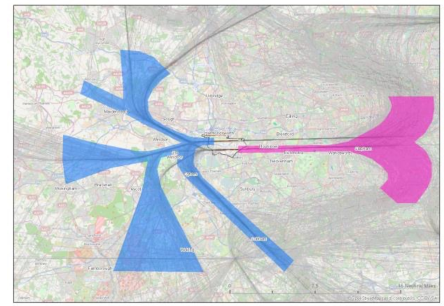
Track density

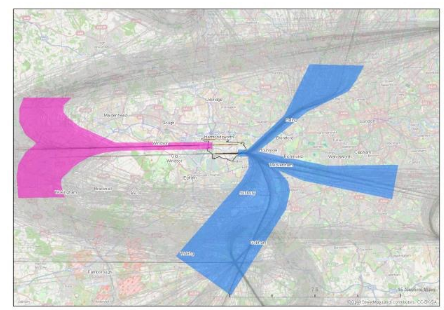


Tracks with height



Overflight – Yes/No





So how could these metrics be used to better reflect how people experience noise?

- By selecting the most appropriate metric or set of metrics to give information about the key concerns
- By using shorter term time periods that relate to different operating modes, different times of day, etc
- By communicating these in a way that gives more information about exposure on a geographical location basis showing where people live
- To consider noise change metrics
- To explain uncertainties and limits to the application of a metric to a specific purpose

Examples…..

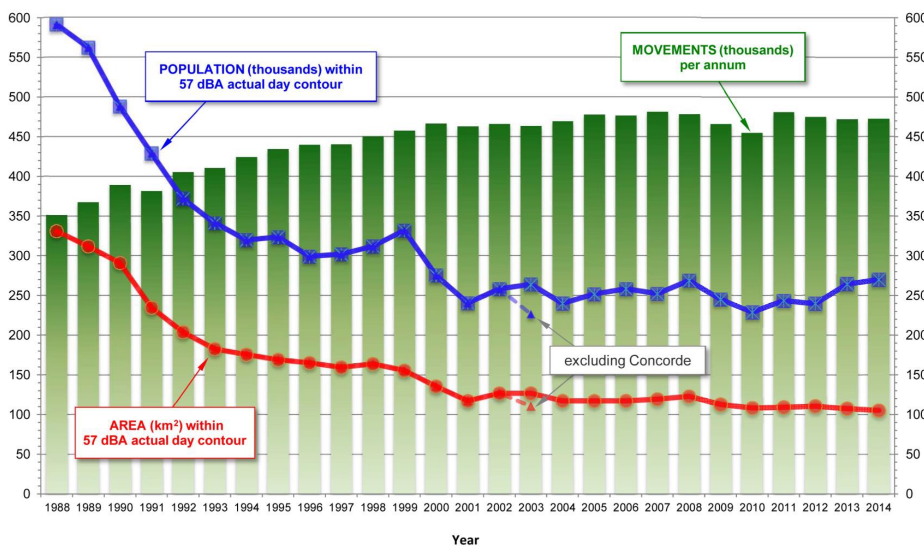
How can the metrics be presented/communicated?

- Commonly as tables, graphs or contours – often based on long term averages

Heathrow 2014 day actual contours – area, population and household estimates

Leq (dBA)	Area (km^2)	Population	Households
> 57	104.9	270,100	105,200
> 60	57.3	121,800	46,400
> 63	33.8	47,100	17,700
> 66	19.5	12,400	4,700
> 69	9.4	3,300	1,200
> 72	5.1	300	100

Note: Populations and households are given to the nearest 100.



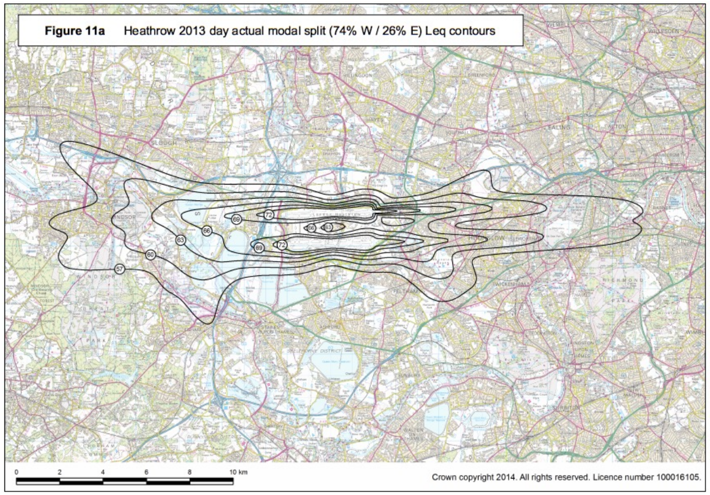


Figure 11a Heathrow 2013 day actual modal split (74% W / 26% E) Leq contours

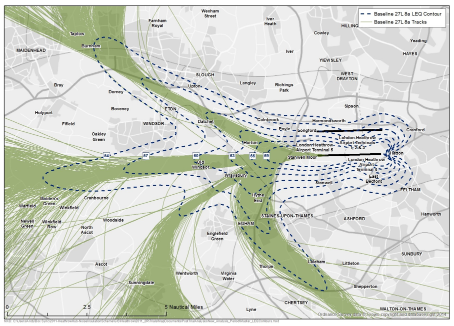
”But how do these relate to my day-to-day experience”
”But I live outside the contour and I am annoyed”

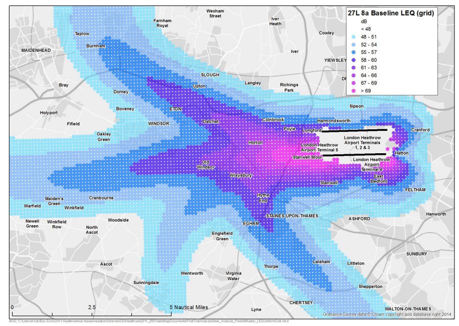
$L_{Aeq,T}$ can be used by refining it to reflect operating patterns and become more reflective of experience and understanding - and can be presented in different ways.

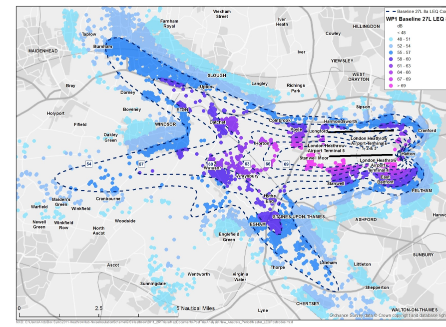
e.g. $L_{Aeq,8hr}$ presented here in different ways to reflect the runway alternation pattern at Heathrow Airport

Contours with flight tracks | Grid – no definitive lines | Postcode Points – where people live

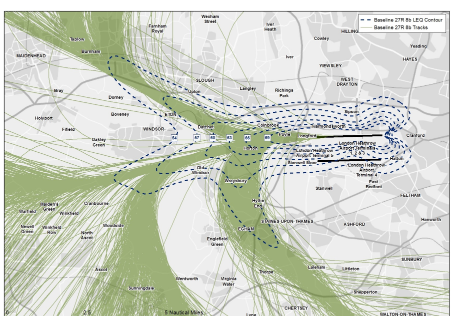
07:00 – 15:00

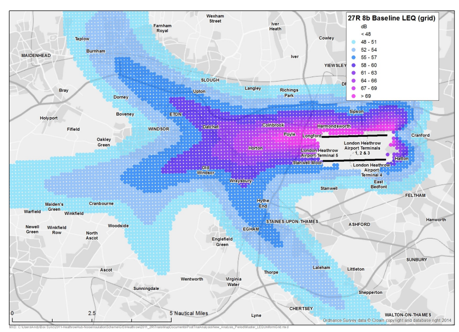


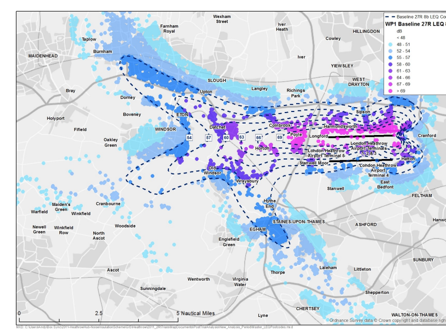




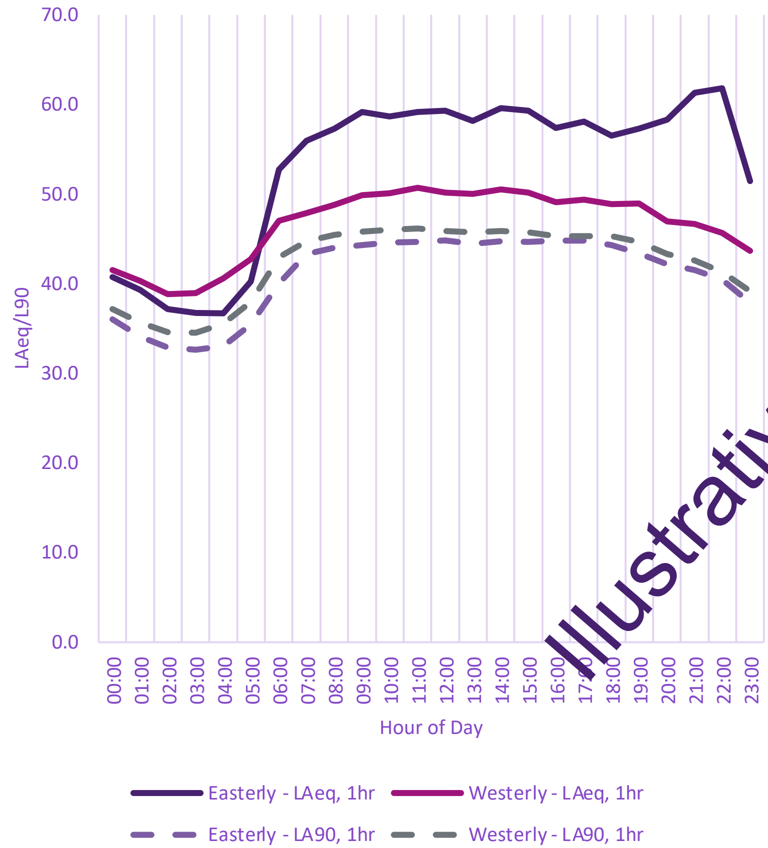
15:00 – 23:00

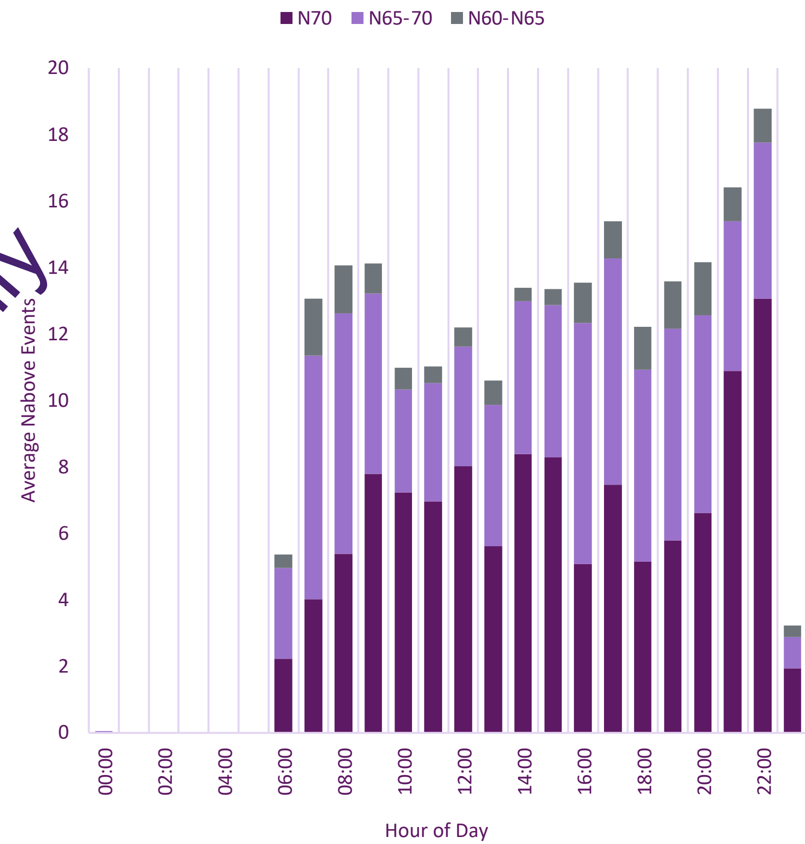






By time of day – 'But I am disturbed more in the evening"





Illustrative only

'How do the levels vary between different aircraft?'

Comparison of average Sound Event Level (SEL) for different aircraft.

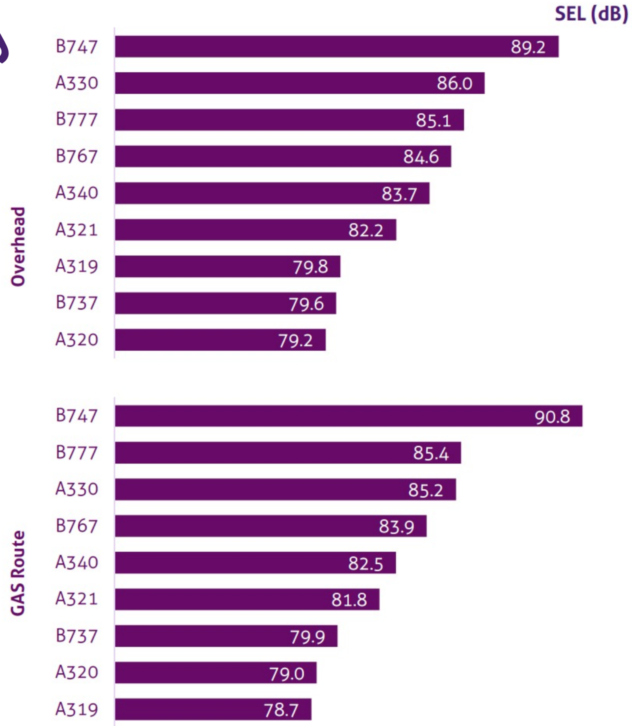
- The plots to the right show the average (arithmetic mean) SEL of each aircraft type for which at least 20 movements were registered within the **overhead** cone (upper chart) and on the GAS route (lower chart).

Overhead aircraft

- The highest average SEL noise levels for aircraft considered within the 60° cone above the noise monitor is from the B747 at 90.8dBA. Below that the B777 and the A330 (both twin-engine aircraft) generated average SEL values around 5 dB less than the larger B747.
- The small twin engine aircraft form the quietest group of aircraft between 79.2 and 82.2dB.

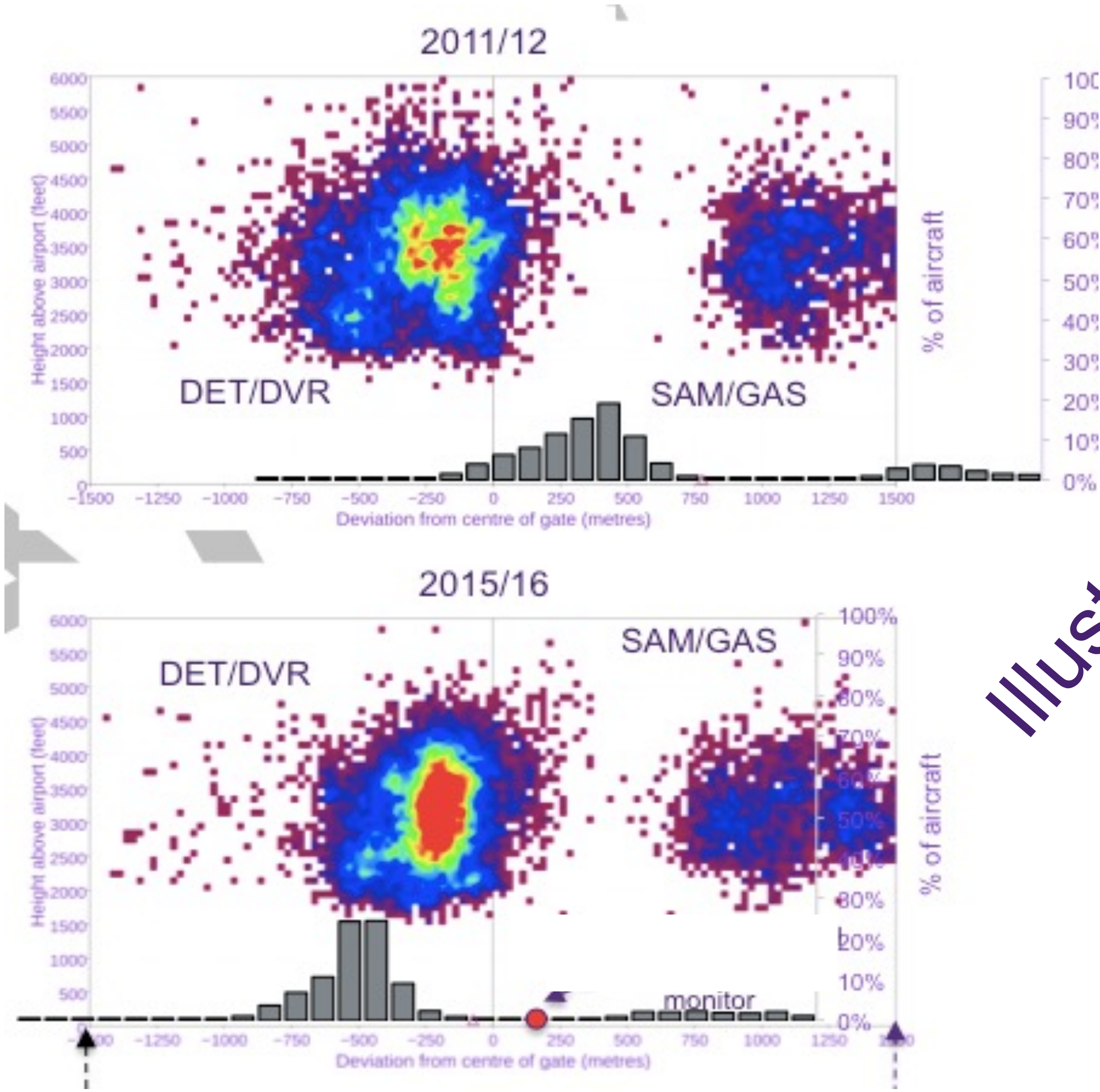
Aircraft using the GAS route

- When comparing aircraft on the GAS route only, the average SEL of the B747 was about 5dB greater than the B777. The A340 (the other 4 engine aircraft) was on average around 8.3 dB less than the B747.
- The A330, B777 and B767 comprise the next loudest group of aircraft generally falling between 83-86dB.



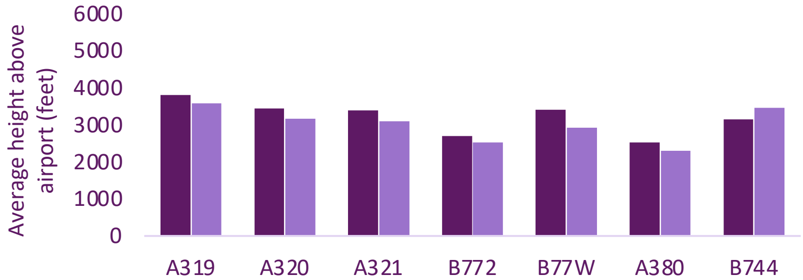
"I think the flights have become more concentrated"

P-gates showing concentrations as 'heat maps' can be shown for various years



Illustrative only

“I think the planes have got lower”

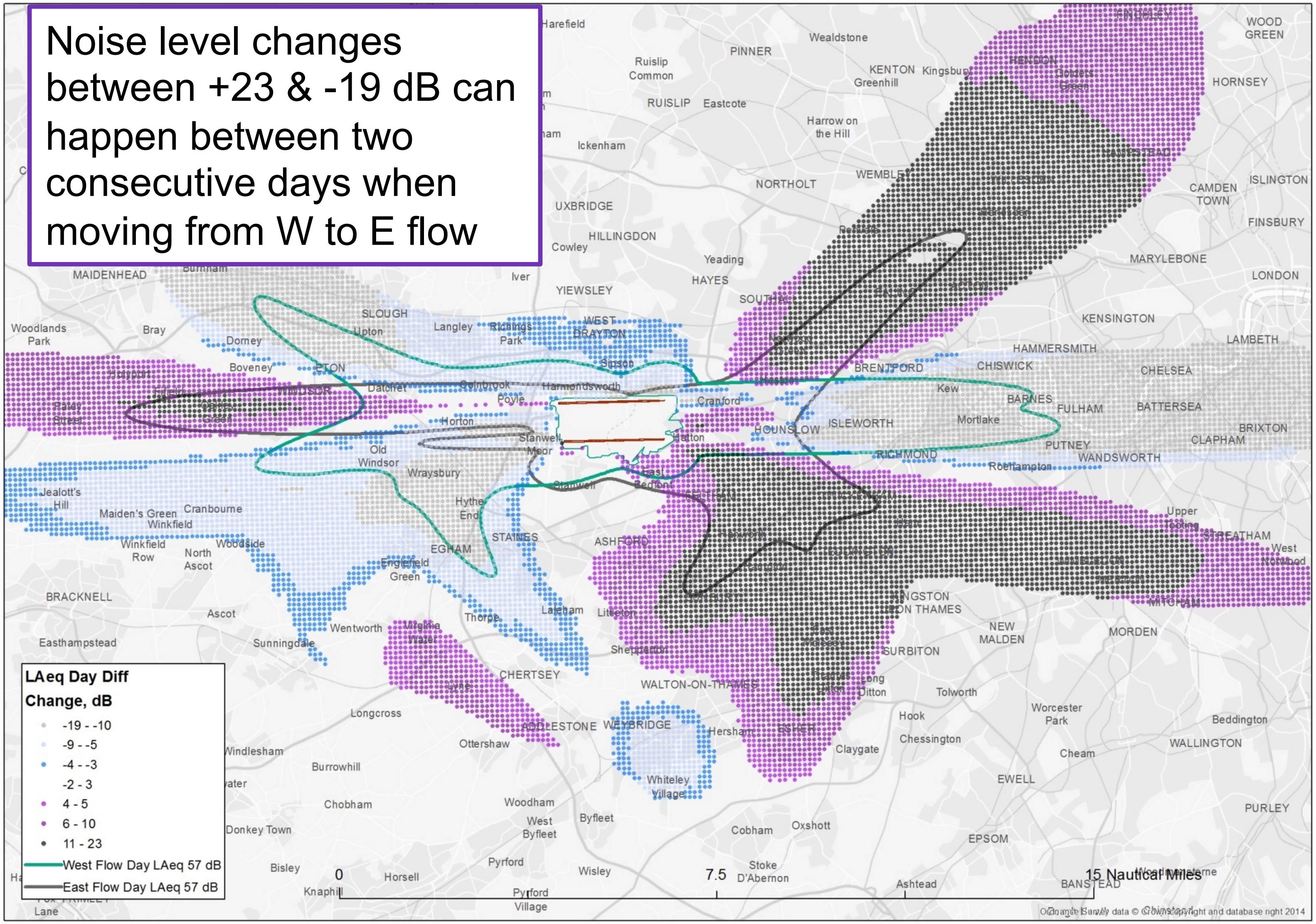


Average height at DVR gate (feet)	2011/12	2015/16	Difference
09R DVR/DET	3392	3127	-265
09R SAM/GAS	3402	3163	-239

Noise Change over shorter time periods is important to individual perception

By day

Noise level changes between +23 & -19 dB can happen between two consecutive days when moving from W to E flow



Change maps from 2014 trials based on N65 clearly showed areas of changes in noise exposure – not shown as substantial increases in Leq metics

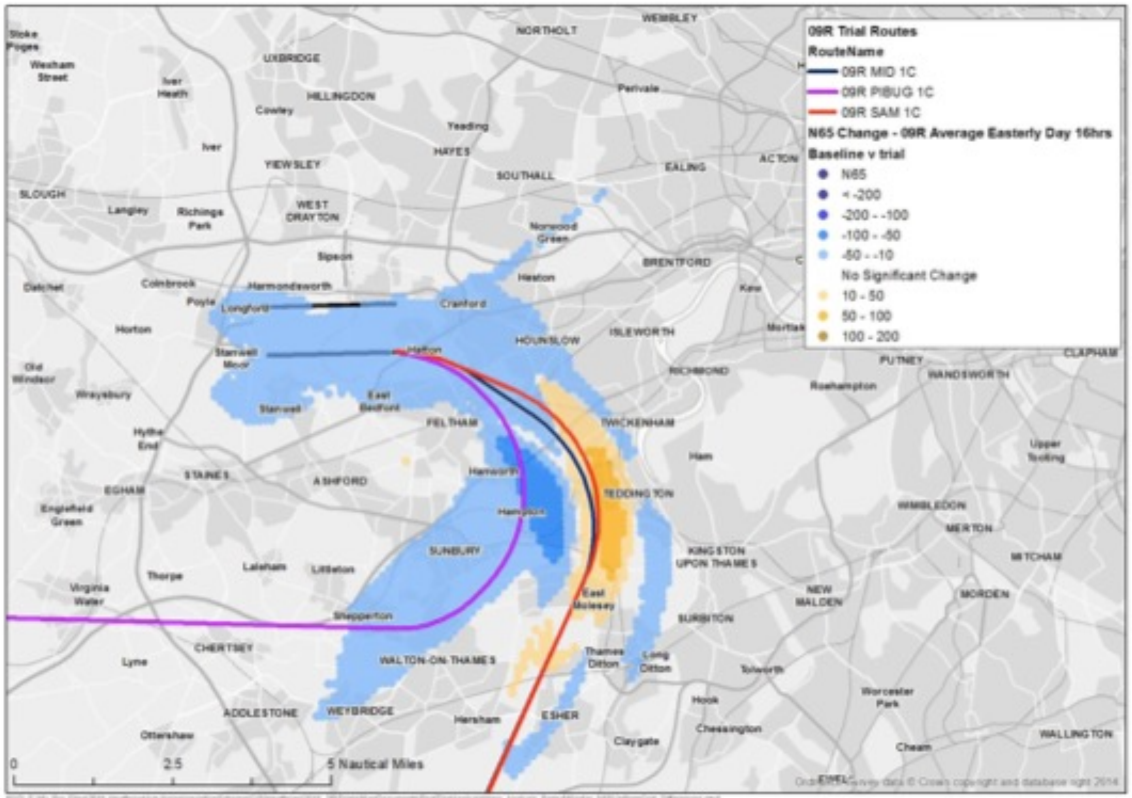
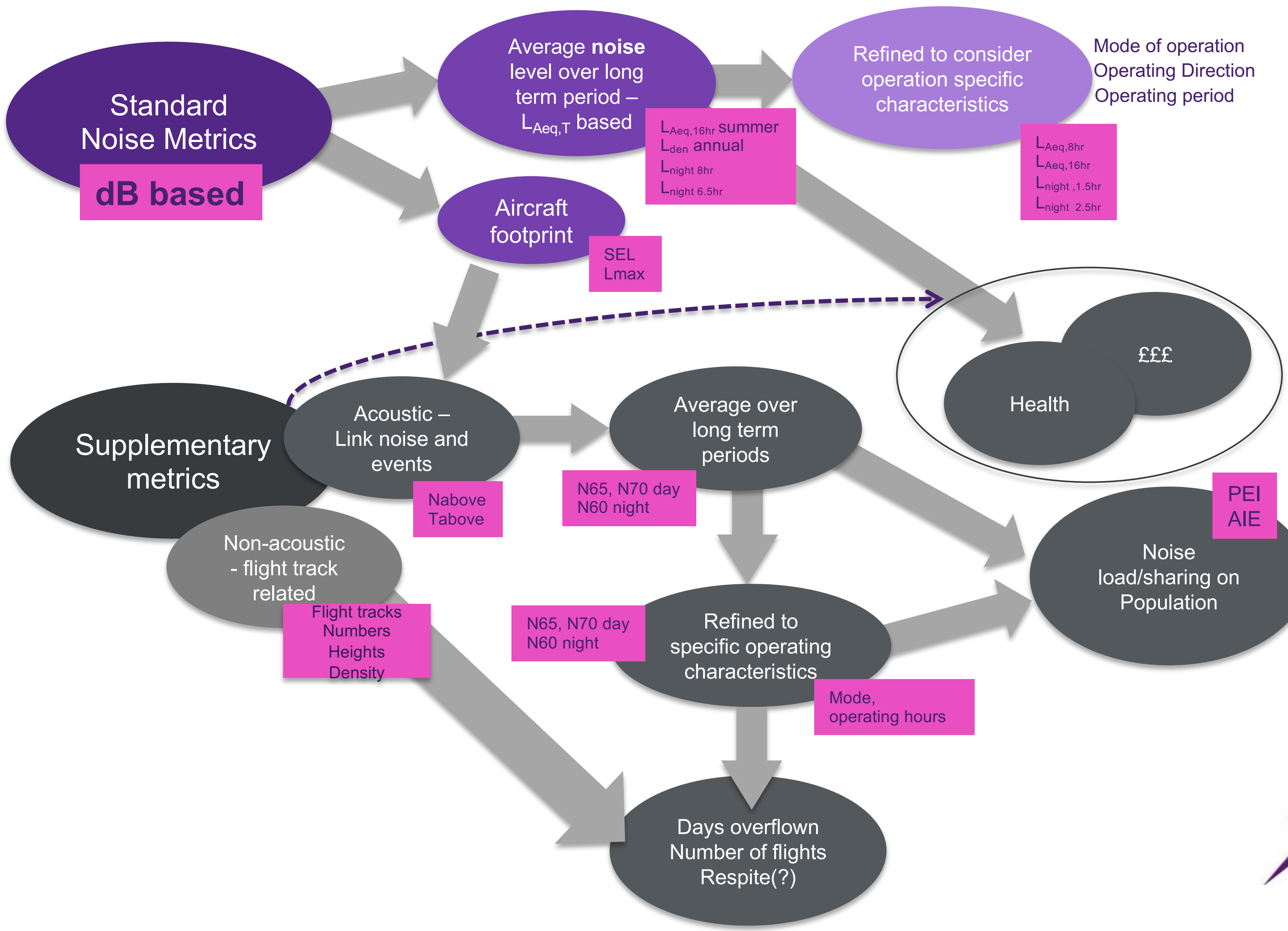


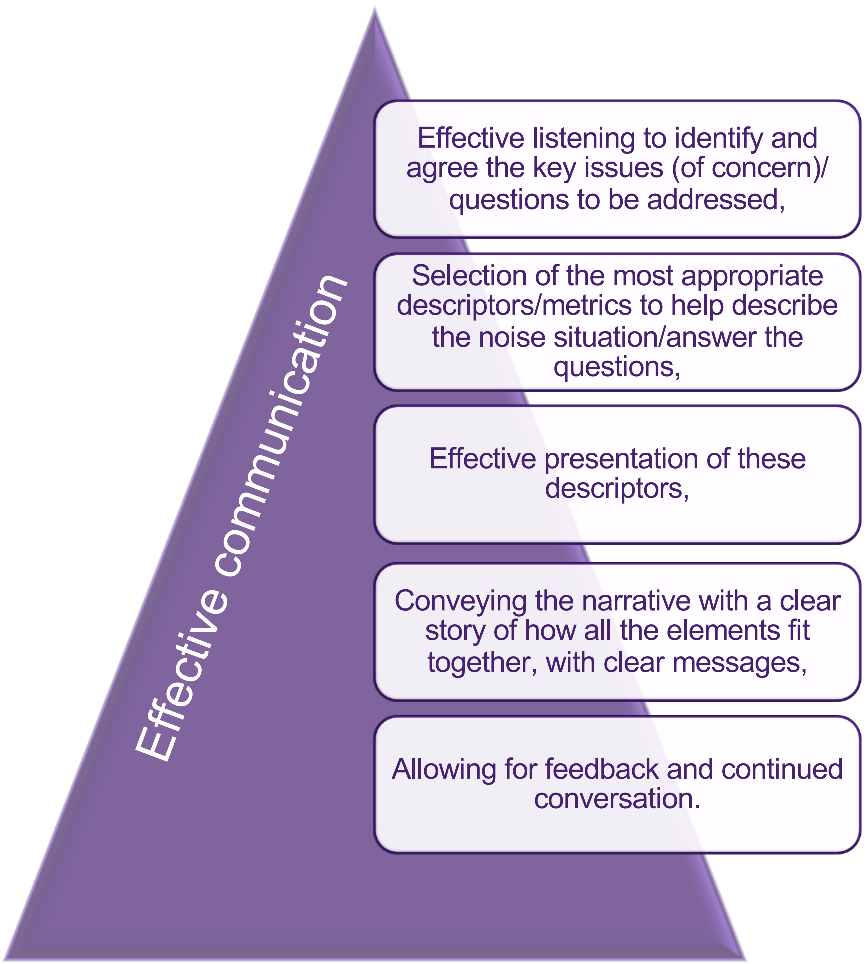
Fig. 5.10 N65 (16hr) change

The world of metrics can complex and confusing ……. Need the right set of tools from the toolbox presented in a clear way!



Why are metrics important?

They are a tool for understanding of, and for effective communication about, the noise environment



BUT

need to fit the need

policy makers have different needs to local community

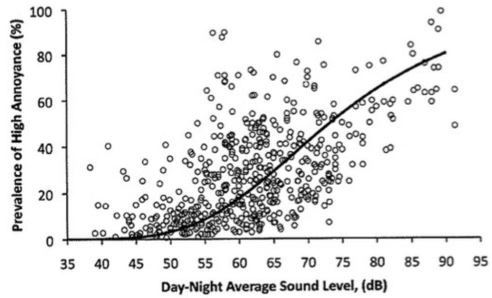
each metric has its own value and provides a set of information in the jigsaw.

Used in isolation, each has limitations.

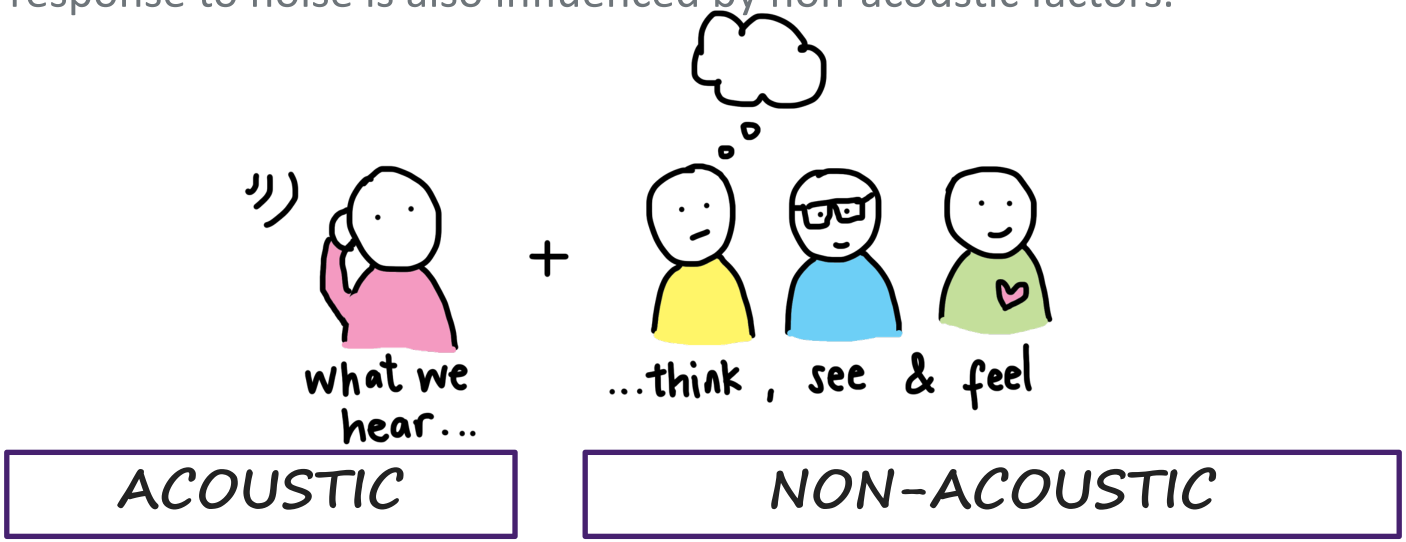
Used together in the right combination for the need - they should be able to communicate impact in an understandable manner that relates to the individual to better reflect experience and help to build trust and dialogue

Final caution – objective metrics can only describe the acoustic characteristics of the environment.

They can be used to predict a response to noise (such as annoyance) using dose-response relationships derived research based on the acoustic factors.



But response to noise is also influenced by non-acoustic factors.



So there are limits to what we can ask noise metrics alone to predict!

Studies indicate that, at best, one-third of the variance in annoyance response can be explained by acoustic characteristics

20-30%

ACOUSTIC FACTORS

30-50%

NON- ACOUSTIC FACTORS

the rest

UNEXPLAINED

Variation in subjective responses, error

Variance based on multiple regression analysis – simple graphical representation is not possible here!
0% indicates that the model explains none of the variability of the response data around its mean.
100% indicates that the model explains all the variability of the response data around its mean.

Source: EU COSMA, HYENA, NORAH, ENNAH, Babisch (2014), Kroesen (2008), Schreckenberg (2007), Flindell (2007), Guski (1999), etc.....

Thank you for listening