

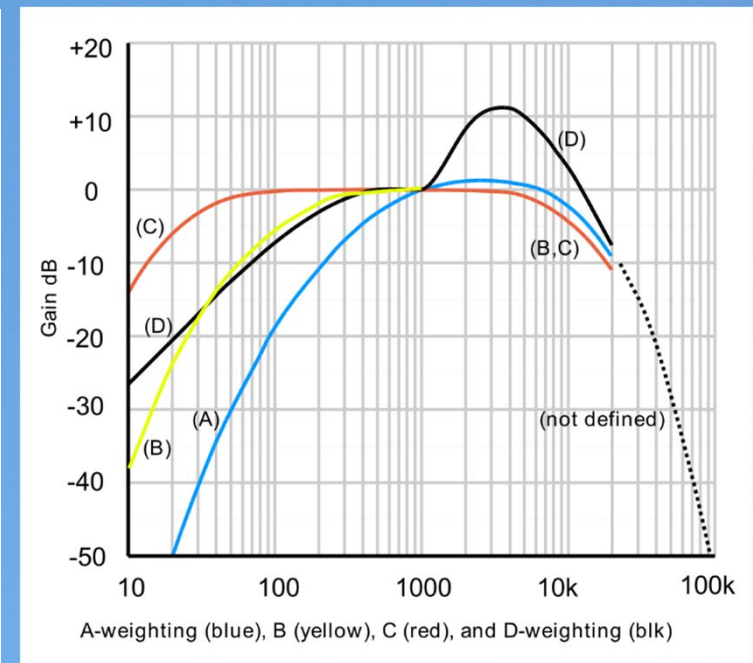
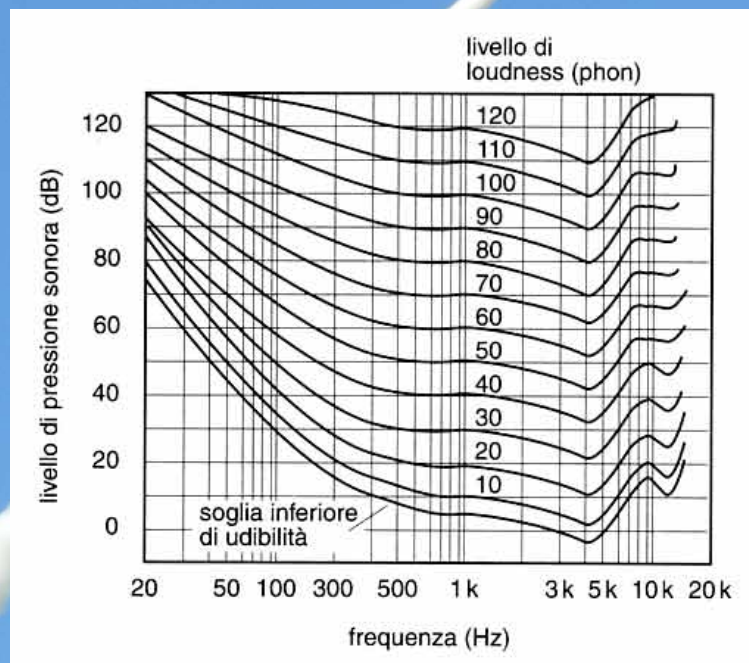
# Aircraft and Air-traffic noise Metrics

Let's discover which metrics are  
used for...

# Measuring Noise

## Pressure and frequency

10 Log X	X
100	10000000000
90	1000000000
80	100000000
70	10000000
60	1000000
50	100000
40	10000
30	1000
20	100
10	10
0	1
-10	0.1
-20	0.01
-30	0.001
-40	0.0001
-50	0.00001
-60	0.000001
-70	0.0000001
-80	0.00000001
-90	0.000000001
-100	0.0000000001



# Measuring Noise

## L<sub>aeq</sub>

The exact definition of  $L_{Aeq}$  in mathematical terms is:

$$L_{Aeq(T)} = 10 \log_{10} \frac{1}{T} \int_0^T \left( \frac{p_A(t)}{p_o} \right)^2 dt$$

where:

$L_{Aeq(T)}$  is the equivalent continuous A-weighted sound pressure level (dB(A)) measured over the time period  $T$ ;

$p_A(t)$  is the instantaneous A-weighted sound pressure (N/m<sup>2</sup>) varying with time  $t$ ;

$p_o$  is the reference sound pressure (N/m<sup>2</sup>).

The alternative and approximate formula to be used for calculating  $L_{eq}$  is:

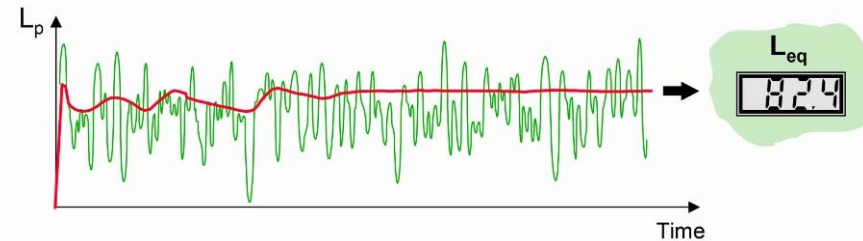
$$L_{eq} = 10 \log_{10} \left( \frac{1}{T} (t_1 \cdot 10^{L_1/10} + t_2 \cdot 10^{L_2/10} + \dots + t_n \cdot 10^{L_n/10}) \right)$$

where:

$L_{eq}$  is the equivalent continuous sound level (dB(A)) measured over the time period  $T$ .

$L_1, L_2, L_3, \dots, L_n$  are individual sound levels maintained for short periods of time;

$t_1, t_2, t_3, \dots, t_n$  are the durations associated with the respective sound levels.



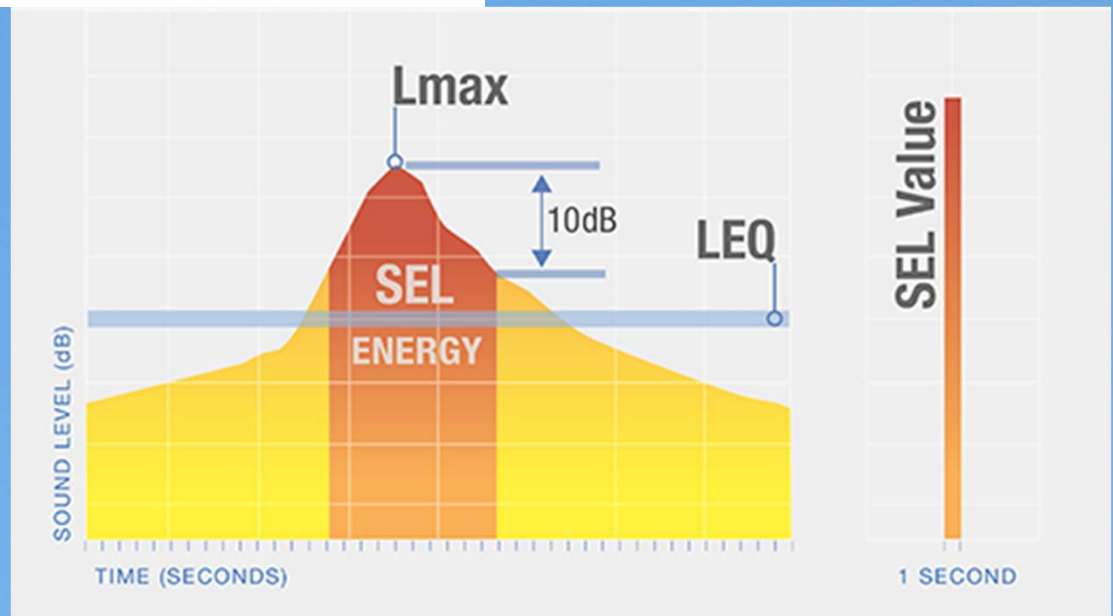
# Measuring Noise

## SEL

$$L_{AE,T} = 10 \lg \left[ \frac{\int_{t_1}^{t_2} p_A^2(t) dt}{p_0^2 T_0} \right] \text{dB} = 10 \lg \left( \frac{E_{A,T}}{E_0} \right) \text{dB} = L_{Aeq,T} + 10 \lg \left( \frac{T}{T_0} \right) \text{dB}$$

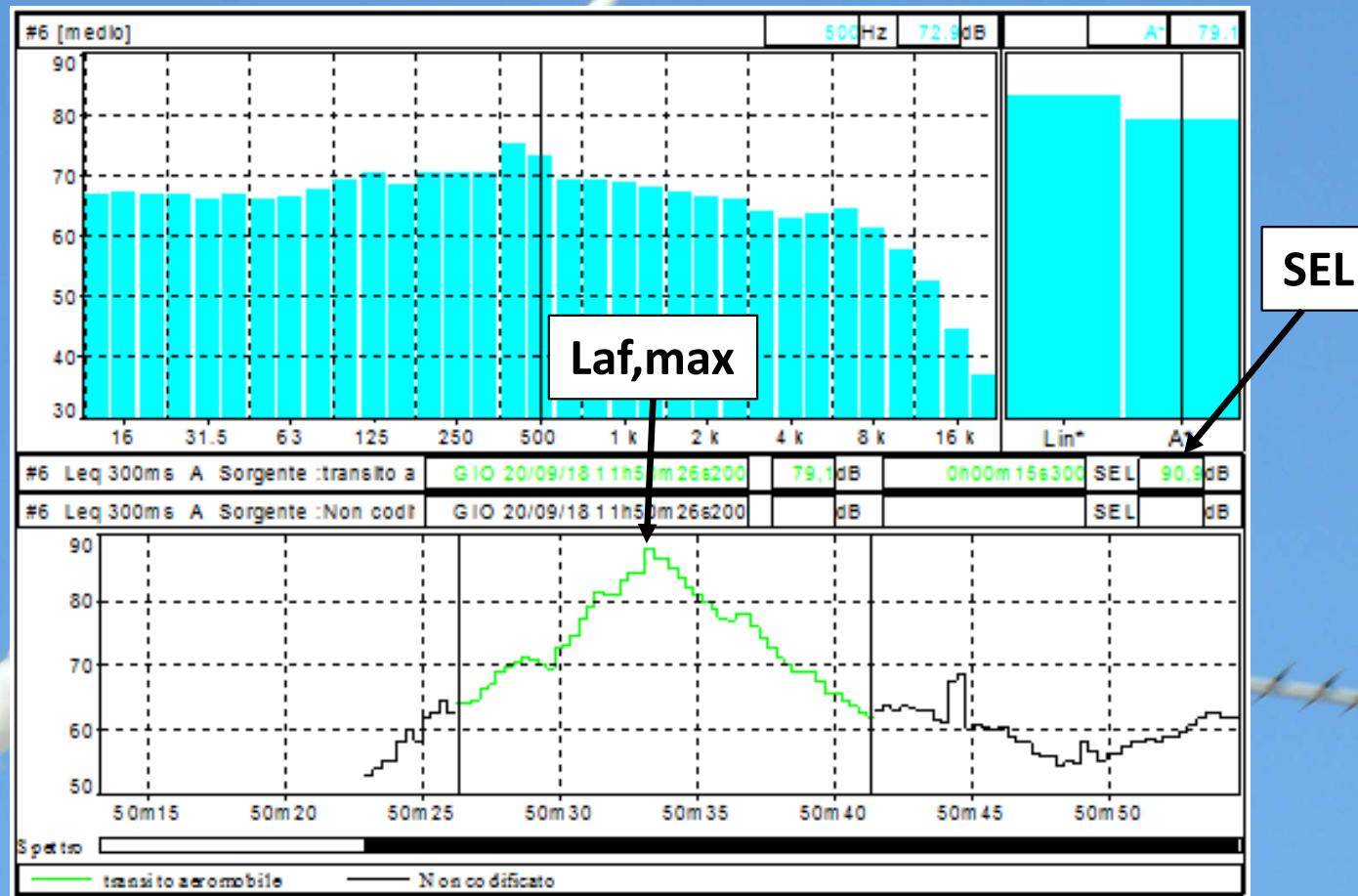
where

- $E_{A,T}$  is the A-weighted sound exposure in pascal-squared seconds over time interval  $T$
- $E_0$  is the reference value given by  $p_0^2 T_0 = (20 \mu\text{Pa})^2 \times (1 \text{ s}) = 400 \times 10^{-12} \text{ Pa}^2\text{s}$ ;
- $T$  is the measurement time interval, in seconds, starting at  $t_1$  and ending at  $t_2$ , and
- $T_0$  is the reference value of 1 s for sound exposure level.



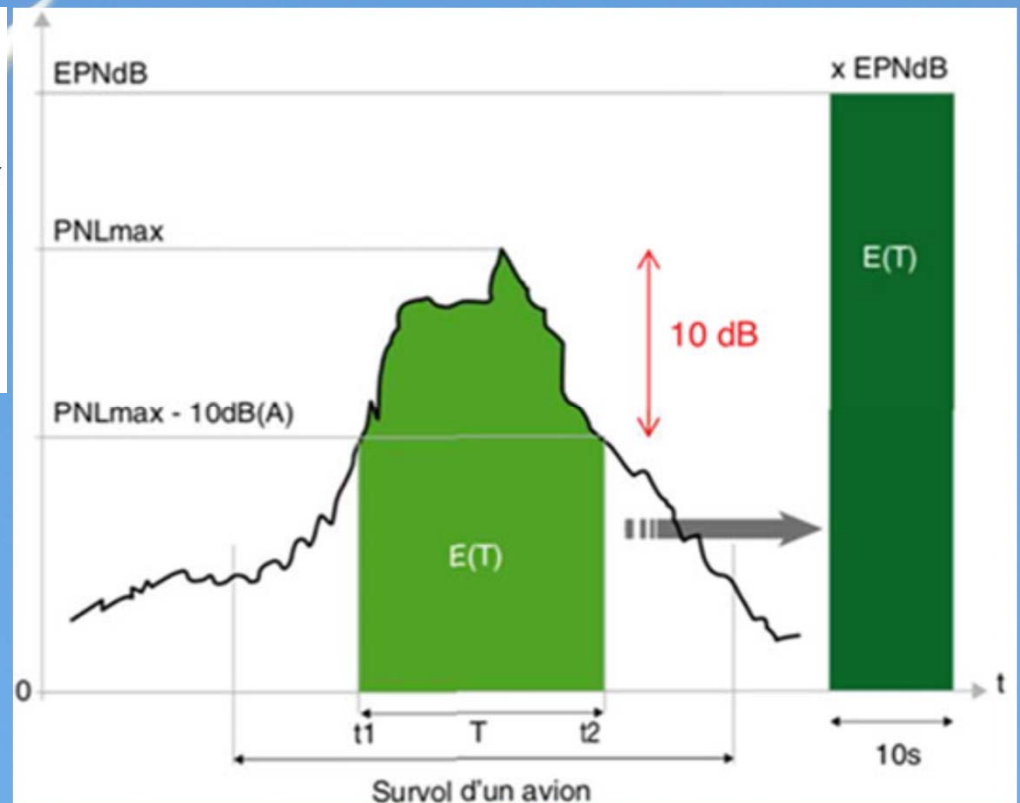
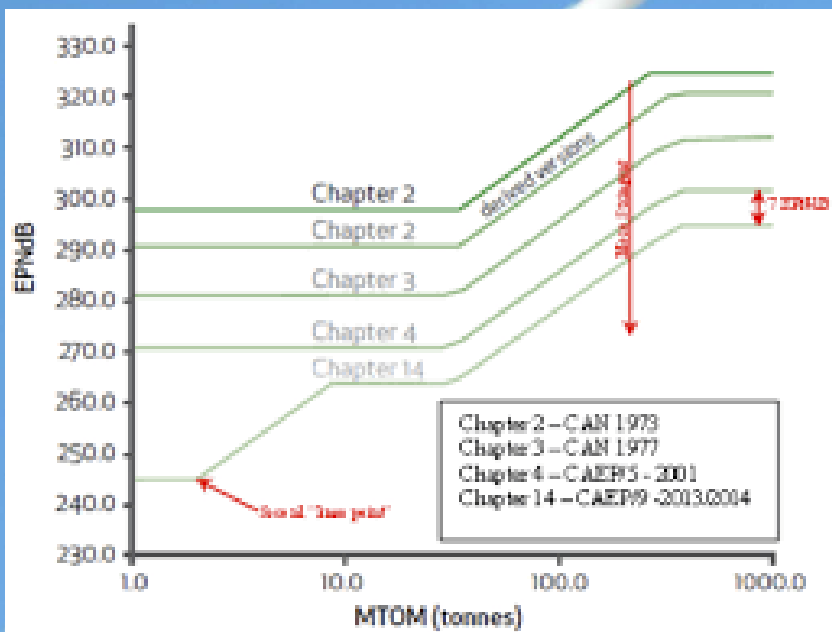
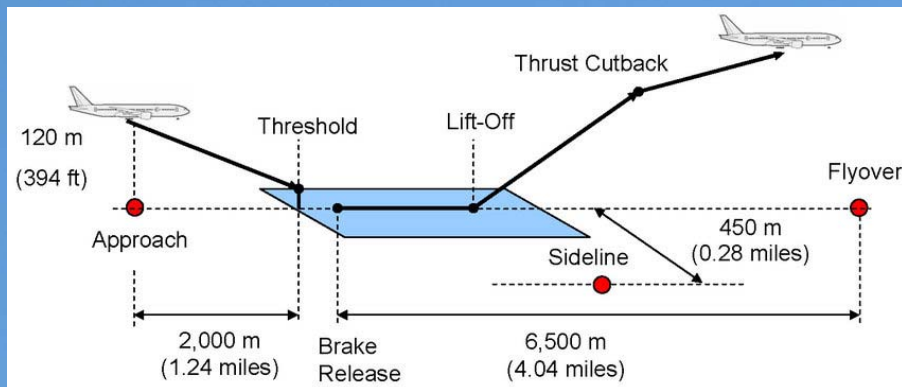
# Measuring Noise

Ex. Of time history



# From the source...

## Noise certification ICAO



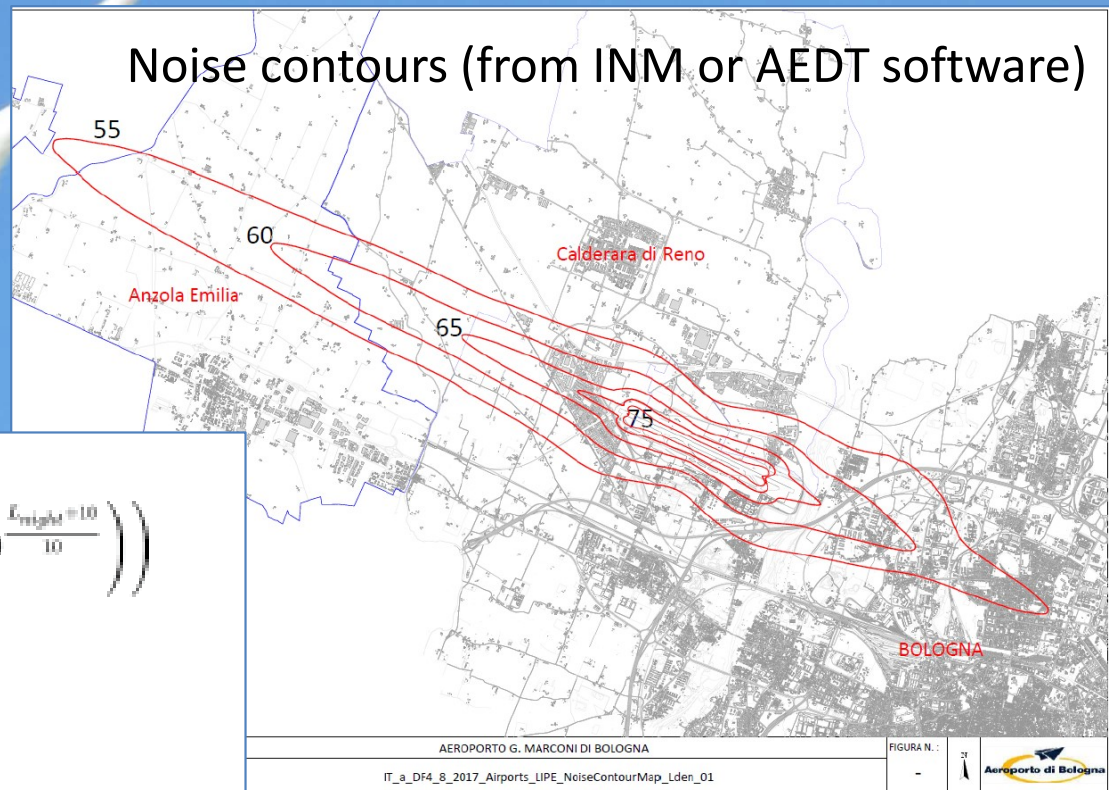
# Territory management

Lden

Lden

Exposed population

Fascia-curve dB(A)	Popolazione esposta
50-54	37000
55-59	17000
60-64	4300
65-69	0
70-74	0
> 75	0



$L_{den}$  is calculated as:<sup>[5]</sup>

$$L_{den} = 10 \cdot \log_{10} \left( \frac{1}{24} \left( 12 \cdot 10^{\frac{L_{day}}{10}} + 4 \cdot 10^{\frac{L_{evening}+5}{10}} + 8 \cdot 10^{\frac{L_{night}+10}{10}} \right) \right)$$

Where the long-term average noise levels are defined as:

Part of the day	hours	penalty (dB)
day	07:00 - 19:00	0
evening	19:00 - 23:00	5
night	23:00 - 07:00	10

# Territory management

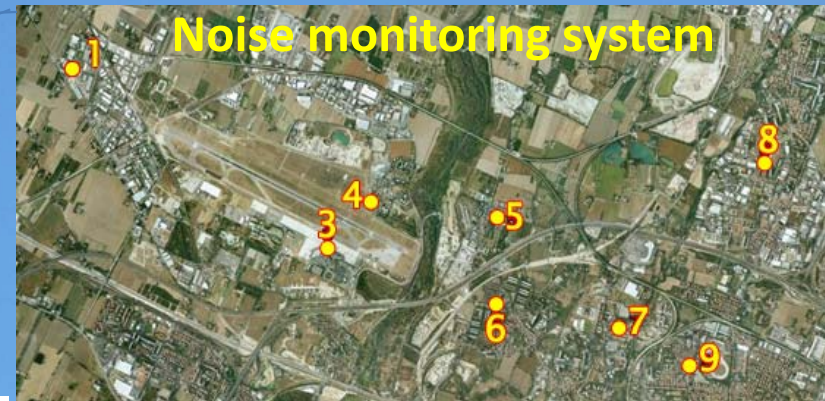
LVA - Italy

$$L_{VAd} = \left[ \frac{1}{T_d} \sum_{i=1}^{N_d} 10^{SELi / 10} \right] \text{ dB(A)}$$

$$L_{VAn} = \left[ \frac{1}{T_n} \sum_{i=1}^{N_n} 10^{SELi / 10} \right] + 10 \text{ dB(A)}$$

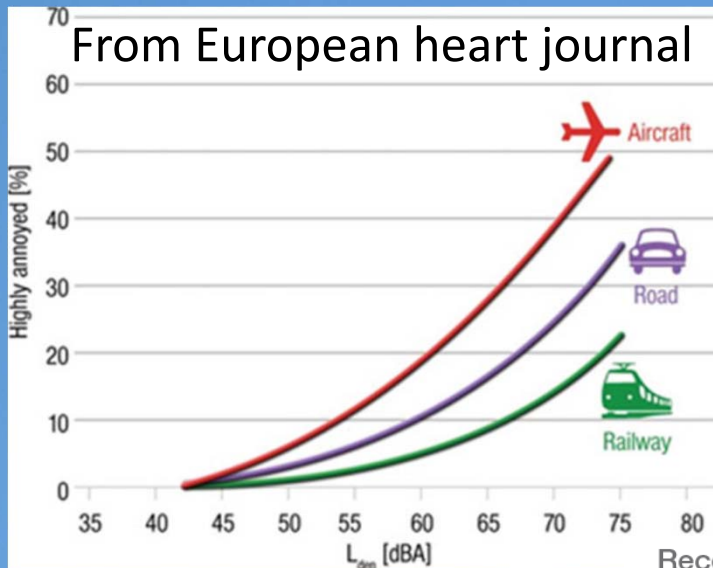
$$L_{VAj} = 10 \log \left[ \frac{17}{24} 10^{L_{VAd} / 10} + \frac{7}{24} 10^{L_{VAn} / 10} \right] \text{ dB(A)}$$

$$L_{VA} = 10 \log \left[ \frac{1}{N} \sum_{j=1}^N 10^{L_{VAj} / 10} \right] \text{ dB(A)}$$



# Health assessments

## W.H.O. Noise guidelines



### Recommendations

For average noise exposure, the GDG **strongly** recommends reducing noise levels produced by aircraft below **45 dB  $L_{den}$** , as aircraft noise above this level is associated with adverse health effects.

For night noise exposure, the GDG **strongly** recommends reducing noise levels produced by aircraft during night time below **40 dB  $L_{night}$** , as aircraft noise above this level is associated with adverse effects on sleep.

To reduce health effects, the GDG strongly recommends that policy-makers implement suitable measures to reduce noise exposure from aircraft in the population exposed to levels above the guideline values for average and night noise exposure. For specific interventions the GDG recommends implementing suitable changes in infrastructure.

# Aircraft and Air-traffic noise Metrics

03/06/2024 – U.E.C.N.A. meeting

Thanks for your attention

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