Is It Time to Retire a 30-Year-Old Aviation Single Noise Metric?

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AICA | **AVIATION-IMPACTED COMMUNITIES ALLIANCE**

Presentation recorded on 5/15/2023 by CL Christiansen for the public

Problems with FAA's DNL65 Noise Policy

FAA Noise Policy and ASNA

NextGen Procedure Changes but No Change to "Significant" Noise Definition

DNL65 is a (statistically) *INVALID* Metric for Locations "Away from Airports"

FAA Uses a "Single Metric" not a "Single System"	Does DNL "account" for duration and number of events?	Concentrated Flight Paths	Reduced Spacing Between Noise Events	Since NextGen the # of People Exposed to Aviation Noise @DNL65+ Has INCREASED	1,000 planes/day: DNL65 DOES NOT 'closely correspond to real-world values'	Large estimation error "Away from Airports"	Neighborhood Environmental Survey (NES) Study shows DNL65 Threshold is Invalid

Problem: FAA Uses a "Single Metric" not a "Single System"

49 U.S. Code § 47502, ASNA, required the FAA to:

(1) establish a **single system** of measuring noise for which there is a highly reliable relationship between projected noise exposure and the **surveyed reactions of people to noise** to be used to measure noise at airports and their surrounding areas;

(2) establish a **single system** for determining the exposure of individuals to noise which results from the operations of an airport and which includes noise intensity, duration, frequency, and time of occurrence.

FAA states that no single metric is adequate (page 3 of 4/14/20 Report to Congress FAA Reauthorization Act of 2018 (Pub. L. 115-254) Section 188 and Sec 173):

- "As will be discussed in this report, **no single metric can cover all situations** due to the dynamic acoustical and operational characteristics of aviation noise."

Problem: FAA Uses a "Single Metric" Not a "Single System"

Yet, the FAA does not use the required **single system**

- It uses the single noise metric DNL65 to define "significant" noise even after admitting that "no single metric can cover all situations".

- FAA misinterprets ASNA when they state, in the [TC-21-4 Analysis of the Neighborhood Environmental Survey (update 2/23/21)](#)
  - "Through the Aviation Safety and Noise Abatement Act (ASNA) of 1979, Congress directed the Federal Aviation Administration (FAA) to establish a **single metric** for assessing land use compatibility with respect to noise from aircraft operations, and …"

Problem: Does DNL "account" for duration and number of events?

Table 1 from FAA Report to Congress, April 14, 2020, page 19
Additions in Red are for Emphasis

Table 1. Noise Metrics

	Noise Level	Time of Day	Number of Events
L_{eq}	✓		✓
DNL	✓	✓	✓ ?
LAeq(hr) (e.g. 16hr, 8hr)	✓	✓	✓
L_{den}	✓	✓	✓
CNEL	✓	✓	✓
SEL and CSEL	✓		
L_{max}	✓		
PSF[a]	✓		
NA[b]	✓	✓	✓
TA[c]	✓		
Time Audible[d]	✓		

Time of Day is easy to account for using different thresholds.

[a] PSF, or pounds per square foot, is functionally a measure of "noise level" instead of decibels. PSF is typically used as a measure of the peak overpressure of a sonic boom.
[b] NA is the number of noise events above a certain noise level threshold.

For remaining footnotes see FAA report

The FAA included this table in its 2020 Report to Congress on Alternative Metrics

AICA corrected it in its Technical Response for Congressional Quiet Skies Caucus Staffers Re. FAA's Report to Congress: DNL Metric and DNL 65 Standard for Airplane Noise. June 2020

Problem: NextGen Procedure Changes but No Change to "Significant" noise definition

Logan International, Boston Area
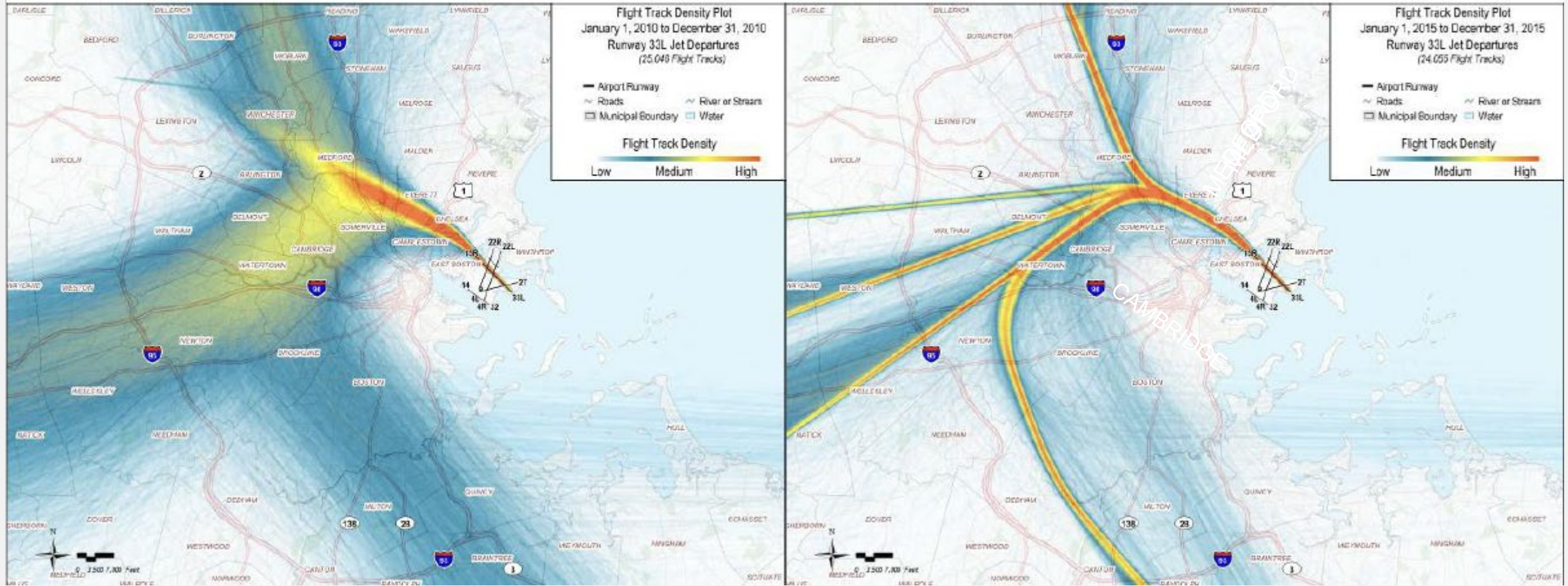
Now residents "away from airports" but under flightpaths have similar numbers of noise events as those "close to airports", not as loud but a significant problem. There often are 200 to 400 noise events per day.

Problem: NextGen Procedure Changes but no change to "Significant" noise definition

NextGen reduces time between aviation noise events

6 Large Jet Arrivals to Boston in 7 Minutes, 8 NM from the Runway (location's DNL < 55dB)

Examples like this one occur daily, across the country, at locations "away from the airport" where arrivals or departures disturb homes, the outdoors, places of worship, and schools every minute for hours each day and night.

DNL65 does not capture this factor of aviation disturbances.

Plane	Cumulative Minutes	Minutes between Aviation Noise Events
1	01:13.7	**01:13.7**
2	02:22.8	**01:09.0**
3	03:25.7	**01:02.9**
4	04:36.3	**01:10.6**
5	06:00.2	**01:23.9**
6	07:08.7	**01:08.5**

Problem: Since NextGen the # of People Exposed to Aviation Noise @DNL65+ Has ...

Historical Trends in Noise Exposure and Enplanements
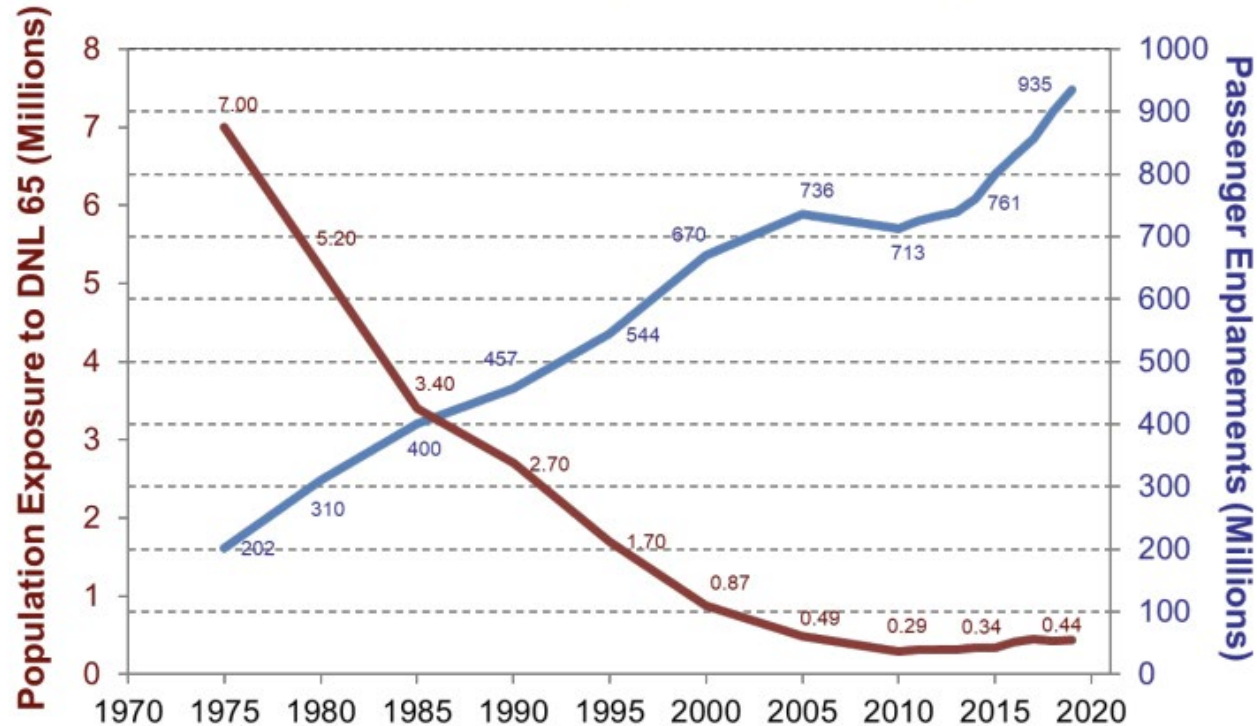
Over a ninety percent decrease in community noise exposure while increasing enplanements by nearly a factor of five; however, the noise experience is different than it was in decades past

source: FAA enplanement data and noise analyses using AEDT

Federal Aviation Administration

The FAA likes to use this graphic to show a steep decline in the number exposed to significant noise at the same time there has been a steep increase in the number of passengers.

HOWEVER, the noise exposure trend is misleading because

- **Outdated DNL65 is used to count the number exposed;**
- **Trend covers 45 years;**
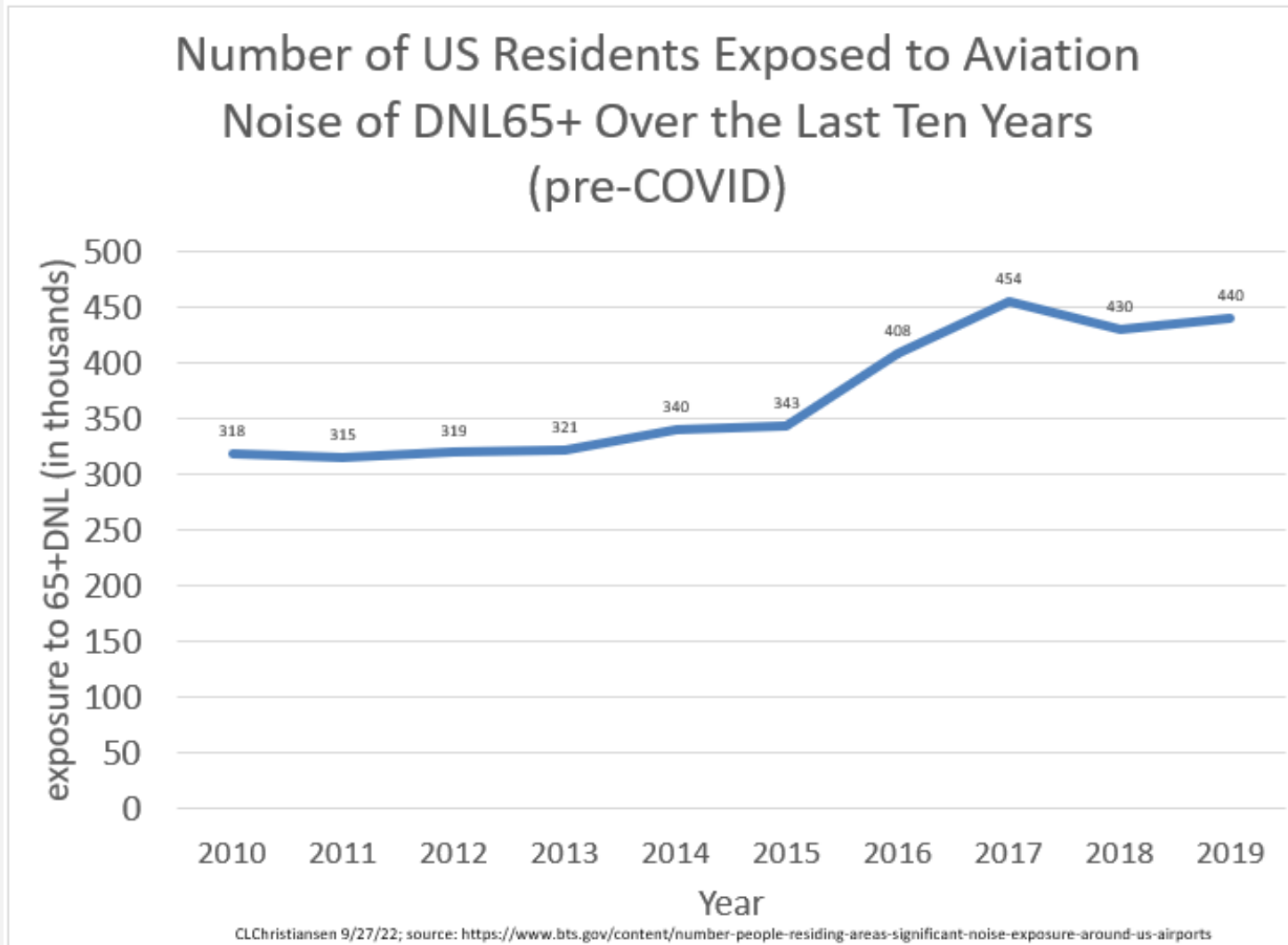- **Graph is an example of how to "Lie with Statistics";**
- **AND ...**

Problem: Since NextGen the # of People Exposed to Aviation Noise @DNL65+ Has INCREASED

Number of US Residents Exposed to Aviation Noise of DNL65+ Over the Last Ten Years (pre-COVID)

CLChristiansen 9/27/22; source: https://www.bts.gov/content/number-people-residing-areas-significant-noise-exposure-around-us-airports

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Upward trend in number exposed since 2010 with a 39% increase over the last 10 pre-Covid years.

Problem: DNL65 Invalid Metric for "Away from Airport" Locations (and isn't great for "Close to Airport" either)
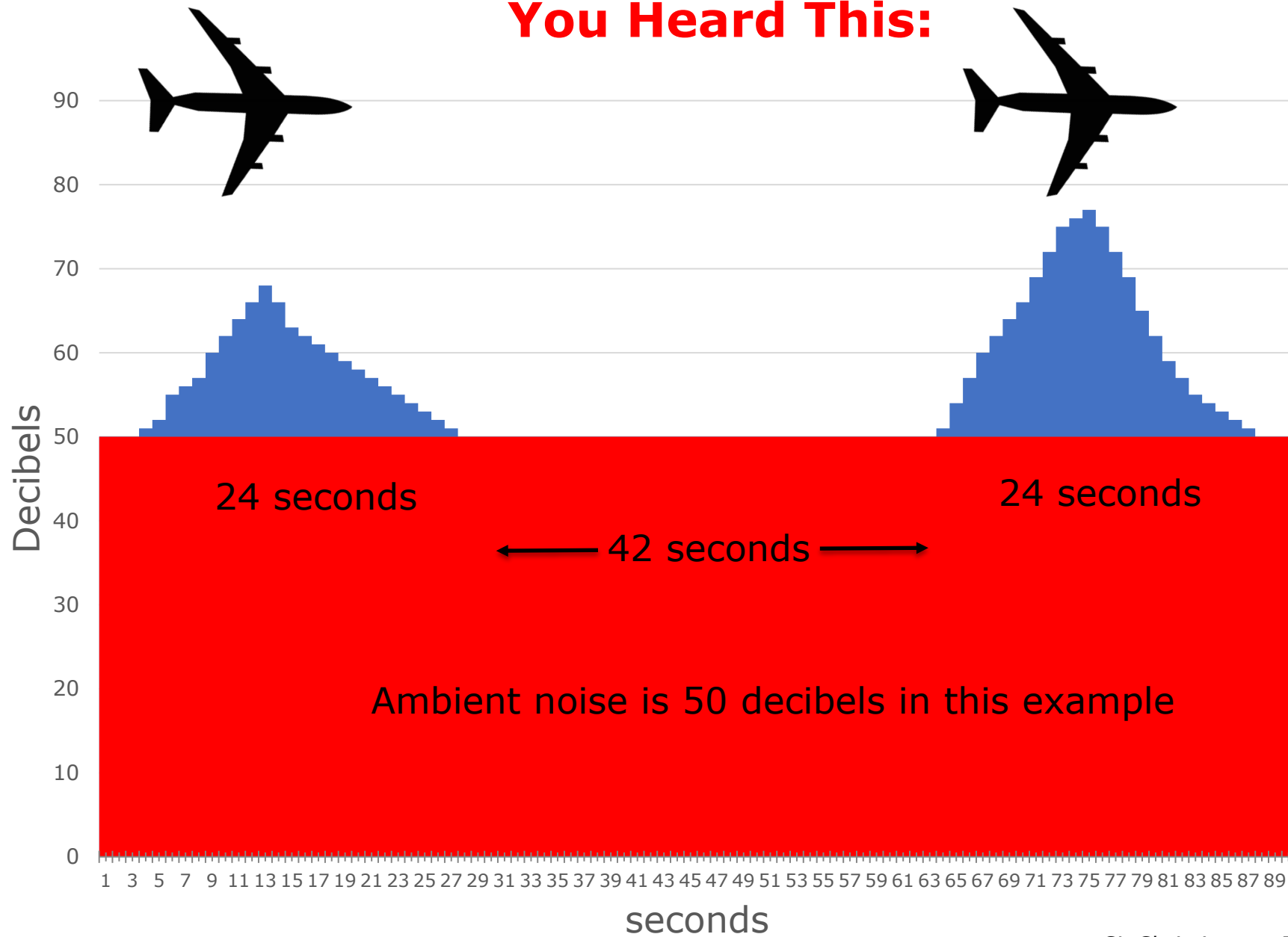
A measurement system is ***valid*** if it measures what it claims to measure (e.g., "significant noise"), and the ***results closely correspond to real-world values*** (e.g., "survey reactions of people to noise")

- **In statistics:**
  - [A measurement system](#) is ***valid*** if it is both *accurate* and *precise*.
  - We also use the terms **'unbiased with small error (or variability)'**
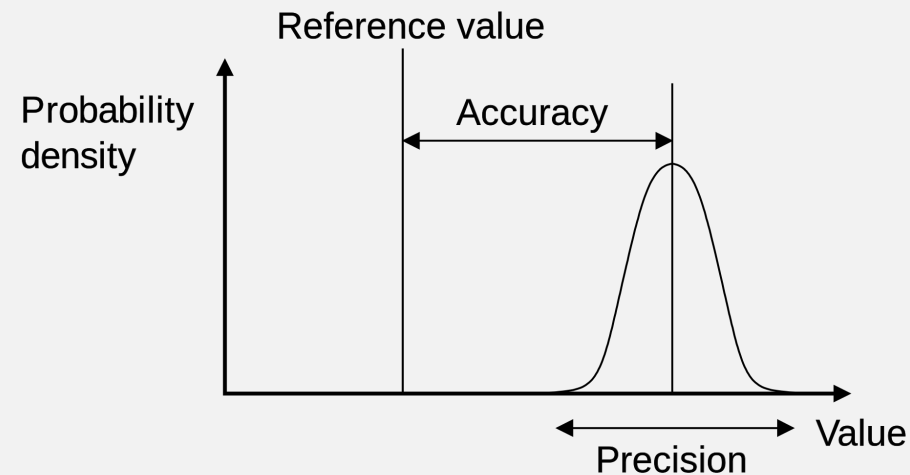
[By Pekaje at English Wikipedia](#)

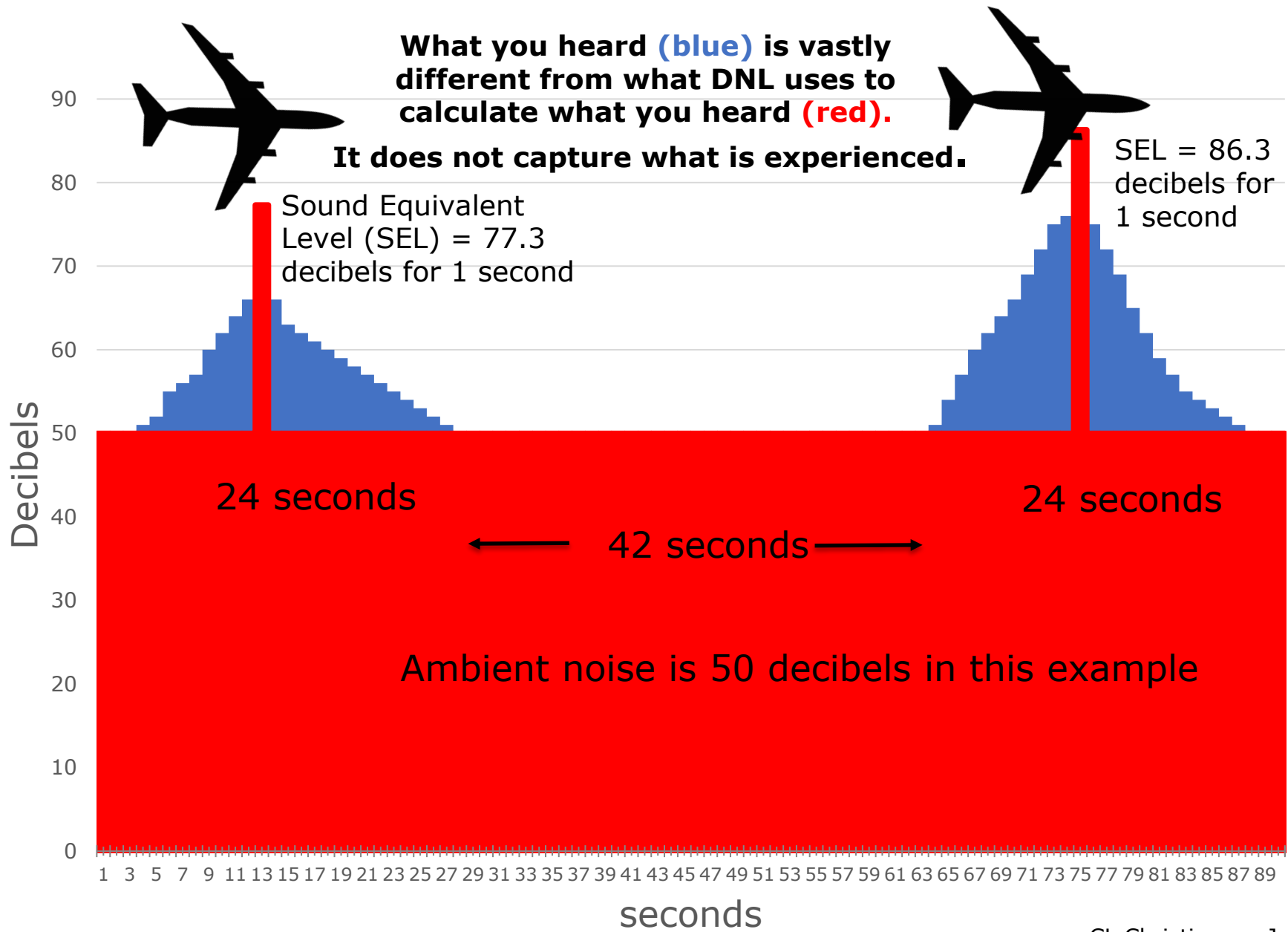DNL is calculated as if you heard this:

You heard 2 seconds of aviation noise out of 90 seconds. 77.3 decibels for 1 second and 86.3 decibels for 1 second

90 seconds

Ambient noise is 50 decibels in this example

Decibels

seconds

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What you heard (blue) is vastly different from what DNL uses to calculate what you heard (red).

It does not capture what is experienced.

Sound Equivalent Level (SEL) = 77.3 decibels for 1 second

SEL = 86.3 decibels for 1 second

24 seconds

24 seconds

42 seconds

Ambient noise is 50 decibels in this example

seconds

Decibels

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Problem: DNL65 Invalid Metric for "Away from Airport" Locations: DOES NOT closely correspond to real-world values

Four Scenarios that Result in a Yearly Noise Exposure DNL = 65
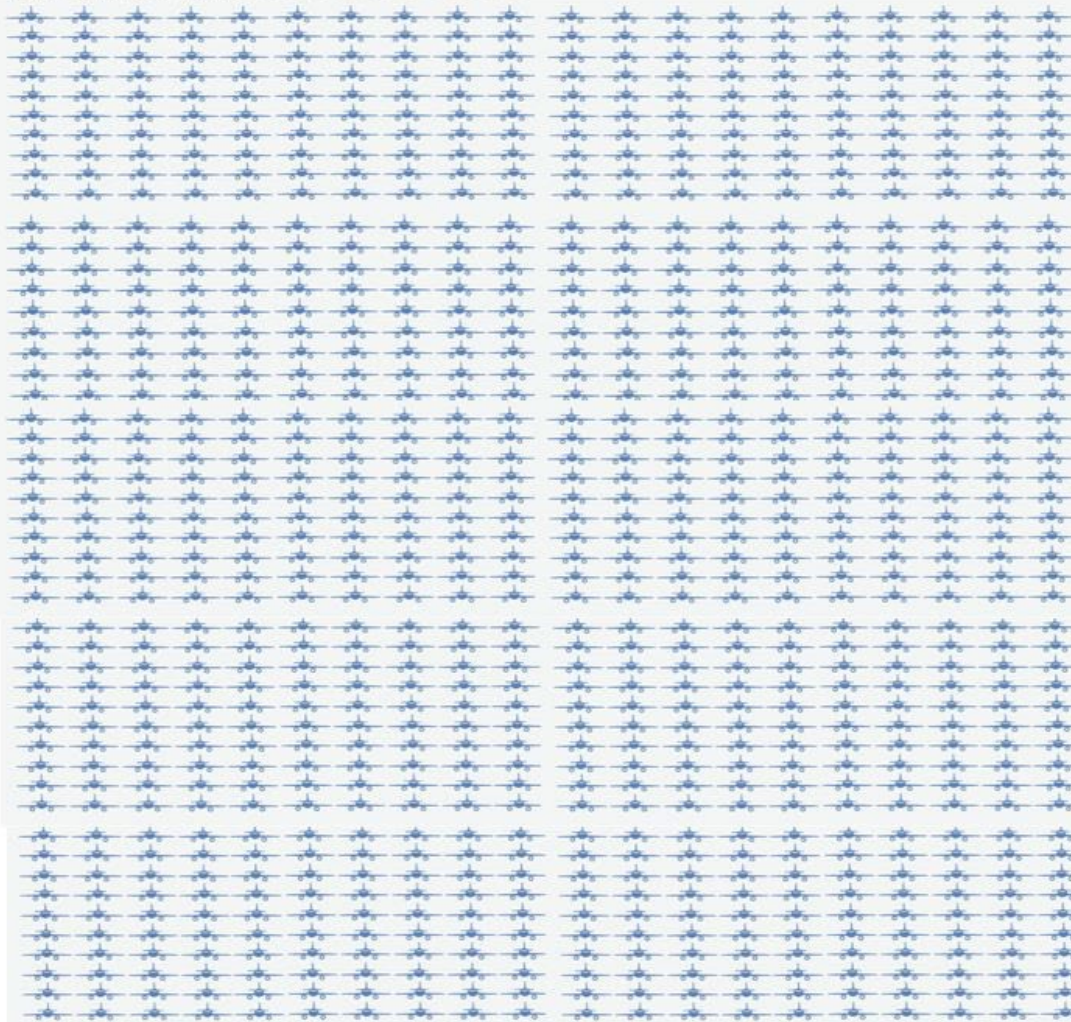
1 EVENT/DAY SEL 114.4 dBA = DNL 65

10 EVENTS/DAY SEL 104.4 dBA = DNL 65

100 EVENTS/DAY SEL 94.4 dBA = DNL 65

1,000 EVENTS/DAY SEL 84.4 dBA = DNL 65

Aviation events 5+ miles from the runway end usually have a single event noise exposure level (SEL) less than 90 dBA.
This means that the FAA's use of DNL allows up to 1,000 low flying departure, arrival, or approaches per day to cross over the same residents before it considers there to be a significant aviation noise impact.

Locations "away from airports" need **1,000+ noise events per day** to reach significant noise – the scenario that the FAA only recently disclosed.

Because of this flawed metric and threshold, no one **"away from airports"** has significant noise.

Problem: DNL65 **Invalid** Metric for "Away from Airport" Locations: Large estimation error away from airport
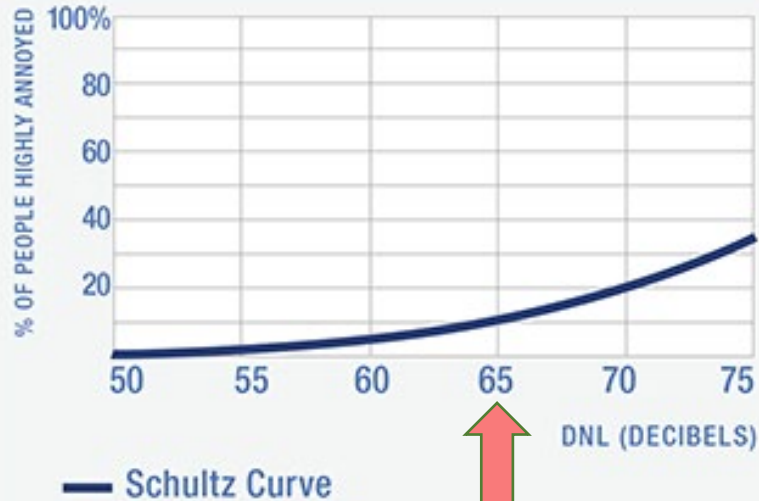
DNL65 is both *biased* and estimated with *large error (variability)* "Away from Airports"

- According to Vincent Mestre, February 26,2021 (ANE Symposium):
  - Now, with good data, the margin of error is about
    - ±1.5 dB @ 65 DNL,
    - ±3 dB @ 60 DNL,
    - ±5 dB around 55 DNL, and
    - ±10 dB at ≤ 50 DNL

Estimated DNL of 50, 55, and 60, but with 95% Confdence, DNL Could Be Any Value shown in Red Interval																									
DNL50	40	41	42	43	44	45	46	47	48	49	**50**	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65
DNL55	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	**55**	56	57	58	59	60	61	62	63	64	65
DNL60	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	**60**	61	62	63	64	65

Problem: Neighborhood Environmental Survey (NES) Study Shows DNL65 Threshold is Invalid

SCHULTZ CURVE

NATIONAL CURVE
- National Curve
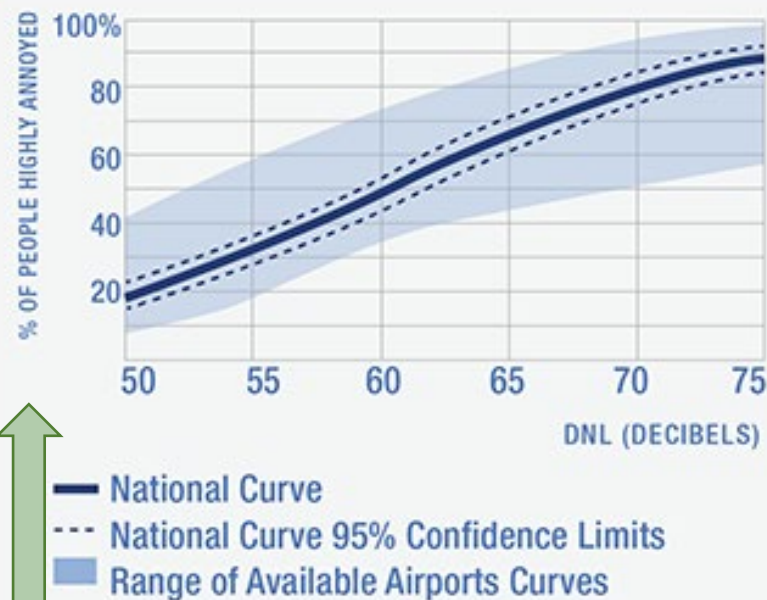- - - National Curve 95% Confidence Limits
- Range of Available Airports Curves

*Federal Interagency Committee on Noise (FICON). (1992). Federal Agency Review of Selected Airport Noise Analysis Issues. Report for the Department of Defense, FICON, Washington, DC.

1992, 30 years ago

2021

TC-21-4_Analysis of NES

Jan 2021 released NES study shows:
- 12.3% of people highly annoyed at DNL46
- instead of the antiquated Schultz Curve and 1992 FICON 12.3%* highly annoyed at DNL65.

WHY?

Schultz Curve	NES Curve
All transportation noise	Aviation noise
Combination of multiple surveys and questions	Specific study designed to capture annoyance to aviation noise
Used data from multiple countries	US data from residents living around 20 US airports
Inappropriate statistical model (best they had)	State of the art statistical model
Inconsistent with what communities report as significant noise	Closer to what communities report as significant noise

SOLUTIONS: Two "Must Haves" for FAA's Noise Policy and Process

Separate Mitigation Efforts Close To and Away From Airports

Develop a *VALID SYSTEM* OF METRICS to Define "Significant Noise" Close To and Away From Airports for Regulatory Purposes

| Sound Proofing (Close to Airports) | Prevention and Redesign (Away from Airports) | In Addition to DNL, Alternative Regulatory Metrics for "Away from Airports" | Nabove is Valid (Accurate and Precise) for "Away from Airports" (ASCENT) | Use NES's **Nabove50dB** to Assess Alternative Metrics |

SOLUTIONS: Separate AIP Mitigation Fund Metrics from NEPA Metrics

FAA uses the single metric DNL65 to define:

1. Residential Land Use Compatibility in the vicinity of airports (Part 150 based on ASNA)

2. Eligibility for noise mitigation funded with Airport Improvement Program (AIP) grants and airport revenues

3. Significant Noise and Significant/Reportable Increases in Noise in NEPA (Catex, EA, EIS) for Noise Sensitive Areas

   - FAA Reference: "In its policies and procedures implementing NEPA, the FAA has exercised its **discretion** to specify DNL 65 dBA as the "significance threshold" for the noise effects of its actions."

FAA Noise Policy must separate metric usage for #2 and #3 for locations "Away from Airports" where aviation noise event numbers and frequency affect residents more than intensity of noise.

SOLUTIONS: How to Create a Valid System of Metrics to Assess Noise?

Developing Noise Metrics For Regulatory Purposes:

- Take public comments/complaints and create metrics that capture the cause of the complaint. For example:
  - Too many planes (e.g. Nabove)
  - Almost constant noise (e.g. Nabove per hour)
  - Wakes me before 5am (e.g. Nabove with penalties)
  - Without planes, I live in a quiet community (e.g. Account for Ambient Noise)
- Include a multi-disciplinary team in the regulatory decision-making process
  - Contract with the National Academies of Medicine
  - Include environmental health, statistical, measurement theory, medical, public health, sleep, psychological, and pediatric experts

SOLUTIONS: Develop a *VALID SYSTEM* OF METRICS to Define "Significant Noise"

Which Noise Metrics For Regulatory Purposes?

Some thoughts:

- **Do include** a metric that captures variation in noise

- **Don't use** a single metric that takes log10 of the average $10^{\wedge}(SPL(A)_i)$ of aviation noise over 86,400 seconds for each day of the year, including all the zeros for seconds when there is no aviation noise – it is invalid and complicated

- **Do use** Nabove for away from airport locations – the number of noise events, especially under NextGen paths, is what affects residents' health and quality of life even though the sound intensity is lower than close to airports
  - It is easy to count and to understand counts
  - It is easy to understand when it is too much

HEAD IN THE FREEZER AND FEET IN THE FIRE, BUT ON AVERAGE HIS TEMPERATURE IS JUST **RIGHT**
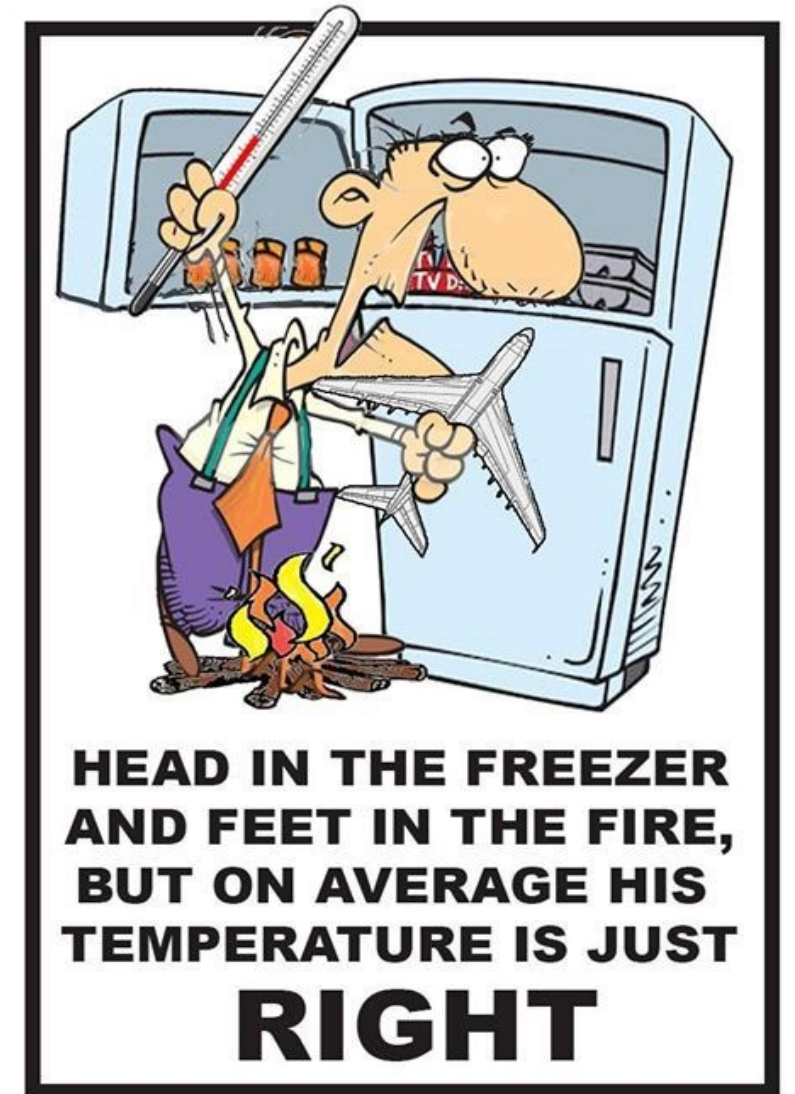
SOLUTIONS: Do Include Metrics That Do Not Correlate Well with DNL

Independent Metric Candidates	Slope	Constant	R^2
Community Noise Equivalent Level or Day-Evening Night Average Sound Level (CNEL/Lden)	.9999	.6399	.99998
Weighted Equivalent Continuous Perceived Noise Level (WECPNL)	1.0793	7.6323	.99951
24 Hour Average Sound Level ($LA_{eq}(24$ hour)	1.0001	-2.7943	.99999
Daytime Average Sound Level ($LA_{eq}(day)$), typically 12 hours, 7 am to 7pm.	1	-1.195	1
Effective Perceived Noise Level (EPNL)	1.0741	43.576	.9995
Tone Corrected Perceived Noise Level ($PNLT_{max}$)	1.43281	13.521	.9722
Nighttime Average Sound Level ($LA_{eq}(night)$)	1	-8.5235	.99999
Sound Exposure Level (SEL)	1	46.582	.99999
Maximum A-weighted Noise Level (LA_{max})	1.4353	3.8479	.98381
Time Above a Tone Corrected Perceived Noise Level (TAPNL) threshold	1.7872	-54.523	.54849
C-weighted Sound Exposure Level (SELC)	.7495	67.338	.98824
Maximum C-weighted Noise Level (LC_{max})	1.2035	24.128	.97864
Time Above 65 dBA (TA 65 dBA)	.8963	-28.588	.51406
Noise Exposure Forecast (NEF)	1.074	-40.326	.99951
Time Above 65 dBC (TA65 dBC)	1.9629	-59.688	.70822
Number of Events Above 70 dBA (NA70 dBA)	12.46	-632.42	.91298

*Slope and constant from the form y = mx + b, x = A-Weighted Lmax, y = dependent metric.

In 2011 Mestre et.al wrote: "...this approach can help to determine whether noise metrics other than DNL could yield meaningfully different predictions of noise exposure for a typical airport, and hence, support predictions of noise impacts potentially different than those produced by DNL."

NOTE: "Away from airport" locations' SELs tend to be <80 so Nabove70dB has similar problems as DNL above 65 (1,000 jets/events needed)

Mestre, V., Schomer,P., Fidell, S., and Berry, B. (2011). "Technical support for Day-Night AverageSound Level (DNL) replacement metric research," Report Number: DOT/FAA/AEE/2011-02

SOLUTIONS: Count the Number of Aviation Noise Events

Use NES data to Scientifically Determine How the Number of Aviation Noise Events Affects High Annoyance

- Calculate N-Above and T-Above noise levels from 45 dB-A to 65 dB-A in increments of 5dB, on granular geographic grids for all airports included in the Neighborhood Environmental Survey (NES)

Run a statistical model with "NUMBERABOVE50" as the only independent variable

Table 9-4. Model Coefficients for Model with NUMBERABOVE50

Coefficient	Estimate	Standard Error	Lower 95% Confidence Limit	Upper 95% Confidence Limit
Intercept, β_0	-9.9748	1.0179	-12.1054	-7.8443
DNL, β_1	0.1673	0.0181	0.1295	0.2051
NUMBERABOVE50, β_2	0.0043	0.0018	0.0006	0.0080
NUMBERABOVE50x DNL, β_3	-0.00008	0.00003	-0.00014	-0.00001

- Analyze the association between N-Above and annoyance levels for N-45, N-50, N-55, N-60, and N-65 using statistical methods and models similar to the ones used to analyze the association between DNL65 and annoyance in the NES study. Compare the models based on model fit statistics that assess the amount of variance explained by DNL compared with N-Above when predicting high-annoyance levels.

NOTE:NES used 50dB for Nabove, BWI uses 55dB, Ascent used 60/50dB (day/night) (and 50 events to define annoyance)

This Presentation is Dedicated to My Friend and Colleague Carl N. Morris, PhD

Carl received his BS in Aeronautical Engineering from the California Institute of Technology in 1960 and then attended Indiana University until 1962. He obtained his Ph.D. in statistics from Stanford University under advisor Charles Stein in 1966. ([Wikipedia](#))

Carl loved his family, his students, puns, baseball, and statistics!

July 20, 1938 – April 27, 2023