F-16 Training over the Gila

Community Input to the Environmental Impact Statement

FEBRUARY 2019

NOISE

When an F 16C/D fighter jet flies at full power 500 feet overhead, a person on the ground below will hear 116 decibels of noise—as loud as the siren of a fire engine 25 feet away. The proposal by the Air Force for Holloman Air Force Base to conduct 10,000 annual sorties of F-16s practicing combat maneuvers as low as 500 feet above the mountains and valleys of the Gila River basin will clearly generate a lot of noise in a quiet area day and night. And a thousand of those sorties will cause sonic booms.

Loud aircraft noise is widely recognized as an environmental problem. It can harm hearing. It disturbs sleep. It startles people repeatedly and can lead to hypertension, coronary disease, and impairments to human neuro-endocrine systems. Even low levels of aircraft noise can cause distraction, fatigue, irritability, headache, nausea, and impaired concentration and memory.

On the detrimental effects of noise in general:

- TED Talks Daily: *Why noise is bad for your health -- and what you can do about it*. Tuesday, Feb 12, 2019
  https://www.ted.com/talks/mathias_basner_why_noise_is_bad_for_your_health_and_what_you_can_do_about_it

- *Children and Noise. Children's Health and the Environment. WHO Training Package for the Health Sector. World Health Organization. Last Update: December 2009*
  https://www.who.int/ceh/capacity/noise.pdf

Peaceful Gila Skies

A coalition of business and community leaders, sportsmen and concerned citizens, united in our goal of protecting the Gila Region from military aircraft training.

www.peacefulgilaskies.com | 575.538.8078 | peacefulgilaskies@gmail.com

On the detrimental effects of aircraft noise specifically:

- *Aviation Noise Impacts: State of the Science.* Noise Health. 2017 Mar-Apr; 19(87): 41–50. *Mathias Basner, MD, PhD, MSc, Charlotte Clark, Anna Hansell, James I. Hileman, Sabine Janssen, Kevin Shepherd, and Victor Sparrow*
  https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5437751//

- *Military Aviation Noise: A Comprehensive Literature Survey. Draft. Stirling Consulting Reference Publication No. 2 ©. March 2017. Dale A. Sterling*
  https://www.researchgate.net/publication/313997245_Military_Aviation_Noise_A_Comprehensive_Literature_Survey_Draft

On the detrimental effects of sonic booms:

- "Studies of community residents' reactions to long-term sonic boom exposure are ongoing. Preliminary results indicate that reactions to sonic booms are far more severe than reactions to other types of noise at similar levels of noise exposure." (p. 4)

  Human Response to Sonic Booms—Recent NASA Research. Kevin P. Shepherd, Sherilyn A. Brown, Jack D. Leatherwood, David A. McCurdy, and Brenda M. Sullivan. NASA Langley Research Center, Hampton VA 23681.
  https://www.cs.odu.edu/~mln/ltrs-pdfs/NASA-internoise-95-kps.pdf

A supersonic plane breaking the sound barrier (Photo Credit : Pixabay)

Loud aircraft noise can have detrimental effects on wildlife, as well, causing stress, masking predator/prey detection, and interfering in communication necessary for reproduction and even navigation, among other problems. See the following for examples:

- *A synthesis of two decades of research documenting the effects of noise on wildlife. Graeme Shannon, Megan F. McKenna, Lisa M. Angeloni, Kevin R. Crooks, Kurt M. Fristrup, Emma Brown, Katy A. Warner, Misty D. Nelson, Cecilia White*, *Jessica Briggs*. *First published: 26 June 2015.*
  https://doi.org/10.1111/brv.12207

- *Natural Sounds. National Park Service.*
  https://www.nps.gov/subjects/sound/effects_wildlife.htm

Military jet noise is significantly louder than civilian aircraft noise. It is louder, in part, for reasons of aerodynamics and engine design that are geared to enhancing power and performance. These jets are weapons, after all, and the noise is louder because of the way they are used. Military jets often fly at low elevations. They practice contouring landscape to avoid detection. The sudden climbs, turns, and accelerations of training and combat maneuvers are more extreme and consequently louder than the gradual kinds of changes in altitude and direction that commercial aircraft typically make.

With passage of the *Noise Pollution and Abatement Act of 1972,* the Environmental Protection Agency (EPA), the Federal Aviation Administration (FAA) and other federal agencies started to address the problem of aircraft noise by developing standard ways to measure it, by recommending acceptable levels of aircraft noise in communities, by researching noise mitigation practices, and by setting noise performance standards for the engines of civilian aircraft.

None of these agencies regulate the noise levels of military aircraft, however. The principal mitigating strategy available for reducing these noise effects is for the military to limit where its aircraft train. **The Air Force's proposal for Holloman's F-16 training specifically seeks authorization to establish the Lobos Military Operations Area (MOA) in order to fly F-16s in this place in a manner that is not otherwise allowed because of the known detrimental effects.**

To assess the levels of military aircraft noise in communities and to predict the response of people exposed to that noise, the United States Air Force (USAF) focuses on these three principal metrics:

- **Day-night Average Sound Level (DNL or L_{dn})**
- **Federal Land Use Compatibility Guidelines for Noise**
- **Annoyance and Noise Dose-Response Relationships**

These metrics will be examined in sequence following a few introductory remarks and a brief glossary.

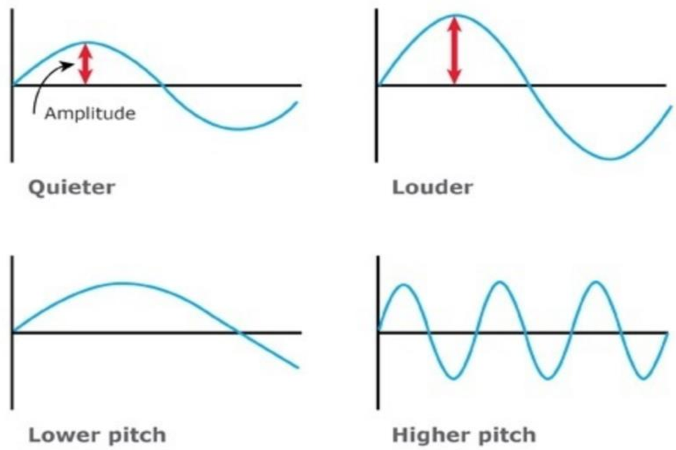
Noise would seem to be simple: You know it when you hear it. But actually noise is complex, hard to understand, and more difficult to explain. Physics, physiology, psychology are all key to understanding its generation, its perception, and its impact on people. The terms of its analysis are often unfamiliar, even counter-intuitive, and the mathematics exceed common mastery. The study of noise impacts and the metrics to measure them began largely in industrial workspaces and later around urban airports after WWII. The technical reports that formalized these studies focused on measuring noise in urban areas and predicting the response to that noise of people living in those areas.

These metrics are standard now and have been embedded within federal policy for more than 25 years. Today, however, their usefulness and their predictive value is increasingly challenged as inadequate when applied uniformly across communities regardless of size, character, and economy, and as misguided when applied in quiet rural and wild landscapes.

In order to understand these metrics, a few terms need to be defined that are not part of common speech or that are used in uncommonly specific ways.

Glossary

Sound is a pressure wave that moves through a medium like air or water or the ground. It has amplitude and frequency and duration.

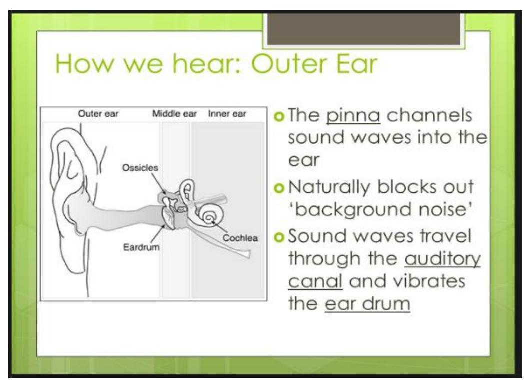


https://www.sciencelearn.org.nz/resources/573-measuring-sound

Decibels (dB) are the logarithmic unit of measure of the pressure wave's amplitude—its height on a graph, its energy in the world of experience. The higher the amplitude the more intense the wave. An increase of 10 decibels represents a 100-fold increase of intensity.

Decibels (dB) are also the unit of measure for loudness, which is how people and animals perceive the sound pressure wave. Due to the structural limitations of our auditory senses, an increase of 10 dB represents only a doubling of loudness. The threshold of human hearing is 0 dB.

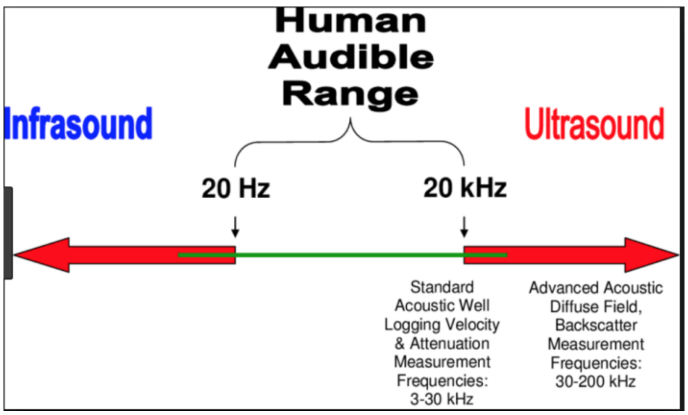
Note: *This unit of measure is commonly confusing to people. For example, when a sound pressure level increases from 50 dB to 60 dB, the arithmetic increase is only 20%, but the perceived increase in loudness is 100%, and the logarithmic increase in energy is 1,000%.*



https://slideplayer.com/slide/9535292/

The important thing to remember is that loudness more or less doubles with each increase of 10 dB. A 10 dB increase is twice as loud as the reference sound. A 20 dB increase is 4 times as loud. A 30 dB increase is 8 times as loud. Etc.

Hertz is the unit of measure for frequency or wavelength on a graph. One Hertz is a cycle of wavelength that takes one second to complete.



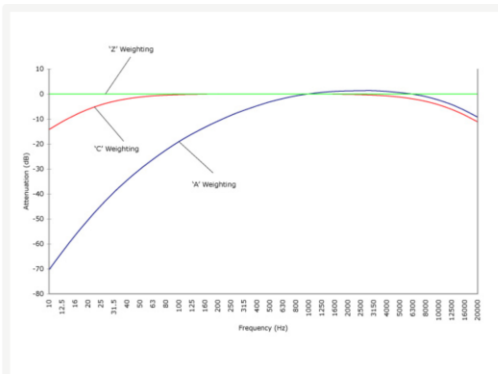
Humans and animals hear frequency as pitch. People can hear sounds in the range of 20 Hz to 20,000 Hz but are more sensitive to sounds that range between 500 Hz and 8,000 Hz. Many animals can hear higher frequencies—think dog whistles.

https://www.researchgate.net/publication/239866577_Evaluation_of_Non-Nuclear_Techniques_for_Well_Logging_Technology_Evaluation

Frequency weighting is used to adjust sound level meters to represent what people actually hear given the physiological limitations of the ear.

A-Weighted Sound Level is the most common form of weighting. It de-emphasizes the lower and higher frequencies that the average person cannot hear. It is denoted as dBA or dB(A).

Note: There are other frequency weighting formulas, as well, that address different features of sound projection and perception: C-weighting (dB(C)) for peak sound pressure, for example, or Z-weighting (dB(Z)) for no weighting at all.



Frequency Weighting Curves – 'A', 'C' & 'Z'

Image from: Noise News: What Are A, C and Z Frequency Weightings?
https://www.cirrusresearch.co.uk/blog/2011/08/what-are-a-c-z-frequency-weightings/

Ambient Sound is the totality of local sounds in a particular place or environment. The sounds vary in loudness over time.

Natural Ambient Sound is the totality of sounds that are not anthropogenic in a particular place or environment. The sounds vary in loudness over time.

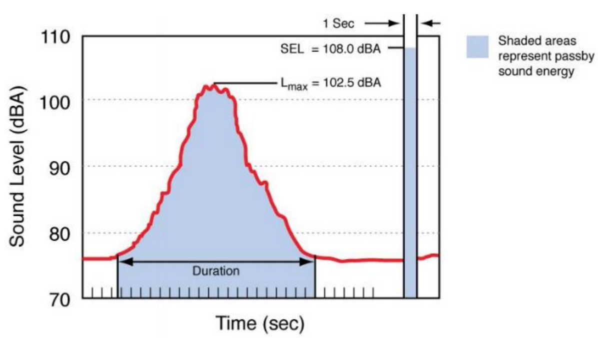
Soundscape is the totality of all sounds in a particular place or environment. The sounds vary in loudness over time.

Noise is an unwanted sound. The determination of when sound is noise can be complicated, and volume is not the only issue. Response also depends on the psychology of personal choice or control, on a person's expectations, and on perceptions of context, setting, and frequency. The woman who puts straight pipes on her Harley "Fat-Boy" motorcycle enjoys the sound of power as she throttles down the street at 90 dB. The people by the open window whose conversation is interrupted by the noise of the motorcycle are annoyed. If she cruises up and down the street repeatedly, the people at the window become angry. The rider on the balky mule climbing up the north wall of West Fork Canyon leaps to the ground, startled by the noise of the F-16 passing over his shoulder at 100 dB, afraid his animal will shy catastrophically. The boy at the airshow is thrilled by the sound of F-16s passing 100 feet over head at 500 mph. The person who brought the boy is pleased to be wearing noise-cancelling headphones.

If your livelihood depends on servicing aircraft, the sound of jets may be tolerable, if not actually welcome. If you live under a newly-designated flight corridor to a busy airport, the noise may make you very upset—and devalue your property.

The sounds of nature are generally pleasing. People expect these sounds to be pleasant and seek them out, but the noise of an F-16 flying low overhead and at high speed is commonly deemed unpleasant—especially in a landscape setting that is especially valued for its rural, wild or natural character.

Figure A-4 Graphical Depiction of Sound Exposure Level
Source: HMMH, 2011



A Few Relevant Noise Metrics

L_{max} "is the highest sound level measured during a single aircraft overflight, [for example]. For an observer, the noise level starts at the ambient noise level, rises up to the maximum level as the aircraft flies closest to the observer, and returns to the ambient level as the aircraft recedes into the distance." (p. A-6)

Appendix A - Noise Terminology. Nashville International Airport. December 2012.

https://www.flynashville.com/about/Documents/final_bna_nem_december_2012_Apendices.pdf

LA_{max} is the maximum A-weighted sound pressure level recorded during a single aircraft overflight.

SEL (Sound Exposure Level) represents all the acoustic energy (a.k.a. sound pressure) of an individual noise event as if that event had occurred within a one-second time period. SEL captures both the level (magnitude) and the duration of a sound event in a single numerical quantity, by "squeezing" all the noise energy from an event into one second. This provides a uniform way to make comparisons among noise events of various durations.

Fundamentals of Noise and Sound. Federal Aviation Administration.
https://www.faa.gov/regulations_policies/policy_guidance/noise/basics/

Equivalent Sound Level (L_{eq}) measures the average acoustic energy over a period of time to take account of the cumulative effect of multiple noise events. This could, for example, provide a measure of the aggregate sound at a location that has airplane flyovers throughout the day. LEQ is defined as the level of continuous sound over a given time period that would deliver the same amount of energy as the actual, varying sound exposure.

Fundamentals of Noise and Sound. Federal Aviation Administration.

I. Day-Night Average Sound Level (DNL or L_{dn})

The Day-Night Average Sound Level is used to reflect a person's cumulative exposure to sound over a 24-hour period, expressed as the noise level for the average day of the year on the basis of annual aircraft operations. The DNL noise metric provides a mechanism to describe the effects of environmental noise in a simple and uniform way. DNL is the standard noise metric used for all FAA studies of aviation noise exposure in airport communities. (This metric can be applied to other transportation noise, as well, but it is useful rely on definitions of the FAA in the case of the Lobos MOA.) *Fundamentals of Noise and Sound. Federal Aviation Administration.*

To account for the more intrusive character of sound in the nighttime, the DNL calculation deliberately increases by 10 dB the level of each sound recorded between 10 pm and 7am. This penalty modestly raises the 24-hour average. DNL is typically A-weighted.

DNL is a version of Equivalent Sound Level (L_{eq} see glossary) and has the same benefit for comparing different soundscapes.

Note: There are other versions of L_{eq}, as well. Day-Evening-Night-Level (DENL or L_{den}) is used in Europe. It has the same structure as DNL but adds an additional 5 dB penalty for noise in the evening between the hours of 7 pm and 10 pm. Community Noise Equivalent Level (CNEL) is used in California. It has the same structure as DENL.

https://www.noisequest.psu.edu/pdfs-documents/effects.pdf

$$L_{dn} = 10\log\left(\frac{1}{86,400}\sum_{i=1}^{N} 10^{(SPL_i+W_i)/10}\right)$$

where:		
	L_{dn}	=Day-Night Average Sound Level, DNL, for one day
	SPL_i	=Instantaneous A-weighted sound level, measured every 0.5s
	86,400	=number of seconds in one day
	W_i	=time of day weighting for ith A-weighted sound level
	N	=86,400/Δt

In June 1980, in a report entitled *Guidelines for Considering Noise in Land Use Planning and Control,* the Federal Committee on Urban Noise (FICUN) recommended adoption of the DNL metric as the most suitable descriptor of noise levels in urban areas. Organized to develop coordinated federal policies on noise, the FICUN membership included representatives from the Environmental Protection Agency (EPA), the Federal Aviation Administration (FAA), the Department of Housing and Urban Development (HUD), the Department of Defense (DOD), the Federal Highway Administration (FHA), and the Department of Veterans Affairs (VA).

In 1981, FAA formally adopted DNL as its principal metric for determining effects on people in urban areas from noise generated by aircraft. Despite these established endorsements, there are problems with the DNL metric that have emerged over the last 3 decades.

Problems with DNL in the case of the Lobos MOA:

- **DNL is a notional sound. It is not actually something that a person can hear. When an F-16 flies 500 feet overhead, the person on the ground can hear 116 dB of noise each time. He or she does not hear DNL, however, and the reported averaged dB for DNL is always substantially lower than the sound pressure that is actual heard. The discrepancy would seem to minimize the problem of environmental detriment.**

- **DNL was developed to describe aircraft noise in the vicinity of airports in urban areas. Note the title of the committee recommending the standard: Federal Committee on Urban Noise [bold added for emphasis]. The glossary for an F-22 bed-down analysis, notes that DNL is an appropriate measure for noise "around military airfields" [bold added for emphasis].**

  Distribution, Glossary, Acronyms, and Abbreviations. Final EIS for Initial F-22 Beddown April 2000. https://www.acc.af.mil/Portals/92/Docs/AFD-070806-033.pdf

DNL appears to be inadequate for describing soundscapes in quiet natural places where people value the absence of noise and the presence of natural sounds such as wind in the trees or water flowing in a stream. For more on this problem, see: *Chapter 3. Technology for a Quieter America. National Academy of Engineering of the National Academies. The National Academies Press. 2010.* *https://www.nap.edu/catalog/12928/technology-for-a-quieter-america*

In the explanation of why there is a 10 dB penalty for noise between the hours of 10 pm and 7 am, the Air Force glossary, which was cited above, noted the "intrusive" nature of noise during those quiet hours. The contrast that quiet times provide makes intrusive noise seem louder—more annoying. The quiet "enhances" the sound, the term given to this phenomenon.

The same phenomenon is also discernable during daylight hours in quiet rural areas and wilderness, areas like the proposed Lobos MOA, where the ambient sound levels may well average 30 dB or less. No penalty is currently assigned in that case—but the first Air Force Land Use Planning guide (1957) recommended a 10 dB penalty for this situation. The Air Force guide also recommended a 5 dB penalty if a community had no prior experience with intrusive noise, and an additional 5 dB penalty for impulsive noise. See table below.

Penalties like these "normalize" the DNL. Normalizing is a process that makes adjustments to the basic DNL value "to account for specific characteristics and factors of the sound." For an informative review of normalizing benefits, see:

On Normalizing DNL to Provide Better Correlation with Response. Paul D. Schomer, Schomer & Associates, Champaign, Illinois. Sound and Vibration. December 2002
https://acousticecology.org/wind/winddocs/noise/Schomer_On%20Normalizing%20DNL%202002.pdf

Table from: *On Normalizing DNL to Provide Better Correlation with Response. 2002*

Table 1. Corrections to be added to the measured DNL of intruding noise to obtain normalized DNL.[5]

Type of Correction	Description	Correction Added to measured DNL (dB)
Seasonal Correction	Summer (or year-round operation)	0
	Winter only (or windows always closed)	–5
Correction for Outdoor Noise Level Measured in Absence of Intruding Noise	Quiet suburban or rural community (remote from large cities and from industrial activity and trucking.	+10
	Normal suburban community (not located near industrial activity)	+5
	Urban residential community (not immediately adjacent to heavily traveled roads and industrial areas)	0
	Noisy urban residential community (near relatively busy roads or industrial areas)	–5
	Very noisy urban residential community	–10
Correction for Previous Exposure and Community Attitudes	No prior experience with little intruding noise	+5
	Community has had some previous exposure to intruding noise but little effort is being made to control the noise. This correction may also be applied in a situation where the community has not been exposed to the noise previously, but the people are aware that bona fide efforts are being made to control the noise.	0
	Community has had considerable previous exposure to the intruding noise and the noisemaker's relations with the community are good.	–5
	Community aware that operation causing noise is very necessary and it will not continue indefinitely. This correction can be applied for an operation of limited duration and under emergency circumstances.	–10
Pure Tone or Impulse	No pure tone or impulsive character	0
	Pure tone or impulsive character present	+5

- Other observed limitations of the DNL metric include:
  - DNL is insensitive to the impact of very loud isolated events.[1]
  - DNL is a relatively insensitive measure of sleep disturbance.[1]
  - DNL is insensitive to the time when an event occurs. Noise early in the night causes different sleep disturbances than noise early in the morning.[1]
  - DNL does not take into account other sound characteristics (for example sound tonality, impulsiveness, and spectral character) that can influence annoyance and sleep disturbance levels.[1]
  - A-weighting does not reflect the results of research studies in pyscho-acoustics over the past 40 years.[1]

[1] *Chapter 3. Technology for a Quieter America. National Academy of Engineering of the National Academies. The National Academies Press.*

II. Federal Land Use Compatibility Guidelines

Table C 4. Land Use Compatibility with Yearly Day-Night Average Sound Levels (DNL)

Land Use	Yearly Day-Night Average Sound Level (DNL) in Decibels					
	Below 65	65–70	70–75	75–80	80–85	Over 85
Residential Use						
Residential (other than mobile and transient lodgings)	Y	N [1]	N [1]	N	N	N
Mobile Home Parks	Y	N	N	N	N	N
Transient Lodgings	Y	N [1]	N [1]	N [1]	N	N
Public Use						
Schools	Y	N [1]	N [1]	N	N	N
Hospitals and Nursing Homes	Y	25	30	N	N	N
Churches, Auditoriums, and Concert Halls	Y	25	30	N	N	N
Government Services	Y	Y	25	30	N	N
Transportation	Y	Y	Y [2]	N [3]	Y [4]	Y [4]
Parking	Y	Y	Y [2]	Y [3]	Y [4]	N
Commercial Use						
Offices - Business and Professional	Y	Y	25	30	N	N
Wholesale and Retail - Building Materials, Hardware, and Farm Equipment	Y	Y	Y [2]	Y [3]	Y [4]	N
Retail Trade - General	Y	Y	25	30	N	N
Utilities	Y	Y	Y [2]	Y [3]	Y [4]	N
Communication	Y	Y	25	30	N	N
Manufacturing and Production						
Manufacturing - General	Y	Y	Y [2]	Y [3]	Y [4]	N
Photographic and Optical	Y	Y	25	30	N	N
Agriculture (except livestock) and Forestry	Y	Y [6]	Y [7]	Y [8]	Y [8]	Y [8]
Livestock Farming and Breeding	Y	Y [6]	Y [7]	N	N	N
Mining and Fishing, Resource Production, and Extraction	Y	Y	Y	Y	Y	Y
Recreational						
Outdoor Sports Arenas and Spectator Sports	Y	Y [5]	Y [5,6]	N	N	N
Outdoor Music Shells and Amphitheaters	Y	N	N	N	N	N
Nature Exhibits and Zoos	Y	Y	N	N	N	N
Amusements, Parks, Resorts, and Camps	Y	Y	Y	N	N	N
Golf Courses, Riding Stables, and Water Recreation	Y	Y	25	30	N	N

Notes: Data for this table were taken from the Standard Land-Use Coding Manual.

1 Where the community determines that residential or school uses must be allowed, measures to achieve outdoor to indoor Noise Level Reduction (NLR) of at least 25 dB and 30 dB should be incorporated into building codes and be considered in individual approvals. Normal residential construction can be expected to provide an NLR of 20 dB; thus, the reduction requirements are often stated as 5, 10, or 15 dB over standard construction and normally assume mechanical ventilation and closed windows year-round. The use of NLR criteria will not eliminate outdoor noise problems.

2 Measures to achieve NLR of 25 dB must be incorporated into the design and construction of the portion of the buildings where the public is received such as in office areas, noise-sensitive areas, or where the normal noise level is low.

3 Measures to achieve NLR 30 dB must be incorporated into the design and construction of the portion of the buildings where the public is to be received such as in office areas, noise-sensitive areas, or where the normal noise level is low.

4 Measures to achieve NLR 35 dB must be incorporated into the design and construction of the portion of the buildings where the public is received such as in office areas, noise-sensitive areas, noise-sensitive areas, or where the normal noise level is low.

5 Land use is compatible provided special sound reinforcement systems are installed.

6 Residential buildings that require an NLR of 25.

7 Residential buildings that require an NLR of 30.

8 Residential buildings not permitted.

Key:

Y (YES) = Land use and related structures compatible without restrictions.

N (No) = Land use and related structures are not compatible and should be prohibited.

25, 30, or 35 dB = Land use and related structures generally compatible; measures to achieve NLR of 25, 30, or 35 dB must be incorporated into design and construction of structures.

For more information on the table above, see:
Federal Agency Review of Selected Airport Noise Analysis Issues. Federal Interagency Committee on Noise. August 1992.
http://www.gsweventcenter.com/GSW_RTC_References/1992_0801_FICON.pdf

The 1980 FICUN report also provided specific guidelines to correlate appropriate land use and/or noise mitigation strategies with DNL measurements. Noise below the DNL threshold of 65 dB(A) was deemed insignificant to all urban land uses.

In 1981, the FAA published Part 150 of Title 14 of the Code of Federal Regulations that was based on DNL and the FICUN land use compatibility guidelines for the purpose of airport noise compatibility planning. Title 14 CFR 150 was formally adopted in 1985.

The benefit of the FICUN land use compatibility guidelines and their DNL correlations was that they were simple to understand, and they appeared to be robustly scientific. They quickly became embedded in Federal Regulation, and by now they are a precedent with significant history—having likely been cited for every Air Force action that required an Environmental Impact Statement or an Environmental Assessment since 1981.

Despite this formidable status, however, there are problems with the FICUN land use compatibility guidelines and the 65 dB(A) threshold.

Problems with the FICUN Land Use Compatibility Guidelines in the case of the Lobos MOA

- The principal use of these guidelines is for noise compatibility planning in the vicinity of airports. The 65 dB(A) threshold of compatibility for residential use is an urban standard that might have been acceptable nearly 40 years ago in areas where ambient sound levels were already high and people were “acclimated” to urban noise.

Rural areas under the proposed Lobos MOA are quiet, however. People move there or stay there to avoid the noisy industrial and commercial turmoil of big cities. Peace and tranquility are one of the principal amenities locally, and people sacrifice convenience and even job opportunities to enjoy this tranquility. The salience of natural sounds is also an especially pleasing characteristic of the adjacent areas of wilderness.

To cite an urban threshold of noise where residential use becomes intolerable (65 dB(A)) and apply it as a meaningful measure of noise management or mitigation in the rural and wild areas of the Lobos MOA is obtusely inappropriate.

- The FICUN 65 dB(A) noise threshold for residential use is twice as loud as the EPA threshold of 55 dB(A). See: *EPA Identifies Noise Levels Affecting Health and Welfare.* EPA Press Release—April 2, 1974
  https://archive.epa.gov/epa/aboutepa/epa-identifies-noise-levels-affecting-health-and-welfare.html

It is four times louder than the 45 dB(A) threshold for noise levels outside bedrooms that is recommended by the World Health Organization (WHO). For good measure, in such cases, WHO includes an L_{max} threshold of 60 dB(A).

WHO also recommends that “existing quiet outdoor areas [such as parklands and conservation areas] should be preserved and the ratio of intruding noise to natural background sound should be kept low.” *Environmental Noise Guidelines for the European Region*. World Health Organization. 2018. http://www.euro.who.int/en/health-topics/environment-and-health/noise/environmental-noise-guidelines-for-the-european-region

It is worth noting that no health organization of national stature, such as the National Institute of Health, had a seat on the FICUN committee or for that matter on any of the successor committees to FICUN, including FICON (Federal Interagency Committee on Noise formed in 1990), and FICAN (Federal Interagency Committee on Aviation Noise formed in 1993.)

- The FICUN land use compatibility guidelines are merely guidelines. Enforcement is deferred to local and state government--if they adopt the guidelines into zoning ordinances and statutes for the purposes of public health and welfare. Local zoning regulations are not enforceable against the Department of Defense, of course, for reasons of federal primacy.

- And finally, there is this observation regarding the FICUN guidelines by Sanford Fidell, a prominent expert in acoustic engineering and quantitative social research, who has over 162 publications, generally on the topic of environmental sound metrics

"None of the interpretations of compatibility made in the FICUN report were supported by any form of comprehensive, community- or theory-based, peer-reviewed, or otherwise objective study, and none have been meaningfully revised. What informally seemed to some to be an acceptable level of noise pollution near military airfields six decades ago is not necessarily still acceptable in modern civil society." (p.28)

A Review of US Aircraft Noise Regulatory Policy. Why do Federal aircraft noise regulatory policies only rarely accomplish their own goals? Sanford Fidell. Acoustics Today. Fall 2015. Vol. 11, Issue 4. https://pdfs.semanticscholar.org/8cd0/c8c0783fa5519b38f4d595074a113fc3159f.pdf

III. Annoyance and the Noise Dose-Response Relationship

Annoyance is the current preferred metric used by the military and agencies like the FAA to assess community reaction to the noise of military aircraft. It would seem an odd word to use, when the effects can easily be characterized as stress and consequent harms such as increased incidences of hypertension, anxiety, sleep disturbance, etc. which have genuine health consequences.

But there is a history to this usage, and a rationale.

In the 1970s, the linkage between workplace noise and hearing impairment was well understood from safety studies at factories, but very little scientific work at that time had specifically addressed other health issues consequent to noise. Records of activity impairments (speech interference, for example) and tallies of complaints received by authorities were standard ways to measure the intensity of community reaction to rising levels of noise. The use of these metrics were reported in the 1974 Levels Document by the EPA. The report also briefly noted the results of several social surveys conducted in the 1960s and 1970s that specifically correlated DNL and levels of annoyance recorded in the associated questionnaires. For more on EPA Levels Document, see: *EPA550/9- 47-004, Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety, (1974)*
https://www.rosemonteis.us/documents/usepa-1974

It seemed that the coordinated use of survey questionnaires in which respondents document their level of annoyance with rising levels of noise on a scale that is designed by social scientists yielded more valid data than a review of irregular complaints by angry people. It was certainly simpler. There were fewer variables for the analysts. The issue of noise had a consistent frame.

And checking off levels of annoyance in a questionnaire was easy to do for the parties queried--certainly easier than writing letters of complaint.

Annoyance as a metric had the added benefit of not being an actionable harm according to tort law. The tally of complaints was eventually abandoned.

Even better, in 1978, T.J. Schultz published an article in the Journal of the Acoustical Society of America (1978) on the topic of transportation noise and community reaction, showing that annoyance levels recorded through social surveys conducted in different communities (and even in different countries) could be synthesized, graphed, matched with levels of DNL, and reported in the form of a dose-response relationship.
Synthesis of Social Surveys on Noise Annoyance. *Journal of the Acoustical Society of America. August 1974. 64(2): 377-405.* https://www.ncbi.nlm.nih.gov/pubmed/361792

Note: "*The dose–response relationship, or exposure–response relationship, describes the change in effect on an organism caused by differing levels of exposure to a stressor after a certain exposure time, or to a food. This may apply to individuals, or to populations*."
Wikipedia: Dose-Response Relationship

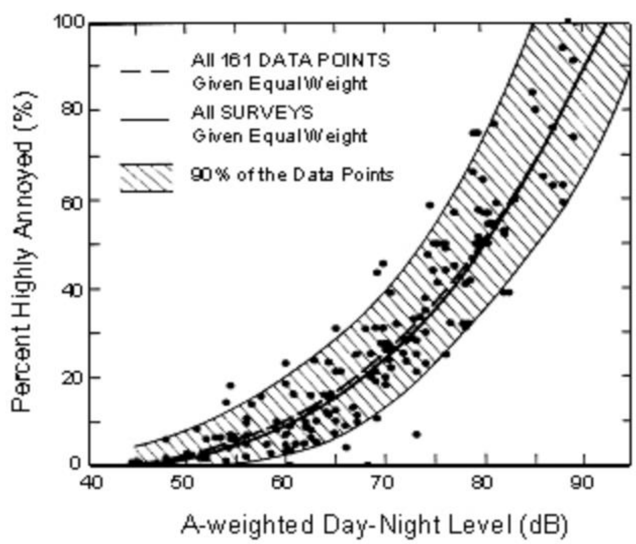
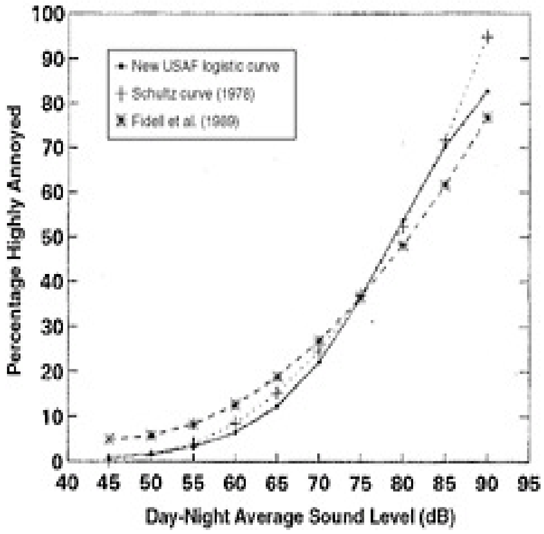


Figure 1. Original Schultz curve and data.

Graph from: *On Normalizing DNL to Provide Better Correlation with Response.*

The original Schultz Curve was based on 11 surveys and 161 data points. The curve graphed above was "fitted" to the data associated with different modes of transportation. The intersection of a particular level of dB(A) could easily be matched with the percentage of residents likely to be "highly annoyed" by the noise of those transportation modes.

Note: The cutoff for "highly annoyed" is 72 on a scale of 0-100, the cutoff for "annoyed" is 50 on a scale of 0-100, and the cutoff for "a little annoyed" is 28 on a scale of 0-100.



Originally controversial, the Schultz Curve has been refined over time, with more surveys and data points added to the analysis, often specifically on the issue of aircraft noise, resulting in the additional still closely "fitted" curves denoted to the side here.

In 1990, the Federal Interagency Committee on Noise (FICON) was formed, and in 1992 it issued a report that expressly recommended using DNL and the statistical and graphic correlation of "highly annoyed" as the most appropriate measure for assessing community response to noise around airports.

https://www.nap.edu/read/12928/chapter/5#21

In particular, FICON-recommended use of the curve that is denoted as the New USAF Logistic Curve in the graph above. This curve is also known as the FICON Curve. It was formally adopted by the American National Standards Institute (ANSI) in 2005 and had been adopted internationally by the Organization for Standardization (ISO) in 2003. For information of FICON Report, see: *Federal Agency Review of Selected Airport Noise Analysis Issues. Federal Interagency Committee on Noise. August 1992.*
http://www.gsweventcenter.com/GSW_RTC_References/1992_0801_FICON.pdf

Note: The 1992 FICON report also recommended that research no longer be supported on the topic of noise impacts stemming from DNL 60 dB or lower. It is a recommendation that seems likely to have delayed the growing understanding of noise effects on health.

The FICON iteration of the Schultz Curve shows that a little more 12% of people residing in areas where DNL averages 65 dB report themselves as "highly annoyed" by transportation noise, while only 3% are "highly annoyed" by a level of 55 dB. The dose-response graphs would seem to confirm the earlier FICUN noise metric of 65 dB(A) as the threshold significant effect.

But there are problems with the Schultz Curve methodology.

Problems with Annoyance and the Noise Dose-Response Relationship:

- Not all experts agree on the slope of the dose-response curve. The World Health Organization (WHO), for example, finds a much larger percentage of people "highly annoyed" by lower levels of noise than the FICON Curve denotes. In this case, 65dB made 45.5% of residents "highly annoyed"—not just 12.3%.

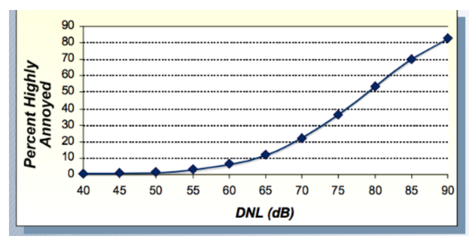
Table 30. The association between exposure to aircraft noise (L_{den}) and annoyance (%HA)

L_{den} (dB)	%HA
40	1.2
45	9.4
50	17.9
55	26.7
60	36.0
65	45.5
70	55.5

Graph from: *Environmental Noise Guidelines for the European Region*. ISBN 978 92 890 5356 3. © *World Health Organization 2018.* (p.69)
http://www.euro.who.int/__data/assets/pdf_file/0008/383921/noise-guidelines-eng.pdf

- The original Schultz curve had a lot scatter to its data points, which makes the rigor of the dose-response relationship tentative. Some communities are likely to be more tolerant of transportation noise than others. And some may be much less tolerant. Large cities that have high background noise already are likely to be more tolerant. Communities that are economically dependent on aircraft transportation or deployment are likely to be more tolerant of noise, as well. Rural and retirement and resort communities that rely on natural amenities are much less likely to be. If all these traits are in the mix of surveyed communities, the scatter is to be expected.

But in subsequent versions of Schultz, the dose-response curves often show only the clean curve slopes and not the full set of data points, a practice that cloaks the actual variability of response.



The graph at the left above, for example, is displayed in a document published by USAF: *Aircraft Noise. An Environmental Perspective. HQ ACC/A7ZP Integrated Planning Branch 129 Andrews Street, Suite 102 Langley AFB, VA 23665-2769*
https://www.acc.af.mil/Portals/92/Docs/AFD-070807-016.pdf

As more surveys and more data points were added to the dose-response analyses, the issue of scatter became more clearly a problem. See the graphs on the next page.

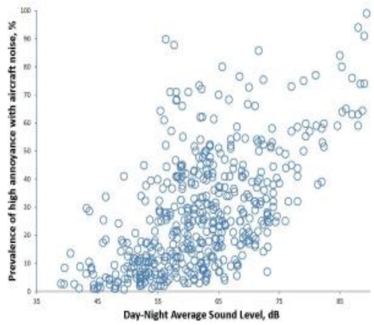


Figure 3. Illustration of the great variability in field measurements of aircraft noise-induced annoyance prevalence rates in approximately 550 communities.

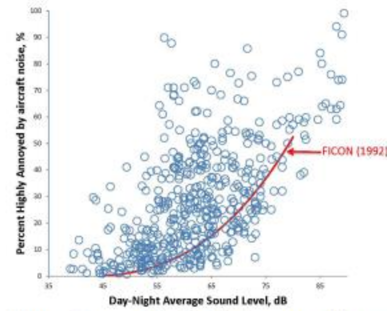


Figure 4. Summary of worldwide observations of the prevalence of all transportation noise-induced annoyance. The solid curve in the figure is a dosage-response relationship relied on in the United States to predict annoyance prevalence rates in all communities to all transportation noise sources.

Graphs from: (p. 31) *A Review of US Aircraft Noise Regulatory Policy. Why do Federal aircraft noise regulatory policies only rarely accomplish their own goals? Sanford Fidell. Acoustics Today. Fall 2015. Vol. 11, Issue 4.*
https://pdfs.semanticscholar.org/8cd0/c8c0783fa5519b38f4d595074a113fc3159f.pdf

Sanford Fidell, an expert cited previously, who has collaborated with T.J. Schultz and worked for the USAF, noted this problem of scatter in his journal review of federal policy on aircraft noise. He observed the high variability of survey results denoted in the graphs above, which chart annoyance levels among residents responding to noise, and the marginal location of the FICON line within the cloud of data points. He concluded that the FICON line failed to account for the majority of variance in the dose-response relationship of noise to DNL.

He has had this concern for a while. He had also commented in an earlier article that:

- "In hindsight, the purely descriptive and exclusively acoustic approach to the problem of predicting community reaction to noise that Schultz pioneered has not been as much of a panacea as once hoped, because the resulting relationships fail to take into account or explain the great variability of community reaction. A less than compelling dosage-effect relationship provides the appearance but not the substance of a systematic basis for policy interpretations which in reality reflect the charters and interests of regulatory agencies at least as much as information about actual noise effects." *(p. 3011) The Schultz curve 25 years later: A research perspective. Sanford Fidel. Journal of the Acoustical Society of America. 114 (6), Pt. 1, Dec. 2003.*
  http://www.vlieghinder.nl/images/knipsels/25_years_Schultz_Curve_2003_.pdf

Other experts have concurred or have had similar reservations about the efficacy of noise dose-response relationship endorsed by FICON:

- "Further analyses (Basner et al. 2017) of surveys on noise annoyance have shown that cumulative measures of noise exposure per se, expressed in units similar to Day-Night Average Sound Level (DNL), rarely account for as much as half of the variance in community-level data. The prevalence of noise-induced annoyance in communities is clearly moderated by factors other than noise exposure. Acoustic factors that have been identified as moderating community response to transportation noise include maximum sound levels, numbers of flights, fleet composition, and their respective distributions over time. All of these factors are highly correlated with cumulative noise exposure. Non-acoustic factors include

individual noise sensitivity, community economic dependence on airport operation, fear of crashes, attitudes of malfeasance and misfeasance toward the noise source, and so forth. In the aviation industry, all "non-DNL factors" are commonly referred to as "non-acoustic." (p. 2) *Fifty Years of Aircraft Noise Annoyance – Time to Introduce New Ideas. Truls Gjestland. INTER-NOISE 2018. Impact of Noise Control Engineering. 26-29 August. Chicago. Illinois*
http://www.norskakustiskselskap.org/uploads/2018/Truls_Gjestland_keynote.pdf

- "Quite apart from the difficulty the public experiences in grasping the concept of a time-weighted average sound exposure level expressed in decibel notation, DENL has another major practical limitation. It doesn't work particularly well as a predictor of aircraft noise impacts. FICON's 1992 relationship accounts for less than a fifth of the variance in the association between aircraft noise exposure and the prevalence of high annoyance in communities (Fidell, 2003; Fidell and Silvati, 2004)." *(p. 15) Supplemental Metrics for Day/Night Average Sound Level and Day/Evening/Night Average Sound Level. Final Report of the I-INCE Technical Study Group on Metrics for Environmental Noise Assessment and Control (TSG 9). April 2015.*
  http://i-ince.org/files/publications/iince151.pdf

- The DNL and the dose-response relationship are especially weak predictors in naturally quiet areas and places managed for naturalness:
  - "Neither 'day-night average sound level' nor 'percent highly annoyed' is an appropriate metric for measuring noise in naturally quiet areas. Because of the logarithmic nature of the decibel, short-duration sounds of high amplitude compared with background noise can significantly increase the day-night level, even though the sound remains at the background level most of the time. As for percent highly annoyed, this is hardly the best measure of satisfaction for areas where quiet and solitude are valued. "(Chap. 3 p. 24) *Technology for a Quieter America. 2010.*
    https://www.nap.edu/read/12928/chapter/5#24

  - "Applying the DNL metric to en route aircraft sound environments found in sample parks does not adequately describe current levels of adverse visitor response within these parks. Again, it should be noted that noise assessment criteria in terms of DNL have evolved from the study of urban land uses in the vicinity of airports, not remote areas affected by en route aircraft. In addition, DNL does not consider background sound, or more simply "stated, the relative difference in ambient sound levels and the levels generated by aircraft activity." *(Sec. 2 p. 5) Methodology for the Measurement and Analysis of Aircraft Sound Levels Within National Parks. National Park Service Contract #CX 8000-7-0028. Final Report March 1989.*
    http://npshistory.com/publications/sound/aircraft-sound-levels.pdf

    Note: Natural soundscapes are just as much an asset in wilderness as they are in national parks. F-16 training maneuvers and flight altitudes are significantly more intense, lower, and louder than en route aircraft.

  - "The results show that annoyance response in low background noise regions are much higher than those in high background regions, even though aircraft noise levels are the same. It can be concluded that background noise level is one of the important factors in the estimation of community annoyance from aircraft noise exposure."

    Effect of background noise levels on community annoyance from aircraft noise. Lim C., et al. 2008. Journal of the Acoustical Society America. 123(2):766-71.
    https://www.ncbi.nlm.nih.gov/pubmed/18247881

Conclusion

The proposed Lobos MOA is filled with natural amenities—remote, tranquil, a beautiful place of forests and grassy valleys, a few small towns, modest farms and ranches, and a wilderness of mountains and streams. A quiet refuge from the loudness of the modern world. DNL metrics, Land Use Compatibility Guidelines, and Noise Dose-Response Relationships, for reasons outlined previously, are inadequate to assure the protection of this area, these amenities, and the people who care about them.

F-16 training is not a suitable use of this area.