

# Ambient Noise Measurement for UAM Metric Analysis & Research

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Fall 2019 ATWG, NASA-GRC

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## FOCUS OF THE PRESENTATION

- Prediction of **human response to EVTOL noise** using **psychoacoustic evaluation** (“listening tests”) that includes **Ambient Noise**
- Ensure that such tests are **ecologically valid**: include
  - Realistic simulations using **auralization techniques**
  - Accurate modeling of **sound propagation** in the environment
  - Accurate simulation of **sound levels** and **spatial auditory cues**
  - Realistic **signal-noise** ratios by including **ambient sound**
- Enable evaluation & comparison of **relevant metrics and criteria** using multiple methods in the laboratory to establish psychometric data

# HUMAN RESPONSE TO AIRCRAFT NOISE: “ANNOYANCE” ca. 1950s-1960s

- **Current EPNL metric for certification uses NOY scale, tone-corrected PNL**
- “Scaling Human Reactions to the Sound from Aircraft” Karl Kryter, JASA **1959**
- Judged Noisiness of a Band of Random Noise Containing an Audible Pure Tone  
Kryter & Pearsons JASA **1965**

- TASK: “Assume that the noise would occur in your home 20 to 30 times during the day and night”
- MONAURAL SOUND
- PISTON vs JET AIRCRAFT or NOISE STIMULI
- PRESUMES NOISINESS SIMILAR TO LOUDNESS: annoyance is a perceptual attribute that is internally evaluated on a decibel RATIO SCALE

TDH-39



AR-1, KLH

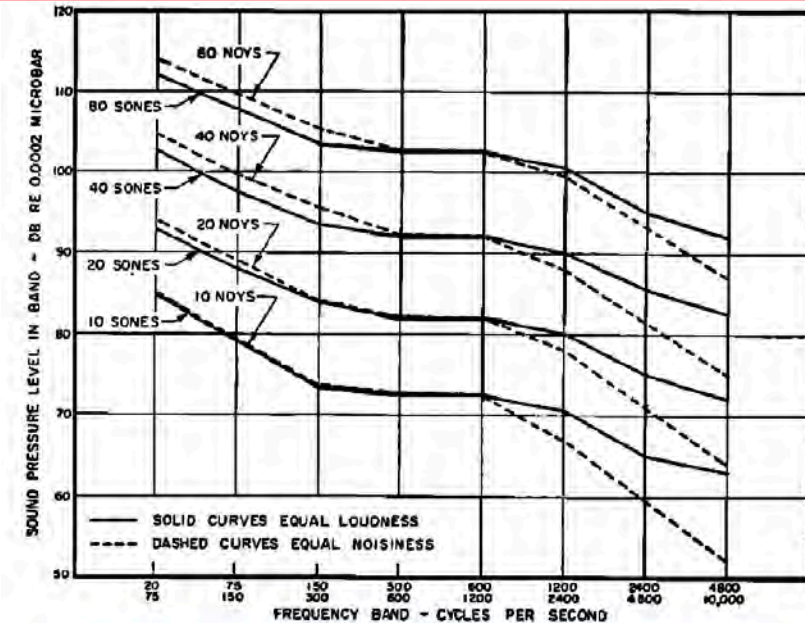


FIG. 14. Contours of equal loudness (after Stevens<sup>7</sup>) and equal noisiness (Kryter<sup>5</sup>).

# HUMAN DETECTION TO AIRCRAFT NOISE: "DETECTION" NPS STUDIES ca. 1980s-1990s

NPOA Report No. 93-1

BBN Report No. 7197

## EVALUATION OF THE EFFECTIVENESS OF SFAR 50-2 IN RESTORING NATURAL QUIET TO GRAND CANYON NATIONAL PARK

FINAL REPORT

Sanford Fidell, Karl Pearsons, and Mathew Sneddon

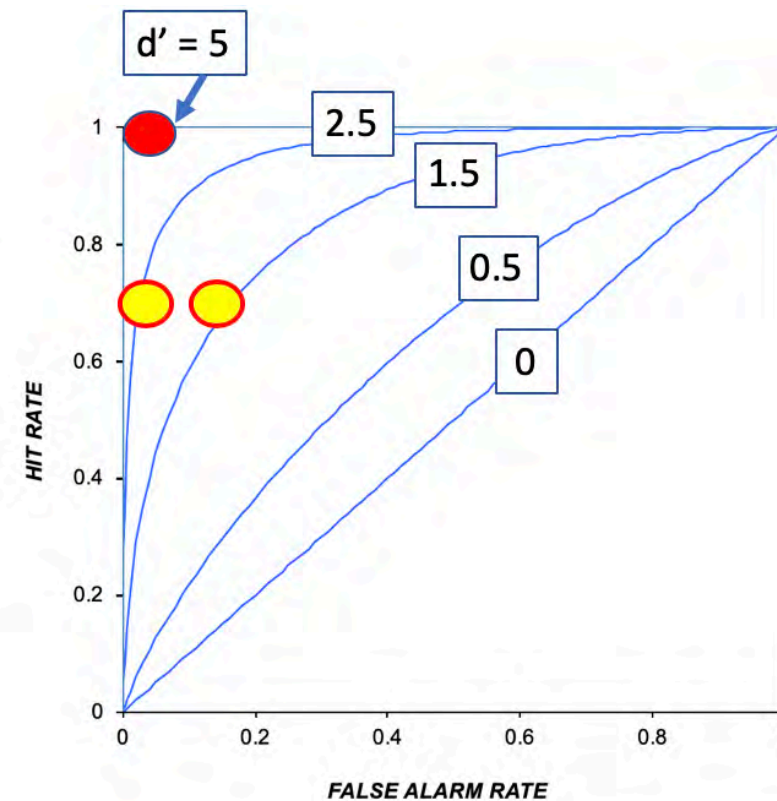
## METHODOLOGY FOR THE MEASUREMENT AND ANALYSIS OF AIRCRAFT SOUND LEVELS WITHIN NATIONAL PARKS

*National Park Service*

Final Report  
March 1989

Paul H. Dunholter, P.E.  
Vincent E. Mestre, P.E.  
Roswell A. Harris, Ph.D., P.E.  
Louis F. Cohn, Ph.D., P.E.

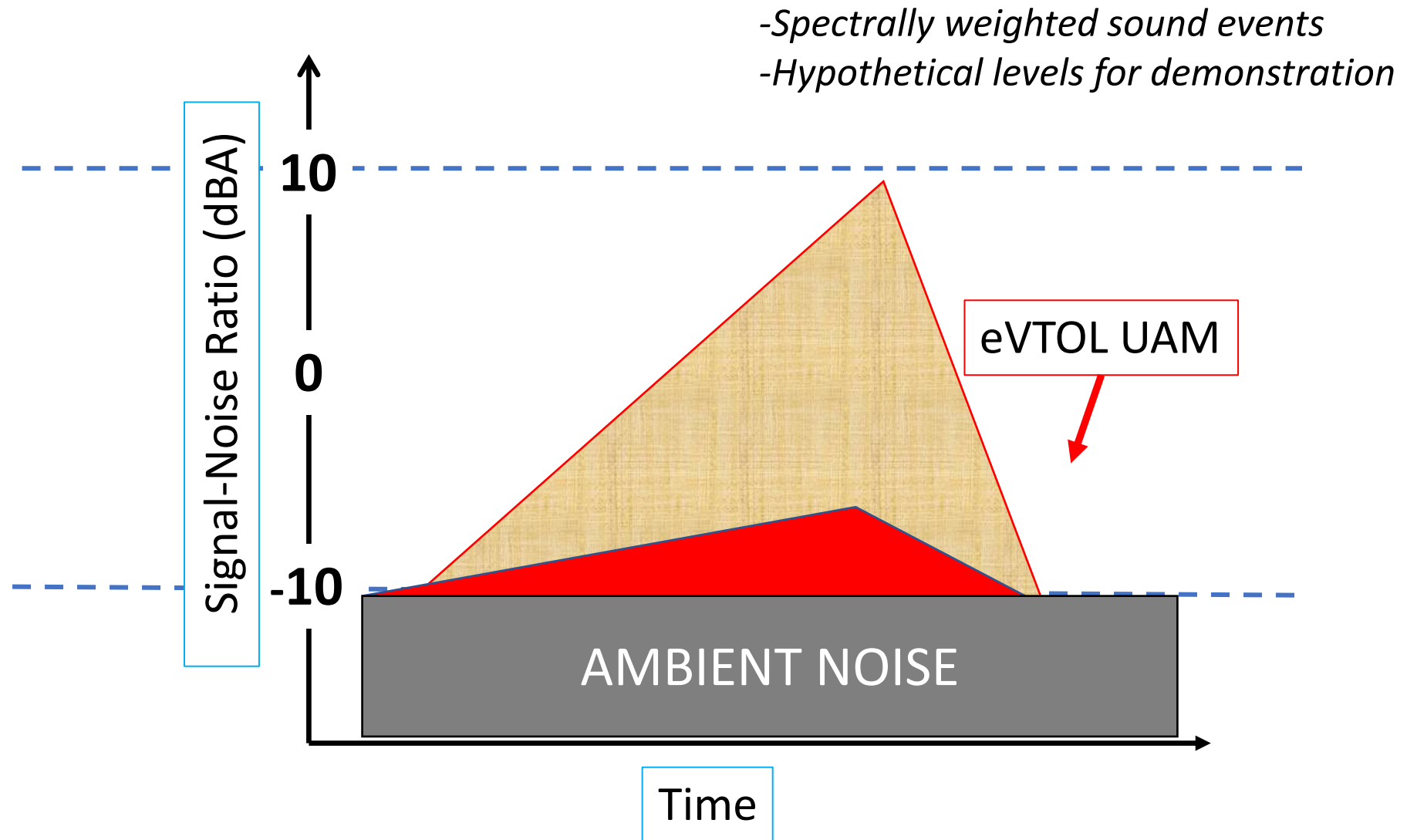
"[In] low sound level settings, the **loudness** of the sound may play a less prominent role .... **signal detection or audibility** appears to be the **most important factor** in predicting annoyance.



- **ANNOYANCE and DETECTION: “Extreme” signal-noise endpoints**

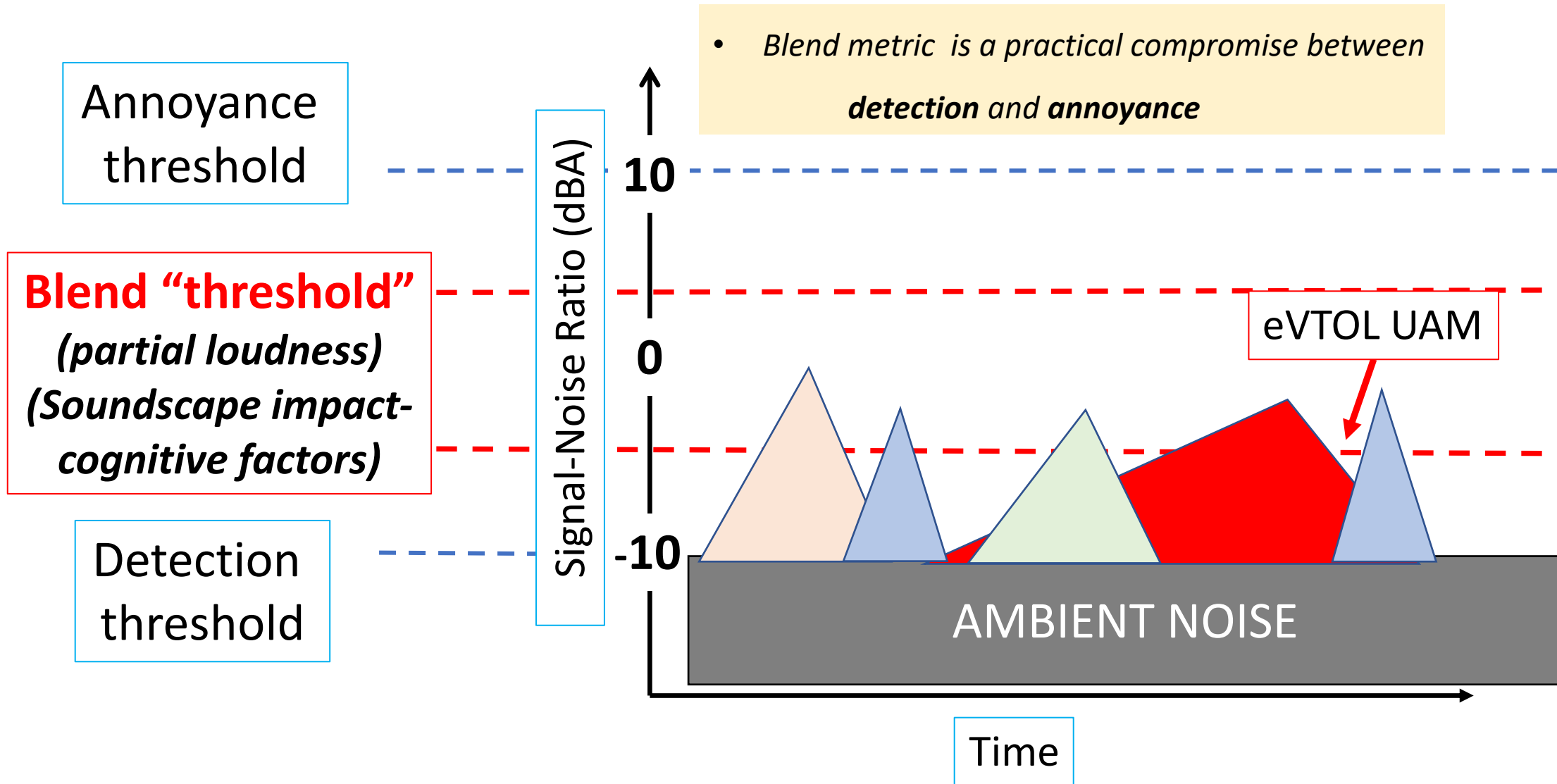
**Annoyance  
threshold  
(EPNL, Noys)**

**Detection  
threshold  
( $d'$  :  $d$ -prime)**

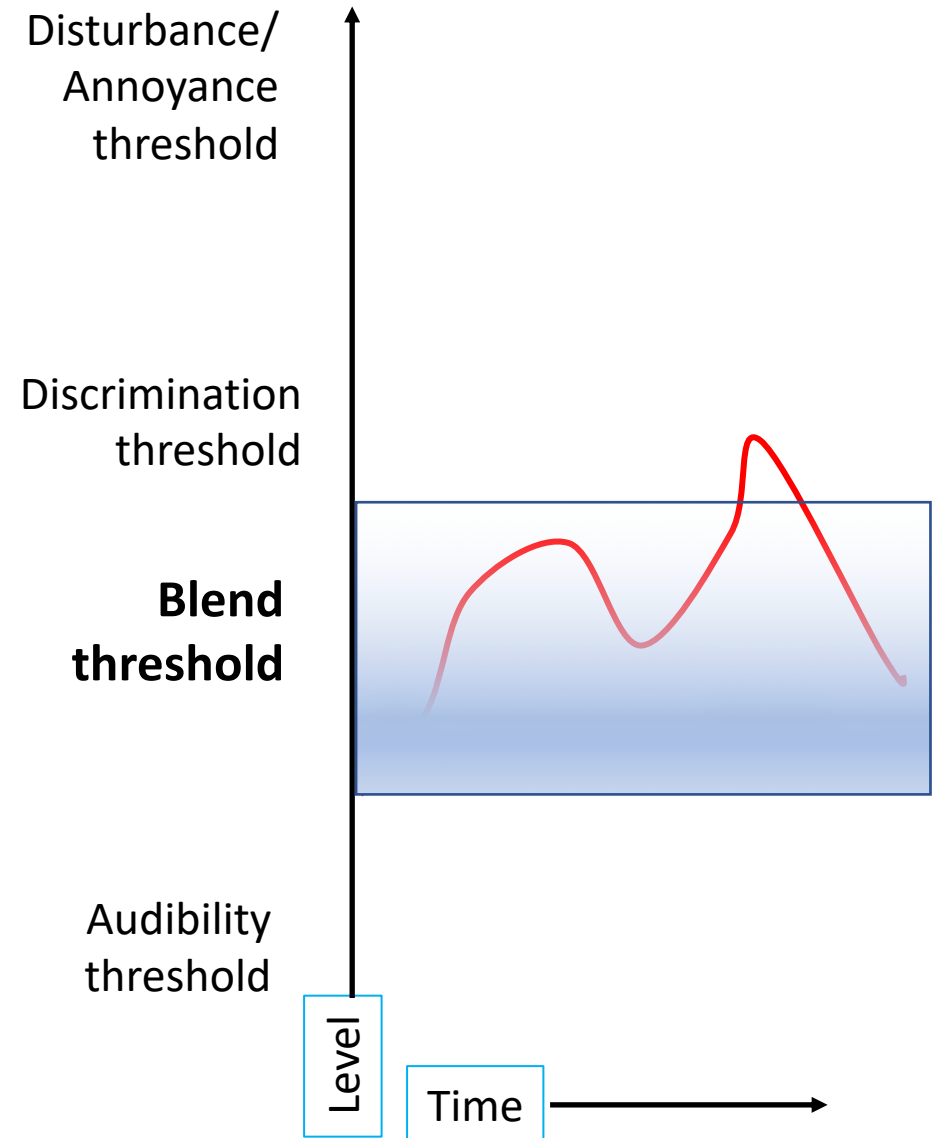


• **BLEND METRIC:**

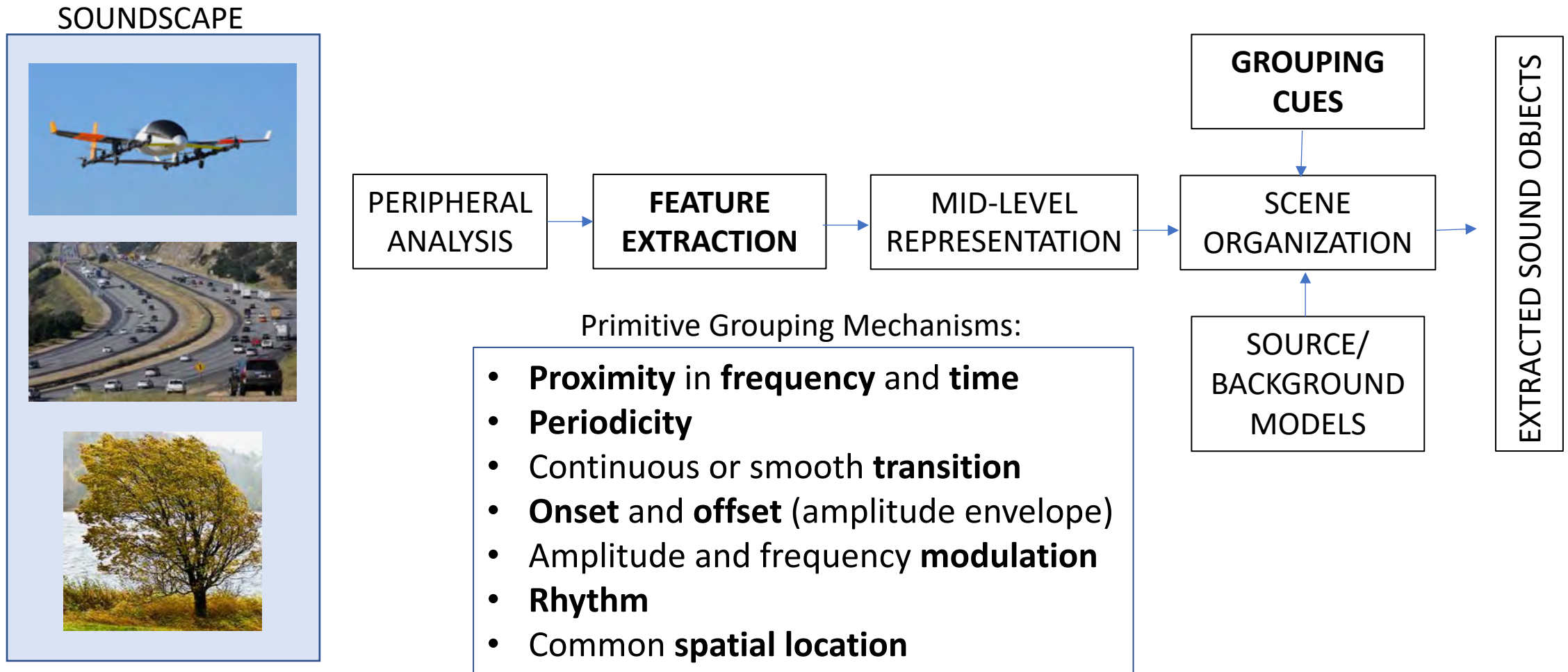
Signal-Noise region where EVTOL noise **does not dominate** other ambient sources



- **Blend:** EVTOL events **identified** at a specific detection rate equivalent or less than that of other ambient sound “objects”
- Ensures that the existing **soundscape** is not significantly changed
- Blend threshold factors are **complex**:
  - **Spectral** and **spatial** characteristics of **time-varying signal** and **noise**
  - **Intelligibility** of the source
  - **Familiarity** with the source
  - Cognitive sense of source **“control”**

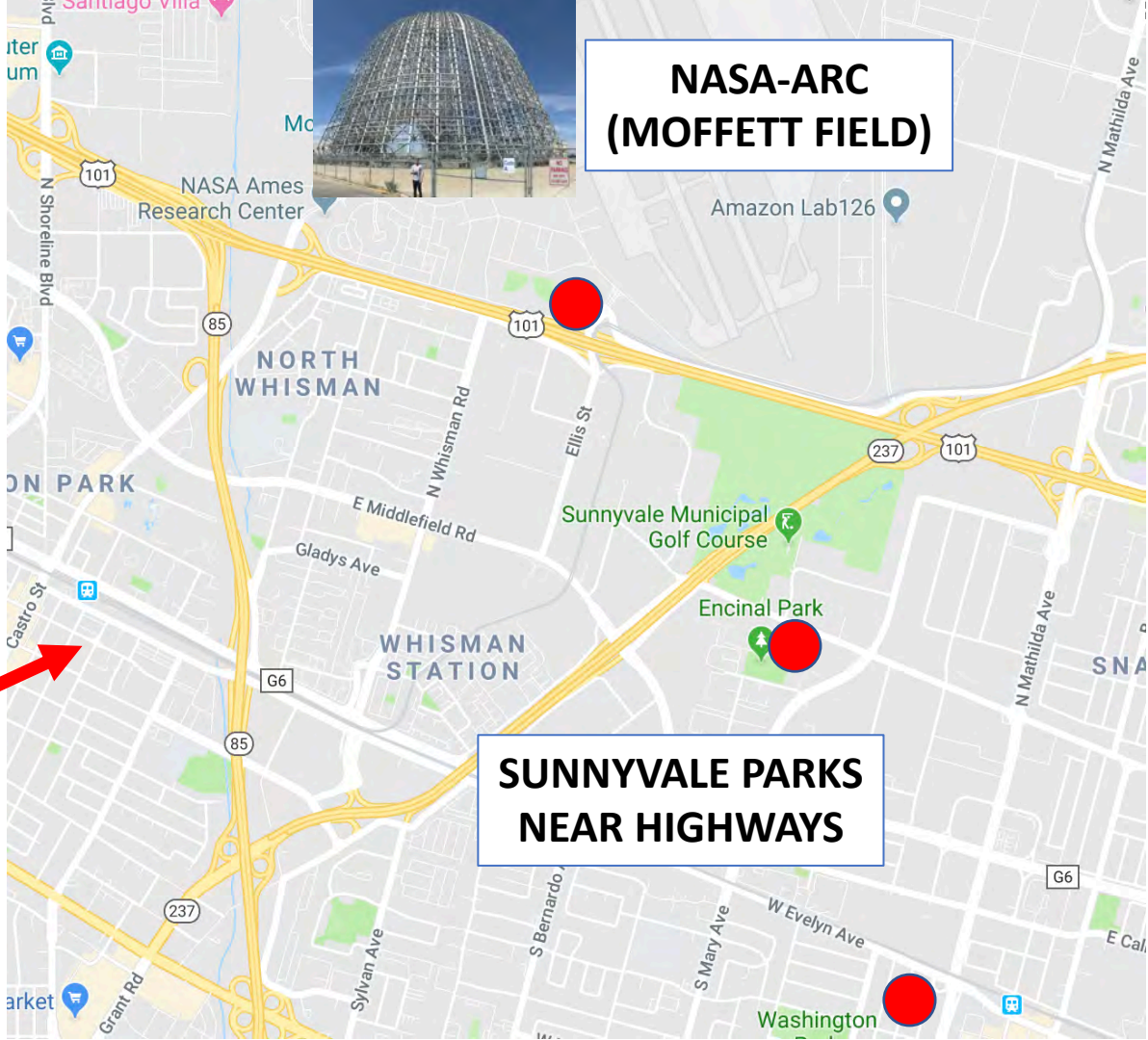
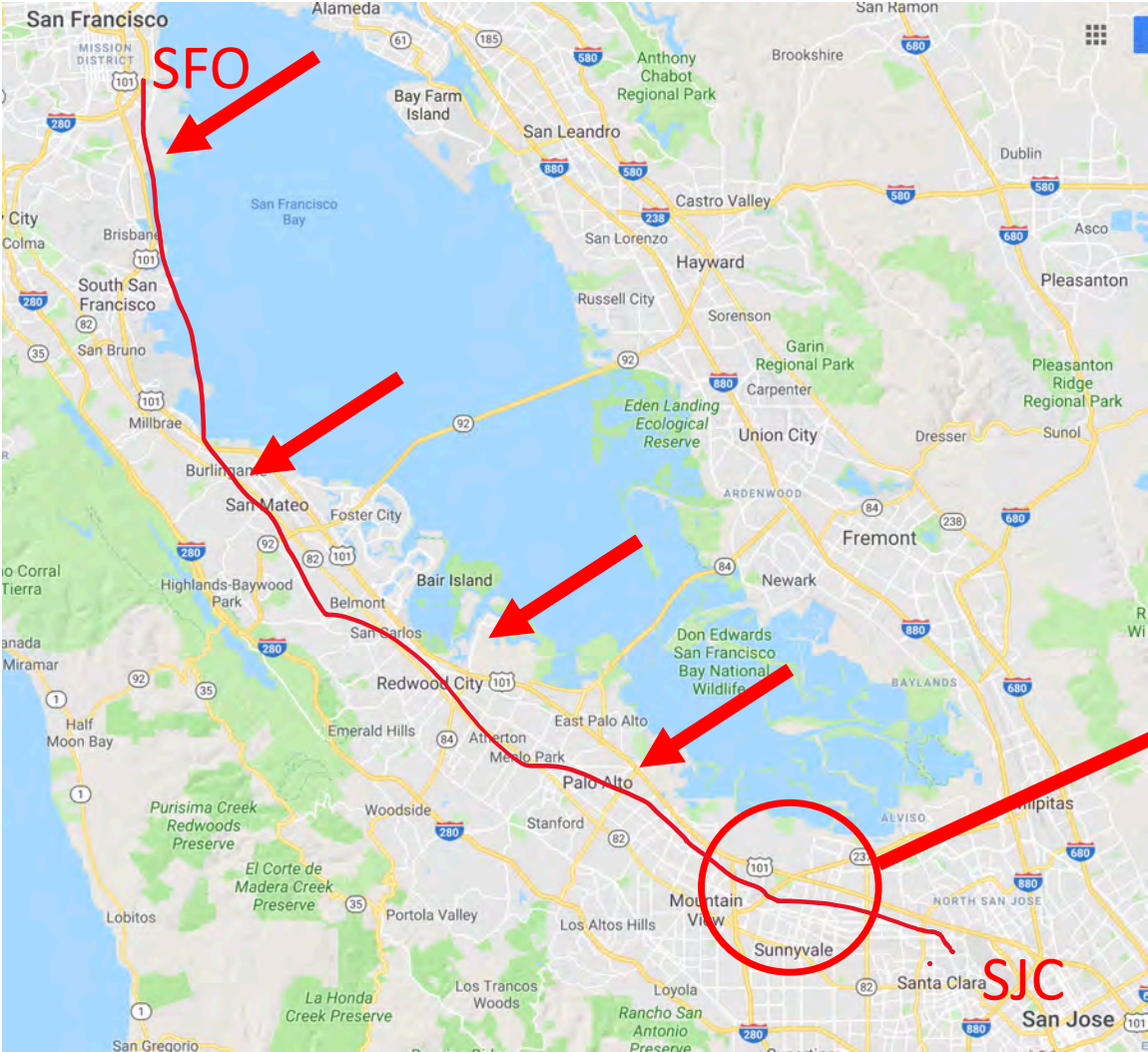


- **Auditory Scene Analysis:** perception of **soundscape** as multiple **sound objects**
- **Sound objects** are identified by perceptual **grouping mechanisms**
- Sound objects **blend** to the degree sound object separation **fails**





# RECORD AMBIENT AT POTENTIAL VERTIPOINT LOCATIONS AND ROUTES (SF PENINSULA)



# MICROPHONE CONFIGURATION FOR AMBIENT FIELD RECORDING

LOW-NOISE SPL  
CALIBRATION  
MICROPHONE  
(ANSI Type 1)

Z: DIPOLE

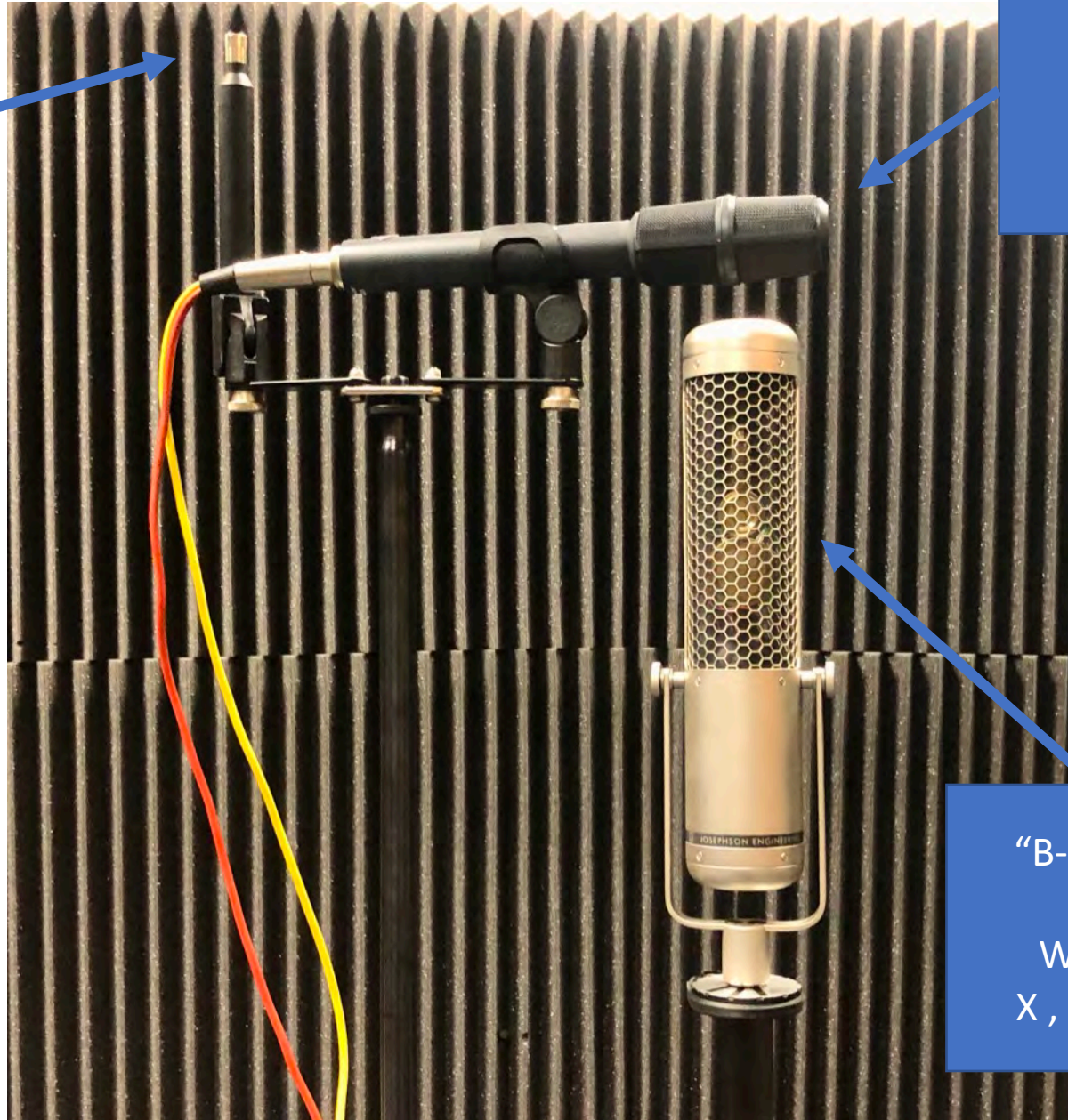
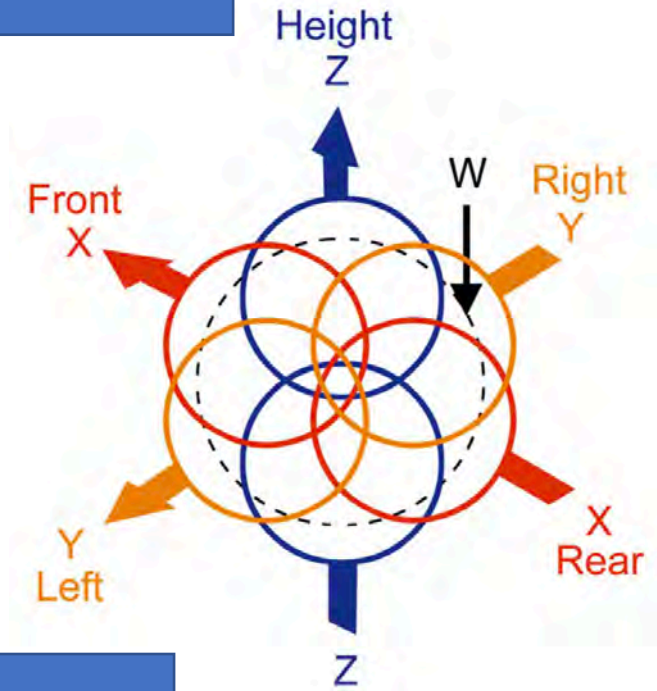
RECORDED WITH  
BATTERY POWERED  
4 CHANNEL DIGITAL  
RECORDER & MIC  
PREAMPLIFIERS

192 kHz SRATE  
24 BIT DYNAMIC RANGE

BINAURAL "DUMMY HEAD"  
MIC FOR 6 CHANNEL  
RECORDING

"B-FORMAT"

W : OMNI  
X , Y: DIPOLE

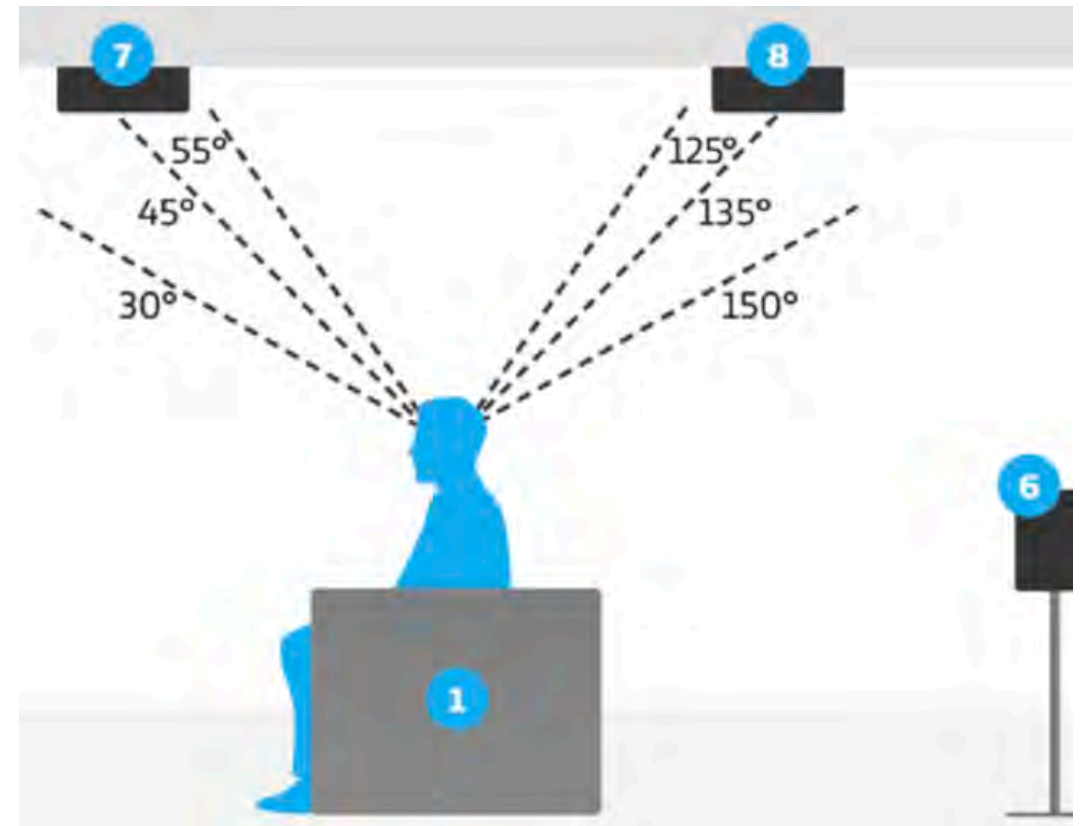


# AURALIZATION LOUDSPEAKER SYSTEM: 7.1.4 ATMOS (DOLBY MULTICHANNEL)

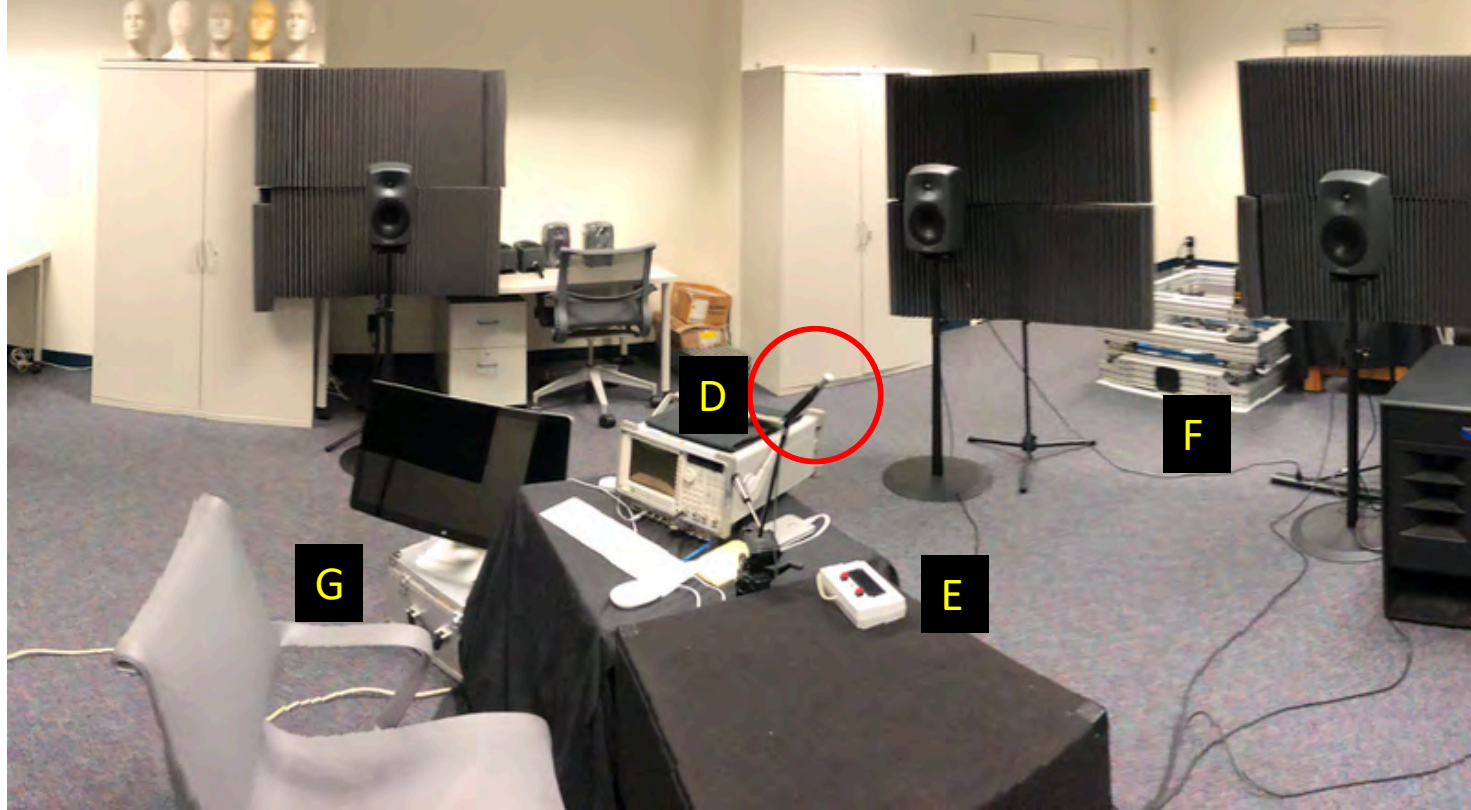
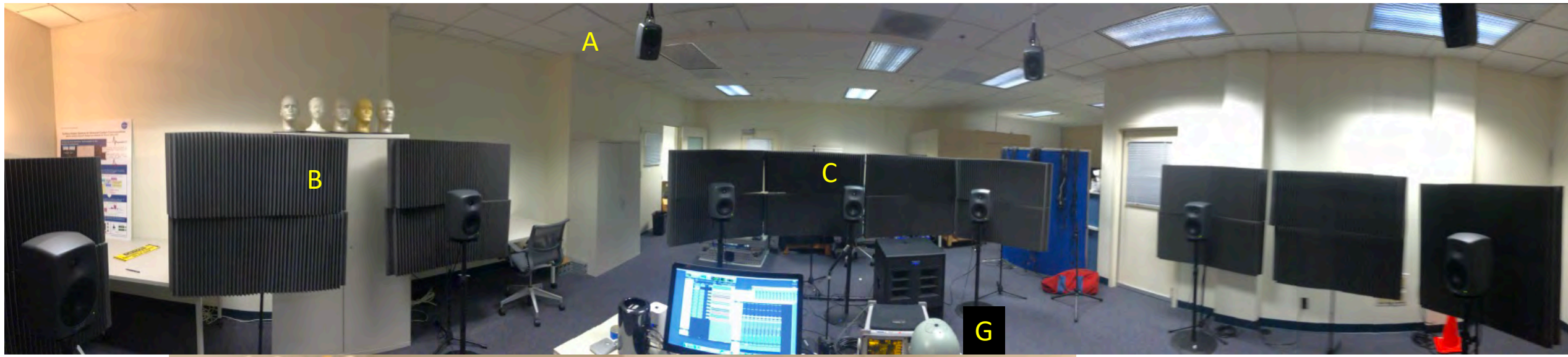
PERSPECTIVE



SECTION



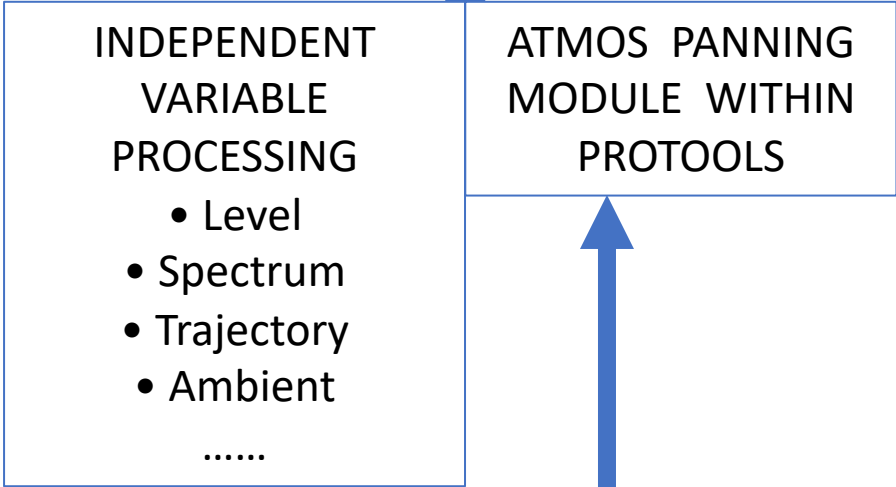
- SEVEN SURROUND LOUDSPEAKERS (L, C, R, LSS, RSS, LSR, RSR) + SUBWOOFER
- FOUR OVERHEAD LOUDSPEAKERS



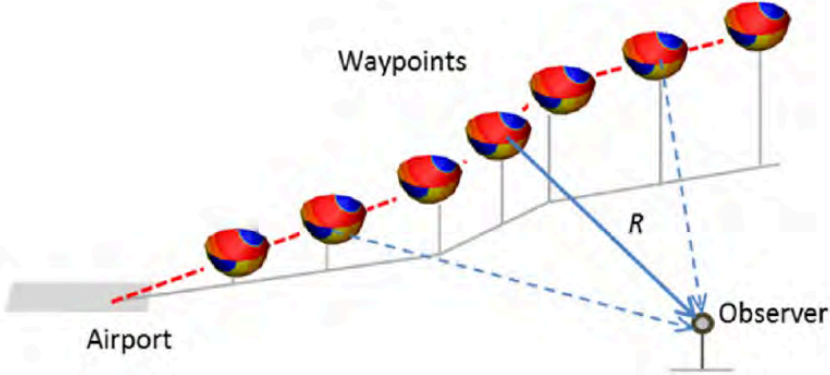
- A: OVERHEAD LOUDSPEAKER
- B: ABSORPTIVE PANEL
- C: EAR-LEVEL LOUDSPEAKERS
- D: REAL TIME ANALYZER & CALIBRATION MIC (RED)
- E: SUBJECT RESPONSE DEVICE
- F: MULTI-AXIS VIBRATION PLATFORM
- G: DUMMY HEAD MIC FOR CALIBRATION AT SUBJECT SEAT



**MULTICHANNEL AMBIENT RECORDINGS**



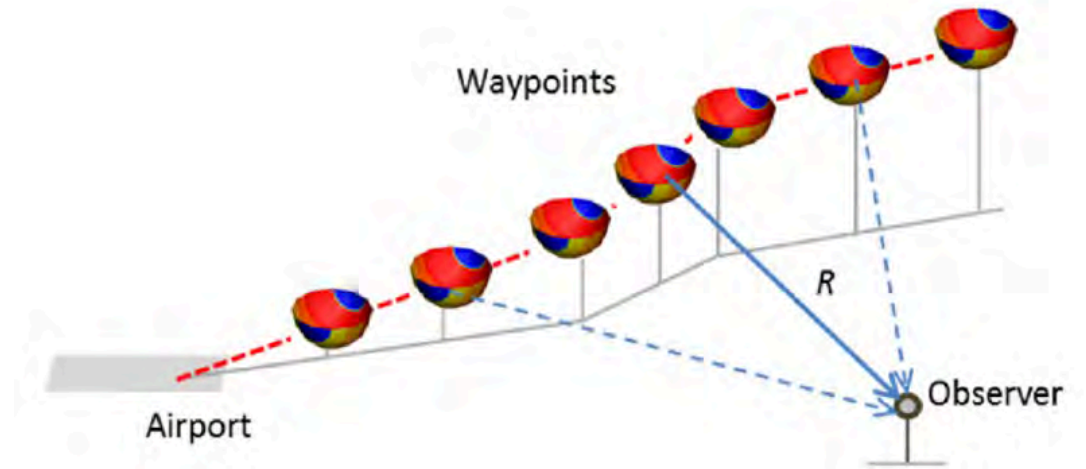
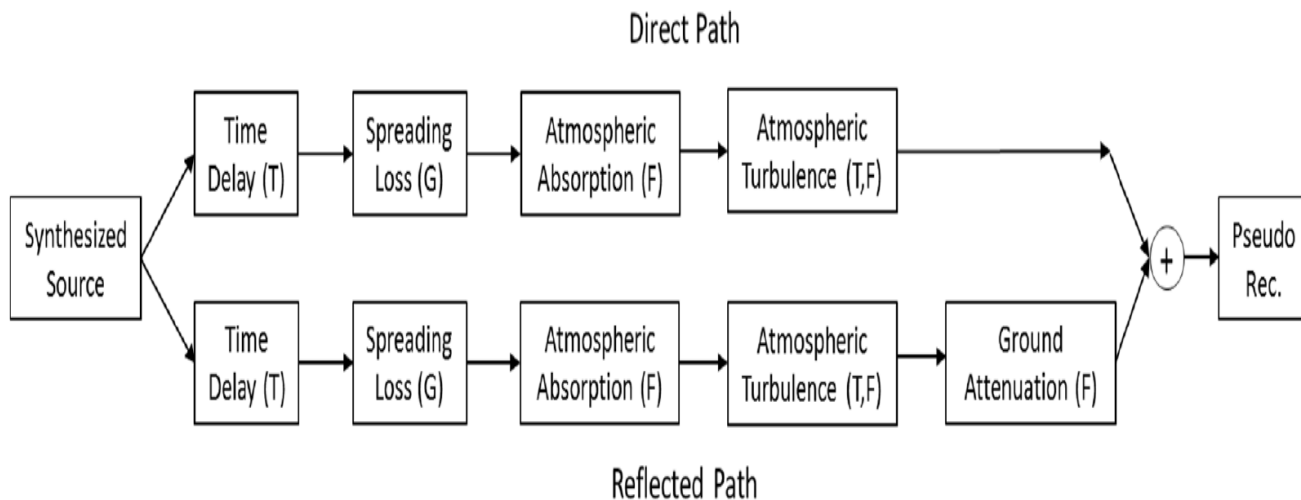
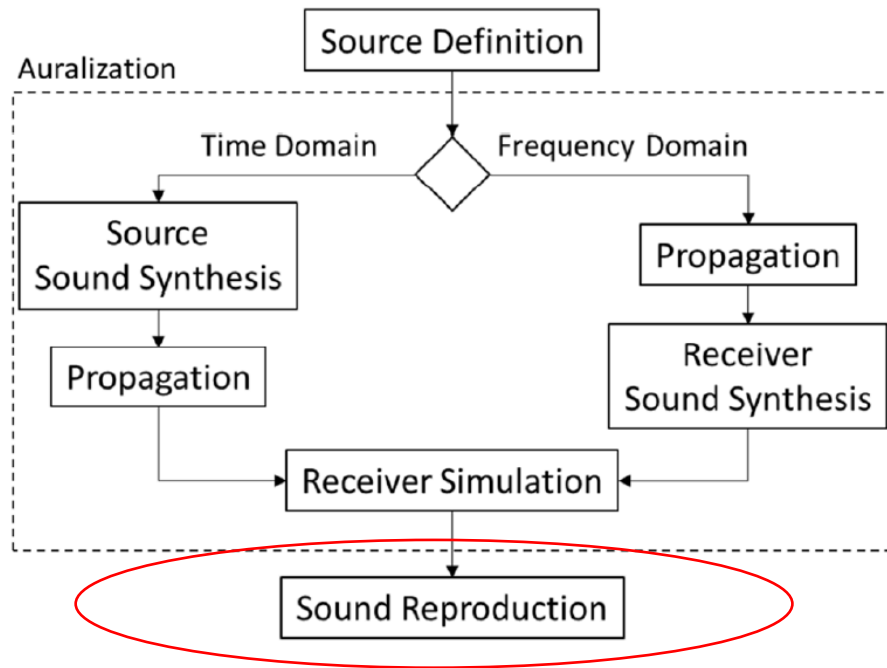
Source-Receiver Trajectory vs Time



**NASA LaRC NAF AURALIZATION OF CONCEPT EVTOL**

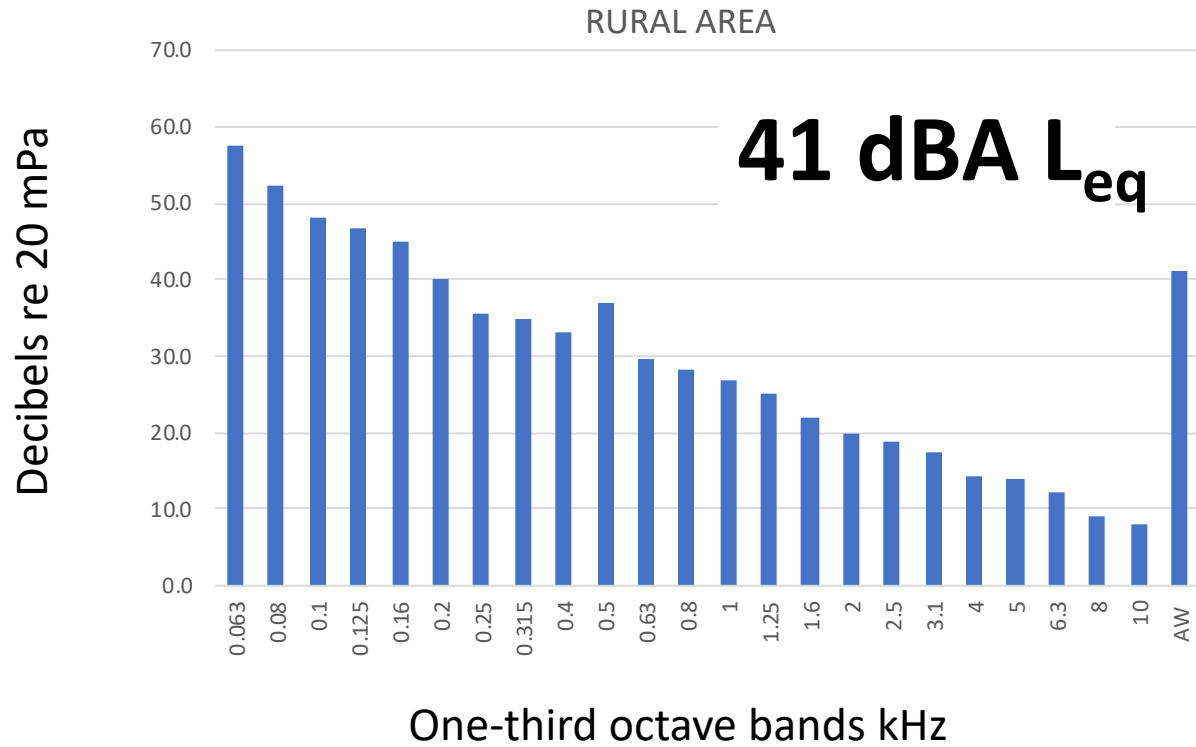
# NASA AURALIZATION FRAMEWORK (NAF)

- Generation of acoustic stimuli for a given EVTOL, on a given path relative to a user



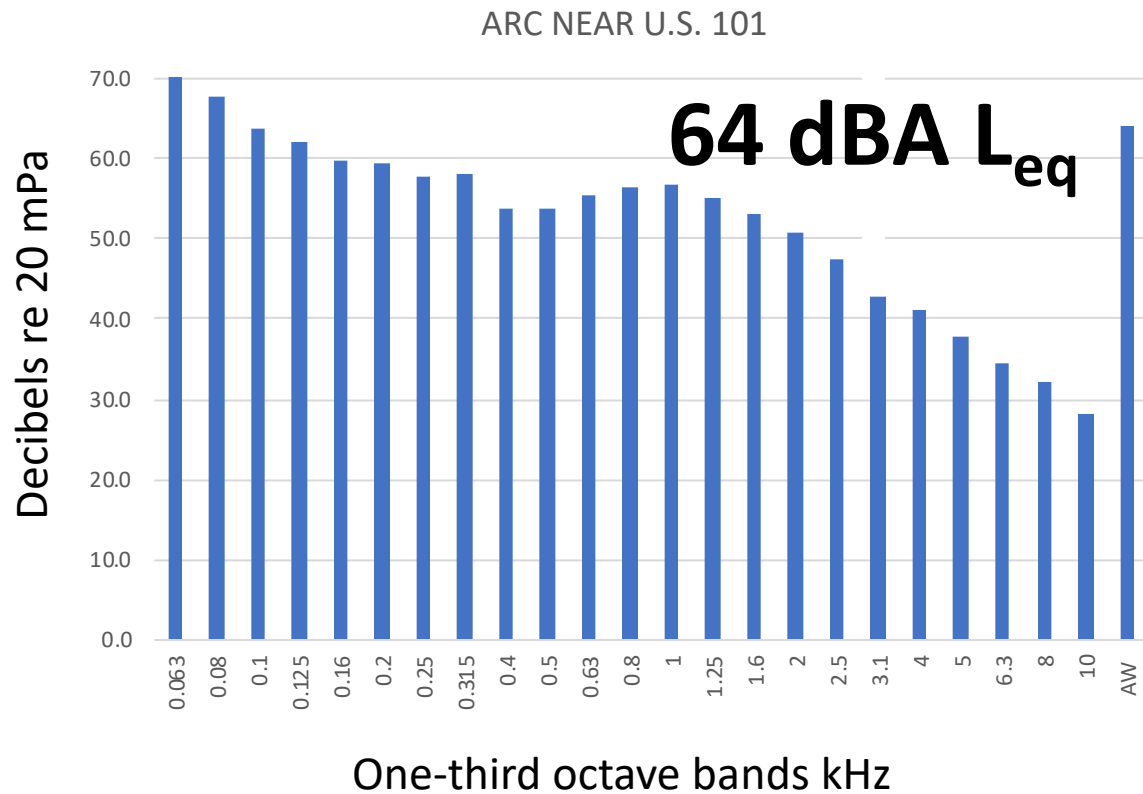
# RURAL- PARK AREA (17:00)

*Soundscape: dominated by wind through trees, birds, ocean and fog horn*



# INDUSTRIAL PARK – MULTIFAMILY HOUSING NEAR FREEWAY (10:00)

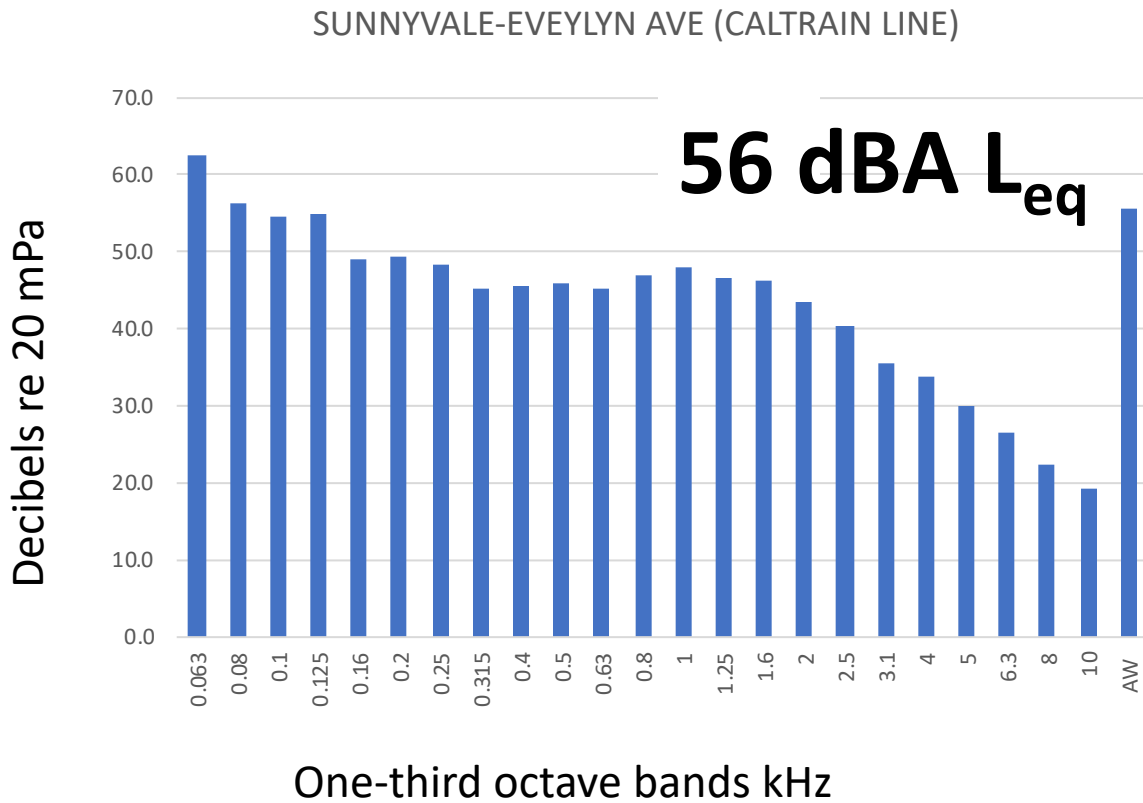
*Soundscape: dominated by freeway traffic noise, motorcycle-truck single events*





# MULTIFAMILY HOUSING NEAR CALTRAIN LINE (10:00)

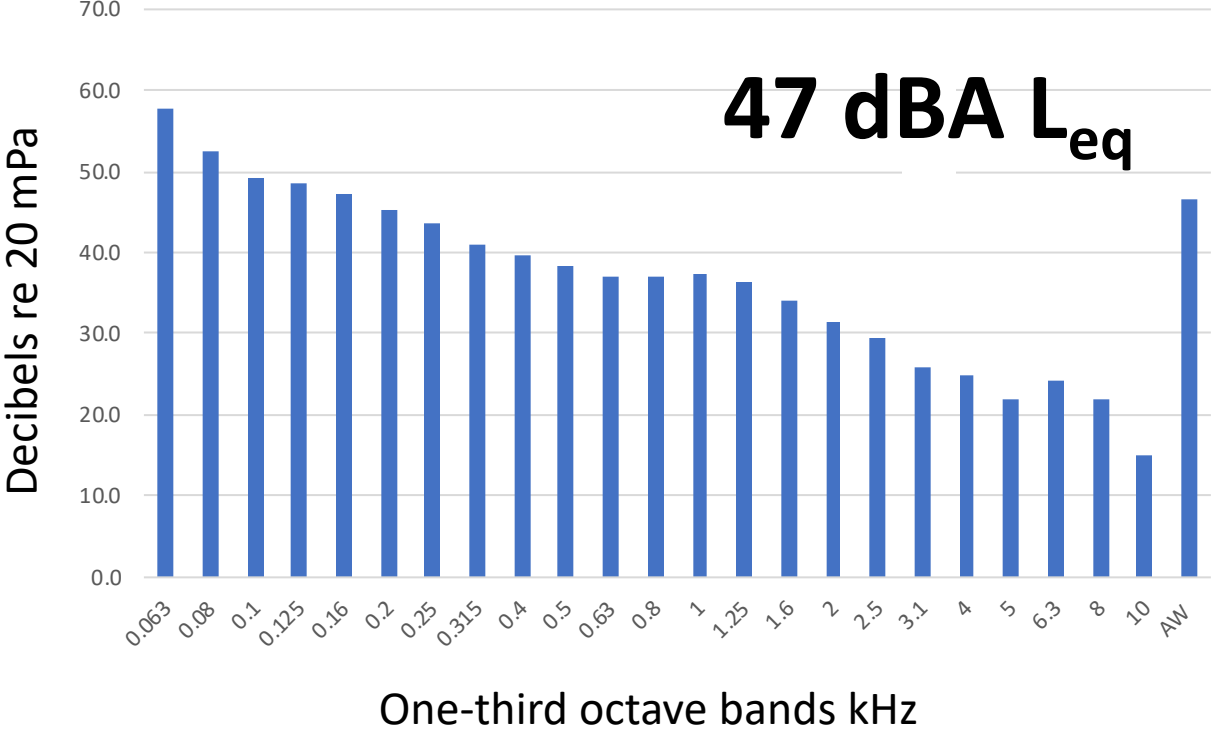
*Soundscape: road traffic single events, power tools, distant highway*



# PUBLIC PARK NEAR MULTIFAMILY HOUSING AND TWO FREEWAYS (14:00)

*Soundscape: distant highway noise, birds, people, park activity*

ENCINAL PARK, SUNNYVALE



# PSYCHOACOUSTIC EVALUATION CAPABILITIES

- **Vary magnitude of independent variable of interest**  
*(partial loudness; sharpness (spectrum); time factors...etc.)*
- **Randomize or separately evaluate ambient noise conditions**
- ***Method of Limits:*** continual increments or decrements using adaptive **staircase methods** to adjust acoustic parameter to match a subjective criterion
- ***Paired comparison:*** relative judgments of whether one of a pair of signals contains more or less of the attribute of interest
- ***Subjective scale rating:*** scales for attributes (1-9 scale)
- ***Multivariate tests, Factor analysis-*** principal components analysis (PCA) etc.

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