

Methods for recording and documenting ambient environmental noise, for use in listening tests

(focusing on UAM-AAM eVTOL vehicle community noise response)

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➤ **Outline**

- 1. WHAT: Ambient noise as defined by acoustical engineers and psychoacoustics**
- 2. WHY: Psychoacoustic motivations for including ambient sound in listening tests**
- 3. HOW: Recommendations for recording and reproduction of ambient sound; Suggested metadata structure**

- **A NASA Technical Memorandum is under development to address the UNWG 2020 white paper recommendations for ambient sound**

It is recommended that...

Standardized processes for measuring and cataloging ambient noise be developed, and to make those data available to **support subjective response studies** for metric and predictive model development”

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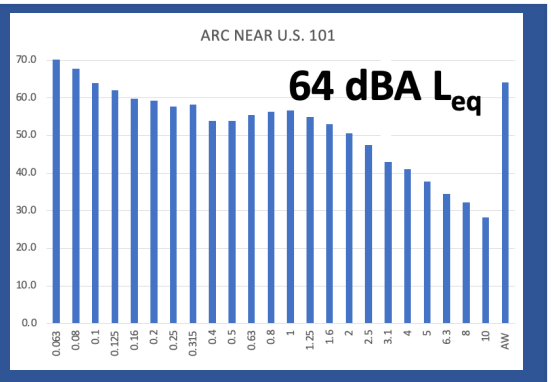
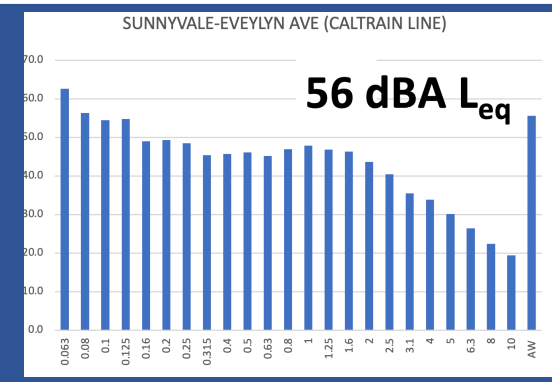
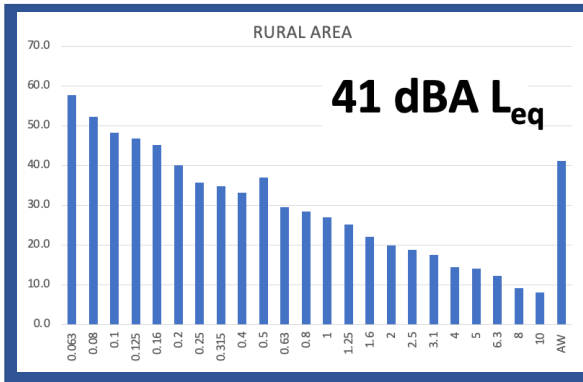
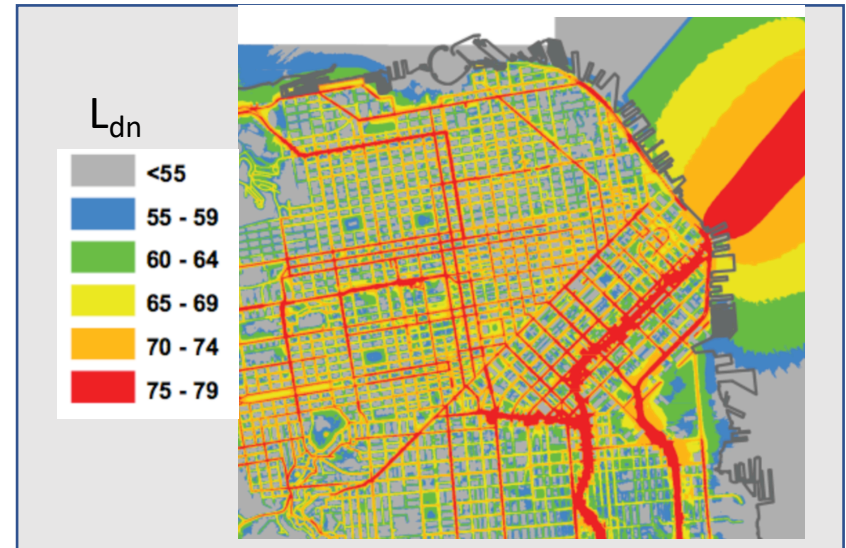
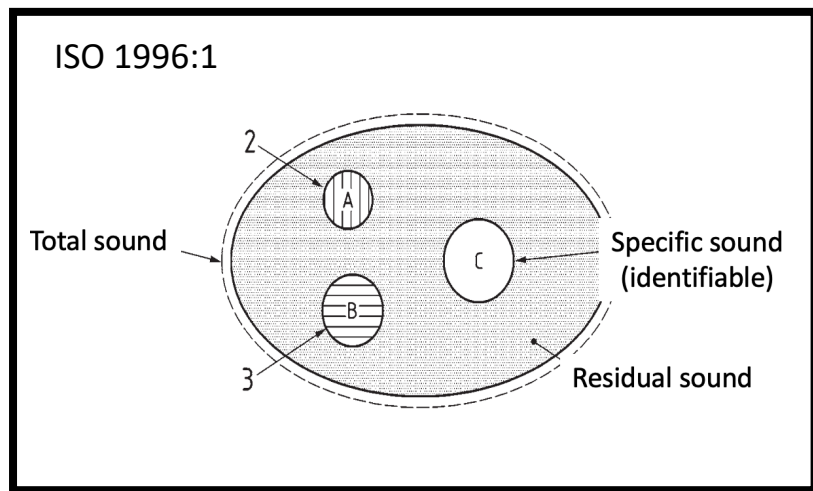
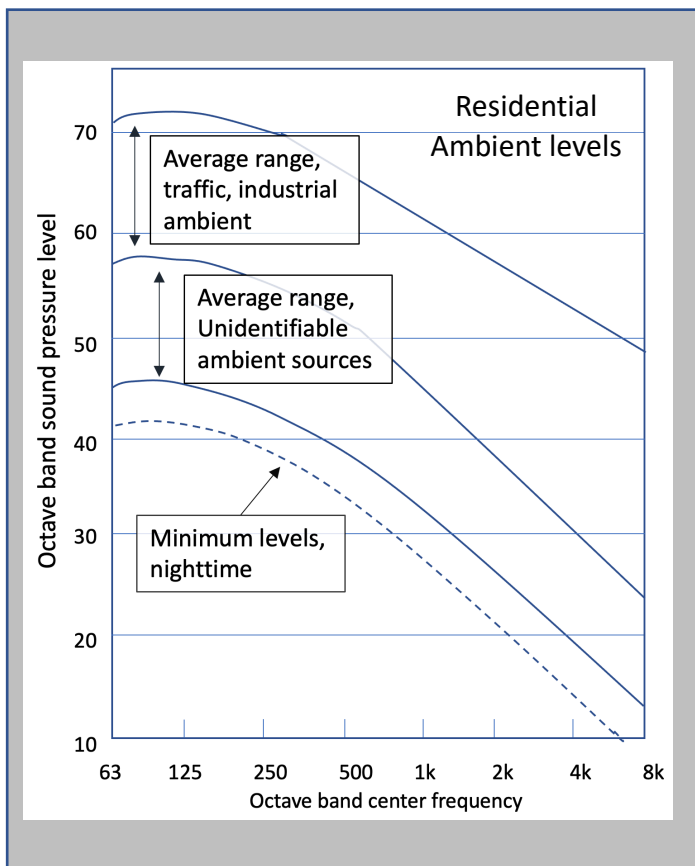
➤ **Why are realistic, repeatable ambient sound recordings important for assessment of eVTOL noise in listening tests?**

→ • **Acoustical engineering definitions in standards and regulations**

- Ambient noise consists of multiple **identifiable and unidentifiable** sound sources
- Ambient noise levels depend on **time and location**
- Ambient noise levels **vary over a wide range** even in a single location
- **Regulations, EIRs are based on “significant impacts” to the ambient** based on objective acoustical measurements.

➤ Ambient environmental noise: acoustical engineering definitions

- “what remains after a noise source being investigated is turned off” (Morfey)
- “all-encompassing noise associated with a given environment at a specified time, being usually a composite of sound from many sources at many directions, near and far; no particular sound is dominant” (Harris, Schomer)
- “the lowest sound level repeating itself during a minimum ten-minute period” (S.F Noise Ordinance)



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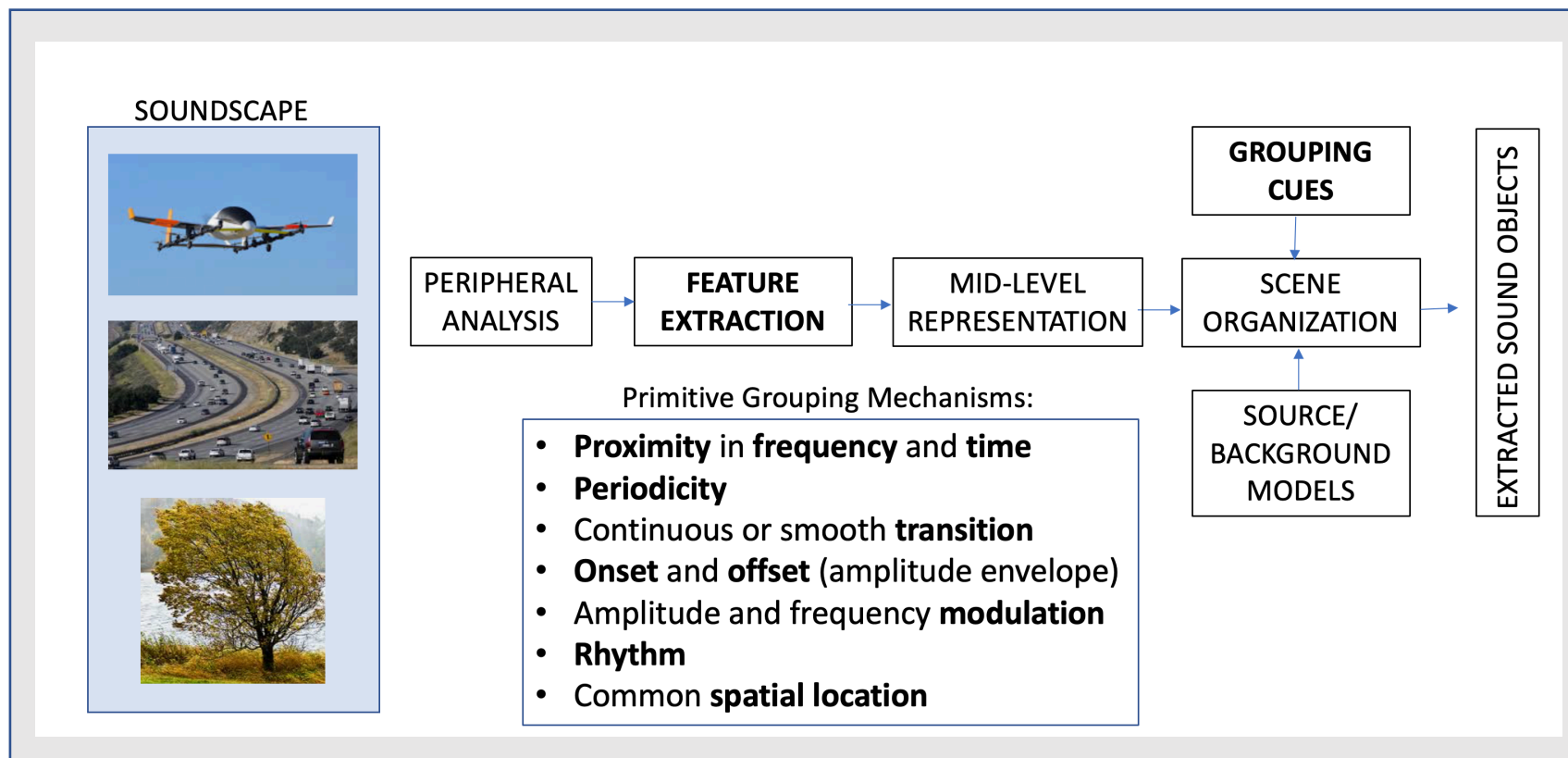
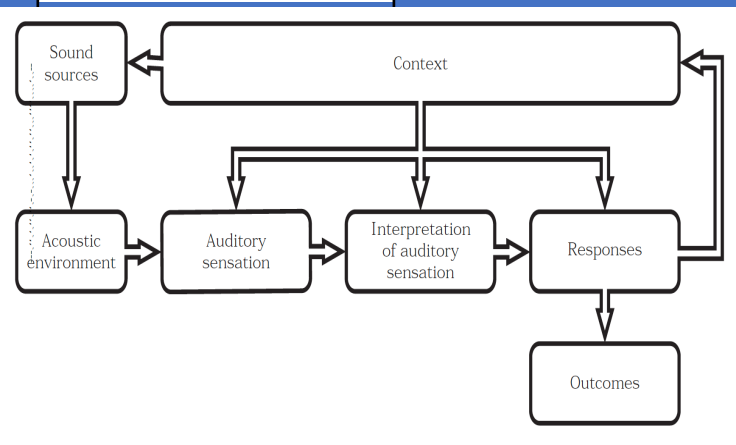


- **Psychoacoustic bases**

- Communities are sensitive to **soundscape** and to the impact of new sounds
- **Auditory scene analysis** describes how the soundscape is cognitively processed, and the particular importance of **spatial auditory cues**
- **Partial specific loudness** explains how the ambient can reduce the loudness of a dominant sound source, such as an eVTOL
- Improved metrics for predicting community response (detection, annoyance, etc.) will depend on **realistic simulations of ambient noise** in listening tests
- Researchers will benefit from ability to **share** ambient sound recordings

➤ Ambient environmental noise: perceptual bases (1)

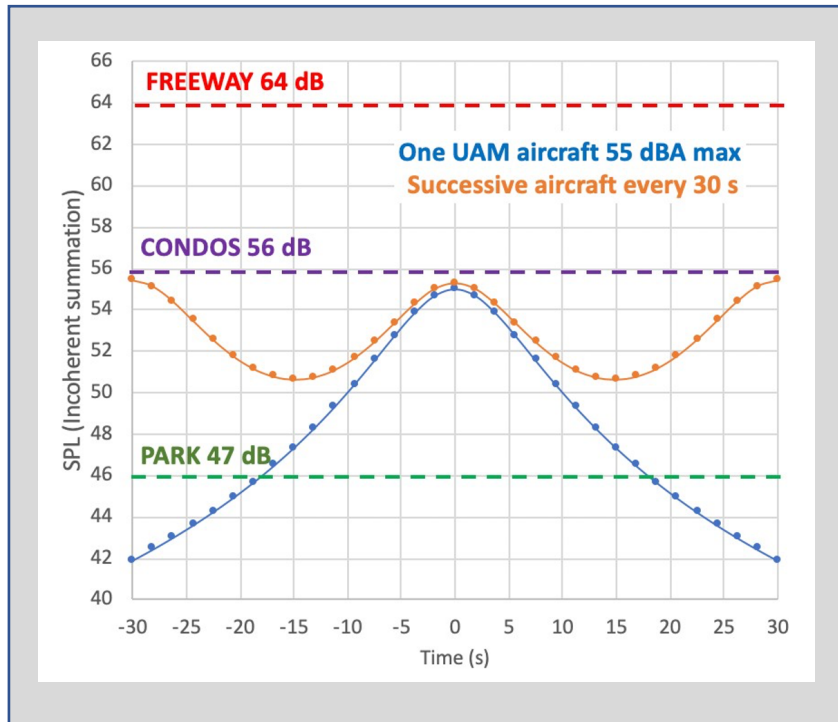
- **Soundscape:** “The acoustic environment as perceived or experienced and/or understood by a person or people, in context” (ISO 12913): i.e., the **perceived ambient**
- **Auditory Scene Analysis** describes how ambient sound sources are perceived & grouped, using binaural hearing cues and auditory streaming



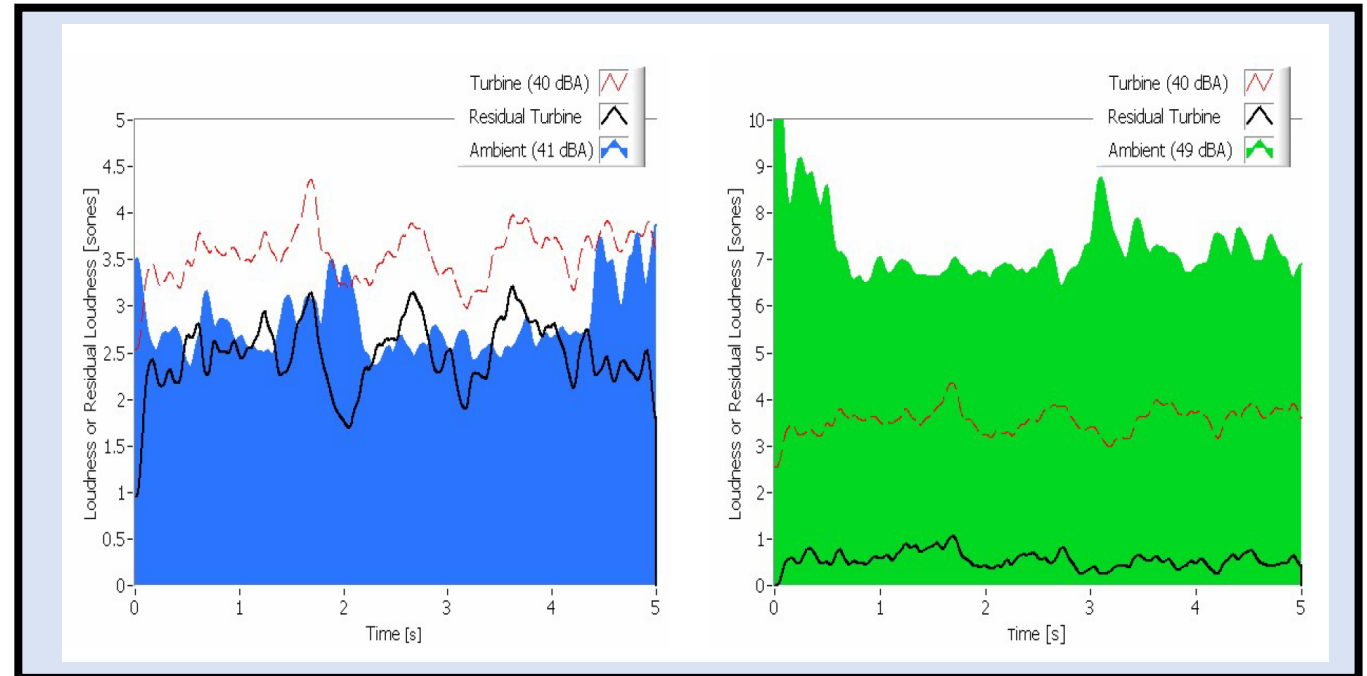
➤ Ambient environmental noise: perceptual bases (2)

- **Auditory masking** describes how eVTOL noise is partially or completely obscured by another sound source
- **Partial specific time-varying loudness (PSTVL)** describes how the judgment of the loudness a particular sound (e.g., an eVTOL) is affected when heard simultaneously in the presence of another sound (e.g., the ambient), as a function of time.
- The overall loudness of an eVTOL event can be calculated from the average short-term partial loudness, or the maximum of long-term partial loudness

eVTOL incoherent summation, 100 mph, 1000 ft



Nelson (2007) wind turbine data



➤ Limitations of prior analyses due to ambient simulation

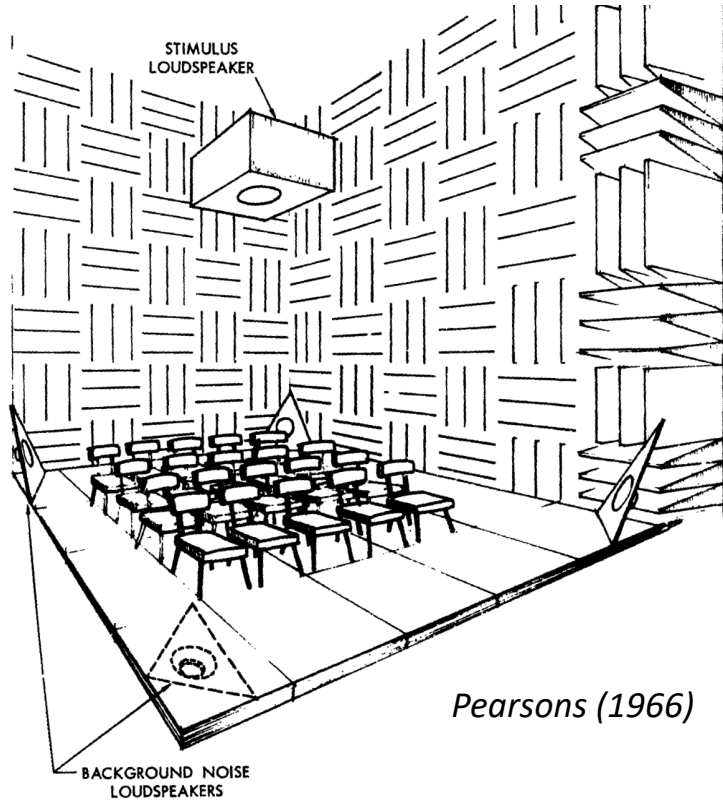


FIGURE 5. ANECHOIC CHAMBER FACILITY FOR DURATION AND BACKGROUND LEVEL TESTS

- No ambient included in forming aircraft noise scale
 - *Kryter (1959)*
- Spatial audio cues not included
 - *Namba and Kuwano (1980)*
- Uncontrolled existing ambient outdoors
 - *Bishop (1966)*
- Noise generator used as an ambient proxy
 - *Berglund et al. (1975)*
- Indoor environment simulated via low-pass noise filtering
 - *Powell and Rice (1975)*
- Comparison of community noise survey data to L_{dn} (DNL) or long-term average (24 hr L_{Aeq}) measurements
 - *Lim et al. (2008)*
 - *Fields (1998)*

It may happen, for example, that the noise from a particular source is masked by the background noise in one community but is much more intense than the background noise in another community. The two communities will respond quite differently to these two stimulus situations. In a sense, ***the background noise level plays the role of a reference level with which the noise under consideration is compared.*** (*Stevens, et al., 1955*).

➤ **Criteria for repeatable, realistic ambient recordings for listening tests**

Recording technique

- **calibrated** sound pressure levels, concurrent data measurement
- lack of distortion from electronics; wind; vibration; **movement**
- sufficient **signal-to-noise** ratio
- minimize influence of **reflections**
- capture **spatial cues** matching the perspective of a listener
- **document within a standardized metadata structure**

Location

- traceable to a **representative** location and activity time of a target community

Sound reproduction

- appropriate **match between the recording and playback** method
- adequate representation of the **frequency and timbral characteristics** of sound sources
- adequate representation of the **spatial characteristics** of sound sources
- a sense of **immersion** within the **environmental context**
- exclusion of **extraneous sounds** not representative of the target ambient
- non-conflicting **visual cues** (if visual cues such as video are used)
- control of **proprioceptive cues**
- mitigation of **adverse sound exposure** over the duration of the experiment (**fatigue** effects)

➤ Rationale for standardized metadata for ambient recordings

- Another researcher or recording engineer to **replicate the recording process** used
- Allow a researcher to use an appropriate method for **playback** of the recording
- Provide **calibration information** so that acoustical analyses can be applied to the recording and for calibrating playback levels
- Allow **comparison between different recordings** based on informational “tags”
- Provide **point-of-contact information** for the recordist and the location of the original data
- Indicate **recording details** regarding audio file size, type, and configuration
- **Goal:** potential **sharing** of ambient recordings and data between researchers, perhaps from a common repository of data.

Metadata categories


Sound file identifiers (unique information for identifying a particular recording)

Sound file detail (information on the digital sound file format and duration)

Instrumentation (details regarding the microphones and set up used, ancillary video information)

Recording locale and time (UTC)

Measurement notes (important information regarding the recording location, circumstances, or equipment, photos, maps, diagrams, weather, etc.)

Metadata Category	Metadata tag	Example contents	Notes	Critical
SOUND FILE IDENTIFIERS	Folder name	Moffett Field near highway Feb 6-7 2020	A folder containing multiple recordings	
	File name	2.6.2020_Location1.wav	The name of the audio file, including extension	*
	Part of set	file 1 of 8 sequentially-recorded files over 2 days	Description of related files in a single recording session	
	Recording type generic description (e.g.: SL meter; multichannel; binaural)	Multichannel B-format & Sound Level Meter		
	MD5 hash	4adb0ec3007d249bc2f5e4d58d2f1e60	Unique identifier	
	POC	"Durand Begault" Durand.R.Begault@nasa.gov	Person to contact for additional info, email or tel. no.	
	Recording Engineer	Durand Begault	Optional	
SOUND FILE DETAIL	Media location	NASA Ames Code TH	physical location or URL of file for download	*
	sample rate	44.1 khz		*
	bit depth	24		*
	# channels	5		
	Duration (time interval)	1 hour (continuous)		*
	Channel assignment	1= W (omni) ; 2-Dipole X channel (Left-Right); 3=Dipole Y channel (Front-Back); 4 = Dipole Z channel (Up-Down); 5= Omni SLM microphone	Indicate for multichannel recordings the relationship between a specific microphone and the audio channel	*
	FSD (calibration) dB SPL - dBVU	94 dB SPL = -18 dB VU		
	Calibration file	2.6.2020_Location1_Calibration.wav (channel 5)	Indicate if there is a separate audio file for calibration	
	Calibration method	Chan 5: Bruel & Kjaer 4231. Chan 1-4: diffuse pink noise set to equal chan 5 response	Note if different methods used; e.g., multiple microphones indicate any gain adjustment relative to the calibration file. (usually based on the microphone preamplifier setting)	
	Range adjustment re calibration file (offset)	+10 dB		
	Intended playback	1st order ambisonics (B format)		*
	INSTRUMENTATION	Recorder	Sound Devices 744T	
Microphone information		Soundfiled ST 350; AC output, B&K 2250 SLM		*
Video file information		none	Information about name/location of a related video file	
Video-audio synchronization		N/A	Possibilities include clapboard; SMPTE or other time code	
Additional notes		Windscreens used; mounted on a tripod at about 4 ft above the ground.		
RECORDING LOCALE	location (generic description)	In an open field near a major highway (US 101)		*
	location (street, city, state, country)	Equiba and Cody Road, Moffett Field, CA, USA		*
	location (GPS)	37.4051982,-122.0563209,15.66	From Google Maps URL	
	Date, time start	2020-02-06-13:00 (UTC-7)	Format: Year-Month-Day-Time (Local)-UTC offset	
MEASUREMENT NOTES	Date, time end	2020-02-06-13:59(UTC-7)		
	notes on measurement condition (wind; unusual ambient events)	Standard commute day during llnch hour on a Thursday. Wind apx. 10 mph (per Wunderground URL)	Note special circumstances that would affect the ambient level (e.g., holidays; global pandemic)	
	Is file continuous?	yes; bystander talks to recordist 45 min 10 s into the recording	Note any interruptions	
MEASUREMENT NOTES	Screened for personal identifying information?	yes- no personal information	Any speech should be reviewed for privacy considerations, possibly edited (note)	
	Applicable standards	n/a	Indicate anyreference or document guiding the recording method	
	Photos or other data?	 More photos and video available from the POC	could include maps, diagrams, etc.	

- Suggestions regarding the metadata or other recommendations or critique are solicited from the UNWG
- A written version of this presentation is planned as a NASA technical memorandum
- No prescriptive recommendations are intended for a particular recording or playback methodology beyond the suggestions offered here. Methodologies appear to be “ongoing” in their development (e.g., Ambisonic, VR) and in some cases nascent.

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