

REPORT DOCUMENTATION PAGE			<i>Form Approved</i> <i>OMB No. 0704-0188</i>	
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1. AGENCY USE ONLY (Leave blank)		2. REPORT DATE January 2011		3. REPORT TYPE AND DATES COVERED Letter Report
4. TITLE AND SUBTITLE An Examination of the Spectral Class Low Frequency Limit for Helicopters			5a. FUNDING NUMBERS FA4SCL MMF11	
6. AUTHOR(S) Noah Schulz, Eric Boeker			5b. CONTRACT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) U.S. Department of Transportation Research and Innovative Technology Administration John A. Volpe National Transportation Systems Center Environmental Measurement and Modeling Division, RVT-41 Cambridge, MA 02142-1093			8. PERFORMING ORGANIZATION REPORT NUMBER DOT-VNTSC-FAA-14-03	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) U.S. Department of Transportation Federal Aviation Administration Office of Environment and Energy Washington D.C.			10. SPONSORING/MONITORING AGENCY REPORT NUMBER	
11. SUPPLEMENTARY NOTES				
12a. DISTRIBUTION/AVAILABILITY STATEMENT			12b. DISTRIBUTION CODE	
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14. SUBJECT TERMS Aircraft Noise, Noise Prediction, Noise Model, Helicopter Noise, Integrated Noise Model, Helicopter Noise Data, Noise Metrics, Low Frequency Noise			15. NUMBER OF PAGES 59	
			16. PRICE CODE	
17. SECURITY CLASSIFICATION OF REPORT Unclassified	18. SECURITY CLASSIFICATION OF THIS PAGE Unclassified	19. SECURITY CLASSIFICATION OF ABSTRACT Unclassified	20. LIMITATION OF ABSTRACT	



U.S. Department
Of Transportation

**Research and Innovative
Technology Administration**

Memorandum

Subject: An Examination of the Spectral Class Low Frequency Limit for Helicopters
Volpe Report # DOT-VNTSC-FAA-14-03

Date: January 25, 2011

From: Noah Schulz and Eric Boeker
Volpe Center

Reply to
Attn. of: RVT-41

To: Bill He (FAA AEE)

cc: Joe DiPardo (FAA AEE), Rebecca Cointin (FAA AEE), Barry Brayer (FAA AWP), Keith Lusk (FAA AWP), Larry Tonish (FAA AWP), Gregg Fleming (Volpe Center), Chris Roof (Volpe Center), Cynthia Lee (Volpe Center)

Currently, INM and AEDT do not use spectral data below 50 Hz in their noise computations. However, helicopter rotor rotational noise is dominant below 50Hz¹, with a fundamental frequency at the blade-pass frequency (BPF) and harmonics at integer multiples of BPF. Noise data for several helicopters have been measured for inclusion in the INM/AEDT database with expanded spectral data down to 12.5 Hz (the limit of the current Larson-Davis measurement equipment used by the Volpe Center). Since a number of INM/AEDT metric calculations and adjustments are frequency-dependent, omission of this expanded spectral data may have an effect on the accuracy of results when modeling helicopters or other aircraft with substantial low frequency noise components. Conversely, the inclusion of these data may change the noise level results in INM/AEDT and may cause inconsistencies in the database if only a limited number of aircraft have expanded spectral data. The purpose of this effort is to determine what effects, if any, inclusion of low frequency data will have on resulting noise modeling. The results of which would determine if and how an expanded-spectra capability should be included in AEDT.

Research Overview

This investigation has several parts: first, identification of existing helicopter data sets containing spectral data in the range between 12.5 Hz and 10 kHz; examination of these frequency data, including blade-pass frequency; and creation and comparison of Noise-Power-Distance curves (NPDs) from both standard- and expanded-spectra data sets. Following this, an exploration of the effects of expanded spectral data sets on individual frequency-dependent noise computations will be made.

¹ Johnson, W. Helicopter Theory. Mineola, NY: Dover Publications, 1994.



1. Aircraft Identification

Five helicopters were investigated: the Bell 407, Eurocopter EC130, Robinson R22, Robinson R44 and Schweizer 300C. All five study helicopters were measured in recent years by the Volpe Center Acoustics Facility, in contrast to noise data measured on other HNM/INM helicopters which were measured by various outside contractors over the past few decades. All study helicopters have main-rotor blade-pass frequencies within the frequency range of interest, between 12.5 and 50 Hz (see Table 1). The Bell 407 and Eurocopter are comparable in size, and are substantially larger than the R44, R22, or 300C, each with a maximum gross weight of more than double the next largest helicopter, the R44. During aircraft source measurements for INM/AEDT, noise data were captured from one-third octave frequency bands 11-43, covering the nominal center frequency range from 12.5 to 20,000 Hz^{2,3}. Current INM noise computations do not include noise data in Bands 11-16 and 41-43 (12.5 to 40 Hz and 12,500 to 20,000 Hz, respectively).

Table 1. Subject Helicopters

<i>Aircraft</i>	<i>Passenger Capacity (including pilot)</i>	<i>Main Rotor Blade Count</i>	<i>Main Rotor Blade-Pass Frequency (Hz)</i>	<i>Powerplant Count</i>	<i>Max. Gross Weight (lb)</i>
Bell 407	7	4	27.5	1	5000
Eurocopter EC130	7	3	26.3	1	5351
Robinson R22	2	2	17.3	1	1370
Robinson R44	4	2	13.6	1	2400
Schweizer 300C	2	3	23.6	1	2050

² Lau, Michael, et al., "Aircraft Source Noise Measurement Studies: 2006-2008 Summary of Measurements, Data and Analysis for the: Cessna 182 Skylane, Cessna 208 Caravan I, Dornier 228-202, Dornier 328-100, Piper PA-42 Cheyenne III, Bell 407, Robinson R44 Raven, Schweizer 300C," Volpe National Transportation Systems Center: Cambridge, MA, September 2009 (Draft).

³ Reherman, Clay, et al., "Fitchburg Municipal Airport Noise Measurement Study: Summary of Measurements, Data, and Analysis for the Maule M-7-235C, Piper twin Comanche PA-30, Piper Navajo Chieftain PA-31-350, Piper Warrior PA-28-161, Beech 1900D, Eurocopter EC-130 Helicopter, Robinson R-22 Helicopter," Volpe National Transportation Systems Center: Cambridge, MA, November 2005.



Inclusion of Bands 11-16 in a plot of one-third octave band levels (see Figure 1) illustrates the dominance of main-rotor blade-pass frequency in the low frequency regime. Smaller increases at harmonic frequencies of BPF can also be seen.

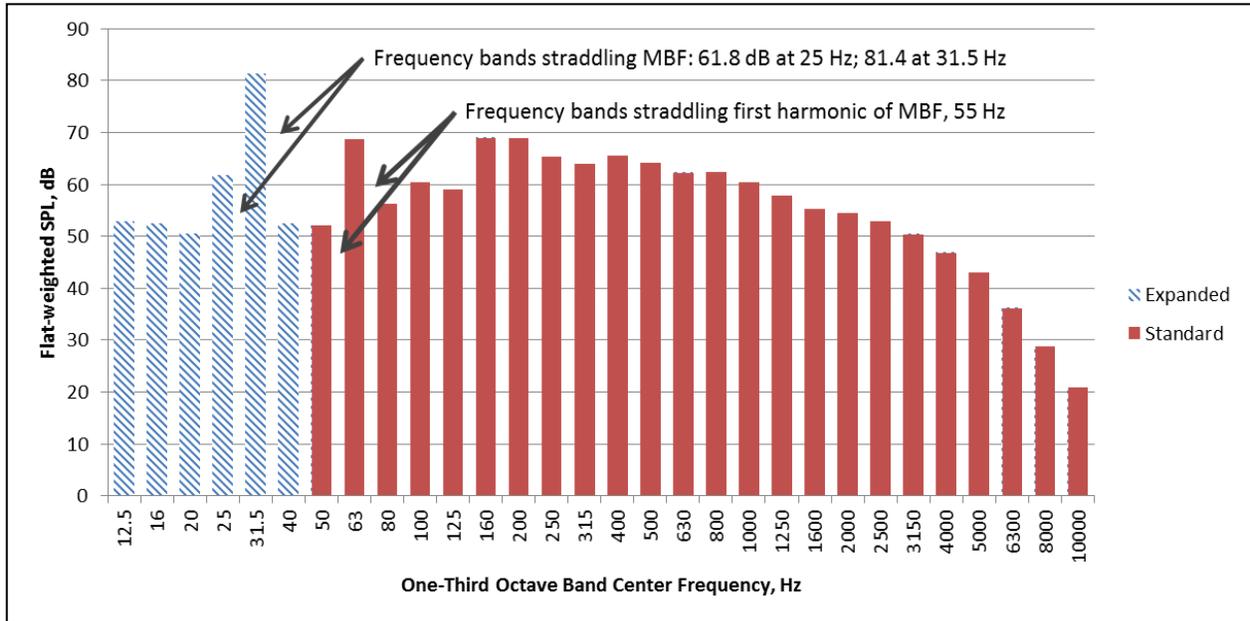


Figure 1. Bell 407 Departure, Source Normalized to 1,000 Feet

Sound pressure levels (SPL) were computed from both the standard and expanded spectra and compared⁴. This was done for both dynamic operations (departure, approach, level flight) (see Table 2) and static operations (hover, idle) (see Table 3). Overall, the computed SPL values for the expanded spectra were higher than the SPL values for the standard spectra during dynamic events for all aircraft. Un-weighted dynamic event spectra, as shown in Figure 1, show large increases when using expanded spectra, ranging from 0.6 to 6.2 dB across all five helicopters. The Bell 407 departure event showed the maximum increase of 6.2 dB in overall SPL. A-weighted values illustrate small increases across all aircraft, with changes of sound level less than 0.1 dB. C-weighted SPL show greater increases between expanded and standard spectra, with a maximum increase of 4.2 dB for the Bell 407, and an average increase over all dynamic events of 1.17 dB across all five aircraft. Flat, A-, and C-weighted static events illustrate small differences as well, with changes of less than 0.1 dB between expanded and standard spectra. Currently, INM and AEDT use flat, or unweighted, spectral classes; weightings are applied for specific metric types.

For static events, trends were similar for East and West microphone locations; therefore, frequency-dependent calculations for all aircraft were made with East Microphone data. As little

⁴ In this letter report, the term “standard spectra” refers to the frequency range 50 Hz to 10 kHz, and “expanded spectra” includes a frequency range of 12.5 Hz to 10 kHz. These ranges correspond to one-third octave bands 17-40 and 11-40, respectively, as defined by the Specification for Octave-Band and Fractional Octave-Band Analog and Digital Filters, American National Standard, ANSI S1.11-2004, New York, NY: American National Standards Institute, 2004.



variation was seen in static events for the three aircraft initially analyzed, the corresponding data was not processed for the two additional aircraft. Additionally, little change was seen between center, East, and West microphones for dynamic events; the EC130 and R22 analysis focused solely on data collected at the centerline microphone location.

The differences observed between static and dynamic events are most likely caused by Blade-Vortex Interaction (BVI), or “blade slap”, which is more pronounced in dynamic events, particularly approach.⁵ BVI noise is loudest perpendicular to the approaching rotor disk as the rotor blade edges encounter the vortices produced by the preceding trailing edge. Although BVI noise is less apparent in level flight and departure events, linear-thickness noise caused by the blade’s displacement of air perpendicular to the rotor disk could cause noise level increases in those events⁶. Linear-thickness noise radiates most strongly in the plane of the rotor disk, and its amplitude increases with the helicopter’s forward speed. Both BVI and linear-thickness noise are dominant in the low-frequency regime, as they are intimately tied to the helicopter’s blade passage frequency, although harmonics can be seen above 200 Hz.

⁵ Schmitz, F. H., and Y.H. Yu. “Helicopter Impulsive Noise: Theoretical and Experimental Status – NASA Technical Memo 84390”, Washington, D.C.: National Aeronautics and Space Administration, 1983.

⁶ Ibid.



Table 2. Overall SPL, Standard vs. Expanded Spectra, Dynamic Events⁷

		Spectrum	Event SPL, dB		
			Level Flight	Departure	Approach
Bell 407	Flat Weighted	Expanded	83.98	82.63	88.25
		Standard	82.54	76.42	82.38
		difference	1.44	6.21	5.87
	A-weighted	Expanded	75.34	70.05	76.61
		Standard	75.34	70.05	76.60
		difference	Less than 0.1	Less than 0.1	Less than 0.1
	C-weighted	Expanded	83.13	80.48	86.21
		Standard	82.32	76.25	82.32
		difference	0.82	4.23	3.89
Eurocopter EC130	Flat Weighted	Expanded	83.20	80.68	88.97
		Standard	80.58	78.64	87.84
		difference	2.61	2.03	1.13
	A-weighted	Expanded	77.12	75.74	81.93
		Standard	77.12	75.74	81.93
		difference	Less than 0.1	Less than 0.1	Less than 0.1
	C-weighted	Expanded	81.58	79.20	88.14
		Standard	80.47	78.56	87.80
		difference	1.12	0.64	0.35
Robinson R22	Flat Weighted	Expanded	84.62	83.92	82.73
		Standard	84.05	83.61	82.37
		difference	0.57	0.31	0.36
	A-weighted	Expanded	78.98	76.85	77.14
		Standard	78.98	76.85	77.14
		difference	Less than 0.1	Less than 0.1	Less than 0.1
	C-weighted	Expanded	84.19	83.45	82.33
		Standard	83.88	83.31	82.17
		difference	0.31	0.14	0.16
Robinson R44	Flat Weighted	Expanded	81.35	77.66	80.24
		Standard	77.23	74.07	78.41
		difference	4.12	3.59	1.83
	A-weighted	Expanded	70.74	66.64	72.06
		Standard	70.74	66.64	72.06
		difference	Less than 0.1	Less than 0.1	Less than 0.1
	C-weighted	Expanded	78.38	75.09	78.95
		Standard	77.00	73.97	78.34
		difference	1.38	1.12	0.60
Schweizer 300C	Flat Weighted	Expanded	72.73	72.55	74.25
		Standard	70.54	70.68	71.69
		difference	2.20	1.87	2.56
	A-weighted	Expanded	64.68	65.39	65.52
		Standard	64.68	65.39	65.52
		difference	Less than 0.1	Less than 0.1	Less than 0.1
	C-weighted	Expanded	71.22	71.10	72.56
		Standard	70.42	70.57	71.56
		difference	0.80	0.53	1.00

⁷ Values calculated at a source-to-receiver distance of 1,000 feet.



Table 3. Overall SPL, Standard vs. Expanded spectra, Static events⁴

		Spectrum	Event SPL, dB			
			Flight Idle	Ground Idle	HIGE ⁸	HOGE ⁹
Bell 407	Flat Weighted	Expanded	66.99	55.37	70.69	69.53
		Standard	66.99	55.37	70.69	69.53
		difference	Less than 0.1	Less than 0.1	Less than 0.1	Less than 0.1
	A-weighted	Expanded	66.97	55.86	70.49	68.52
		Standard	66.97	55.86	70.49	68.58
		difference	Less than 0.1	Less than 0.1	Less than 0.1	Less than 0.1
	C-weighted	Expanded	66.89	55.17	70.64	69.49
		Standard	66.89	55.17	70.64	69.72
		difference	Less than 0.1	Less than 0.1	Less than 0.1	-0.22
Robinson R44	Flat Weighted	Expanded	64.27	64.51	69.12	68.90
		Standard	64.27	64.51	69.12	68.90
		difference	Less than 0.1	Less than 0.1	Less than 0.1	Less than 0.1
	A-weighted	Expanded	60.73	59.42	67.52	67.60
		Standard	60.73	59.42	67.52	67.60
		difference	Less than 0.1	Less than 0.1	Less than 0.1	Less than 0.1
	C-weighted	Expanded	64.22	64.46	69.08	68.87
		Standard	64.22	64.46	69.08	68.87
		difference	Less than 0.1	Less than 0.1	Less than 0.1	Less than 0.1
Schweizer 300C	Flat Weighted	Expanded	55.98	46.88	59.86	63.76
		Standard	55.98	46.88	59.86	63.76
		difference	Less than 0.1	Less than 0.1	Less than 0.1	Less than 0.1
	A-weighted	Expanded	54.97	44.50	59.48	62.50
		Standard	54.97	44.50	59.48	62.50
		difference	Less than 0.1	Less than 0.1	Less than 0.1	Less than 0.1
	C-weighted	Expanded	55.85	46.74	59.74	63.73
		Standard	55.85	46.74	59.74	63.73
		difference	Less than 0.1	Less than 0.1	Less than 0.1	Less than 0.1

2. Comparison of NPDs developed with standard/expanded spectra

The Volpe-internal NPD generation tool LCorrect Version 2.2 allows for the development of Noise-Power-Distance curves with expanded spectral data. This section focuses on A-weighted NPDs based on the A-weighted Sound Exposure Level (SEL, denoted by the symbol L_{AE}) and A-weighted Maximum Sound Level (MXA, denoted by the symbol L_{Amax}) metrics; C-weighted NPDs are discussed in Section 3.3, below. Tone-corrected metrics are only defined down to 50 Hz¹⁰, and therefore this low frequency analysis is not applicable to those metrics. A-weighted SEL (see Appendix A) and MXA (see Appendix B) NPDs based on both standard and expanded spectra were compared, and the results show only small changes in value as the source-to-receiver distance increases¹¹. Level flight and departure events show changes of less than 0.1 dB, with a few exceptions beyond 10,000 feet, where differences of up to 0.35 dB were noted for the Bell 407. Approach events generally show the greatest difference between standard and

⁸ Hover In Ground Effect event

⁹ Hover Out-of-Ground Effect event

¹⁰ Federal Aviation Regulations, Part 36, Noise Standards: Aircraft Type and Airworthiness Certification, Washington, D.C: Federal Aviation Administration, September 1992.

¹¹ For the EC130 and R22, analysis was limited to data from the center microphone for dynamic events.



expanded spectra, with expanded-spectra NPDs showing increases ranging from less than 0.1 dB up to 0.46 dB at 25,000 feet. Static events show changes of less than 0.1 dB for the three helicopters studied¹², excepting the Bell 407 HOGE event, where the expanded spectrum produced levels from 0.49 dB to 0.77 dB lower than standard spectrum.

3. Analysis of expanded spectra on frequency-dependent calculations

Several INM/AEDT calculations have frequency-sensitive components: atmospheric absorption, line-of-sight blockage, C-weighted metrics, and Time Audible (TAUD). The effects of the expanded spectral data on these frequency-dependent computations were analyzed. Since modification of INM/AEDT would be necessary to perform these expanded-spectra calculations, these calculations were made using external tools and adapting the current INM methodology¹³ to include the expanded spectral data.

3.1. Atmospheric absorption

Atmospheric absorption values were calculated using both standard and expanded spectra for seven atmospheric conditions over a range of temperature and relative humidity values (see Appendix C). For the EC130, R22, R44 and 300C, the differences between atmospheric absorption for standard and expanded spectra did not exceed 0.1 dB for all of the tested atmospheric conditions. For the Bell 407, the differences between atmospheric absorption for standard and expanded spectra did not exceed 0.1 dB for most of the tested atmospheric condition. The one exception was the HOGE event, where differences of up to -0.19 dB at 10,000 feet were observed for a 40 degrees Fahrenheit, 40 percent humidity atmosphere (see Figure 2). This result differs from those for the EC130, R22, R44 and 300C, where the differences between atmospheric absorption corrections never exceeded 0.1 dB. This may be due to the unique NPD and spectral values for the 407 HOGE event.

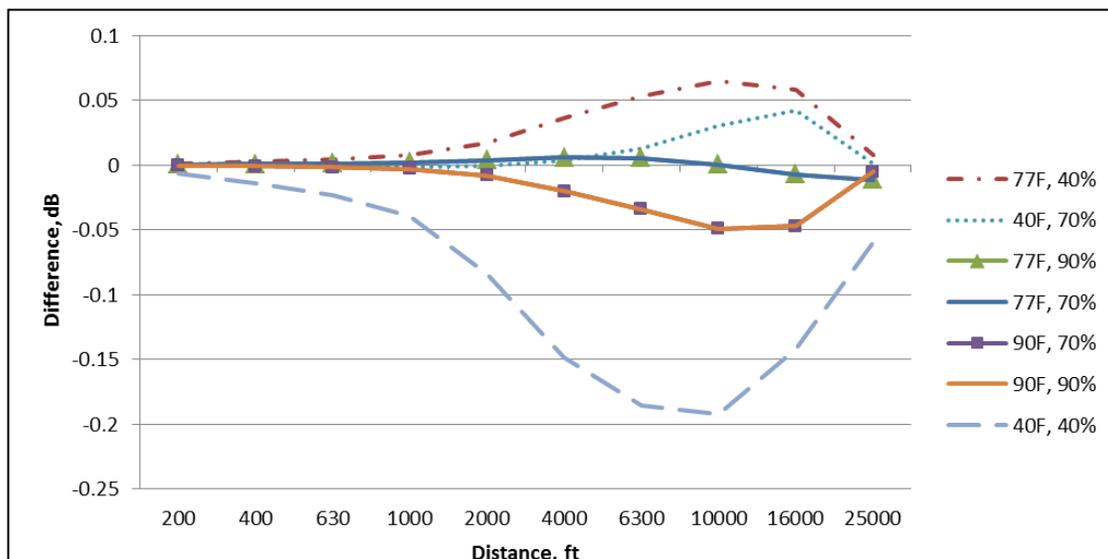


Figure 2. Difference (Standard - Expanded) in Atmospheric Absorption Adjustment for the Bell 407 Helicopter

¹² Bell 407, Robinson R44, and Schweizer 300C.

¹³ Boeker, et al., *INM Version 7.0 Technical Manual*, FAA Report No. FAA-AEE-08-01, Washington, DC: Federal Aviation Administration, January 2008.



3.2. Line-of-Sight Blockage

The line of sight blockage calculation method described in the INM 7.0 Technical Manual⁸ was expanded to calculate Fresnel Numbers for the expanded frequency bands 11-16. The Fresnel Number (N_0) equation is frequency dependent and is used to compute barrier effects:

$$N_0 = \pm 2 \cdot \left(\frac{\delta_0}{\lambda} \right)$$

where

- δ_0 path length difference determined by source-barrier-receiver geometry
- λ wavelength of the sound radiated by the source

The resulting barrier effect values were used to calculate the overall Line-of-Sight Blockage Adjustment (LOS_{ADJ}) for a range of path length difference (see Appendix D)¹⁴.

Differences in line-of-sight blockage adjustment of up to 6.86 dB were calculated, with average differences across all aircraft and barrier heights of 1.78 dB for level flight events, 2.01 dB for departure events, and 1.96 dB for approach events. There is a marked difference between standard and expanded values of LOS_{ADJ} in the middle range of tested path length difference. As the path length increases, LOS_{ADJ} approaches the INM upper limit of 18 dB for both standard and expanded spectra. However, sound readily diffracts around barriers smaller than its wavelength,¹⁵ allowing for significantly lower attenuation of low-frequency noise and limiting the effect of LOS_{ADJ} for barriers with heights close to the low-frequency wavelengths.

3.3. C-weighted Metrics

C-weighted filtering allows for greater low frequency sensitivity compared to A-weighting. C-weighting is taken into account in INM/AEDT as a frequency-based adjustment to the A-weighted NPDs using the spectral class data. As expected, the inclusion of expanded low frequency noise data has a greater effect on C-weighted metrics (see Appendix E). As discussed in Section 2, little change is seen in A-weighted values between expanded and standard spectra; however, use of expanded spectra in calculating C-weight adjustments results in greater change, with notable increases in SPL at all INM/AEDT distances. For example, a C-weighted NPD for the 300C level flight event has higher values at every INM/AEDT distance, from 0.71 dB higher at 200 feet to 3.42 dB higher at 25,000 feet (see Figure 3). Similar increases are seen across all dynamic events; static events show little to no difference when using expanded spectra, due to low sound pressure levels across the low frequency regime for static events. As the use of expanded spectra has very little effect (less than 0.1 dB) on the resulting A-weighted NPDs, the C-weighted adjustments with expanded spectra can be applied to standard-spectra A-weighted NPDs without loss of fidelity.

¹⁴ Values of path length difference were calculated assuming barrier extension perpendicular to the line of sight, 200 feet from the receiver, with line of sight distance of 1,000 feet between source and receiver. Barrier elevation is the distance a given barrier extends beyond the vector describing the direct line of sight from source to receiver.

¹⁵ Wavelengths for frequencies of interest range from approximately 90.4 ft at 12.5 Hz to 28.3 ft at 40 Hz.

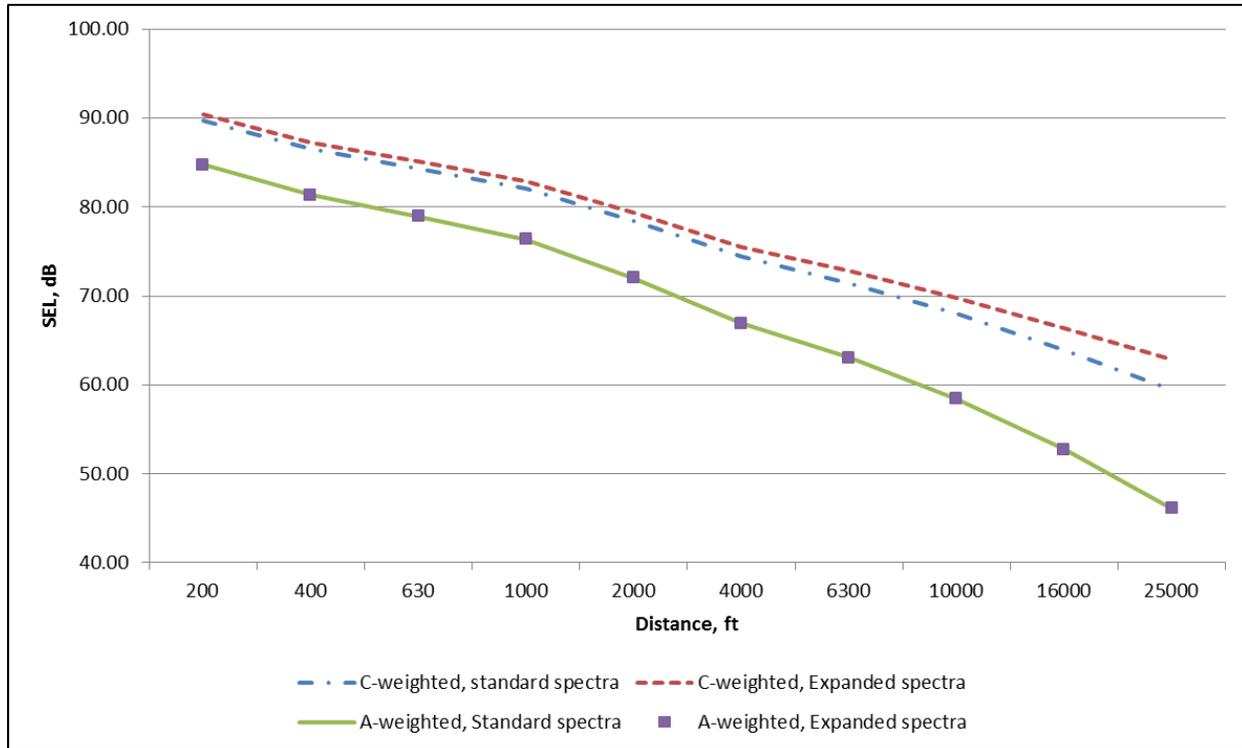


Figure 3. Comparison of the Effects of Expanded Spectral Data on A- and C-weighted NPDS for the Schweizer 300C, Level Flight Event

3.4. Time Audible

The Time Audible (TAUD) metric relies on standard values for the reference threshold of human hearing¹⁶, as well as standard values of human hearing sensitivity. The detectability level, $D'L$, is a frequency-specific value that relies on constant values of human aural efficiency and threshold detection. Values for reference threshold of hearing are not given below 20 Hz in the ISO standard; therefore, values for 12.5 and 16 Hz were extrapolated via a sixth-order polynomial regression (see Appendix F). Similarly, values for frequency-specific receiver efficiency (η_{band}) below 31.5 Hz, and Equivalent Auditory System Noise (EASN) below 50 Hz were estimated via fourth-order polynomial regression¹⁷. Using expanded spectra from the Bell 407 approach event, overall detectability D' was unchanged over its value using standard spectra, where both values of $D'L_{total}$ were 70.2. However, the individual octave band containing the Bell 407's MBF was detectable, as its $D'L_{band}$ value exceeded the detectability threshold. Similar results for overall detectability were obtained for the EC130, R22, R44 and 300C, where individual low frequency bands were detectable, but had only a negligible impact on overall detectability. Figure 4 shows that much of the low frequency noise from the approaching helicopter is masked by the EASN level, which increases quickly below 50 Hz and minimizes the effect of low frequency noise on overall detectability. EASN level decreases above 50 Hz, dropping below 20 dB above 125 Hz, making detection much more likely to occur in the mid-to-high frequency range. Therefore, use of expanded spectra is unlikely to have an

¹⁶ Acoustics – Reference zero for the calibration of audiometric equipment – Part 7, International Standard, ISO 389-7, Geneva: International Organization for Standardization, 1998.

¹⁷ Fidell, S., and Horonjeff, R., A graphic method for predicting audibility of noise sources. Technical Report AFWAL-TR-82-3086, Flight Dynamics Laboratory, Wright-Patterson Air Force Base, Ohio, 1982.



effect on TAUD unless there are prominent aircraft tones and low background ambient noise in the low frequency bands. Time audible calculations are based on the overall detectability of the aircraft on a particular flight segment, and depend on the value of $D'L_{total}$ to determine the percentage of time the aircraft is audible over the time period of interest.

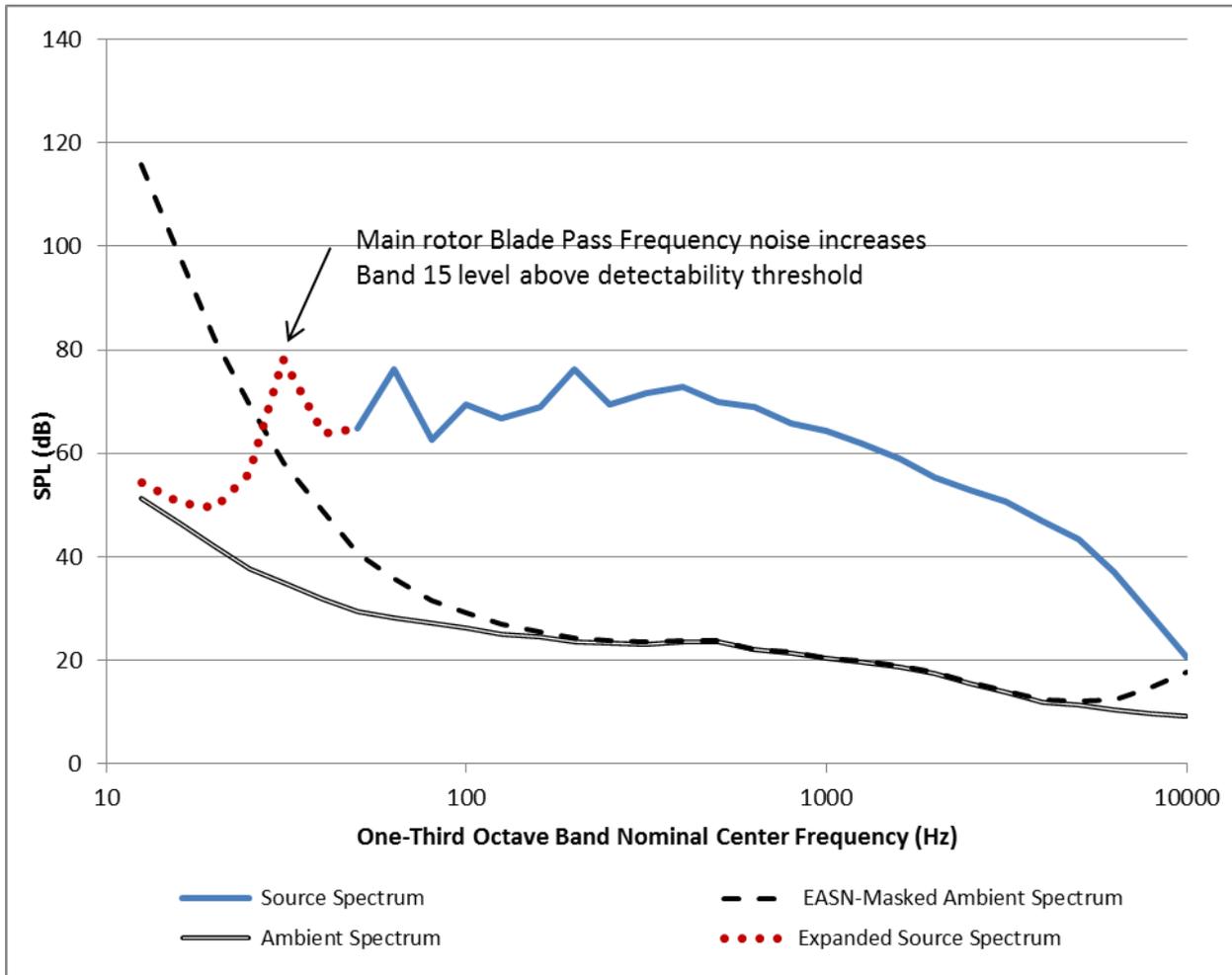


Figure 4. Comparison of Standard and Expanded Bell 407 Level Flight Spectra with EASN Threshold and Sample Ambient Spectra¹⁸

4.

¹⁸ Ambient spectra from Hawaii Volcanoes National Park, Site 3A, Existing Ambient Without Air Tours (Lee, et. al., Baseline Ambient Sound Levels in Hawai'i Volcanoes National Park, Report No. DOT-VNTSC-FAA-06-07, Cambridge, MA: John A. Volpe National Transportation Systems Center, April 2006.)



Conclusions

The use of expanded low frequency spectra has effects on a number of INM/AEDT calculations. A-weighted noise levels and Time Audible computations are minimally affected, whereas C-weighted metrics show the greatest changes. The frequency dependent adjustments, which show the greatest increase between standard and expanded spectra, are applied to the A-weighted NPDs. As there is minimal change these A-weighted NPDs, they could be used in INM/AEDT with expanded-spectral data to better represent the low frequency contributions to these adjustments. The small aircraft sample set limits the applicability of these results; although results from all five aircraft are generally similar, several results for the larger Bell 407 stand apart.

The helicopter noise datasets used as the basis for this report were collected over a number of years, with a range of measurement equipment and different processing methods. The methods in current use were adapted for this research to allow for the inclusion of low-frequency bands, and therefore direct comparisons between aircraft within and outside the study would be made with some caveats. The results of this research have illuminated that there are consistencies across the aircraft that show clearly the effects of low-frequency noise. As such, the inclusion of an expanded-spectra capability is recommended for AEDT.

To that end, we make the following recommendations. The AEDT spectral class low frequency limit should be expanded to include one-third octave band 11, with a center frequency of 12.5 Hz. Additionally, the feasibility of making new, expanded-spectra source measurements for helicopters without low-frequency data should be explored, and the source measurement protocols should be amended to include low-frequency data for future rotorcraft source measurements.

Further verification of the portability of rotorcraft source data processed using earlier methods into the current methodology is recommended as well. This could allow for the reprocessing of previously captured low-frequency data that were excluded in previous processing methods. Additional research into low-frequency noise effects on audibility should be made as well, with a focus on Time Audible calculation; if possible, correlation of the resulting values with field observation is recommended. To ensure the accuracy of audibility calculations, the current EASN floor should be expanded in the low-frequency regime to 12.5 Hz. This expansion will require further research as well, as current standards do not extend beyond 20 Hz.

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Appendix A: SEL NPDs

Table A-1. SEL NPD Comparison, Bell 407

Bell 407 High Cruise Tour Events									
Distance, ft	Left Microphone			Center Microphone			Right Microphone		
	Standard spectra, dB	Expanded spectra, dB	Difference, dB	Standard spectra, dB	Expanded spectra, dB	Difference, dB	Standard spectra, dB	Expanded spectra, dB	Difference, dB
200	96.96	96.96	Less than 0.1	92.76	92.76	Less than 0.1	93.02	93.02	Less than 0.1
400	93.58	93.58	Less than 0.1	89.45	89.45	Less than 0.1	89.56	89.56	Less than 0.1
630	91.22	91.22	Less than 0.1	87.18	87.18	Less than 0.1	87.11	87.11	Less than 0.1
1000	88.63	88.63	Less than 0.1	84.72	84.72	Less than 0.1	84.41	84.41	Less than 0.1
2000	84.21	84.21	Less than 0.1	80.63	80.63	Less than 0.1	79.80	79.80	Less than 0.1
4000	78.83	78.83	Less than 0.1	75.79	75.79	Less than 0.1	74.20	74.21	Less than 0.1
6300	74.55	74.55	Less than 0.1	71.98	71.98	Less than 0.1	69.80	69.81	Less than 0.1
10000	69.42	69.43	Less than 0.1	67.39	67.40	Less than 0.1	64.55	64.58	Less than 0.1
16000	63.36	63.37	Less than 0.1	61.78	61.79	Less than 0.1	58.33	58.41	Less than 0.1
25000	56.91	56.94	Less than 0.1	55.40	55.43	Less than 0.1	51.62	51.84	0.22

Bell 407 Departure Events									
Distance, ft	Left Microphone			Center Microphone			Right Microphone		
	Standard spectra, dB	Expanded spectra, dB	Difference, dB	Standard spectra, dB	Expanded spectra, dB	Difference, dB	Standard spectra, dB	Expanded spectra, dB	Difference, dB
200	88.61	88.61	Less than 0.1	90.50	90.48	Less than 0.1	89.89	89.89	Less than 0.1
400	85.12	85.12	Less than 0.1	87.02	87.02	Less than 0.1	86.40	86.40	Less than 0.1
630	82.65	82.65	Less than 0.1	84.59	84.59	Less than 0.1	83.92	83.92	Less than 0.1



1000	79.93	79.93	Less than 0.1	81.93	81.94	Less than 0.1	81.19	81.20	Less than 0.1
2000	75.27	75.27	Less than 0.1	77.51	77.52	Less than 0.1	76.52	76.53	Less than 0.1
4000	69.68	69.69	Less than 0.1	72.34	72.36	Less than 0.1	70.85	70.87	Less than 0.1
6300	65.36	65.38	Less than 0.1	68.38	68.39	Less than 0.1	66.41	66.44	Less than 0.1
10000	60.40	60.43	Less than 0.1	63.73	63.76	Less than 0.1	61.21	61.27	Less than 0.1
16000	54.80	54.87	Less than 0.1	58.23	58.31	Less than 0.1	55.27	55.41	0.14
25000	48.95	49.12	0.17	52.14	52.31	0.17	49.04	49.38	0.35

Bell 407 Approach Events									
Distance, ft	Left Microphone			Center Microphone			Right Microphone		
	Standard spectra, dB	Expanded spectra, dB	Difference, dB	Standard spectra, dB	Expanded spectra, dB	Difference, dB	Standard spectra, dB	Expanded spectra, dB	Difference, dB
200	89.51	89.58	Less than 0.1	94.98	95.03	Less than 0.1	94.76	94.76	Less than 0.1
400	86.22	86.29	Less than 0.1	91.75	91.80	Less than 0.1	91.49	91.49	Less than 0.1
630	83.96	84.04	Less than 0.1	89.54	89.59	Less than 0.1	89.23	89.23	Less than 0.1
1000	81.53	81.61	Less than 0.1	87.16	87.21	Less than 0.1	86.78	86.78	Less than 0.1
2000	77.54	77.62	Less than 0.1	83.22	83.27	Less than 0.1	82.66	82.66	Less than 0.1
4000	72.89	72.98	Less than 0.1	78.49	78.55	Less than 0.1	77.61	77.61	Less than 0.1
6300	69.30	69.40	0.11	74.72	74.78	Less than 0.1	73.48	73.49	Less than 0.1
10000	65.00	65.14	0.14	70.07	70.13	Less than 0.1	68.31	68.31	Less than 0.1
16000	59.77	59.99	0.21	64.23	64.33	0.10	61.76	61.78	Less than 0.1
25000	53.83	54.23	0.40	57.40	57.60	0.20	54.27	54.33	Less than 0.1



Table A-2. SEL NPD Comparison, Eurocopter EC130

EC130 Level Flight Events			
Center Microphone			
Distance, ft	Standard spectra, dB	Expanded spectra, dB	Difference, dB
200	86.63	86.63	Less than 0.1
400	83.22	83.22	Less than 0.1
630	80.82	80.82	Less than 0.1
1000	78.19	78.19	Less than 0.1
2000	73.75	73.75	Less than 0.1
4000	68.41	68.41	Less than 0.1
6300	64.18	64.19	Less than 0.1
10000	59.06	59.08	Less than 0.1
16000	52.86	52.89	Less than 0.1
25000	46.08	46.16	Less than 0.1

EC130 Departure Events			
Center Microphone			
Distance, ft	Standard spectra, dB	Expanded spectra, dB	Difference, dB
200	87.98	88.02	Less than 0.1
400	84.53	84.56	Less than 0.1
630	82.08	82.11	Less than 0.1
1000	79.40	79.43	Less than 0.1
2000	74.89	74.92	Less than 0.1
4000	69.51	69.54	Less than 0.1
6300	65.25	65.29	Less than 0.1
10000	60.04	60.08	Less than 0.1
16000	53.61	53.65	Less than 0.1
25000	46.47	46.52	Less than 0.1

EC130 Approach Events			
Center Microphone			
Distance, ft	Standard spectra, dB	Expanded spectra, dB	Difference, dB
200	93.94	93.94	Less than 0.1
400	90.72	90.72	Less than 0.1
630	88.51	88.52	Less than 0.1
1000	86.15	86.15	Less than 0.1
2000	82.25	82.26	Less than 0.1
4000	77.65	77.66	Less than 0.1
6300	74.04	74.05	Less than 0.1
10000	69.67	69.68	Less than 0.1
16000	64.26	64.26	Less than 0.1
25000	57.95	57.97	Less than 0.1



Table A-3. SEL NPD Comparison, Robinson R22

R22 Level Flight Events			
Center Microphone			
Distance, ft	Standard spectra, dB	Expanded spectra, dB	Difference, dB
200	90.04	90.04	Less than 0.1
400	86.64	86.64	Less than 0.1
630	84.26	84.26	Less than 0.1
1000	81.66	81.66	Less than 0.1
2000	77.28	77.28	Less than 0.1
4000	72.08	72.08	Less than 0.1
6300	68.04	68.05	Less than 0.1
10000	63.28	63.29	Less than 0.1
16000	57.67	57.68	Less than 0.1
25000	51.65	51.67	Less than 0.1

R22 Departure Events			
Center Microphone			
Distance, ft	Standard spectra, dB	Expanded spectra, dB	Difference, dB
200	88.43	88.43	Less than 0.1
400	84.87	84.87	Less than 0.1
630	82.32	82.32	Less than 0.1
1000	79.50	79.50	Less than 0.1
2000	74.75	74.75	Less than 0.1
4000	69.31	69.31	Less than 0.1
6300	65.35	65.35	Less than 0.1
10000	61.01	61.01	Less than 0.1
16000	56.26	56.26	Less than 0.1
25000	51.41	51.42	Less than 0.1

R22 Approach Events			
Center Microphone			
Distance, ft	Standard spectra, dB	Expanded spectra, dB	Difference, dB
200	89.64	89.64	Less than 0.1
400	86.22	86.22	Less than 0.1
630	83.80	83.80	Less than 0.1
1000	81.16	81.16	Less than 0.1
2000	76.72	76.72	Less than 0.1
4000	71.45	71.45	Less than 0.1
6300	67.42	67.42	Less than 0.1
10000	62.75	62.75	Less than 0.1
16000	57.42	57.42	Less than 0.1
25000	51.85	51.85	Less than 0.1



Table A-4. SEL NPD Comparison, Robinson R44

R44 Level Flight Events									
	Left Microphone			Center Microphone			Right Microphone		
Distance, ft	Standard spectra, dB	Expanded spectra, dB	Difference, dB	Standard spectra, dB	Expanded spectra, dB	Difference, dB	Standard spectra, dB	Expanded spectra, dB	Difference, dB
200	87.71	87.72	Less than 0.1	87.93	87.93	Less than 0.1	88.02	88.02	Less than 0.1
400	84.32	84.32	Less than 0.1	84.64	84.64	Less than 0.1	84.61	84.61	Less than 0.1
630	81.93	81.93	Less than 0.1	82.37	82.37	Less than 0.1	82.21	82.21	Less than 0.1
1000	79.31	79.31	Less than 0.1	79.93	79.93	Less than 0.1	79.58	79.58	Less than 0.1
2000	74.90	74.90	Less than 0.1	75.86	75.86	Less than 0.1	75.11	75.11	Less than 0.1
4000	69.65	69.65	Less than 0.1	71.05	71.05	Less than 0.1	69.81	69.81	Less than 0.1
6300	65.61	65.62	Less than 0.1	67.29	67.30	Less than 0.1	65.76	65.78	Less than 0.1
10000	60.90	60.92	Less than 0.1	62.78	62.79	Less than 0.1	61.12	61.14	Less than 0.1
16000	55.35	55.39	Less than 0.1	57.25	57.26	Less than 0.1	55.71	55.76	Less than 0.1
25000	49.28	49.39	0.11	50.94	50.98	Less than 0.1	49.75	49.86	0.11

R44 Departure Events									
	Left Microphone			Center Microphone			Right Microphone		
Distance, ft	Standard spectra, dB	Expanded spectra, dB	Difference, dB	Standard spectra, dB	Expanded spectra, dB	Difference, dB	Standard spectra, dB	Expanded spectra, dB	Difference, dB
200	88.25	88.29	Less than 0.1	87.53	87.53	Less than 0.1	89.02	89.06	Less than 0.1
400	84.89	84.92	Less than 0.1	84.27	84.27	Less than 0.1	85.61	85.64	Less than 0.1
630	82.56	82.59	Less than 0.1	82.02	82.02	Less than 0.1	83.20	83.23	Less than 0.1
1000	80.03	80.06	Less than 0.1	79.61	79.61	Less than 0.1	80.55	80.59	Less than 0.1
2000	75.80	75.83	Less than 0.1	75.68	75.68	Less than 0.1	76.07	76.11	Less than 0.1
4000	70.79	70.82	Less than 0.1	71.14	71.14	Less than 0.1	70.77	70.80	Less than 0.1
6300	66.91	66.95	Less than 0.1	67.69	67.69	Less than 0.1	66.73	66.77	Less than 0.1
10000	62.36	62.39	Less than 0.1	63.60	63.60	Less than 0.1	62.08	62.13	Less than 0.1
16000	57.02	57.06	Less than 0.1	58.64	58.65	Less than 0.1	56.62	56.68	Less than 0.1
25000	51.30	51.36	Less than 0.1	52.92	52.95	Less than 0.1	50.54	50.64	Less than 0.1



R44 Approach Events									
	Left Microphone			Center Microphone			Right Microphone		
Distance, ft	Standard spectra, dB	Expanded spectra, dB	Difference, dB	Distance, ft	Standard spectra, dB	Expanded spectra, dB	Difference, dB	Distance, ft	Standard spectra, dB
200	92.02	92.05	Less than 0.1	92.43	92.77	0.25	89.02	89.05	Less than 0.1
400	88.75	88.78	Less than 0.1	89.19	89.54	0.26	85.76	85.79	Less than 0.1
630	86.49	86.53	Less than 0.1	86.97	87.32	0.26	83.51	83.55	Less than 0.1
1000	84.05	84.08	Less than 0.1	84.58	84.93	0.27	81.11	81.14	Less than 0.1
2000	79.94	79.97	Less than 0.1	80.61	80.97	0.28	77.14	77.18	Less than 0.1
4000	74.95	74.99	Less than 0.1	75.89	76.28	0.29	72.51	72.54	Less than 0.1
6300	70.97	71.01	Less than 0.1	72.18	72.59	0.31	68.93	68.97	Less than 0.1
10000	66.13	66.17	Less than 0.1	67.68	68.13	0.34	64.70	64.75	Less than 0.1
16000	60.19	60.23	Less than 0.1	62.14	62.65	0.38	59.62	59.67	Less than 0.1
25000	53.37	53.43	Less than 0.1	55.73	56.34	0.46	53.82	53.90	Less than 0.1



Table A-5. SEL NPD Comparison, Schweizer 300C

300C Level Flight Events									
Distance, ft	Left Microphone			Center Microphone			Right Microphone		
	Standard spectra, dB	Expanded spectra, dB	Difference, dB	Standard spectra, dB	Expanded spectra, dB	Difference, dB	Standard spectra, dB	Expanded spectra, dB	Difference, dB
200	86.50	86.50	Less than 0.1	84.75	84.75	Less than 0.1	85.97	85.97	Less than 0.1
400	83.08	83.08	Less than 0.1	81.34	81.34	Less than 0.1	82.55	82.55	Less than 0.1
630	80.67	80.67	Less than 0.1	78.95	78.95	Less than 0.1	80.13	80.13	Less than 0.1
1000	78.00	78.00	Less than 0.1	76.35	76.35	Less than 0.1	77.45	77.45	Less than 0.1
2000	73.45	73.45	Less than 0.1	72.02	72.02	Less than 0.1	72.83	72.84	Less than 0.1
4000	67.91	67.91	Less than 0.1	66.95	66.95	Less than 0.1	67.16	67.16	Less than 0.1
6300	63.53	63.53	Less than 0.1	63.05	63.05	Less than 0.1	62.63	62.63	Less than 0.1
10000	58.29	58.31	Less than 0.1	58.41	58.41	Less than 0.1	57.17	57.18	Less than 0.1
16000	51.99	52.02	Less than 0.1	52.73	52.73	Less than 0.1	50.52	50.54	Less than 0.1
25000	44.89	44.97	Less than 0.1	46.10	46.12	Less than 0.1	42.96	43.03	Less than 0.1

300C Departure Events									
Distance, ft	Left Microphone			Center Microphone			Right Microphone		
	Standard spectra, dB	Expanded spectra, dB	Difference, dB	Standard spectra, dB	Expanded spectra, dB	Difference, dB	Standard spectra, dB	Expanded spectra, dB	Difference, dB
200	88.56	88.56	Less than 0.1	87.29	87.29	Less than 0.1	87.09	87.08	Less than 0.1
400	85.08	85.08	Less than 0.1	83.91	83.91	Less than 0.1	83.64	83.64	Less than 0.1
630	82.61	82.61	Less than 0.1	81.55	81.55	Less than 0.1	81.21	81.21	Less than 0.1
1000	79.88	79.88	Less than 0.1	78.99	78.99	Less than 0.1	78.52	78.52	Less than 0.1
2000	75.24	75.24	Less than 0.1	74.69	74.69	Less than 0.1	73.94	73.94	Less than 0.1
4000	69.71	69.71	Less than 0.1	69.59	69.59	Less than 0.1	68.40	68.40	Less than 0.1
6300	65.44	65.44	Less than 0.1	65.62	65.62	Less than 0.1	64.08	64.09	Less than 0.1
10000	60.37	60.38	Less than 0.1	60.87	60.87	Less than 0.1	58.95	58.96	Less than 0.1
16000	54.20	54.21	Less than 0.1	55.00	55.01	Less than 0.1	52.77	52.79	Less than 0.1
25000	47.11	47.14	Less than 0.1	48.12	48.14	Less than 0.1	45.78	45.84	Less than 0.1



300C Approach Events									
Distance, ft	Left Microphone			Center Microphone			Right Microphone		
	Standard spectra, dB	Expanded spectra, dB	Difference, dB	Standard spectra, dB	Expanded spectra, dB	Difference, dB	Standard spectra, dB	Expanded spectra, dB	Difference, dB
200	85.11	85.10	Less than 0.1	85.09	85.09	Less than 0.1	85.52	85.52	Less than 0.1
400	81.63	81.63	Less than 0.1	81.71	81.71	Less than 0.1	82.13	82.13	Less than 0.1
630	79.17	79.17	Less than 0.1	79.37	79.37	Less than 0.1	79.76	79.76	Less than 0.1
1000	76.46	76.46	Less than 0.1	76.83	76.83	Less than 0.1	77.16	77.16	Less than 0.1
2000	71.82	71.82	Less than 0.1	72.64	72.64	Less than 0.1	72.76	72.76	Less than 0.1
4000	66.27	66.27	Less than 0.1	67.76	67.76	Less than 0.1	67.49	67.49	Less than 0.1
6300	61.98	61.98	Less than 0.1	64.01	64.01	Less than 0.1	63.38	63.39	Less than 0.1
10000	56.95	56.95	Less than 0.1	59.51	59.51	Less than 0.1	58.51	58.52	Less than 0.1
16000	50.94	50.95	Less than 0.1	53.89	53.89	Less than 0.1	52.64	52.68	Less than 0.1
25000	44.15	44.17	Less than 0.1	47.24	47.26	Less than 0.1	45.97	46.09	Less than 0.1



Appendix B: MXA NPDs

Table B-1. MXA NPD Comparison, Bell 407

Bell 407 Level Flight Events									
Distance, ft	Left Microphone			Center Microphone			Right Microphone		
	Standard spectra, dB	Expanded spectra, dB	Difference, dB	Standard spectra, dB	Expanded spectra, dB	Difference, dB	Standard spectra, dB	Expanded spectra, dB	Difference, dB
200	97.10	97.10	Less than 0.1	90.44	90.44	Less than 0.1	89.41	89.41	Less than 0.1
400	90.71	90.71	Less than 0.1	84.13	84.13	Less than 0.1	82.94	82.94	Less than 0.1
630	86.37	86.37	Less than 0.1	79.88	79.88	Less than 0.1	78.52	78.52	Less than 0.1
1000	81.77	81.77	Less than 0.1	75.41	75.41	Less than 0.1	73.81	73.82	Less than 0.1
2000	74.35	74.35	Less than 0.1	68.32	68.32	Less than 0.1	66.18	66.19	Less than 0.1
4000	65.96	65.96	Less than 0.1	60.46	60.46	Less than 0.1	57.58	57.59	Less than 0.1
6300	59.70	59.70	Less than 0.1	54.69	54.69	Less than 0.1	51.20	51.22	Less than 0.1
10000	52.57	52.58	Less than 0.1	48.09	48.10	Less than 0.1	43.95	43.98	Less than 0.1
16000	44.46	44.47	Less than 0.1	40.44	40.45	Less than 0.1	35.68	35.77	Less than 0.1
25000	36.08	36.11	Less than 0.1	32.11	32.14	Less than 0.1	27.04	27.27	0.23

Bell 407 Departure Events									
Distance, ft	Left Microphone			Center Microphone			Right Microphone		
	Standard spectra, dB	Expanded spectra, dB	Difference, dB	Standard spectra, dB	Expanded spectra, dB	Difference, dB	Standard spectra, dB	Expanded spectra, dB	Difference, dB
200	84.64	84.64	Less than 0.1	86.29	86.29	Less than 0.1	85.56	85.56	Less than 0.1
400	78.15	78.15	Less than 0.1	79.81	79.81	Less than 0.1	79.06	79.06	Less than 0.1
630	73.70	73.70	Less than 0.1	75.40	75.40	Less than 0.1	74.61	74.61	Less than 0.1
1000	68.97	68.97	Less than 0.1	70.74	70.75	Less than 0.1	69.88	69.88	Less than 0.1
2000	61.31	61.31	Less than 0.1	63.31	63.32	Less than 0.1	62.20	62.20	Less than 0.1
4000	52.71	52.71	Less than 0.1	55.13	55.14	Less than 0.1	53.53	53.53	Less than 0.1
6300	46.43	46.43	Less than 0.1	49.19	49.21	Less than 0.1	47.13	47.13	Less than 0.1
10000	39.48	39.48	Less than 0.1	42.53	42.57	Less than 0.1	39.96	39.96	Less than 0.1
16000	31.88	31.88	Less than 0.1	35.00	35.07	Less than 0.1	32.05	32.05	0.15
25000	24.18	24.18	0.17	26.97	27.14	0.17	24.08	24.08	0.35



Bell 407 Approach Events									
Distance, ft	Left Microphone			Center Microphone			Right Microphone		
	Standard spectra, dB	Expanded spectra, dB	Difference, dB	Standard spectra, dB	Expanded spectra, dB	Difference, dB	Standard spectra, dB	Expanded spectra, dB	Difference, dB
200	84.59	84.60	Less than 0.1	91.62	91.63	Less than 0.1	91.54	91.54	Less than 0.1
400	78.29	78.31	Less than 0.1	85.38	85.39	Less than 0.1	85.26	85.27	Less than 0.1
630	74.06	74.08	Less than 0.1	81.20	81.20	Less than 0.1	81.03	81.03	Less than 0.1
1000	69.62	69.65	Less than 0.1	76.82	76.82	Less than 0.1	76.58	76.58	Less than 0.1
2000	62.62	62.64	Less than 0.1	69.86	69.87	Less than 0.1	69.44	69.44	Less than 0.1
4000	54.96	55.00	Less than 0.1	62.13	62.14	Less than 0.1	61.39	61.39	Less than 0.1
6300	49.39	49.45	Less than 0.1	56.38	56.40	Less than 0.1	55.29	55.29	Less than 0.1
10000	43.10	43.18	Less than 0.1	49.73	49.75	Less than 0.1	48.11	48.11	Less than 0.1
16000	35.82	35.98	0.16	41.85	41.90	Less than 0.1	39.52	39.53	Less than 0.1
25000	27.95	28.29	0.35	33.08	33.23	0.15	30.09	30.15	Less than 0.1

Bell 407 Flight Idle Hover Events						
Distance, ft	East Hover Mic			West Hover Mic		
	Standard spectra, dB	Expanded spectra, dB	Difference, dB	Standard spectra, dB	Expanded spectra, dB	Difference, dB
200	83.64	83.64	Less than 0.1	85.16	85.16	Less than 0.1
400	76.90	76.90	Less than 0.1	78.20	78.20	Less than 0.1
630	72.20	72.20	Less than 0.1	73.29	73.29	Less than 0.1
1000	67.06	67.06	Less than 0.1	67.92	67.92	Less than 0.1
2000	58.38	58.38	Less than 0.1	58.91	58.91	Less than 0.1
4000	47.96	47.96	Less than 0.1	48.41	48.41	Less than 0.1
6300	39.84	39.84	Less than 0.1	40.46	40.46	Less than 0.1
10000	30.27	30.27	Less than 0.1	31.16	31.16	Less than 0.1
16000	19.13	19.13	Less than 0.1	20.08	20.08	Less than 0.1
25000	8.09	8.09	Less than 0.1	8.29	8.29	Less than 0.1



Bell 407 Ground Idle Hover Events						
Distance, ft	East Hover Mic			West Hover Mic		
	Standard spectra, dB	Expanded spectra, dB	Difference, dB	Standard spectra, dB	Expanded spectra, dB	Difference, dB
200	74.54	74.54	Less than 0.1	71.82	71.82	Less than 0.1
400	67.10	67.10	Less than 0.1	63.88	63.88	Less than 0.1
630	61.84	61.84	Less than 0.1	58.16	58.16	Less than 0.1
1000	56.12	56.12	Less than 0.1	51.94	51.94	Less than 0.1
2000	46.61	46.61	Less than 0.1	41.85	41.85	Less than 0.1
4000	35.45	35.45	Less than 0.1	30.60	30.60	Less than 0.1
6300	26.72	26.72	Less than 0.1	22.16	22.16	Less than 0.1
10000	16.34	16.34	Less than 0.1	12.49	12.49	Less than 0.1
16000	4.48	4.48	Less than 0.1	1.89	1.89	Less than 0.1
25000	-6.75	-6.75	Less than 0.1	-8.07	-8.07	Less than 0.1

Bell 407 HIGE Hover Events						
Distance, ft	East Hover Mic			West Hover Mic		
	Standard spectra, dB	Expanded spectra, dB	Difference, dB	Standard spectra, dB	Expanded spectra, dB	Difference, dB
200	86.62	86.62	Less than 0.1	89.76	89.76	Less than 0.1
400	80.02	80.02	Less than 0.1	83.07	83.07	Less than 0.1
630	75.46	75.46	Less than 0.1	78.44	78.44	Less than 0.1
1,000	70.52	70.52	Less than 0.1	73.39	73.39	Less than 0.1
2,000	62.25	62.25	Less than 0.1	64.94	64.94	Less than 0.1
4,000	52.36	52.36	Less than 0.1	54.90	54.90	Less than 0.1
6,300	44.55	44.55	Less than 0.1	47.07	47.07	Less than 0.1
10,000	35.12	35.12	Less than 0.1	37.72	37.72	Less than 0.1
16,000	23.71	23.71	Less than 0.1	26.32	26.32	Less than 0.1
25,000	11.55	11.55	Less than 0.1	13.58	13.58	Less than 0.1



Bell 407 HOGE Hover Events						
Distance, ft	East Hover Mic			West Hover Mic		
	Standard spectra, dB	Expanded spectra, dB	Difference, dB	Standard spectra, dB	Expanded spectra, dB	Difference, dB
200	84.63	84.64	Less than 0.1	90.43	89.95	-0.49
400	78.05	78.06	Less than 0.1	83.92	83.43	-0.49
630	73.52	73.52	Less than 0.1	79.45	78.95	-0.49
1000	68.65	68.64	Less than 0.1	74.66	74.16	-0.50
2000	60.62	60.58	Less than 0.1	66.79	66.28	-0.51
4000	51.33	51.23	-0.10	57.69	57.15	-0.54
6300	44.28	44.09	-0.19	50.72	50.15	-0.57
10000	36.04	35.72	-0.31	42.49	41.87	-0.62
16000	26.35	25.87	-0.48	32.64	31.95	-0.69
25000	15.93	15.36	-0.57	21.79	21.02	-0.77



Table B-2. MXA NPD Comparison, Eurocopter EC130

EC130 Level Flight Events			
Center Microphone			
Distance, ft	Standard spectra, dB	Expanded spectra, dB	Difference, dB
200	83.64	83.65	Less than 0.1
400	77.22	77.22	Less than 0.1
630	72.85	72.85	Less than 0.1
1000	68.22	68.22	Less than 0.1
2000	60.77	60.77	Less than 0.1
4000	52.42	52.42	Less than 0.1
6300	46.22	46.22	Less than 0.1
10000	39.09	39.11	Less than 0.1
16000	30.85	30.88	Less than 0.1
25000	22.13	22.21	Less than 0.1

EC130 Departure Events			
Center Microphone			
Distance, ft	Standard spectra, dB	Expanded spectra, dB	Difference, dB
200	83.97	83.97	Less than 0.1
400	77.50	77.50	Less than 0.1
630	73.08	73.08	Less than 0.1
1000	68.40	68.40	Less than 0.1
2000	60.88	60.88	Less than 0.1
4000	52.49	52.49	Less than 0.1
6300	46.26	46.26	Less than 0.1
10000	39.04	39.04	Less than 0.1
16000	30.57	30.57	Less than 0.1
25000	21.48	21.50	Less than 0.1

EC130 Approach Events			
Center Microphone			
Distance, ft	Standard spectra, dB	Expanded spectra, dB	Difference, dB
200	91.19	91.19	Less than 0.1
400	84.96	84.96	Less than 0.1
630	80.78	80.78	Less than 0.1
1000	76.41	76.41	Less than 0.1
2000	69.50	69.50	Less than 0.1
4000	61.89	61.89	Less than 0.1
6300	56.31	56.31	Less than 0.1
10000	49.93	49.93	Less than 0.1
16000	42.47	42.48	Less than 0.1
25000	34.23	34.24	Less than 0.1



Table B-3. MXA NPD Comparison, Robinson R22

R22 Level Flight Events			
Center Microphone			
Distance, ft	Standard spectra, dB	Expanded spectra, dB	Difference, dB
200	90.04	90.04	Less than 0.1
400	86.64	86.64	Less than 0.1
630	84.26	84.26	Less than 0.1
1000	81.66	81.66	Less than 0.1
2000	77.28	77.28	Less than 0.1
4000	72.08	72.08	Less than 0.1
6300	68.04	68.05	Less than 0.1
10000	63.28	63.29	Less than 0.1
16000	57.67	57.68	Less than 0.1
25000	51.65	51.67	Less than 0.1

R22 Departure Events			
Center Microphone			
Distance, ft	Standard spectra, dB	Expanded spectra, dB	Difference, dB
200	88.43	88.43	Less than 0.1
400	84.87	84.87	Less than 0.1
630	82.32	82.32	Less than 0.1
1000	79.50	79.50	Less than 0.1
2000	74.75	74.75	Less than 0.1
4000	69.31	69.31	Less than 0.1
6300	65.35	65.35	Less than 0.1
10000	61.01	61.01	Less than 0.1
16000	56.26	56.26	Less than 0.1
25000	51.41	51.42	Less than 0.1

R22 Approach Events			
Center Microphone			
Distance, ft	Standard spectra, dB	Expanded spectra, dB	Difference, dB
200	89.64	89.64	Less than 0.1
400	86.22	86.22	Less than 0.1
630	83.80	83.80	Less than 0.1
1000	81.16	81.16	Less than 0.1
2000	76.72	76.72	Less than 0.1
4000	71.45	71.45	Less than 0.1
6300	67.42	67.42	Less than 0.1
10000	62.75	62.75	Less than 0.1
16000	57.42	57.42	Less than 0.1
25000	51.85	51.85	Less than 0.1



Table 0-4. MXA NPD Comparison, Robinson R44

R44 Level Flight Events									
Distance, ft	Left Microphone			Center Microphone			Right Microphone		
	Standard spectra, dB	Expanded spectra, dB	Difference, dB	Standard spectra, dB	Expanded spectra, dB	Difference, dB	Standard spectra, dB	Expanded spectra, dB	Difference, dB
200	84.12	84.13	Less than 0.1	84.66	84.66	Less than 0.1	84.73	84.73	Less than 0.1
400	77.71	77.71	Less than 0.1	78.36	78.36	Less than 0.1	78.31	78.31	Less than 0.1
630	73.35	73.35	Less than 0.1	74.12	74.12	Less than 0.1	73.93	73.94	Less than 0.1
1000	68.72	68.73	Less than 0.1	69.66	69.66	Less than 0.1	69.29	69.30	Less than 0.1
2000	61.30	61.30	Less than 0.1	62.58	62.58	Less than 0.1	61.81	61.82	Less than 0.1
4000	53.04	53.05	Less than 0.1	54.77	54.77	Less than 0.1	53.50	53.50	Less than 0.1
6300	47.03	47.04	Less than 0.1	49.04	49.04	Less than 0.1	47.49	47.50	Less than 0.1
10000	40.31	40.34	Less than 0.1	42.52	42.53	Less than 0.1	40.83	40.86	Less than 0.1
16000	32.72	32.77	Less than 0.1	34.94	34.96	Less than 0.1	33.38	33.43	Less than 0.1
25000	24.72	24.83	0.11	26.70	26.74	Less than 0.1	25.48	25.60	0.12

R44 Departure Events									
Distance, ft	Left Microphone			Center Microphone			Right Microphone		
	Standard spectra, dB	Expanded spectra, dB	Difference, dB	Standard spectra, dB	Expanded spectra, dB	Difference, dB	Standard spectra, dB	Expanded spectra, dB	Difference, dB
200	82.57	82.57	Less than 0.1	81.54	81.54	Less than 0.1	84.13	84.13	Less than 0.1
400	76.20	76.20	Less than 0.1	75.26	75.27	Less than 0.1	77.70	77.70	Less than 0.1
630	71.89	71.89	Less than 0.1	71.05	71.05	Less than 0.1	73.32	73.32	Less than 0.1
1000	67.36	67.36	Less than 0.1	66.63	66.63	Less than 0.1	68.67	68.67	Less than 0.1
2000	60.12	60.12	Less than 0.1	59.69	59.69	Less than 0.1	61.18	61.18	Less than 0.1
4000	52.10	52.10	Less than 0.1	52.14	52.14	Less than 0.1	52.87	52.87	Less than 0.1
6300	46.25	46.25	Less than 0.1	46.71	46.72	Less than 0.1	46.87	46.87	Less than 0.1
10000	39.69	39.69	Less than 0.1	40.62	40.63	Less than 0.1	40.22	40.22	Less than 0.1
16000	32.32	32.32	Less than 0.1	33.61	33.63	Less than 0.1	32.73	32.73	Less than 0.1
25000	24.67	24.67	Less than 0.1	25.96	25.99	Less than 0.1	24.75	24.75	Less than 0.1



R44 Approach Events									
	Left Microphone			Center Microphone			Right Microphone		
Distance, ft	Standard spectra, dB	Expanded spectra, dB	Difference, dB	Standard spectra, dB	Expanded spectra, dB	Difference, dB	Standard spectra, dB	Expanded spectra, dB	Difference, dB
200	88.44	88.44	Less than 0.1	87.40	87.40	Less than 0.1	82.88	82.89	Less than 0.1
400	82.17	82.17	Less than 0.1	81.15	81.15	Less than 0.1	76.61	76.62	Less than 0.1
630	77.93	77.93	Less than 0.1	76.95	76.95	Less than 0.1	72.40	72.40	Less than 0.1
1000	73.48	73.48	Less than 0.1	72.55	72.55	Less than 0.1	67.99	67.99	Less than 0.1
2000	66.36	66.36	Less than 0.1	65.57	65.57	Less than 0.1	61.01	61.01	Less than 0.1
4000	58.36	58.37	Less than 0.1	57.85	57.85	Less than 0.1	53.37	53.37	Less than 0.1
6300	52.41	52.41	Less than 0.1	52.16	52.17	Less than 0.1	47.82	47.83	Less than 0.1
10000	45.56	45.57	Less than 0.1	45.66	45.66	Less than 0.1	41.59	41.60	Less than 0.1
16000	37.58	37.59	Less than 0.1	38.07	38.08	Less than 0.1	34.45	34.48	Less than 0.1
25000	28.83	28.85	Less than 0.1	29.73	29.74	Less than 0.1	26.72	26.77	Less than 0.1



R44 Flight Idle Hover Events						
Distance, ft	East Hover Mic			West Hover Mic		
	Standard spectra, dB	Expanded spectra, dB	Difference, dB	Standard spectra, dB	Expanded spectra, dB	Difference, dB
200	76.82	76.82	Less than 0.1	82.98	82.98	Less than 0.1
400	70.24	70.24	Less than 0.1	76.35	76.35	Less than 0.1
630	65.71	65.71	Less than 0.1	71.76	71.76	Less than 0.1
1000	60.85	60.85	Less than 0.1	66.82	66.82	Less than 0.1
2000	52.95	52.95	Less than 0.1	58.74	58.74	Less than 0.1
4000	44.22	44.22	Less than 0.1	49.73	49.73	Less than 0.1
6300	38.01	38.01	Less than 0.1	43.31	43.31	Less than 0.1
10000	31.16	31.16	Less than 0.1	36.25	36.25	Less than 0.1
16000	23.32	23.32	Less than 0.1	28.24	28.24	Less than 0.1
25000	14.71	14.71	Less than 0.1	19.54	19.54	Less than 0.1

R44 Ground Idle Hover Events						
Distance, ft	East Hover Mic			West Hover Mic		
	Standard spectra, dB	Expanded spectra, dB	Difference, dB	Standard spectra, dB	Expanded spectra, dB	Difference, dB
200	75.59	75.59	Less than 0.1	77.63	77.63	Less than 0.1
400	69.00	69.00	Less than 0.1	71.03	71.03	Less than 0.1
630	64.46	64.46	Less than 0.1	66.51	66.51	Less than 0.1
1000	59.61	59.61	Less than 0.1	61.71	61.71	Less than 0.1
2000	51.79	51.79	Less than 0.1	54.05	54.05	Less than 0.1
4000	43.34	43.34	Less than 0.1	45.81	45.81	Less than 0.1
6300	37.52	37.52	Less than 0.1	40.03	40.03	Less than 0.1
10000	31.25	31.25	Less than 0.1	33.65	33.65	Less than 0.1
16000	24.17	24.17	Less than 0.1	26.33	26.33	Less than 0.1
25000	16.34	16.34	Less than 0.1	18.29	18.29	Less than 0.1



R44 HIGE Hover Events						
Distance, ft	East Hover Mic			West Hover Mic		
	Standard spectra, dB	Expanded spectra, dB	Difference, dB	Standard spectra, dB	Expanded spectra, dB	Difference, dB
200	83.78	83.78	Less than 0.1	87.85	87.85	Less than 0.1
400	77.19	77.19	Less than 0.1	81.22	81.22	Less than 0.1
630	72.64	72.64	Less than 0.1	76.63	76.63	Less than 0.1
1000	67.72	67.72	Less than 0.1	71.65	71.65	Less than 0.1
2000	59.55	59.55	Less than 0.1	63.40	63.40	Less than 0.1
4000	50.05	50.05	Less than 0.1	53.81	53.81	Less than 0.1
6300	42.92	42.92	Less than 0.1	46.62	46.62	Less than 0.1
10000	35.02	35.02	Less than 0.1	38.63	38.63	Less than 0.1
16000	26.46	26.46	Less than 0.1	29.95	29.95	Less than 0.1
25000	17.68	17.68	Less than 0.1	21.04	21.04	Less than 0.1

R44 HOGE Hover Events						
Distance, ft	East Hover Mic			West Hover Mic		
	Standard spectra, dB	Expanded spectra, dB	Difference, dB	Standard spectra, dB	Expanded spectra, dB	Difference, dB
200	83.60	83.60	Less than 0.1	89.14	89.14	Less than 0.1
400	77.08	77.08	Less than 0.1	82.59	82.59	Less than 0.1
630	72.59	72.59	Less than 0.1	78.09	78.09	Less than 0.1
1000	67.78	67.78	Less than 0.1	73.26	73.26	Less than 0.1
2000	59.88	59.88	Less than 0.1	65.33	65.33	Less than 0.1
4000	50.75	50.75	Less than 0.1	56.22	56.22	Less than 0.1
6300	43.81	43.81	Less than 0.1	49.35	49.35	Less than 0.1
10000	35.69	35.69	Less than 0.1	41.37	41.37	Less than 0.1
16000	25.96	25.96	Less than 0.1	31.87	31.87	Less than 0.1
25000	15.05	15.05	Less than 0.1	21.00	21.00	Less than 0.1



Table 0-5. MXA NPD comparison, Schweizer 300C

300C Level Flight Events									
Distance, ft	Left Microphone			Center Microphone			Right Microphone		
	Standard spectra, dB	Expanded spectra, dB	Difference, dB	Standard spectra, dB	Expanded spectra, dB	Difference, dB	Standard spectra, dB	Expanded spectra, dB	Difference, dB
200	81.85	81.85	Less than 0.1	79.70	79.70	Less than 0.1	82.57	82.57	Less than 0.1
400	75.42	75.42	Less than 0.1	73.27	73.27	Less than 0.1	76.13	76.13	Less than 0.1
630	71.03	71.03	Less than 0.1	68.91	68.91	Less than 0.1	71.74	71.74	Less than 0.1
1000	66.36	66.37	Less than 0.1	64.30	64.30	Less than 0.1	67.06	67.06	Less than 0.1
2000	58.80	58.80	Less than 0.1	56.96	56.96	Less than 0.1	59.43	59.43	Less than 0.1
4000	50.25	50.25	Less than 0.1	48.88	48.88	Less than 0.1	50.75	50.75	Less than 0.1
6300	43.90	43.90	Less than 0.1	43.00	43.01	Less than 0.1	44.25	44.25	Less than 0.1
10000	36.66	36.67	Less than 0.1	36.37	36.37	Less than 0.1	36.78	36.79	Less than 0.1
16000	28.31	28.34	Less than 0.1	28.63	28.64	Less than 0.1	28.09	28.11	Less than 0.1
25000	19.27	19.35	Less than 0.1	20.08	20.09	Less than 0.1	18.60	18.67	Less than 0.1

300C Departure Events									
Distance, ft	Left Microphone			Center Microphone			Right Microphone		
	Standard spectra, dB	Expanded spectra, dB	Difference, dB	Standard spectra, dB	Expanded spectra, dB	Difference, dB	Standard spectra, dB	Expanded spectra, dB	Difference, dB
200	81.31	81.31	Less than 0.1	81.04	81.04	Less than 0.1	81.60	81.60	Less than 0.1
400	74.82	74.82	Less than 0.1	74.66	74.66	Less than 0.1	75.14	75.14	Less than 0.1
630	70.38	70.38	Less than 0.1	70.33	70.33	Less than 0.1	70.74	70.74	Less than 0.1
1000	65.64	65.64	Less than 0.1	65.75	65.76	Less than 0.1	66.05	66.05	Less than 0.1
2000	58.00	58.00	Less than 0.1	58.44	58.44	Less than 0.1	58.45	58.45	Less than 0.1
4000	49.46	49.46	Less than 0.1	50.33	50.33	Less than 0.1	49.91	49.91	Less than 0.1
6300	43.21	43.21	Less than 0.1	44.39	44.39	Less than 0.1	43.62	43.62	Less than 0.1
10000	36.14	36.14	Less than 0.1	37.63	37.63	Less than 0.1	36.49	36.49	Less than 0.1
16000	27.93	27.93	Less than 0.1	29.72	29.73	Less than 0.1	28.28	28.28	Less than 0.1
25000	18.92	18.92	Less than 0.1	20.90	20.92	Less than 0.1	19.39	19.39	Less than 0.1



300C Approach Events									
Distance, ft	Left Microphone			Center Microphone			Right Microphone		
	Standard spectra, dB	Expanded spectra, dB	Difference, dB	Standard spectra, dB	Expanded spectra, dB	Difference, dB	Standard spectra, dB	Expanded spectra, dB	Difference, dB
200	80.59	80.59	Less than 0.1	79.84	79.84	Less than 0.1	80.44	80.44	Less than 0.1
400	74.11	74.11	Less than 0.1	73.45	73.45	Less than 0.1	74.04	74.04	Less than 0.1
630	69.68	69.68	Less than 0.1	69.13	69.13	Less than 0.1	69.69	69.70	Less than 0.1
1000	64.96	64.96	Less than 0.1	64.59	64.59	Less than 0.1	65.09	65.10	Less than 0.1
2000	57.31	57.31	Less than 0.1	57.38	57.38	Less than 0.1	57.68	57.68	Less than 0.1
4000	48.75	48.75	Less than 0.1	49.50	49.50	Less than 0.1	49.39	49.40	Less than 0.1
6300	42.49	42.49	Less than 0.1	43.77	43.78	Less than 0.1	43.31	43.32	Less than 0.1
10000	35.45	35.45	Less than 0.1	37.27	37.27	Less than 0.1	36.44	36.46	Less than 0.1
16000	27.40	27.41	Less than 0.1	29.60	29.61	Less than 0.1	28.52	28.57	Less than 0.1
25000	18.67	18.69	Less than 0.1	21.02	21.04	Less than 0.1	19.91	20.04	Less than 0.1



300C Flight Idle Hover Events						
Distance, ft	East Hover Mic			West Hover Mic		
	Standard spectra, dB	Expanded spectra, dB	Difference, dB	Standard spectra, dB	Expanded spectra, dB	Difference, dB
200	71.72	71.72	Less than 0.1	68.68	68.68	Less than 0.1
400	64.97	64.97	Less than 0.1	61.91	61.91	Less than 0.1
630	60.25	60.25	Less than 0.1	57.20	57.20	Less than 0.1
1000	55.09	55.09	Less than 0.1	52.09	52.09	Less than 0.1
2000	46.38	46.38	Less than 0.1	43.62	43.62	Less than 0.1
4000	35.96	35.96	Less than 0.1	33.81	33.81	Less than 0.1
6300	27.95	27.95	Less than 0.1	26.40	26.40	Less than 0.1
10000	18.90	18.90	Less than 0.1	17.94	17.94	Less than 0.1
16000	9.30	9.30	Less than 0.1	8.68	8.68	Less than 0.1
25000	0.73	0.73	Less than 0.1	0.09	0.09	Less than 0.1

300C Ground Idle Hover Events						
Distance, ft	East Hover Mic			West Hover Mic		
	Standard spectra, dB	Expanded spectra, dB	Difference, dB	Standard spectra, dB	Expanded spectra, dB	Difference, dB
200	60.96	60.96	Less than 0.1	52.81	52.81	Less than 0.1
400	54.28	54.28	Less than 0.1	46.06	46.06	Less than 0.1
630	49.63	49.63	Less than 0.1	41.43	41.43	Less than 0.1
1000	44.58	44.58	Less than 0.1	36.50	36.50	Less than 0.1
2000	36.11	36.11	Less than 0.1	28.52	28.52	Less than 0.1
4000	26.02	26.02	Less than 0.1	19.64	19.64	Less than 0.1
6300	18.36	18.36	Less than 0.1	13.32	13.32	Less than 0.1
10000	10.03	10.03	Less than 0.1	6.67	6.67	Less than 0.1
16000	1.84	1.84	Less than 0.1	-0.08	-0.08	Less than 0.1
25000	-5.26	-5.26	Less than 0.1	-6.59	-6.59	Less than 0.1



300C HIGE Hover Events						
Distance, ft	East Hover Mic			West Hover Mic		
	Standard spectra, dB	Expanded spectra, dB	Difference, dB	Standard spectra, dB	Expanded spectra, dB	Difference, dB
200	76.11	76.11	Less than 0.1	78.65	78.65	Less than 0.1
400	69.38	69.38	Less than 0.1	71.86	71.86	Less than 0.1
630	64.68	64.68	Less than 0.1	67.10	67.10	Less than 0.1
1,000	59.52	59.52	Less than 0.1	61.92	61.92	Less than 0.1
2,000	50.73	50.73	Less than 0.1	53.20	53.20	Less than 0.1
4,000	40.08	40.08	Less than 0.1	42.88	42.88	Less than 0.1
6,300	31.77	31.77	Less than 0.1	34.85	34.85	Less than 0.1
10,000	22.19	22.19	Less than 0.1	25.29	25.29	Less than 0.1
16,000	11.90	11.90	Less than 0.1	14.00	14.00	Less than 0.1
25,000	2.85	2.85	Less than 0.1	2.71	2.71	Less than 0.1

300C HIGE Hover Events						
Distance, ft	East Hover Mic			West Hover Mic		
	Standard spectra, dB	Expanded spectra, dB	Difference, dB	Standard spectra, dB	Expanded spectra, dB	Difference, dB
200	78.42	78.42	Less than 0.1	81.01	81.01	Less than 0.1
400	71.89	71.89	Less than 0.1	74.48	74.48	Less than 0.1
630	67.39	67.39	Less than 0.1	69.99	69.99	Less than 0.1
1000	62.56	62.56	Less than 0.1	65.17	65.17	Less than 0.1
2000	54.60	54.60	Less than 0.1	57.20	57.20	Less than 0.1
4000	45.36	45.36	Less than 0.1	47.89	47.89	Less than 0.1
6300	38.32	38.32	Less than 0.1	40.73	40.73	Less than 0.1
10000	30.13	30.13	Less than 0.1	32.31	32.31	Less than 0.1
16000	20.53	20.53	Less than 0.1	22.35	22.35	Less than 0.1
25000	9.91	9.91	Less than 0.1	11.41	11.41	Less than 0.1



Appendix D: Line of Sight Blockage Adjustment

Table D-1. Line of Sight Blockage adjustment, Dynamic Events

Aircraft	Event	Barrier Elevation, ft	Path Length Difference (δ_0), ft	expanded	standard	difference
Bell 407	Level Flight	6	0.1	-5.55	-5.74	0.19
		18	1	-7.91	-9.01	1.10
		40	5	-11.80	-14.11	2.30
		57	10	-14.23	-16.89	2.66
		131	50	-18.00	-18.00	0.00
		192	100	-18.00	-18.00	0.00
	Departure	6	0.1	-5.27	-5.84	0.57
		18	1	-6.55	-9.36	2.81
		40	5	-9.52	-14.69	5.16
		57	10	-11.75	-17.48	5.73
		131	50	-18.00	-18.00	0.00
		192	100	-18.00	-18.00	0.00
	Approach	6	0.1	-5.31	-5.96	0.65
		18	1	-6.72	-10.32	3.60
		40	5	-9.71	-16.31	6.60
		57	10	-11.93	-18.00	6.07
		131	50	-18.00	-18.00	0.00
		192	100	-18.00	-18.00	0.00
Eurocopter EC130	Level Flight	6	0.1	-5.74	-6.36	0.63
		18	1	-7.81	-10.81	3.00
		40	5	-10.76	-16.50	5.74
		57	10	-12.76	-18.00	5.24
		131	50	-18.00	-18.00	0.00
		192	100	-18.00	-18.00	0.00
	Departure	6	0.1	-5.94	-6.55	0.62
		18	1	-8.35	-11.51	3.16
		40	5	-11.25	-17.58	6.33
		57	10	-13.16	-18.00	4.84
		131	50	-18.00	-18.00	0.00
		192	100	-18.00	-18.00	0.00
Approach	6	0.1	-5.73	-5.95	0.22	
	18	1	-8.72	-10.28	1.56	



		40	5	-12.50	-16.38	3.88
		57	10	-14.63	-18.00	3.37
		131	50	-18.00	-18.00	0.00
		192	100	-18.00	-18.00	0.00
Robinson R22	Level Flight	6	0.1	-5.89	-6.01	0.12
		18	1	-8.95	-9.59	0.64
		40	5	-13.51	-14.95	1.43
		57	10	-16.04	-17.73	1.69
		131	50	-18.00	-18.00	0.00
		192	100	-18.00	-18.00	0.00
	Departure	6	0.1	-5.71	-5.76	0.05
		18	1	-8.26	-8.51	0.25
		40	5	-12.82	-13.49	0.66
		57	10	-15.42	-16.27	0.85
		131	50	-18.00	-18.00	0.00
		192	100	-18.00	-18.00	0.00
	Approach	6	0.1	-5.90	-5.98	0.08
		18	1	-9.05	-9.49	0.44
		40	5	-13.67	-14.75	1.08
		57	10	-16.18	-17.52	1.34
		131	50	-18.00	-18.00	0.00
		192	100	-18.00	-18.00	0.00
Robinson R44	Level Flight	6	0.1	-5.34	-5.82	0.48
		18	1	-6.68	-9.29	2.61
		40	5	-9.03	-14.38	5.35
		57	10	-10.77	-17.12	6.35
		131	50	-16.55	-18.00	1.45
		192	100	-18.00	-18.00	0.00
	Departure	6	0.1	-5.36	-5.77	0.41
		18	1	-6.90	-9.53	2.63
		40	5	-9.39	-15.27	5.88
		57	10	-11.14	-18.00	6.86
		131	50	-16.86	-18.00	1.14
		192	100	-18.00	-18.00	0.00
	Approach	6	0.1	-7.94	-10.11	2.17
		18	1	-9.48	-13.86	4.38
		40	5	-11.97	-18.00	6.03
		57	10	-13.72	-18.00	4.28



		131	50	-18.00	-18.00	0.00	
		192	100	-18.00	-18.00	0.00	
Schweizer 300C	Level Flight	6	0.1	-5.56	-5.92	0.36	
		18	1	-7.66	-9.75	2.08	
		40	5	-10.75	-15.33	4.58	
		57	10	-12.75	-18.00	5.25	
		131	50	-18.00	-18.00	0.00	
		192	100	-18.00	-18.00	0.00	
	Departure	6	0.1	-5.65	-6.00	0.35	
		18	1	-7.93	-10.02	2.09	
		40	5	-10.94	-15.64	4.70	
		57	10	-12.82	-18.00	5.18	
		131	50	-18.00	-18.00	0.00	
		192	100	-18.00	-18.00	0.00	
	Approach	6	0.1	-5.51	-5.89	0.38	
		18	1	-7.47	-9.73	2.26	
		40	5	-10.47	-15.30	4.82	
		57	10	-12.48	-18.00	5.52	
131		50	-18.00	-18.00	0.00		
192		100	-18.00	-18.00	0.00		



Appendix E: C-Weighted Metrics

Table E-1. C-weight Adjustment, Bell 407

Level Flight			
Distance, ft	Expanded spectra, dB	Standard spectra, dB	Difference (S-E), dB
200	-7.14	-6.38	-0.75
400	-7.32	-6.55	-0.77
630	-7.51	-6.72	-0.79
1000	-7.79	-6.98	-0.82
2000	-8.45	-7.56	-0.89
4000	-9.57	-8.53	-1.04
6300	-10.71	-9.49	-1.21
10000	-12.34	-10.86	-1.48
16000	-14.70	-12.82	-1.88
25000	-17.78	-15.38	-2.41
Departure			
Distance, ft	Expanded spectra, dB	Standard spectra, dB	Difference (S-E), dB
200	-9.19	-5.27	-3.91
400	-9.55	-5.55	-4.00
630	-9.91	-5.83	-4.09
1000	-10.42	-6.20	-4.22
2000	-11.54	-7.00	-4.54
4000	-13.27	-8.17	-5.10
6300	-14.89	-9.23	-5.66
10000	-17.04	-10.59	-6.45
16000	-19.86	-12.31	-7.55
25000	-23.20	-14.35	-8.85
Approach			
Distance, ft	Expanded spectra, dB	Standard spectra, dB	Difference (S-E), dB
200	-9.02	-5.41	-3.61
400	-9.17	-5.49	-3.68
630	-9.34	-5.58	-3.76
1000	-9.60	-5.72	-3.88
2000	-10.26	-6.04	-4.22
4000	-11.51	-6.62	-4.88
6300	-12.86	-7.23	-5.64
10000	-14.93	-8.12	-6.81
16000	-18.01	-9.45	-8.55
25000	-22.03	-11.28	-10.75
Flight Idle			
Distance, ft	Expanded spectra, dB	Standard spectra, dB	Difference (S-E), dB
200	-7.71	-7.71	Less than 0.1
400	-7.85	-7.85	Less than 0.1
630	-7.99	-7.99	Less than 0.1
1000	-8.21	-8.21	Less than 0.1
2000	-8.72	-8.72	Less than 0.1
4000	-9.58	-9.58	Less than 0.1
6300	-10.41	-10.41	Less than 0.1
10000	-11.56	-11.56	Less than 0.1



16000	-13.04	-13.04	Less than 0.1
25000	-14.45	-14.45	Less than 0.1
Ground Idle			
Distance, ft	Expanded spectra, dB	Standard spectra, dB	Difference (S-E), dB
200	1.20	1.20	Less than 0.1
400	1.04	1.04	Less than 0.1
630	0.89	0.89	Less than 0.1
1000	0.69	0.69	Less than 0.1
2000	0.27	0.27	Less than 0.1
4000	-0.49	-0.49	Less than 0.1
6300	-1.56	-1.56	Less than 0.1
10000	-3.92	-3.91	Less than 0.1
16000	-8.33	-8.32	Less than 0.1
25000	-12.90	-12.89	Less than 0.1
HIGE			
Distance, ft	Expanded spectra, dB	Standard spectra, dB	Difference (S-E), dB
200	0.15	0.15	Less than 0.1
400	0.06	0.06	Less than 0.1
630	-0.02	-0.02	Less than 0.1
1000	-0.15	-0.15	Less than 0.1
2000	-0.47	-0.47	Less than 0.1
4000	-1.07	-1.07	Less than 0.1
6300	-1.84	-1.84	Less than 0.1
10000	-3.40	-3.40	Less than 0.1
16000	-6.80	-6.79	Less than 0.1
25000	-12.14	-12.12	Less than 0.1
HOG E			
Distance, ft	Expanded spectra, dB	Standard spectra, dB	Difference (S-E), dB
200	-0.50	-0.63	-0.13
400	-0.63	-0.77	-0.14
630	-0.77	-0.92	-0.15
1000	-0.97	-1.13	-0.16
2000	-1.45	-1.63	-0.18
4000	-2.26	-2.45	-0.19
6300	-3.10	-3.27	-0.17
10000	-4.39	-4.49	-0.10
16000	-6.35	-6.30	Less than 0.1
25000	-8.74	-8.50	0.24



Table E-2. C-weight Adjustment, Eurocopter EC130

Level Flight			
Distance, ft	Expanded spectra, dB	Standard spectra, dB	Difference (S-E), dB
200	-3.02	-2.14	-0.88
400	-3.45	-2.50	-0.95
630	-3.87	-2.86	-1.02
1000	-4.46	-3.34	-1.11
2000	-5.63	-4.29	-1.34
4000	-7.29	-5.55	-1.74
6300	-8.86	-6.70	-2.17
10000	-11.12	-8.29	-2.83
16000	-14.30	-10.48	-3.82
25000	-18.12	-12.99	-5.13
Departure			
Distance, ft	Expanded spectra, dB	Standard spectra, dB	Difference (S-E), dB
200	-1.99	-1.52	-0.47
400	-2.42	-1.90	-0.51
630	-2.86	-2.29	-0.56
1000	-3.46	-2.82	-0.64
2000	-4.60	-3.80	-0.80
4000	-6.05	-4.95	-1.10
6300	-7.37	-5.92	-1.45
10000	-9.33	-7.26	-2.07
16000	-12.31	-9.17	-3.15
25000	-16.19	-11.38	-4.81
Approach			
Distance, ft	Expanded spectra, dB	Standard spectra, dB	Difference (S-E), dB
200	-5.62	-5.32	-0.31
400	-5.80	-5.48	-0.32
630	-5.98	-5.65	-0.33
1000	-6.22	-5.87	-0.35
2000	-6.71	-6.31	-0.39
4000	-7.46	-6.97	-0.49
6300	-8.20	-7.58	-0.61
10000	-9.28	-8.43	-0.85
16000	-10.91	-9.58	-1.33
25000	-13.25	-11.01	-2.24



Table E-3. C-weight Adjustment, Robinson R22

Level Flight			
Distance, ft	Expanded spectra, dB	Standard spectra, dB	Difference (S-E), dB
200	-3.73	-3.48	-0.26
400	-4.18	-3.91	-0.27
630	-4.62	-4.33	-0.29
1000	-5.20	-4.90	-0.31
2000	-6.35	-5.99	-0.35
4000	-7.93	-7.49	-0.43
6300	-9.35	-8.84	-0.51
10000	-11.26	-10.62	-0.64
16000	-13.69	-12.86	-0.83
25000	-16.30	-15.19	-1.10
Departure			
Distance, ft	Expanded spectra, dB	Standard spectra, dB	Difference (S-E), dB
200	-4.19	-4.08	-0.11
400	-4.87	-4.75	-0.12
630	-5.58	-5.46	-0.13
1000	-6.59	-6.46	-0.13
2000	-8.61	-8.46	-0.15
4000	-11.04	-10.87	-0.17
6300	-12.79	-12.60	-0.19
10000	-14.63	-14.42	-0.22
16000	-16.52	-16.26	-0.26
25000	-18.24	-17.93	-0.32
Approach			
Distance, ft	Expanded spectra, dB	Standard spectra, dB	Difference (S-E), dB
200	-3.76	-3.63	-0.13
400	-4.20	-4.06	-0.14
630	-4.63	-4.48	-0.14
1000	-5.19	-5.04	-0.16
2000	-6.31	-6.13	-0.18
4000	-7.84	-7.62	-0.22
6300	-9.22	-8.96	-0.26
10000	-11.03	-10.70	-0.33
16000	-13.30	-12.86	-0.44
25000	-15.77	-15.17	-0.60



Table E-4. C-weight Adjustment, Robinson R44

Level Flight			
Distance, ft	Expanded spectra, dB	Standard spectra, dB	Difference (S-E), dB
200	-6.97	-5.71	-1.26
400	-7.16	-5.86	-1.29
630	-7.35	-6.02	-1.33
1000	-7.64	-6.26	-1.38
2000	-8.33	-6.81	-1.52
4000	-9.54	-7.75	-1.80
6300	-10.79	-8.68	-2.11
10000	-12.61	-10.02	-2.60
16000	-15.28	-11.94	-3.34
25000	-18.77	-14.47	-4.30
Departure			
Distance, ft	Expanded spectra, dB	Standard spectra, dB	Difference (S-E), dB
200	-7.80	-6.77	-1.03
400	-7.99	-6.93	-1.05
630	-8.18	-7.10	-1.08
1000	-8.45	-7.33	-1.12
2000	-9.05	-7.83	-1.22
4000	-9.99	-8.57	-1.42
6300	-10.87	-9.21	-1.66
10000	-12.10	-10.03	-2.07
16000	-13.91	-11.12	-2.79
25000	-16.42	-12.47	-3.95
Approach			
Distance, ft	Expanded spectra, dB	Standard spectra, dB	Difference (S-E), dB
200	-6.45	-5.90	-0.55
400	-6.57	-6.00	-0.56
630	-6.69	-6.11	-0.58
1000	-6.88	-6.28	-0.60
2000	-7.35	-6.68	-0.67
4000	-8.17	-7.35	-0.82
6300	-9.01	-8.01	-1.00
10000	-10.23	-8.91	-1.33
16000	-12.05	-10.11	-1.94
25000	-14.56	-11.55	-3.01
Flight Idle			
Distance, ft	Expanded spectra, dB	Standard spectra, dB	Difference (S-E), dB
200	-2.51	-2.51	Less than 0.1
400	-7.85	-7.85	Less than 0.1
630	-7.99	-7.99	Less than 0.1
1000	-8.21	-8.21	Less than 0.1
2000	-8.72	-8.72	Less than 0.1
4000	-9.58	-9.58	Less than 0.1
6300	-10.41	-10.41	Less than 0.1
10000	-11.56	-11.56	Less than 0.1
16000	-13.04	-13.04	Less than 0.1
25000	-14.45	-14.45	Less than 0.1



Ground Idle			
Distance, ft	Expanded spectra, dB	Standard spectra, dB	Difference (S-E), dB
200	-3.84	-3.84	Less than 0.1
400	-4.18	-4.18	Less than 0.1
630	-4.54	-4.54	Less than 0.1
1000	-5.04	-5.04	Less than 0.1
2000	-6.11	-6.11	Less than 0.1
4000	-7.40	-7.40	Less than 0.1
6300	-8.20	-8.20	Less than 0.1
10000	-8.92	-8.92	Less than 0.1
16000	-9.70	-9.69	Less than 0.1
25000	-10.67	-10.66	Less than 0.1

HIGE			
Distance, ft	Expanded spectra, dB	Standard spectra, dB	Difference (S-E), dB
200	-0.89	-0.89	Less than 0.1
400	-1.07	-1.07	Less than 0.1
630	-1.26	-1.26	Less than 0.1
1000	-1.56	-1.56	Less than 0.1
2000	-2.32	-2.31	Less than 0.1
4000	-3.71	-3.71	Less than 0.1
6300	-5.09	-5.09	Less than 0.1
10000	-6.77	-6.77	Less than 0.1
16000	-8.40	-8.40	Less than 0.1
25000	-9.83	-9.82	Less than 0.1

HOGE			
Distance, ft	Expanded spectra, dB	Standard spectra, dB	Difference (S-E), dB
200	-0.81	-0.81	Less than 0.1
400	-0.94	-0.93	Less than 0.1
630	-1.07	-1.07	Less than 0.1
1000	-1.27	-1.27	Less than 0.1
2000	-1.72	-1.72	Less than 0.1
4000	-2.45	-2.45	Less than 0.1
6300	-3.16	-3.15	Less than 0.1
10000	-4.19	-4.18	Less than 0.1
16000	-5.96	-5.94	Less than 0.1
25000	-9.03	-8.99	Less than 0.1



Table E-5. C-weight Adjustment, Schweizer 300C

Level Flight			
Distance, ft	Expanded spectra, dB	Standard spectra, dB	Difference (S-E), dB
200	-5.63	-4.92	-0.71
400	-5.90	-5.16	-0.74
630	-6.17	-5.40	-0.76
1000	-6.54	-5.74	-0.80
2000	-7.37	-6.46	-0.91
4000	-8.61	-7.50	-1.11
6300	-9.74	-8.40	-1.34
10000	-11.30	-9.57	-1.73
16000	-13.58	-11.19	-2.39
25000	-16.77	-13.35	-3.42
Departure			
Distance, ft	Expanded spectra, dB	Standard spectra, dB	Difference (S-E), dB
200	-4.93	-4.47	-0.46
400	-5.15	-4.67	-0.48
630	-5.38	-4.88	-0.50
1000	-5.71	-5.18	-0.53
2000	-6.44	-5.84	-0.60
4000	-7.60	-6.84	-0.76
6300	-8.69	-7.75	-0.94
10000	-10.21	-8.95	-1.26
16000	-12.48	-10.66	-1.82
25000	-15.72	-13.01	-2.71
Approach			
Distance, ft	Expanded spectra, dB	Standard spectra, dB	Difference (S-E), dB
200	-6.29	-5.39	-0.90
400	-6.51	-5.58	-0.93
630	-6.73	-5.77	-0.96
1000	-7.04	-6.04	-1.00
2000	-7.74	-6.62	-1.12
4000	-8.84	-7.48	-1.36
6300	-9.90	-8.26	-1.63
10000	-11.44	-9.34	-2.10
16000	-13.82	-10.94	-2.88
25000	-17.23	-13.20	-4.03
Flight Idle			
Distance, ft	Expanded spectra, dB	Standard spectra, dB	Difference (S-E), dB
200	-0.13	-0.13	Less than 0.1
400	-7.85	-7.85	Less than 0.1
630	-7.99	-7.99	Less than 0.1
1000	-8.21	-8.21	Less than 0.1
2000	-8.72	-8.72	Less than 0.1
4000	-9.58	-9.58	Less than 0.1
6300	-10.41	-10.41	Less than 0.1
10000	-11.56	-11.56	Less than 0.1
16000	-13.04	-13.04	Less than 0.1
25000	-14.45	-14.45	Less than 0.1



Ground Idle			
Distance, ft	Expanded spectra, dB	Standard spectra, dB	Difference (S-E), dB
200	-1.22	-1.22	Less than 0.1
400	-1.49	-1.49	Less than 0.1
630	-1.78	-1.78	Less than 0.1
1000	-2.24	-2.24	Less than 0.1
2000	-3.49	-3.49	Less than 0.1
4000	-6.01	-6.00	Less than 0.1
6300	-8.65	-8.64	Less than 0.1
10000	-11.85	-11.84	Less than 0.1
16000	-14.54	-14.53	Less than 0.1
25000	-15.89	-15.88	Less than 0.1
HIGE			
Distance, ft	Expanded spectra, dB	Standard spectra, dB	Difference (S-E), dB
200	0.26	0.26	Less than 0.1
400	0.13	0.13	Less than 0.1
630	-0.02	-0.02	Less than 0.1
1000	-0.27	-0.27	Less than 0.1
2000	-0.99	-0.99	Less than 0.1
4000	-2.72	-2.72	Less than 0.1
6300	-4.99	-4.99	Less than 0.1
10000	-8.61	-8.61	Less than 0.1
16000	-12.99	-12.99	Less than 0.1
25000	-16.09	-16.09	Less than 0.1
HOGE			
Distance, ft	Expanded spectra, dB	Standard spectra, dB	Difference (S-E), dB
200	-0.77	-0.77	Less than 0.1
400	-0.90	-0.90	Less than 0.1
630	-1.03	-1.03	Less than 0.1
1000	-1.23	-1.23	Less than 0.1
2000	-1.71	-1.71	Less than 0.1
4000	-2.50	-2.50	Less than 0.1
6300	-3.26	-3.26	Less than 0.1
10000	-4.28	-4.28	Less than 0.1
16000	-5.54	-5.54	Less than 0.1
25000	-6.99	-6.99	Less than 0.1



Appendix F: Time Audible

Table F-1. EASN Threshold

One-Third Octave Band Nominal Center Frequency (Hz)	η_{band}	EASN threshold (dB)
11	-0.12	21.6
12	-0.05	18.6
13	0.00	16.1
14	0.06	14.0
15	0.11	12.3
16	0.16	10.7
17	0.20	40.2
18	0.24	35.0
19	0.28	29.8
20	0.31	25.8
21	0.34	22.2
22	0.37	19.0
23	0.38	16.2
24	0.40	13.4
25	0.42	11.6
26	0.44	9.3
27	0.44	7.8
28	0.44	6.3
29	0.44	6.3
30	0.44	6.3
31	0.42	6.1
32	0.40	5.4
33	0.38	5.2
34	0.37	4.0
35	0.35	2.8
36	0.32	2.4
37	0.29	4.0
38	0.27	8.1
39	0.24	13.1
40	0.20	17.0

Values of EASN below 31.5 Hz were estimated via fourth-order polynomial regression (see Figure F-1). Values of receiver efficiency η were estimated via second-order polynomial regression (see Figure F-2).

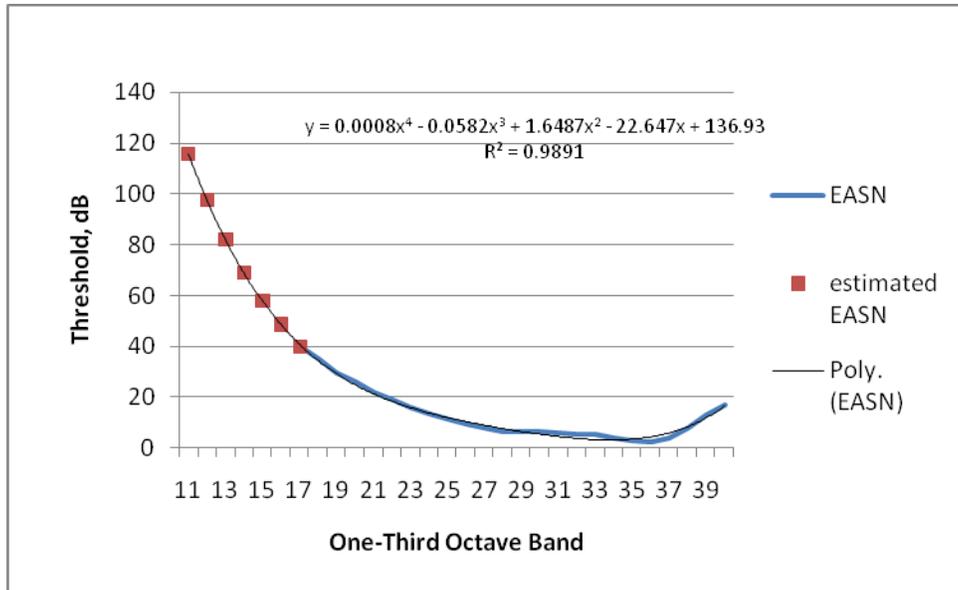


Figure F-1. Polynomial Regression to Estimate Low Frequency Values of EASN

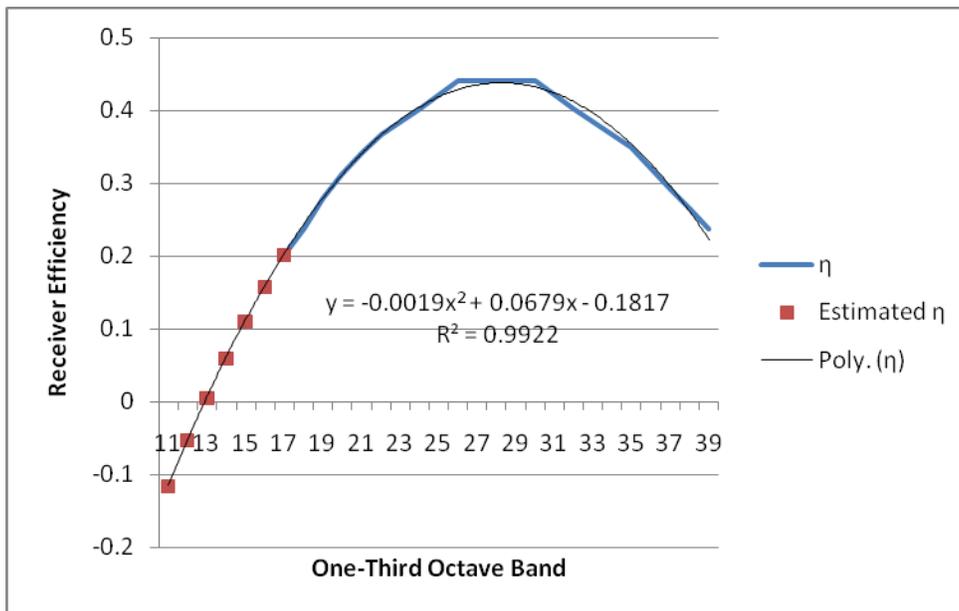


Figure F-2. Polynomial Regression to Estimate Low Frequency Values of Receiver Efficiency η

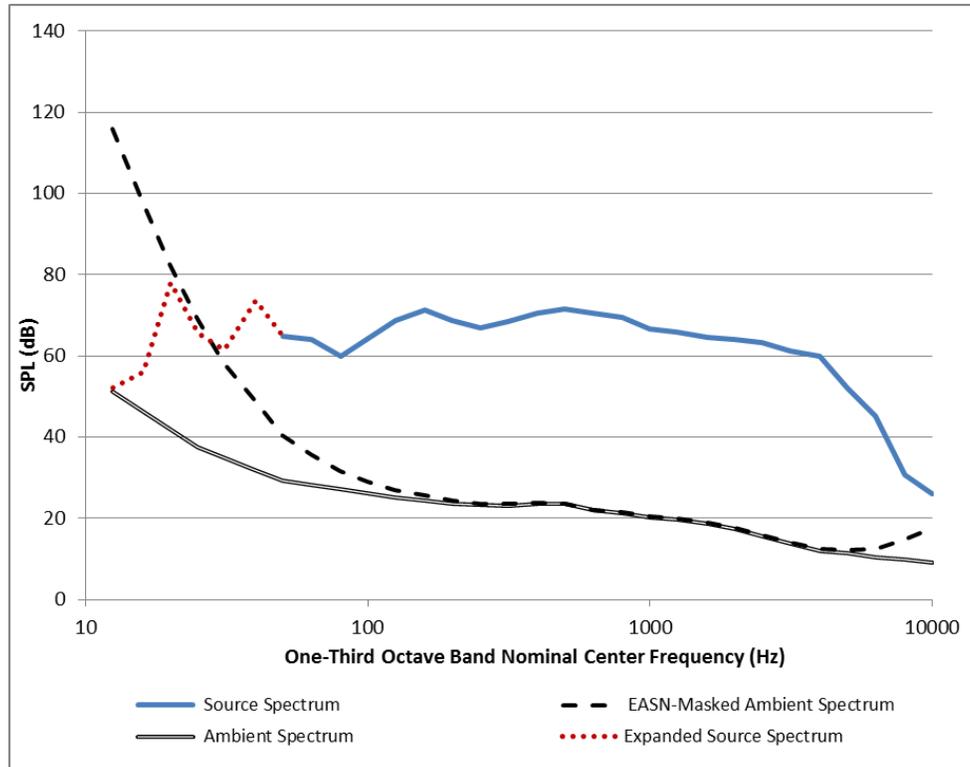


Figure F-3. Comparison of Standard and Expanded Eurocopter EC130 Level Flight Spectra with EASN Threshold and Sample Ambient Spectra

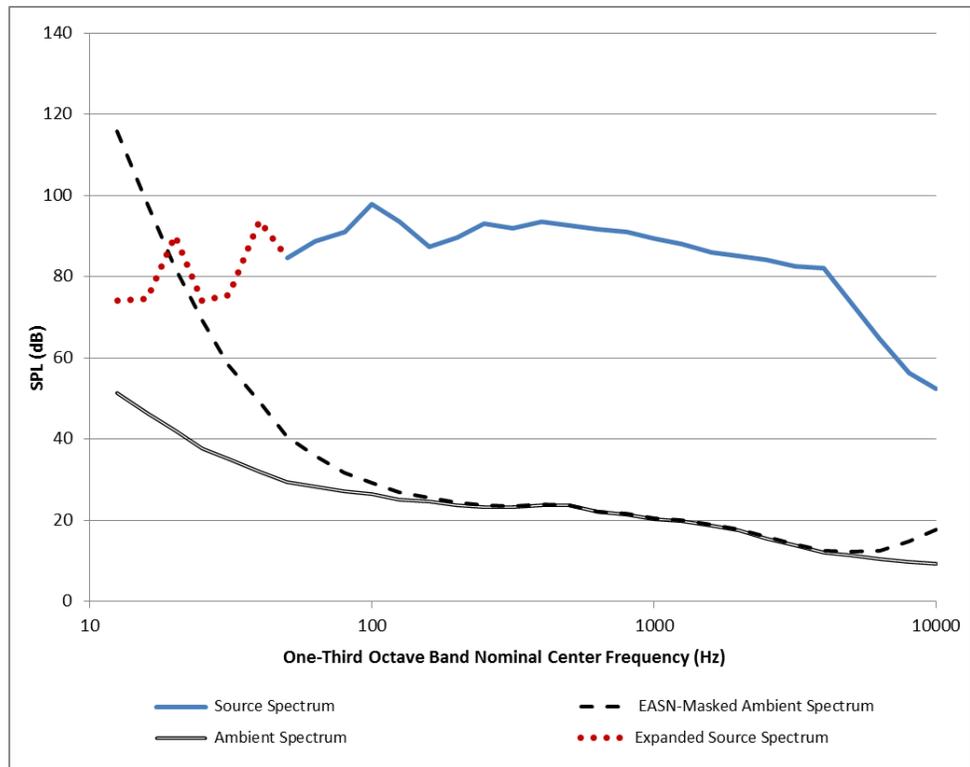


Figure F-4. Comparison of Standard and Expanded Robinson R22 Level Flight Spectra with EASN Threshold and Sample Ambient Spectra

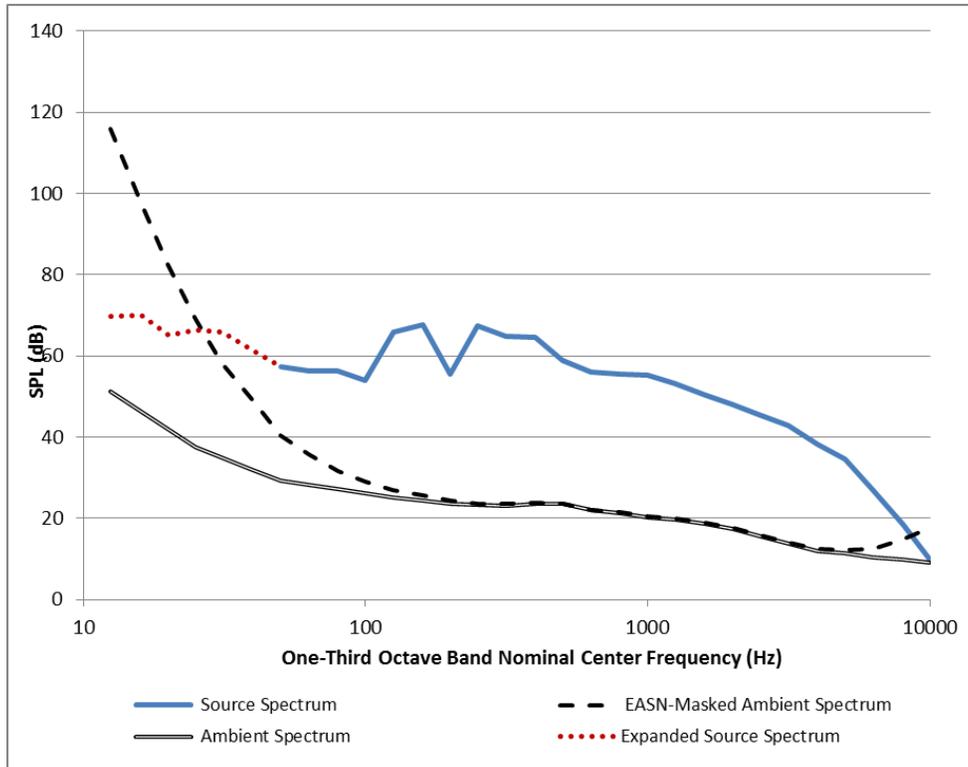


Figure F-5. Comparison of Standard and Expanded Robinson R44 Level Flight Spectra with EASN Threshold and Sample Ambient Spectra

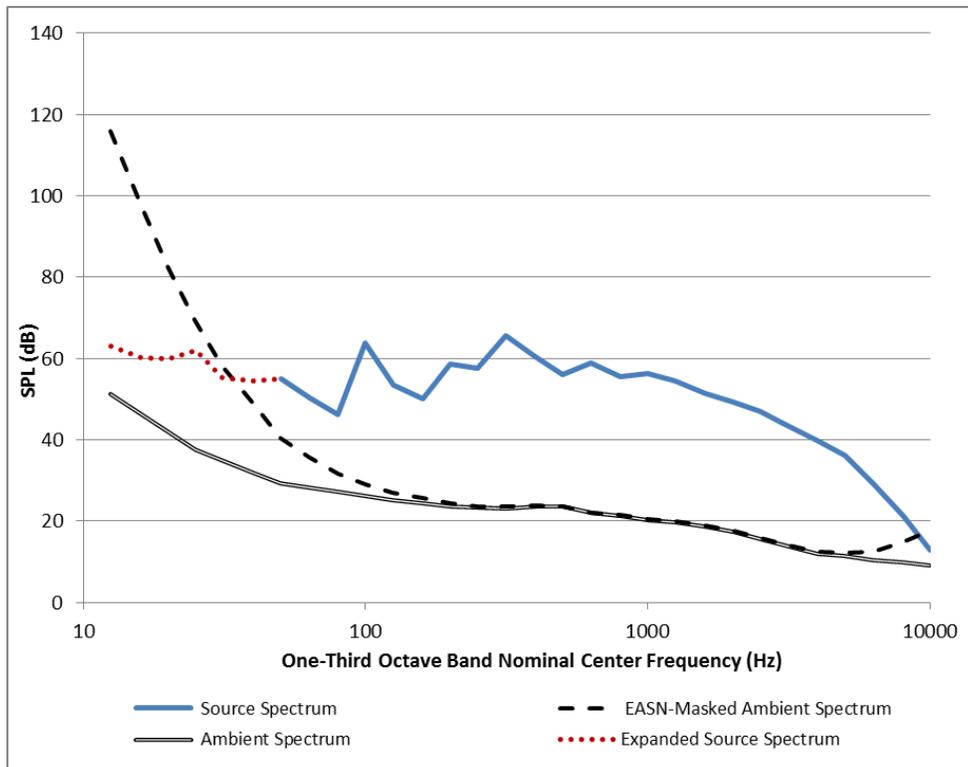


Figure F-6. Comparison of Standard and Expanded Schweizer 300C Level Flight Spectra with EASN Threshold and Sample Ambient Spectra