

Deviation Request ETSO-2C197#2 for an ETSO approval for CS-ETSO applicable to Information Collection and Monitoring Systems (ETSO-2C197)

Consultation Paper

1 Introductory Note

The hereby presented deviation requests shall be subject to public consultation, in accordance with EASA Management Board Decision No 7-2004 as amended by EASA Management Board [Decision No 12-2007](#) products certification procedure dated 11th September 2007, Article 3 (2.) of which states:

“2. Deviations from the applicable airworthiness codes, environmental protection certification specifications and/or acceptable means of compliance with Part 21, as well as important special conditions and equivalent safety findings, shall be submitted to the panel of experts and be subject to a public consultation of at least 3 weeks, except if they have been previously agreed and published in the Official Publication of the Agency. The final decision shall be published in the Official Publication of the Agency.”

2 ETSO-2C197#2 Information Collection and Monitoring Systems

2.1 Summary of Deviation

Deviates from EUROCAE ED-155 by specifying a combined performance for the cockpit area microphone, its preamplifier and the associated recorder channel when these components are all assembled in a single unit.

2.2 Original Requirement

EUROCAE ED-155

I-3.2.3 Audio Frequency Response

- a *When half the Reference Signal level is applied to the input of the area microphone channel and its frequency is swept continuously at a rate not exceeding 0.1 octaves per second over the range defined in Table I-3.1. The level of the signal recovered from the memory shall not vary by more than a total range of +/- 3 dB.*
- b *In respect of the pilot audio channels, the above requirement shall be met for a signal frequency range of at least 150 Hz to 5 kHz. For frequencies below 150 Hz, all pilots audio channels shall attenuate the signals at a nominal 12 dB per octave. A second order high-pass filter characteristic shall be used.*
- c *In respect of the area microphone channel, the above requirement shall be met for a signal frequency range of at least 150 Hz to 20 kHz. For frequencies below 150 Hz, area microphone channel shall attenuate the signals at a nominal 12 dB per octave. A second order high-pass filter characteristic shall be used.*

NOTE: There is a significant value to the mechanical signatures that would be found below 150 Hz. However, there is also the potential for significant audio energy in this region which could saturate the recording. Therefore, it is desirable to have a second order roll off

I-3.3.1 Frequency Response – Area Microphone

The output level of the microphone shall comply with the frequency response requirements listed in Table I-3.1. This requirement shall be met over a sound pressure input range of 60 dB to 94 dB above 20 μ Pa.

I-3.3.4 Frequency Response – Microphone Preamplifier

The microphone preamplifier shall comply with the frequency response requirements listed in Table I-3.1.

NOTE: There is a significant value to the mechanical signatures that would be found below 150 Hz. However, there is also the potential for significant audio energy in this region which could saturate the recording. Therefore, it is desirable to have a second order roll off of the frequency response below 150 Hz rather than a step attenuation.

I-3.2.4 Audio Noise Level – Signal to Noise

With no signal applied to any input channel, the reproduced signal shall be below the output level produced by an input Reference Signal by the value defined in Table I-3.1.

This requirement shall be met across the frequency band as defined in Table I-3.1 with the input both open and short circuited. The above Signal to Noise performance shall be met in the presence of out-of-band input signals at the Reference level when tested in accordance with paragraph I-5.2.3.

NOTE: If audio channels are specified with the audio frequency response of the area channel, the area channel out-of-band signal definition shall apply.

I-3.3.6 Signal to Noise Ratio – Area Microphone Preamplifier

The level of any noise at the output of the preamplifier shall be as least 80 dB below the level of an output signal corresponding to the maximum input signal. This requirement shall be met for input signals up to the level produced by the microphone for which the equipment is designed, when it is exposed to a sound pressure level of 120 dB above 20 μ Pa.

I-3.3.2 Total Harmonic Distortion plus Noise – Area Microphone

The total harmonic distortion plus noise contributed by the microphone shall be less than 1% (-40dB) at sound pressure levels up to 120 dB above 20 μ Pa in a free field at 1 kHz when measured in a 22 kHz bandwidth (unweighted).

I-3.3.5 Total Harmonic Distortion plus noise – Area Microphone Preamplifier

The total harmonic distortion plus noise of the output signal shall not exceed 0.1% for input signals within the range 150 Hz to 20 kHz when measured within a 22 kHz bandwidth (un-weighted). This requirement shall be met for input signals up to the level produced by the microphone for which the equipment is designed, when it is exposed to a sound pressure level of 120 dB above 20 μ Pa.

I-3.2.5 Audio Noise Level – Total Harmonic Distortion plus Noise (THD+N)

The reproduced total harmonic distortion plus noise shall not exceed the value defined in Table I-3.1 when measured in the stated frequency band at input levels of 0 to - 20 dB relative to the stated channel signal level.

NOTE: Overdrive considerations are discussed in paragraph I-2.1.8.

Characteristic	Cockpit Area Microphone	Cockpit Area Microphone Preamplifier	Recorder Cockpit Area Microphone Channel	Recorder Pilot Audio Channel
Frequency Response (minimum)	50 Hz to 17 kHz +/- 6 dB 17 kHz to 20 kHz +/- 10 dB	150 Hz to 20 kHz +/- 3 dB Below 150 Hz (f_c) - 2 nd order roll off (-12dB/octave nominal)	150 Hz to 20 kHz +/- 3 dB Below 150 Hz (f_c) - 2 nd order roll off (-12dB/octave nominal)	150 Hz to 5 kHz +/- 3 dB Below 150 Hz (f_c) - 2 nd order roll off (-12dB/octave nominal)
	150 Hz to 20 kHz +/- 6 dB Below 150 Hz (f_c) - 2 nd order roll off (-12dB/octave nominal) See Note1			
Dynamic Range (minimum)	94dB, max input level \geq 120 dB SPL	116 dB (including 36 dB of selectable attenuation)	80 dB	116dB (including 36 dB of selectable attenuation)
Selectable Input Attenuation	N/A	36 dB in 6 dB steps	none	36 dB in 6 dB steps
Signal to Noise (minimum)	67 dB referenced at 94 dB SPL	80 dB referenced to signal equivalent to 120 dB SPL at microphone	80 dB referenced to signal equivalent to 120 dB SPL at microphone	80 dB referenced to 1 V _{rms} input level with 0dB selectable input attenuation.
Total Harmonic Distortion and Noise (THD+N)	< 1 % (-40dB) at 120 dB SPL 22 kHz BW un-weighted	< 0.1 % (-60dB) at signal equivalent to 120 dB SPL at microphone. 22 kHz BW un-weighted	< 0.1 % (-60dB) at signal equivalent to 120 dB SPL at microphone 22 kHz BW un-weighted	< 0.1 % (-60dB) at 1 V _{rms} input level with 0dB selectable input attenuation, ANSI A weighting < 0.1 % (-60dB) at 4 V _{rms} input level with 12dB selectable input attenuation, ANSI A weighting
Audio Channel Crosstalk (minimum)	N/A	N/A	-72 dB	-72 dB
Input Impedance (minimum)	N/A	Compatible with microphone output	Compatible with preamplifier output	2000 ohm minimum
Polar Response (directivity)	As required by installation location and cockpit configuration	N/A	N/A	N/A
Output Level	Compatible with preamplifier	Compatible with recorder input	N/A	N/A
Channel Sampling Rate	N/A	N/A	44.1 kHz minimum	11.025 kHz minimum

NOTE 1: The frequency response of the area microphone and area microphone preamplifier may be addressed as a combined value instead of individual bandwidth requirements.

NOTE 2: Columns represent functional boundaries and do not preclude physical combinations of these functions such as combining the preamplifier with the recorder.

NOTE 3: Unless otherwise noted, all specifications referenced to 1 kHz sinusoidal input.

NOTE 4: f_c = nominal -3dB point.

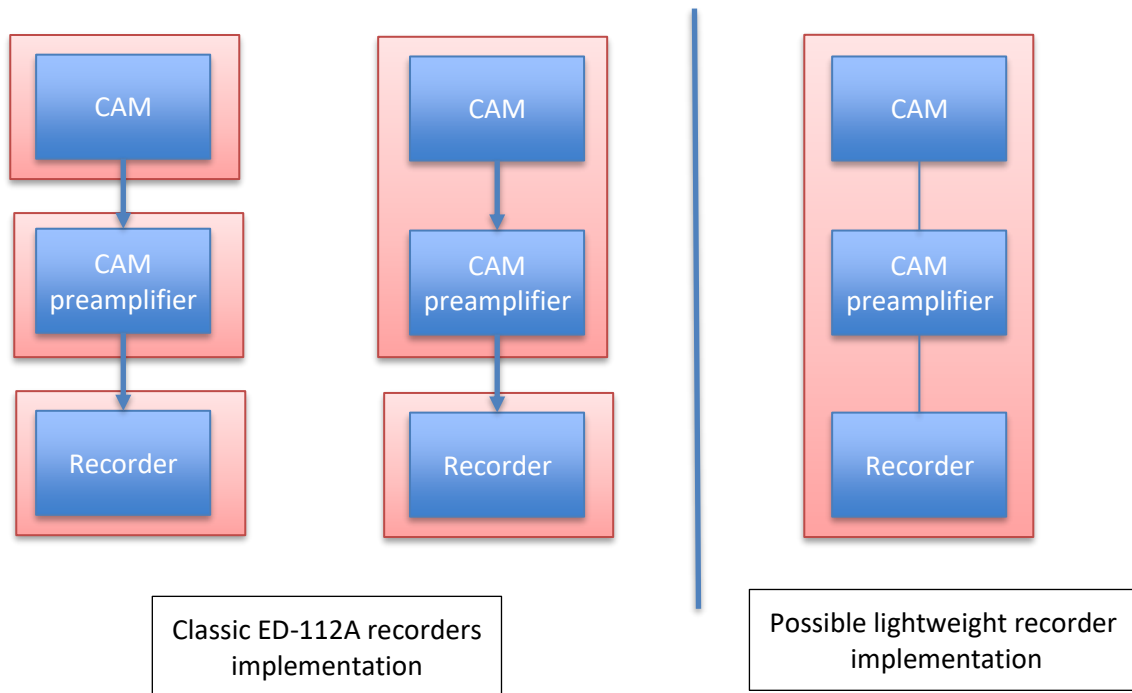
TABLE I-3.1: AUDIO QUALITY SPECIFICATION



2.3 Industry

EUROCAE ED-155, which provides minimum operational performance specification for lightweight flight recording system was derived in 2009 from the document ED-112A. This latter specifies the minimum performance of the flight recorders that large aircraft are required to carry. The ED-112A recorders are mostly designed around a recorder installed in an avionics bay and connected to separate cockpit area microphone and control panel that are installed in the cockpit.

Lightweight flight recorders are intended for smaller aircraft, and their design may more often be based on a single unit that is directly fitted to the aircraft cockpit. In such a case, the cockpit area microphone (CAM) and its preamplifier are directly embedded in the recorder, on the equipment face that also contains the recorder controls.



ED-155 requirements, however, have been derived from the ED-112A without considering that the 3 components (CAM, CAM preamplifier and recorder) might be embedded in a single unit. Such a design does not provide for the access to measurement points between the different units. It is then needed to deviate from ED-155 standard to specify a single performance. Incidentally, the relevant performance that will permit the proper restitution of the cockpit audio is the performance of the complete chain composed of the CAM, its preamplifier and the recorder CAM channel.

2.3.1 Frequency Response

It is noted that the value in the minimum frequency response row that combines the Cockpit Area Microphone and its Preamplifier in Table I-3.1 is $\pm 6\text{dB}$ while the sum of the performance of the individual components is $\pm 9\text{dB}$. The requirement is not consistent as the permitted performance of one component of the combination of two elements is the same as the one of this combination.

Characteristic	Cockpit Area Microphone	Cockpit Area Microphone Preamplifier	Recorder Cockpit Area Microphone Channel	Recorder Pilot Audio Channel
Frequency Response (minimum)	50 Hz to 17 kHz +/- 6 dB 17 kHz to 20 kHz +/- 10 dB	150 Hz to 20 kHz +/- 3 dB Below 150 Hz (f_c) - 2 nd order roll off (-12dB/octave nominal)	150 Hz to 20 kHz +/- 3 dB Below 150 Hz (f_c) - 2 nd order roll off (-12dB/octave nominal)	150 Hz to 5 kHz +/- 3 dB Below 150 Hz (f_c) - 2 nd order roll off (-12dB/octave nominal)
	150 Hz to 20 kHz +/- 6 dB Below 150 Hz (f_c) - 2 nd order roll off (-12dB/octave nominal) See Note1			

NOTE 1: *The frequency response of the area microphone and area microphone preamplifier may be addressed as a combined value instead of individual bandwidth requirements.*

In other words, a manufacturer measuring the values for the CAM and for the CAM preamplifier independently could obtain a combination whose performance would be:

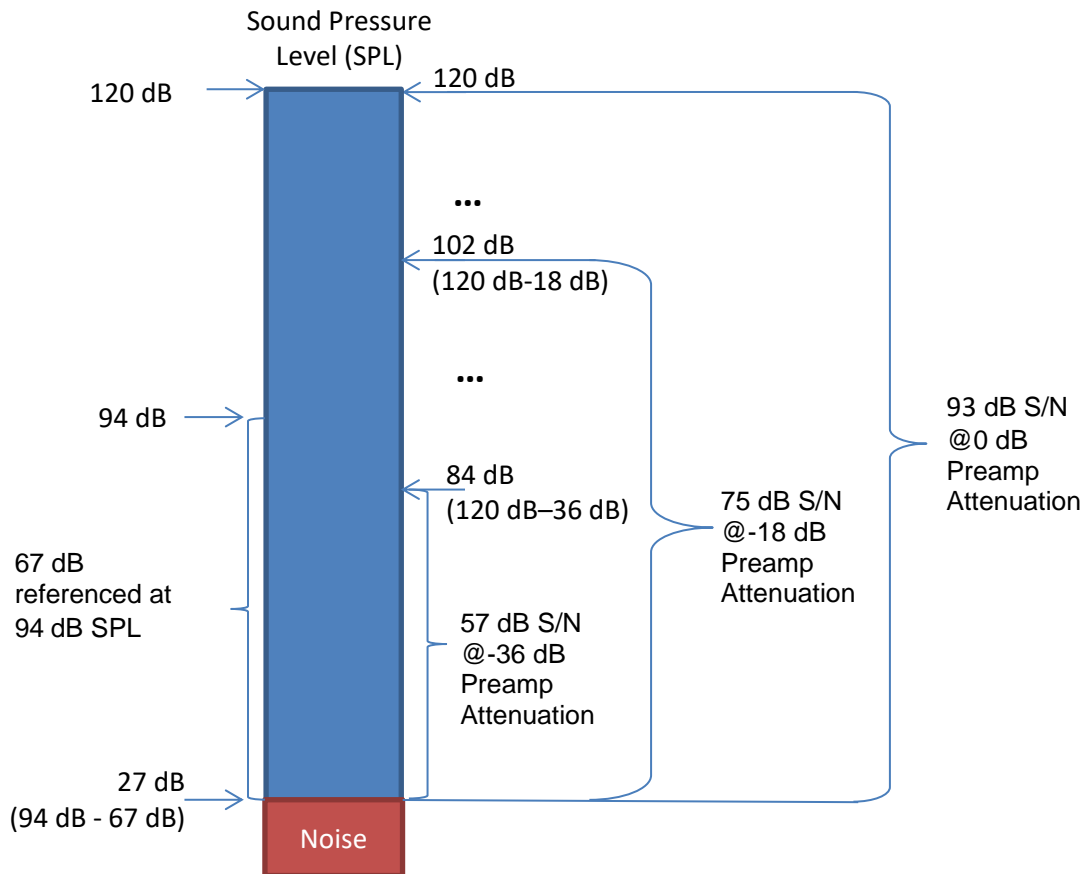
- $\pm 9\text{ dB}$ in the range from 150 Hz to 17 kHz,
- $\pm 13\text{ dB}$ in the range from 17 kHz to 20 kHz.

This deviation therefore intends to permit the use of a single performance requirement for the combined CAM, CAM preamplifier and recorder CAM channel rather than using the individual requirements set for each components in ED-155 Table I-3.1 because all these components are integrated into the crash recorder unit. As a result, the whole CAM audio chain performance requirement is

Cockpit Area Microphone	$\pm 6\text{ dB}$
Cockpit Area Microphone Preamplifier	$\pm 3\text{ dB}$
Recorder Cockpit Area Microphone Channel	$\pm 3\text{ dB}$
Combined performance requirement:	$\pm 12\text{ dB}$

2.3.2 Signal to Noise

The Preamplifier has a selectable input attenuation in 7 steps (36 dB in 6 dB Steps) and the maximum input level is 120 dB Sound Pressure Level (SPL). This results in a maximum of 120 dB, 114 dB, 108 dB, 102 dB, 96 dB, 90 dB and 84 dB SPL. In cases where the output signal of the microphone is more amplified, the noise level also increases. This results in a decreased Signal to Noise Ratio (SNR) (this is illustrated in the next figure).



$$SPL_{maximum} = 120 \text{ dB} - \text{Selectable input attenuation}$$

$$SNR_{Microphone} = SPL_{maximum} - 27 \text{ dB}$$

Also, the noise of the preamplifier itself increases over the programmable gain.

$$SNR_{Preamplifier} = 80 \text{ dB}^1 - \text{Selectable input attenuation}$$

$$SNR_{complete \ chain} = 20 \cdot \log\left(10^{-\frac{SNR_{Microphone}}{20}} + 10^{-\frac{SNR_{Preamplifier}}{20}} + 10^{-\frac{SNR_{Input}}{20}}\right)$$

¹ Signal to Noise of the Cockpit Area Microphone Preamplifier see Table 2

An example calculation for 120dB SPL:

Cockpit Area Microphone SNR 93 dB = $2 \cdot 10^{-5}$

Cockpit Area Microphone Preamplifier SNR 80 dB = $1 \cdot 10^{-4}$

Recorder Cockpit Area Microphone Channel SNR 80 dB = $1 \cdot 10^{-4}$

Combined performance requirement: **73 dB = $2,2 \cdot 10^{-4}$**

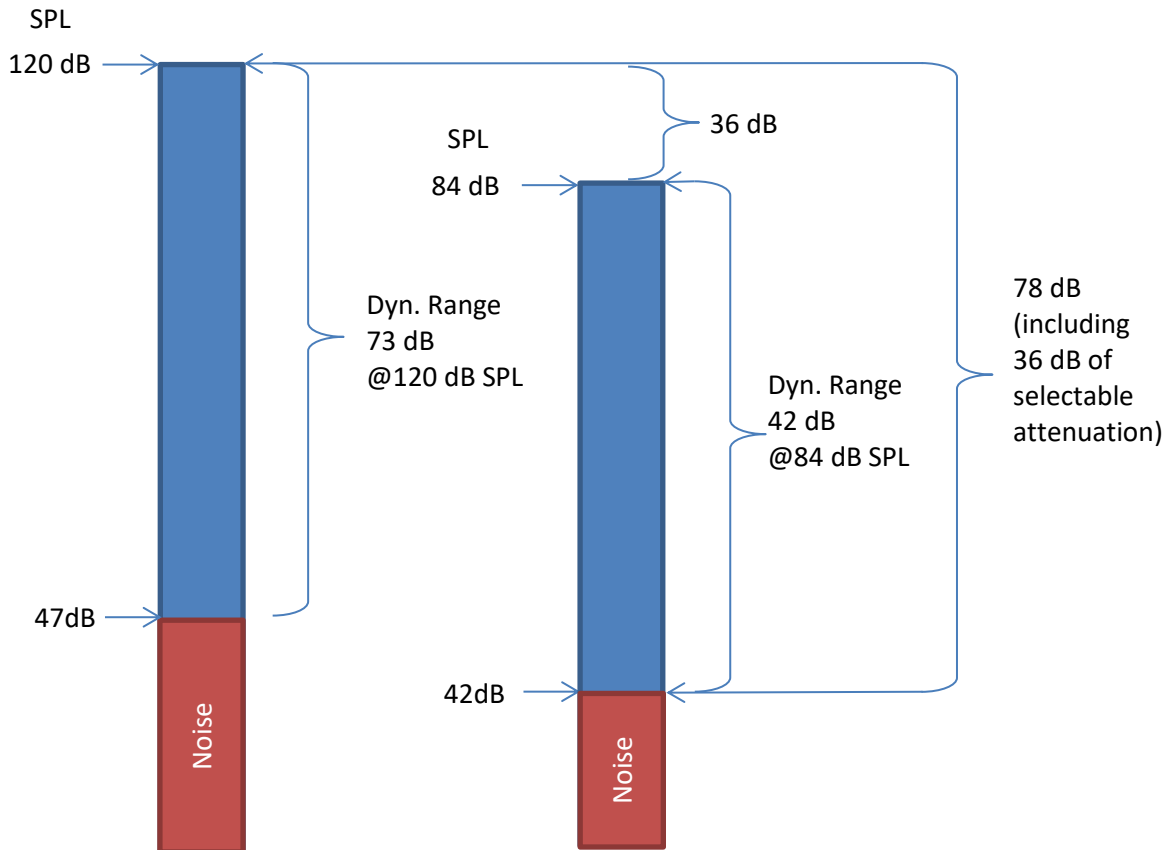
The resulting values of the whole combination are described in the next table:

max SPL	Cockpit Area Microphone SNR	Cockpit Area Microphone Preamplifier SNR	Recorder Cockpit Area Microphone Channel SNR	Resulting SNR
120 dB	93 dB	80 dB	80 dB	73 dB
114 dB	87 dB	74 dB	80 dB	69 dB
108 dB	81 dB	68 dB	80 dB	65 dB
102 dB	75 dB	62 dB	80 dB	59 dB
96 dB	69 dB	56 dB	80 dB	54 dB
90 dB	63 dB	50 dB	80 dB	48 dB
84 dB	57 dB	44 dB	80 dB	42 dB

Table 1: Signal to Noise Ratio for whole combination

2.3.3 Dynamic Range

The Dynamic Range for the combination of Cockpit Area Microphone + Preamplifier + Channel is the difference between the Noise floor and the loudest input signal which can be used. The dynamic range is decreased due to the additional noise of the different parts (Cockpit Area Microphone + Preamplifier + Channel). It is increased due the 36 dB selectable attenuation of the Preamplifier. This is illustrated in the next figure the values are Table 2 values are used:



Dynamic Range is implicitly defined by the SNR Values 42 dB + 36 dB of selectable attenuation. This results in “78 dB including 36 dB of selectable attenuation”.

2.3.4 Total Harmonic Distortion and Noise (THD+N)

The THD+N values have to be accumulated from the CAM, the CAM preamplifier and the CAM channel:

Cockpit Area Microphone	1% = -40 dB
Cockpit Area Microphone Preamplifier	0.1% = -60 dB
Recorder Cockpit Area Microphone Channel	0.1% = -60 dB
Combined performance requirement:	1.2% = -38 dB

2.3.5 Summary

The following table summarizes the proposed combined performance for the cockpit area microphone, its preamplifier and the associated recorder channel when these components are all assembled in a single unit in front of the requirements of ED-155 table I-3.1 for each of the relevant performance. Note for that lines from ED-155 table I-3.1 that are not reproduced in the table 2 below, the ED-155 performance requirement applies.

Characteristic	ED-155 requirement			Deviation ETSO-2C197#2
	Cockpit Area Microphone	Cockpit Area Microphone Preamplifier	Recorder Cockpit Area Microphone Channel	Combined performance for the CAM, CAM preamplifier channel, CAM recorder channel
Frequency Response (minimum)	50 Hz to 17 kHz +/- 6 dB 17 kHz to 20 kHz +/- 10 dB	150 Hz to 20 kHz +/- 3 dB Below 150 Hz (f _c) - 2 nd order roll off (-12dB/octave nominal)	150 Hz to 20 kHz +/- 3 dB Below 150 Hz (f _c) - 2 nd order roll off (-12dB/octave nominal)	150 Hz to 20 kHz +/- 12 dB Two times below 150 Hz (f _c) - 2 nd order roll off (-24dB/octave nominal)
Dynamic Range (minimum)	94dB, max input level >= 120 dB SPL	116 dB (including 36 dB of selectable attenuation)	80 dB	78 dB (including 36 dB of selectable attenuation) as defined in chapter 2.3.3
Selectable Input Attenuation	N/A	36 dB in 6 dB steps	none	36 dB in 6 dB steps
Signal to Noise (minimum)	67 dB referenced at 94 dB SPL	80 dB referenced to signal equivalent to 120 dB SPL at microphone	80 dB referenced to signal equivalent to 120 dB SPL at microphone	Value depending on selected attenuation as defined in chapter 2.3.2 Table 1
Total Harmonic Distortion and Noise (THD+N)	< 1 % (-40dB) at 120 dB SPL 22 kHz BW unweighted	< 0.1 % (-60dB) at signal equivalent to 120 dB SPL at microphone. 22 kHz BW un- weighted	< 0.1 %(-60dB) at signal equivalent to 120 dB SPL at microphone 22 kHz BW un- weighted	< 1.2 %(-38dB) at signal equivalent to 120 dB SPL at microphone 22 kHz BW un- weighted

Table 2: Proposed combined performance compared to the initial ED-155 requirement

2.4 Equivalent Level of Safety

This deviation provides an equivalent level of safety as the combined performance requirement shown in table 2 as a pass/fail criteria when testing the complete audio chain (Cockpit Area Microphone + Preamplifier + Channel) is the same as if the individual components were tested

separately and the Cockpit Area Microphone, Preamplifier and associated channel are embedded in the same article.

2.5 EASA position

We accept the deviation.

