ANNEX B
TO DECISION NUMBER SIXTEEN

PROCEDURES FOR CALIBRATING GROUND-BASED TAPE REPRODUCERS WHICH ARE USED TO REPLAY DATA FROM ANALOG VIDEO FRAMING CAMERA AND ARE OF A DIFFERENT MODEL FROM THE AIRBORNE RECORDER USED WITH THE CAMERA

1. Analysis of Spatial Frequency Characteristics

The purpose of this test is to measure the frequency content of the image that results from playing the recording made on the airborne recorder on the ground video tape reproducer and to compare the results to those achieved by playing this same tape on the airborne recorder. The image amplitude function, A(f), of Test Pattern 1 in the captured video image shall be produced and the frequencies at which the amplitude falls below 50% (3 dB) and 10% (10dB) of their peak values shall be recorded. In obtaining these results, the following six steps shall be completed.

(A) Using the video densitometer, no less than 5 adjacent profile cuts across Test Pattern 1 shall be made for each of the 2 images obtained in Section III, paragraph 3, subparagraph (A) (3) of Decision 16 to the Treaty on Open Skies (hereinafter referred to as Decision 16). These profiles shall be obtained from near the center of each pattern and shall be along the scan lines. Each series of profiles shall be stored in a separate file for later use. The file names used for each series of profile cuts shall be recorded together with names of the image files from which the profiles were made.

(B) The average maximum value $\bar{A}$ max(i) and the average minimum value $\bar{A}$ min(i) shall be calculated for each of the i = 1...30 bar pairs of Test Pattern 1 as follows: $\bar{A}$ max(i) is the average (arithmetic mean) of the maximum grey scale values in the ith bar pair and $\bar{A}$ min(i) is the average of the minimum grey scale values in the ith bar pair, where the average is taken over all of the profiles obtained in subparagraph (A) above.

(C) The amplitude *a(i)* shall be calculated for each of the i = 1, ..., 30 bar pairs of Test Pattern 1 according to the formula:

$$a(i) = \frac{\bar{A}max(i) - \bar{A}min(i)}{2}$$

where $\bar{A}$ max(i) and $\bar{A}$ min(i) are defined in subparagraph (B) above.

The image amplitude function $A(f_j)$ shall be defined for each of the j = 1, ..., 15 bar groups of Test Pattern 1 as the average of the amplitudes of the two bar pairs belonging to the jth bar group.

(D) The steps in subparagraphs (A) through (C) above shall be repeated using the 2 images obtained in Section III, paragraph 3, sub-paragraph (A) (4) of Decision 16.

(E) Graphs shall be plotted for the airborne recorder's image amplitude function. The bar groups where the airborne recorder's image amplitude function first falls below 50% (-3 dB) and 10% (-10 dB) of their peak values shall be recorded.

(F) Graphs shall then be plotted for the ground reproducer's image amplitude function. The bar groups where the ground reproducer's image amplitude function first falls below 50% (-3 dB) and 10% (-10 dB) of their peak values shall be recorded. For the ground reproducer to be deemed acceptable, the bar groups at which the 50% and 10% amplitudes occur shall be of the same width or narrower width (better frequency response) than the corresponding bar groups recorded as the baseline in subparagraph (E) above.

(2) Analysis of Linearity of Amplitude Characteristics

Linearity characteristics shall be quantified by the mean square deviation and maximum absolute deviation obtained from the differences between the reproduced Test Pattern and the input test pattern, using Test Pattern 2 from Annex A of Decision 16 as the input. In obtaining these results, the following five steps shall be completed.

(A) Using the video densitometer, no less than 5 adjacent profile cuts across Test Pattern 2 of Annex A to Decision 16 shall be made for each of the 2 images obtained in Section III, paragraph 3, sub-paragraph (A) (3) of Decision 16. These profiles shall be obtained from near the center of each pattern. Each series of profiles shall be stored in a separate file for later use. The file names used for each series of profiles shall be recorded together with names of the image files from which the profiles were made.

(B) The average airborne recorder value $\overline{A}_2(i)$ shall be calculated for each of the i = 1...512 bars of Test Pattern 2 of Annex A to Decision 16 as the average of the grey scale values in the ith bar, where the average is taken over all of the profiles obtained in subparagraph (A) of this paragraph.

(C) The procedure given in subparagraph (A) of this paragraph shall be repeated using the 2 images obtained in Section III, paragraph 3, sub-paragraph (A) (4) of Decision 16.

(D) The average ground reproducer value $\overline{G}_2(i)$ shall be calculated for each of the i = 1...512 bars of Test Pattern 2 of Annex A to Decision 16 as the average of the grey scale values in the ith bar, where the average is taken over all of the profiles obtained in subparagraph (C) of this paragraph.

(E) Using the ideal values (I) for Test Pattern 2 of Annex A to Decision 16, ($I_2(n)$ = n-1, for n = 1...256, and $I_2(n)$ = 512-n, for n = 257...512), the mean square deviations $S_2(I,G)$ and $S_2(I,A)$ and the absolute maximum deviations $M_2(I,G)$ and $M_2(I,A)$, of the data obtained in subparagraphs (B) and (D) of this paragraph from the ideal shall be obtained as follows:

$$S_2(I,A) = \underset{d=-3..3}{\text{Min}} \frac{1}{512} \sum_{n=1}^{512} (I_2(n+d) - \overline{A}_2(n))^2 \ ,$$

$$S_2(I,G) = \underset{d=-3..3}{\text{Min}} \frac{1}{512} \sum_{n=1}^{512} (I_2(n+d) - \overline{G}_2(n))^2 \ ,$$

$$M_2(I,A) = \underset{d=-3..3}{\text{Min}} \ \underset{n=1..512}{\text{Max}} \left| I_2(n+d) - \overline{A}_2(n) \right| \ ,$$

$$M_2(I,G) = \underset{d=-3..3}{\text{Min}} \ \underset{n=1..512}{\text{Max}} \left| I_2(n+d) - \overline{G}_2(n) \right| ,$$

where $I_2(n)$ = 0, for n< 1, and $I_2(n)$ = 255, for n >512. (The process of minimizing over a set of offsets "d" in the above equations arises from observation of phase misalignments between the ideal and reproduced patterns. The effect of phase misalignment is reduced by using the measures that arise from the best fit between the observed and reproduced patterns.)

The ground tape reproducer shall be deemed acceptable in this test, if the mean square deviation of the ground tape reproducer is no more than 10% greater than the mean square deviation of the airborne recorder (i.e., $S_2(I,G) < 1.1 \bullet S_2(I,A)$) and the absolute maximum deviation of the ground tape reproducer is no more than 5% greater than the absolute maximum deviation of the airborne recorder (i.e., $M_2(I,G) < 1.05 \bullet M_2(I,A)$).

(3) Analysis of Overshoot/Undershoot Characteristics

Overshoot/undershoot characteristics shall be quantified by the mean square deviations and maximum absolute deviations obtained from the differences between the reproduced Test Pattern and the input Test Pattern, using Test Pattern 3 of Annex A to Decision 16 as the input. In obtaining these results, the following four steps shall be completed.

(A) Using the video densitometer, no less than 5 adjacent profile cuts across Test Pattern 3 of Annex A to Decision 16 shall be made for each of the 2 images obtained in Section III, paragraph 3, sub-paragraph (A) (3) of Decision 16.

These profiles shall be obtained from near the center of each pattern. Each series of profiles shall be stored in a separate file for later use. The file names used for each series of profiles shall be recorded together with names of the image files from which the profiles were made.

(B) The average airborne recorder values, $\overline{A}_{3L}$(n) and $\overline{A}_{3D}$(n), shall be calculated for each of the n = 1...16 bar groups of Test Pattern 3 of Annex A to Decision 16 as follows. $\overline{A}_{3L}$(n) is the average of the grey scale values in the peak areas and $\overline{A}_{3D}$(n) is the average of the grey scale values in the trough areas of the nth bar group, where the average is taken over all of the profiles obtained in subparagraph (A) of this paragraph.

(C) The steps of subparagraphs (A) and (B) of this paragraph shall be repeated using the 2 images obtained in Section III, paragraph 3, sub-paragraph (A) (4) of Decision 16 to obtain the values $\overline{G}_{3L}$(n) and $\overline{G}_{3D}$(n) for each of the n = 1...16 bar groups of Test Pattern 3 of Annex A to Decision 16.

(D) Using the ideal values for the n = 1...16 bar groups in Test Pattern 3 of Annex A to Decision 16, $I_{3L}(n)$ = 255 - 2n, $I_{3D}(n)$ = 2n-2 for n = 1...8, and $I_{3L}(n)$ = 273 - 4n, $I_{3D}(n)$ = 4n-18, for n = 9...16), the mean square deviations, $S_{3L}(I,A)$, $S_{3L}(I,G)$, $S_{3D}(I,A)$, and $S_{3D}(I,G)$, and the absolute maximum deviations, $M_{3L}(I,A)$, $M_{3L}(I,G)$, $M_{3D}(I,A)$ and $M_{3D}(I,G)$, of the data obtained in subparagraphs (B) and (C) of this paragraph from the ideal shall be obtained as follows:

$$S_{3L}(I,A) = \frac{1}{16}\sum_{n=1}^{16}(I_{3L}(n) - \overline{A}_{3L}(n))^2 ,$$

$$S_{3L}(I,G) = \frac{1}{16}\sum_{n=1}^{16}(I_{3L}(n) - \overline{G}_{3L}(n))^2 ,$$

$$S_{3D}(I,A) = \frac{1}{16}\sum_{n=1}^{16}(I_{3D}(n) - \overline{A}_{3D}(n))^2 ,$$

$$S_{3D}(I,G) = \frac{1}{16}\sum_{n=1}^{16}(I_{3D}(n) - \overline{G}_{3D}(n))^2 ,$$

$$M_{3L}(I,A) = \underset{n=1..16}{\text{Max}}\left|I_{3L}(n) - \overline{A}_{3L}(n)\right|,$$

$$M_{3L}(I,G) = \underset{n=1..16}{\text{Max}}\left|I_{3L}(n) - \overline{G}_{3L}(n)\right|,$$

$$M_{3D}(I,A) = \underset{n=1..16}{\text{Max}}\left|I_{3D}(n) - \overline{A}_{3D}(n)\right|,$$

$$M_{3D}(I,G) = \underset{n=1..16}{\text{Max}}\left| I_{3D}(n) - \overline{G}_{3D}(n) \right|$$

The ground reproducer shall be deemed acceptable in this test, if the mean square deviations of the ground reproducer are no more than 10% greater than the mean square deviations of the airborne recorder (i.e., $S_{3L}(I,G) < 1.1 \bullet S_{3L}(I,A)$ and $S_{3D}(I,G) < 1.1 \bullet S_{3D}(I,A)$) and the absolute maximum deviations of the ground reproducer are no more than 5% greater than the absolute maximum deviations of the airborne recorder (i.e., $M_{3L}(I,G) < 1.05 \bullet M_{3L}(I,A)$ and $M_{3D}(I,G) < 1.05 \bullet M_{3D}(I,A)$).