2. For upper-adjacent channel interference, at all three levels of the Desired NTSC signal, the critical impairment level for audio was reached at a lower interference level than the voted CCIR 3 impairment level for the video. (However, at the Moderate and Strong Desired levels, a lower CCIR3 impairment level for the video resulted from the color beat. Subject to further study, it is believed possible to minimize the visibility of this beat by precision offset. See *Section 3.7.3*.) At the Weak Desired level, the CCIR 3 impairment level was deemed critical for audio; at the Moderate and Strong Desired levels, the CCIR 4 impairment level was deemed the critical level for audio.

   Therefore, assuming that the color beat can be mitigated by means of precision offset, spectrum planning for upper-adjacent channel interference must be based upon audio impairment.

The delta interference levels, with respect to the voted Video CCIR 3 level, are as follows:

At Weak, Audio CCIR 3 precedes by 5 dB;

At Moderate, Audio CCIR 4 precedes by 2.25 dB, and SAP CCIR 4 precedes by 7.5 dB;

At Strong, Audio CCIR 4 precedes by 0.7 dB, and SAP CCIR 4 precedes by 1.7 dB.

Table 4-1

Degradation of BTSC Audio in the Presence of Upper Adjacent Channel ATV

At Weak Desired power level (-55 dBm nominal; -55.10 dBm actual for audio);
Undesired levels in dBm

Receiver	Video CCIR3		Audio CCIR3		
			13 dB Visual/Aural		7 dB
	Voted[1]	EO&C on Beat[2]	External Speakers[3]	Built-in Speakers[4]	Vis/Aural (Built-in Speakers)[5]
A1	-32.20		-49.20	-47.15	
A2	-35.90*	-50.09		-39.15	
A3	-42.09	-50.09		-46.15	
A4	-33.90*			-38.90	
A5	-40.09			-44.15	
A6	-35.20		-35.20	-37.15	
A7	-50.09	-52.09		-40.15	Not required
A8	-35.90*			-42.90	
B1	-40.09		-50.09	-48.15	
B2	-35.90*			-39.90[6]	
B3	-44.09	-52.09		-42.15	Not required
B4	-42.09	-52.09	>-42.00	-37.15	Not required
B5	-43.09		-49.09	-53.15	-50.15
B6	-44.09			-50.15	
B7	-33.20		-53.20	-53.15	-49.15
B8	-38.09			-41.15	
C1	-39.09	-52.09		-45.15	
C2	-38.09			-42.15	
C3	-35.90*			-43.90	
C4	-38.09			-40.15	
C5	-31.90*			-43.90	
C6	-37.90*			-43.90	
C7	-42.09	-50.09		-43.15	
C8	-42.09	-52.09		-43.15	-42.15
Median	-38.09	-39.09		-43.15	

1. Video CCIR 3 levels for the 7 indicated (*) receivers were determined at the time of supplemental BTSC audio testing (5/15/95). Video CCIR 3 levels for A1, A6, and B7 were found on 4/21/95, in anticipation of the original BTSC testing using receivers having baseband outputs. Video CCIR 3 levels for all other receivers had been found on 4/20/95.

2. On 8 receivers, expert observers noted that, during only the camera-pan portion of the test image, they observed impairment equivalent to CCIR Grade 3 at a lower level of interference than the level at which they voted the Grade 3 level for each receiver. The impairment observed during the pan took the form of diagonal stripes (beat pattern). The median CCIR 3 level shown at the bottom of this column was calculated by replacing the "voted" level for each of the 8 receivers with the level shown in this "EO&C on Beat" column.

3. Audio CCIR 3 levels for the six receivers having baseband outputs were determined using an external amplifier and speakers, per the original Test Plan (Section 4), on 4/21/95.

4. Audio CCIR 3 levels for all 24 receivers were determined using the built-in speaker of each receiver, per the supplemental BTSC audio test plan, on 5/15/95. Comparison of the median CCIR 3 levels for video and audio shows that the audio impairment was the dominant impairment for this test condition.

5. For three of the 24 receivers, the video CCIR 3 level predominated over the audio CCIR 3 level, so further testing at the more robust aural power level was unnecessary. Due to time limitations, only a spot check of three of the remaining receivers was conducted to determine whether the change in audio CCIR 3 level would be linear with respect to a 6-dB change in aural power level. The expected 6-dB improvement was not realized on these three receivers.

6. During this audio test, it was noted that the MTS indicator light on Receiver B2 was flashing. Subsequently, the Test Center determined that this effect was due to low SAP injection level. This was corrected prior to any testing of SAP audio.

Table 4-2

Degradation of BTSC Audio in the Presence of Upper Adjacent Channel ATV

At Moderate Desired power level (-35 dBm nominal; -35.04 dBm actual for audio); Undesired levels in dBm

Receiver	Video CCIR3		Audio CCIR3[3]	Audio CCIR4[4]	SAP CCIR4[5]
	Voted[1]	EO&C on Beat[2]			
A1	-26.47*		-28.72[6]	-33.72[6]	-34.47
A2	-15.47*	-41.04	-17.47	-21.47	N/A
A3	-22.97	-46.04	-20.97	-21.97	N/A
A4	-19.47*		-20.47	-22.47	-25.47
A5	-21.97	-46.04	-21.97[7]	-23.97[7]	N/A
A6	-17.97*		-16.97	-20.97	-19.97
A7	-31.97	-51.04	-17.47	-19.47	N/A
A8	-25.97	-43.04	-22.47	-25.97	-26.97
B1	-21.97	-33.04	-24.97	-30.97	-31.97
B2	-21.97		-19.97	-22.97	-24.97
B3	-25.97	-47.04	-18.97	-22.97	-29.97
B4	-22.97	-46.04	-14.97	-17.97	-18.47
B5	-24.97	-34.04	-31.97	-35.97	-40.97
B6	-28.97	-42.04	-32.97	-39.97	-40.97
B7	-17.97*		-32.97	-35.97	-35.97
B8	-26.97		-20.97	-25.97	-27.97
C1	-19.97*	-46.04	-21.97	-26.97[8]	N/A
C2	-19.47*		-20.47[9]	-24.47	-29.47
C3	-22.97		-23.47	-28.47	N/A
C4	-16.97*		-14.97	-18.97	N/A
C5	-17.97*		-20.47	-22.47	-24.47
C6	-24.97		-24.47	-28.47	-34.47
C7	-21.97	-47.04	-19.97	-23.97	N/A
C8	-21.97	-48.04	-20.97	-24.97	N/A
Median	-21.97	-37.54	-20.97	-24.22	-29.47

1 Video CCIR 3 levels for the 9 indicated (*) receivers were determined at the time of supplemental BTSC audio testing (7/7/95). Video CCIR 3 levels for all other receivers had been found on 4/25/95.

2 On 13 receivers, expert observers noted that, during only the camera-pan portion of the test image, they observed impairment equivalent to CCIR Grade 3 at a lower level of interference than the level at which they voted the Grade 3 level for each receiver. The impairment observed during the pan took the form of diagonal stripes (beat pattern). The median CCIR 3 level shown at the bottom of this column was calculated by replacing the "voted" level for each of the 13 receivers with the level shown in this "EO&C on Beat" column. Comparison of the median levels for the five columns shows that this beat effect was the dominant impairment for this test condition.

3 The audio CCIR 3 level was determined at the Moderate desired power level only for comparison with the results obtained at the Weak desired power level.

4 The CCIR 4 impairment level was deemed the critical level for testing at the Moderate and Strong desired power levels, inasmuch as the entire service area would be affected.

5 It was anticipated that the SAP service would be less robust than the main audio. Nevertheless, it was deemed desirable to apply the same CCIR 4 criterion to the SAP as to the main audio service.

6 The expert observers noted that for receiver A1, male voice is <u>much</u> less affected by impairment. Glockenspiel is affected more by impairment and is determined to be quite annoying, when male voice is only slightly affected. The expert observers averaged them to arrive at an impairment level. [7/7/95 EO&C #1 Rev. 2]

7 The expert observers noted that for receiver A5, the speaker has buzz and VBI noise when no impairment is present. [7/7/95 EO&C #1 Rev. 2]

8 The expert observers noted that for receiver C1, the audio was annoying even with no impairment. It was very difficult to select a CCIR Level 4 impairment. [7/7/95 EO&C #1 Rev. 2]

9 The expert observers noted that for receiver C2, the volume drops when a CCIR Level 3 impairment is inserted. [7/7/95 EO&C #1 Rev. 2]

Table 4-3

Degradation of BTSC Audio in the Presence of Upper Adjacent Channel ATV

At Strong Desired power level (-25 dBm nominal; -24.94 dBm actual for audio); Undesired levels in dBm

Receiver	Video CCIR3		Audio CCIR3[3]	Audio CCIR4[4]	SAP CCIR4[5]
	Voted[1]	EO&C on Beat[2]			
A1[6]	-16.95*		-19.95	-21.95	-21.95
A2	>-10.20*	-28.12	>-10.20	>-10.20	N/A
A3	-13.00	-28.12	-10.20	-13.20	N/A
A4	>-10.20*		>-10.20	-10.20	-12.20
A5	-12.00	-28.12	-13.95	-15.95	N/A
A6	-10.95*		>-10.20	>-10.20	>-10.20
A7	-22.00	-29.12	>-10.20	>-10.20	N/A
A8	-15.00	-28.12	-13.45	-13.70	-14.20
B1	-13.00		-13.95	-15.95	-18.95
B2	-11.95*		-10.20	-12.20	-12.20
B3	-13.00	-28.12	>-10.20	-11.20	-12.20
B4	-12.00	-28.12	>-10.20	-11.20	-11.20
B5	-15.00		-20.95	-22.95	-24.45
B6	-17.00		-21.95	-24.95	-26.95
B7	-10.20*		-22.20	-23.20	-22.20
B8	-16.00		>-10.20	-11.95	-13.70
C1	-10.20*	-28.12	-13.20	Note 7	N/A
C2	-10.95*		-10.20	-12.20	-15.20
C3	-12.00		-13.95	-14.95	N/A
C4	>-10.20*		>-10.20	>-10.20	N/A
C5	>-10.20*		-12.20	-14.20	-13.20
C6	-15.00		-13.70	-15.20	-18.20
C7	-13.95*	-28.12	-10.45	-11.20	N/A
C8	-14.00	-28.12	-11.45	-13.45	N/A
Median	-12.50	-16.48	-10.95	-13.20	-14.20

1 Video CCIR 3 levels for the 11 indicated (*) receivers were determined at the time of supplemental BTSC audio testing (7/21/95). Video CCIR 3 levels for all other receivers had been found on 4/25/95.

2 On 10 receivers, expert observers noted that, during only the camera-pan portion of the test image, they observed impairment equivalent to CCIR Grade 3 at a lower level of interference than the level at which they voted the Grade 3 level for each receiver. The impairment observed during the pan took the form of diagonal stripes (beat pattern). The median CCIR 3 level shown at the bottom of this column was calculated by replacing the "voted" level for each of the 10 receivers with the level shown in this "EO&C on Beat" column. Comparison of the median levels for the five columns shows that this beat effect was the dominant impairment for this test condition.

3 The audio CCIR 3 level was determined at the Strong desired power level only for comparison with the results obtained at the Weak desired power level.

4 The CCIR 4 impairment level was deemed the critical level for testing at the Moderate and Strong desired power levels, inasmuch as the entire service area would be affected.

5 It was anticipated that the SAP service would be less robust than the main audio. Nevertheless, it was deemed desirable to apply the same CCIR 4 criterion to the SAP as to the main audio service.

6 The noise mute was disabled on Receiver A1 for these measurements.

7 Audio CCIR 4 could not be determined for Receiver C1 due to the noise level of the receiver with no impairment.

Table 4-4

Degradation of BTSC Audio in the Presence of Lower Adjacent Channel ATV

At Weak Desired power level (-55 dBm nominal; -54.94 dBm actual for audio for Receivers A1, A6, and B1; -55.01 dBm actual for Receivers B4, B5, and B7); Undesired levels in dBm

Receivers	Video CCIR3[1]	Audio CCIR3[2]	SAP CCIR3[3]
A1	-33.01*	-26.01	-30.01
A2			
A3	-40.04		
A4			
A5			
A6	-42.04	-36.01	-40.01
A7	-43.04		
A8			
B1	-40.04	-36.01	-38.01
B2			
B3	-43.04		
B4	-32.01*	-25.97	-26.97
B5	-40.04	-38.97	-43.47
B6	-42.04		
B7	-33.01*	-29.97	-32.97
B8	-43.04		
C1			
C2	-39.04		
C3	-39.04		
C4			
C5	-45.04		
C6	-40.04		
C7			
C8			
Median	-39.04		

1 Video CCIR 3 levels for the 3 indicated (*) receivers were determined at the time of supplemental BTSC audio testing (7/10/95). Video CCIR 3 levels shown for other receivers had been found on 4/24/95.

2 Audio CCIR 3 levels were determined for six receivers, as specified in the original BTSC audio test plan. The built-in speakers were used. Since none of the six receivers showed the audio to be more critical than the video, no further audio testing was undertaken.

3 As anticipated, the SAP service was found to be less robust than the main audio. However, the SAP was less robust than the video for only one of the six receivers tested (B5). Therefore, no further SAP testing was undertaken.

Table 4-5

Degradation of BTSC Audio
in the Presence of N+14 UHF Taboo Channel ATV

At Weak Desired (-54.88 dBm actual) power level; Undesired levels in dBm

Receivers	Video TOV[1]	Video CCIR3[2]	Audio CCIR3[3]	SAP CCIR[3]
A1	-25.79	-17.71*	>-12.21	>-12.21
A2	-37.45	-32.62	-12.21	
A3	-24.45	-20.62	>-12.21	
A4	-20.45	>-12.21*	>-12.21	>-12.21
A5	-30.79	-26.62	-20.46	
A6	-31.79	-28.62	-18.46	-21.46
A7	-27.79	-21.62	>-12.21	
A8	-14.62	>-12.21*	>-12.21	>-12.21
B1	-28.12	-22.62	-14.46	-17.46
B2	-16.79	>-12.21*	>-12.21	>-12.21
B3	-20.12	>-12.21*	>-12.21	>-12.21
B4	-28.12	-25.62	>-12.21	-12.21
B5	-33.79	-29.62	-15.46	-19.46
B6	-31.79	-31.62		
B7	-17.45	>-12.21*		
B8	-19.45	>-12.21*		
C1	-30.79	-28.62		
C2	-23.79	-14.71*		
C3	-27.45	-25.62		
C4	-16.12	>-12.21*		
C5	-36.12	-31.62		
C6	-21.45	-15.71*		
C7	-24.12	-13.71*		
C8	-25.12	-14.71*		
Median	**-25.45**	-21.62	>-21.62	>-21.62

1 The TOV for each receiver, determined on 5/12/95, was used as the starting level for finding the audio CCIR 3 level for that receiver on 7/21/95.

2 Video CCIR 3 levels for the 12 indicated (*) receivers were determined at the time of supplemental BTSC audio testing (7/21/95). Video CCIR 3 levels for all other receivers had been found on 5/12/95. The median CCIR 3 level shown is the "preliminary" level per the procedure of Section III-4.3.5 of the Test Plan, based upon the individual CCIR 3 levels of 12 of the 24 receivers rather than upon a "median" receiver.

3 After 13 of the 24 receivers had been tested, it was observed that none had exhibited greater sensitivity for audio than for video. Therefore, no further audio testing was undertaken.

Section 5.

IMAGE RESOLUTION

5.1. Introduction

The resolution tests covered in this section measure the ability of the Grand Alliance system to delineate picture detail. Static resolution measures ability to reproduce stationary, time-invariant detail. Dynamic resolution measures the ability of an ATV system to preserve image detail during movement. The tests measured both luminance and chrominance static and dynamic resolution.

5.2. Method

A master videotape containing the necessary test signals, as listed in *Section I-5.3.1* of the Test Plan, was prepared in each format, 720P and 1080I. Each tape was then played back through the Grand Alliance system. The horizontal peaking in the system was turned off during this test.

Expert observers were shown the output of the system "live" on a high-resolution monochrome display. The observers noted the points of limiting resolution, as directed by the Test Plan. Tables 5-1 through 5-4 contain data from the direct observations of the display, in units of C/APH. The experts also provided written comments on their observations, referenced in the table and reproduced following the table. In addition, an archival videotape was made to document all of the tests.

Determination of the limiting vertical resolution is complicated by the aliasing that results from beats between the raster scanning lines and the test pattern. A fortunate property of the zone-plate pattern is that the true vertical resolution appears as concentric circles centered on the "bull's eye," while the aliasing appears as concentric circles centered above and below the raster. Therefore, the aliasing does not obscure the point of true limiting resolution, since a careful observer can discriminate between the opposite curvatures of the true and spurious patterns.

5.3. Data

The resolution test charts (the circular zone plate and radial resolution patterns) when observed through the Grand Alliance system, show that there is no diagonal filtering in this system. However, since high diagonal spatial frequencies are accorded a very limited portion of the video bit budget, these frequencies appear very noisy. Based upon our best understanding of MPEG compression, the Test Center staff believe that this accounts for the "boiling" effects that we and other observers noted, particularly in saturated reds, oranges, and magentas. This quantization noise may be captured and studied by frame freezing the archival recordings made of these signals through the system. As additional archival material, the Test Center made off-monitor photographs of these images. These photographs illustrate the quantization noise which appears in areas of very high spatial frequencies, especially high <u>diagonal</u> frequencies.

5.3.1. Luminance Static Resolution

The limiting resolution, determined using circular zone plate patterns, is presented in Table 5-1. Notes reflecting the expert observers' comments follow the table.

Table 5-1

Luminance Static Resolution (C/APH)*

Description	1080I			720P		
	H	V	D	H	V	D
Limiting resolution	460[1]	400[2]	540[3]	320[4]	275[5]	400[6]

* C/APH: cycles per active picture height

Notes on 1080I [7/5/95 EO&C #2]:

1 There was some very low level, hardly noticeable fixed circular aliasing at 360 C/APH and 520 C/APH in the 3:00 o'clock and 9:00 o'clock locations.

2 Only aliasing in the vertical direction was observed to be strongly noticeable. There was strong aliasing at 520 C/APH in the 6:00 o'clock and 12:00 o'clock positions with concentric circles extending outward. There are several locations of minor aliasing at 250 C/APH (flickering depending on eye movement), 350 C/APH in the 6:00 o'clock and 12:00 o'clock positions.

3 There was minor aliasing at 500 C/APH in the four 45° diagonals (fixed circular pattern, with some mottling).

Notes on 720P [7/5/95 EO&C #22]:

4 Left side of pattern measured 320; right side measured 330.

5 There was stationary aliasing centered at 370 C/APH at 6:00 o'clock and 12:00 o'clock. Limiting vertical resolution was determined at the point where the level of aliasing was just below the level of the true pattern.

6 Diagonal resolution is better at 30° from vertical axis (480 C/APH) than at 45° from vertical axis (400 C/APH).

5.3.2. Chrominance Static Resolution

The limiting resolution, determined using circular zone plate patterns, is presented in Table 5-2. Notes reflecting the expert observers' comments follow the table.

Table 5-2

Chrominance Static Resolution (C/APH)*

Description	1080I			720P		
	H	V	D	H	V	D
Limiting resolution (R-Y)	250	140[1]	260	180[2]	180[2]	230[2]
Limiting resolution (B-Y)	250	140[1]	260	180[3]	180[3]	230[3]

* C/APH: cycles per active picture height

Notes on 1080I R-Y [7/5/95 EO&C #4 Rev 2} and B-Y [7/5/95 EO&C #6 Rev 2]:

1 All aliasing patterns were observed on the vertical axis and all were stationary (unaffected by eye movement). Aliasing patterns were centered above and below the center of the zone plate. These were seen to be strong at 500 C/APH and 250 C/APH and to be noticeable at 380 C/APH and 240 C/APH. The Chief Scientist of ATTC is of the opinion that the additional patterns identified as "noticeable" by the observers are merely optical artifacts of the monitor screen ("Newton's rings"). The expert observers commented that the aliasing patterns exhibited some noticeable mottling but that the usable part of the pattern inside the 260 C/APH circle was clean.

Notes on 720P R-Y [7/18/95 EO&C #24, Rev. 2]:

2 The patterns with and without calibration circles were observed after being passed through the GA system. It was noted that the calibration circles and edges of the pattern cause some blocking artifacts.

Some noise was noticed outside the 150 C/APH calibration circle (slowly changing random pattern; some mottling) and some blockiness was noticed on the periphery of the center circle.

Notes on 720P B-Y [7/5/95 EO&C #26]:

3 Some blockiness was noticed inside the center circle and all other observations are the same as those in Note 2.

5.3.3. Luminance Dynamic Resolution

The limiting resolution, determined using radial resolution patterns, is presented in Table 5-3. Notes reflecting the expert observers' comments follows the table.

Table 5-3

Luminance Dynamic Resolution (C/APH)*

Description	1080I			720P		
	H	V	D	H	V	D
Limiting resolution 0.0 rpm	500	360[1]	540[4]	300[5]	270[5,6]	360[5,7,8]
Limiting resolution 0.5 rpm	500	360[1]	540[4]	300[9]	270[9]	360[8,9]
Limiting resolution 1.5 rpm	500	360[2]	540[4]	300	240[10]	360[8]
Limiting resolution 5.0 rpm	500	200[3]	540[4]	300	210[11]	360[8]

* C/APH: cycles per active picture height

Notes on 1080I [7/5/95 EO&C #7, Rev 1]:

1 The limiting vertical resolution at 0 and 0.5 rpm was nearly 360 C/APH because aliasing (moiré) became predominant before the pattern went to gray in the center.

2 The same observation as in Note 1, but moiré near 360 C/APH appeared slightly more noticeable.

3 The same observation as in Note 1, however the moiré near 360 C/APH in the 3:00 o'clock and 9:00 o'clock positions was high amplitude, and the limiting vertical resolution was judged at 200 C/APH (below where the moiré/aliasing was predominant).

4 *[ATTC Note]* The radial resolution test pattern was designed to have maximum calibrated resolution at the Nyquist frequency of the format. Consequently the diagonal resolution may be more than the maximum calibrated resolution of 540 C/APH.

Notes on 720P [7/6/95 EO&C #1]:

5 Accurate numbers could not be determined.

6 Vertical resolution was limited by aliasing at 270 C/APH, but the pattern could be resolved up to the gray center circle. (A comparison of the input signal to the output of the system showed that there was virtually no loss in the system. All aliasing was observed in the input signal.)

7 Diagonal resolution reached to the edge of the gray circle (360 C/APH).

8 *[ATTC Note]* The radial resolution test pattern was designed to have maximum calibrated resolution at the Nyquist frequency of the format. Consequently the diagonal resolution may be more than the maximum calibrated resolution of 360 C/APH.

9 There was no change in resolution but there was some high frequency noise and mottling inside the 183 C/APH circle.

10 The vertical resolution was decreased due to increased aliasing. Noise and mottling increased.

11 The vertical resolution was decreased further, and there was more noise and mottling.

5.3.4. Chrominance Dynamic Resolution

The limiting resolution, determined using radial resolution patterns, is presented in Table 5-4. Notes reflecting the expert observers' comments follows the table.

Table 5-4

Chrominance Dynamic Resolution (C/APH)*

Description	1080I			720P		
	H	V	D	H	V	D
Limiting resolution (R-Y) 0.0 rpm	258[1]	129[1]	160[1]	175[6]	175[6]	200[6]
Limiting resolution (B-Y) 0.0 rpm	260[1]	135[1]	160[1]	175[7]	175[7]	200[7]
Limiting resolution (R-Y) 0.5 rpm	258[2]	129[2]	160[2]	175[8]	175[8]	200[8]
Limiting resolution (B-Y) 0.5 rpm	260[2]	135[2]	160[2]	175[9]	175[9]	200[9]
Limiting resolution (R-Y) 1.5 rpm	240[3]	129[3]	160[3]	170[10]	170[10]	200[10]
Limiting resolution (B-Y) 1.5 rpm	240[3]	129[3]	160[3]	170[11]	170[11]	200[11]
Limiting resolution (R-Y) 5.0 rpm	135[4]	100[4]	135[4]	170[12]	160[12]	183[12]
Limiting resolution (B-Y) 5.0 rpm	135[4]	100[4]	135[4,5]	170[13]	160[13]	183[13]

* C/APH: cycles per active picture height

Notes on 1080I R-Y [7/5/95 EO&C #12] and B-Y [7/5/95 EO&C #17]:

1 Some stationary (very slow) noise could be observed.

2 Noise was more noticeable and appeared to contain some blockiness, especially around the gray circle in the center.

3 The same observation as in Note 2, but artifacts were more noticeable. Some blockiness at 6:00 and 12:00 o'clock.

4 Severe artifacts could be observed everywhere. Resolution outside the 135 C/APH circle was usable. There were various effects of blockiness and aliasing inside the circle.

Note on 1080I B-Y (only):

5 The reading of diagonal resolution was difficult except when the reading fell on a calibration circle.

Notes on 720P R-Y [7/6/95 EO&C #6]:

6 Some irregularities and noise could be observed in most of the pattern. The pattern inside the 182 C/APH circle was not usable.

8 Noise and aliasing were increased at approximately 150 C/APH, and blockiness became very noticeable inside the 182 C/APH circle.

10 More noise and aliasing up to the 91 C/APH circle. All other artifacts were more noticeable.

12 Same comments as above in Note 10. Generally all artifacts were increased. Lots of noise inside the 91 C/APH circle.

Notes on '20P B-Y [7/6/95 EO&C #11]:

7 Slightly more noise was observed here than with R-Y, especially in the diagonal direction.

9 Same as Note 8, except slightly more noise, especially in the diagonal direction.

11 Same as Note 10, except slightly more noise, especially in the diagonal direction.

13 Same as Note 12, except slightly more noise, especially in the diagonal direction.

Section 6.

DYNAMIC ARTIFACTS

6.1. Introduction

The purpose of this test was to make a comparison of dynamic artifacts present in the Grand Alliance system to those in the luminance resolution tests of the digital systems that were observed in the first round of testing. All of these tests used a luminance circular zone plate pattern.

6.2. Method

The expert observers were first shown the archive recordings made of luminance resolution from systems tested in the first round. These included DSC-HDTV, AD-HDTV, and CCDC systems. There was no archive tape of the DigiCipher system available. The comments which had been written on dynamic artifacts by expert observers in the first round testing of the digital systems—DigiCipher, DSC-HDTV, AD-HDTV, and CCDC—were also shown to the expert observers.

6.3. Data

After measuring the Grand Alliance system, the expert observers made comments as reproduced below. In the case of the 1080I format, they made a comparison with the AD-HDTV interlaced-scan system, which they considered the appropriate comparison system. In the case of 720P, they made comparison to the CCDC progressive-scan system, which they considered the appropriate comparison system.

1080I Dynamic Artifacts: [7/6/95 EO&C #16, Rev. 2]

Overall there is a slight improvement over AD-HDTV.

@K_t = 0.05, 25% Noise Loading:

1) Very noticeable I-frame update at 2-3 Hz on right and left edges.
2) New aliasing circles (low amplitude) along diagonals.
3) New aliasing circles on right and left, top to bottom.

@K_t = 0.10, 25% Noise Loading

1) Same as K_t 0.05
2) An additional row of aliasing circles noticed at 15% and 85% of picture height.

@K_t = 0.20, 25% Noise Loading

1) Same as K_t 0.10
2) Some mottlings noticed in two bands on right and left from top to bottom (about 1" wide).

@K_t = 0.30, 25% Noise Loading

1) Same as K_t 0.20
2) Observations from above are more noticeable.

720P Dynamic Artifacts: [7/6/95 EO&C #17]

Much improvement over CCDC.

@K_t = 0.05, 25% Noise Loading:

1) Some mottliness in 2 vertical bands on right and left.
2) One frame update rate is noticeable but at 5-6 Hz.
3) Some new circular pattern artifacts on left and right top to bottom.

@K_t = 0.10, 25% Noise Loading:

1) Same as K_t 0.05
2) Some general increase in visibility of artifacts.

@K_t = 0.20, 25% Noise Loading:

1) Same as K_t 0.10
2) Some mottliness along center top to bottom.
3) Generally more quantization noise.

@K_t = 0.30, 25% Noise Loading:

1) Same as K_t 0.20
2) All artifacts more noticeable.

Section 7.

TRANSIENT RESPONSE

7.1. Introduction

Transient response is characterized by the time response of a system to specific changing inputs. Generally, this is a measure used for characterizing linear systems. Although ATV systems are not necessarily linear, the transient response for specific inputs still may be specified. The Test Plan provides for testing of transient response to input steps in the horizontal, vertical, and temporal dimensions. A step is defined as a signal that represents a sudden transition from one level to another level. The testing included separate testing of luminance and chrominance.

7.2. Method

The procedures specified in the Test Plan were followed, except that for the temporal response measurements, the video input to the Grand Alliance system was gated on for 8 frames and off for 8 frames.

A master videotape containing the necessary test signals, as listed in *Section I-7.3.1* of the Test Plan, was prepared in each format, 720P and 1080I. Each tape was then played back through the Grand Alliance system. The horizontal peaking in the system was turned off during this test. The output of the system was displayed "live" on either a high-resolution monochrome display or an oscilloscope. Photographs were taken, from which the data presented in the tables were derived. In addition, an archival videotape was made to document all of the tests.

7.3. Data

Horizontal transient response was determined by measuring the rise time of both the step input to the Grand Alliance system and the output step from the system. The imputed rise time of the system, as presented in the tables below, was then determined by applying the well known Law of Addition Rise Times (per Valley & Wallman, MIT Radar Series, Vol. 18). This law states that the square of the output signal rise time is equal to the sum of the squares of the rise times of the input signal and system under test. Therefore, the system rise time may be determined as the square root of the difference of the squares of the output and input rise times. As the Test Plan specifies, the measurements taken in nanoseconds have been converted into normalized units of percentage of picture height.

In the vertical dimension the scanning process, which is essentially a sampling process, gives an amplitude for the test signal for each line. These amplitudes have been taken from waveform photographs and plotted by ATTC. From these plots, a curve-fitting process was used to produce smooth curves. The 10-percent and 90-percent amplitude points of the curve were then determined by interpolation. The vertical transient response data presented in the tables reflect these interpolated values, converted into normalized units of percentage of picture height.

The vertical step response of the luminance channel shows no vertical filtering. However, the vertical step response of the chrominance channels does show the effects of vertical chrominance filtering. The step response shows a pre-shoot before the transition, as might be expected. But, unexpectedly, no overshoot was found. The signal was attenuated by 2 dB and placed on a pedestal to determine whether clipping had eliminated the overshoots. No evidence of such clipping was found. Such lack of symmetry suggests that these filters are not phase linear. The Test Plan did not provide for moving of these transitions vertically. So, it is unknown whether the asymmetry is due to coincidence of these transitions with block

boundaries and might not have been observed had the transition been on a different line, as was suggested to ATTC staff by members of the Grand Alliance team.

The tests of diagonal resolution, reported in Section 5, showed that there is no diagonal filter for either luminance or chrominance in the Grand Alliance system. However, in the tests of diagonal transient response, reported in this section, the measured rise time of the steps did show significant variations. Members of the Grand Alliance team indicated to ATTC staff that these variations may be related to the positions of the steps relative to block boundaries.

7.3.1. Luminance Step Response

TABLE 7-1

Luminance Step Response

Description	1080I				720P			
	0 dB		-12 dB		0 dB		-12 dB	
	Time	%APH	Time	%APH	Time	%APH	Time	%APH
Horizontal transient response	10.72 nS	0.074%	19.69 nS	0.135%	10.84 nS	0.112%	10.56 nS	0.109%
Vertical transient response	No vertical filtering							
Diagonal transient response	No diagonal filtering							

%APH: percentage of active picture height

7.3.2. Chrominance Step Response

TABLE 7-2

Chrominance Step Response

Description	1080I				720P			
	0 dB		-12 dB		0 dB		-12 dB	
	Time	%APH	Time	%APH	Time	%APH	Time	%APH
Horizontal transient response (R-Y)								
Rise time	40.11 nS	0.275%	38.10 nS	0.262%	31.85 nS	0.328%	25.88 nS	0.267%
Fall time	42.00 nS	0.288%	32.26 nS	0.222%	24.91 nS	0.257%	41.40 nS	0.426%
Vertical transient response (R-Y)								
Fall time	5.10 TVL	0.472%	4.70 TVL	0.435%	1.70 TVL	0.236%	1.70 TVL	0.236%
Diagonal transient response (R-Y)	No diagonal filtering							
Horizontal transient response (B-Y)								
Rise time	30.71 nS	0.211%	39.62 nS	0.272%	32.61 nS	0.336%	18.95 nS	0.195%
Fall time	23.94 nS	0.164%	30.64 nS	0.210%	25.29 nS	0.261%	36.08 nS	0.372%
Vertical transient response (B-Y)								
Fall time	5.20 TVL	0.481%	5.60 TVL	0.519%	1.70 TVL	0.236%	1.80 TVL	0.250%
Diagonal transient response (B-Y)	No diagonal filtering							

%APH: percentage of active picture height
TVL: Television lines

7.3.3. Luminance Temporal Response

The Luminance Temporal Response test has two parts. The first uses a window test signal to measure any frame-by-frame amplitude transients resulting from a cut between the test signal and black. The second uses a radial resolution pattern to measure any frame-by-frame build-up or decay in resolution resulting from such a cut.

As required by the Test Plan, photographs were obtained both with the full-amplitude test signal and with the signal attenuated by 12 dB. All of the photographs have been archived by the Test Center.

Unlike any of the systems tested in the first round, the Grand Alliance HDTV system contains a scene-change detector which ensures that the first frame following a scene change is transmitted as an "I" frame. The scene-change detection is discussed in a memo from J. Mailhot (AT&T) to C. Rhodes (ATTC), reproduced in *Section 14*. The system recognized the temporal steps used in this test as scene changes. No temporal transient effects were discernible on either test pattern at either transition, from pattern to black or from black to pattern.

7.3.4. Chrominance Temporal Response

No temporal transient effects were discernible on either the window or the radial resolution test pattern, at either transition.

Section 8.

EFFECTS OF CONCATENATION OF SPATIAL/TEMPORAL PROCESSING

A videotape was prepared by ATTC in accordance with *Section I-8* of the Test Plan. The tape was viewed and commented upon by the expert observers of the Task Force on Digital-Specific Testing. Refer to their report in *Part II* for their observations.

Section 9.

INTEROPERABILITY AND PACKETIZATION TESTS

The tests in this Section address the operation, management, and robustness of the Grand Alliance system bit stream and compliance of the Grand Alliance system with the MPEG-2 compression and transport syntax.

Most of these tests rely on "data tapes" containing the output of the Grand Alliance system's encoder (*i.e.* the signal for transmission), as described in *Section 9* of the Test Plan. While the data tapes were completed by ATTC using the Grand Alliance system when it was at the Test Center, further work on these tapes was conducted by other laboratories. The report of each of these laboratories is included below.

9.1. Switching between Compressed Data Streams—*Results to be supplied.*

9.2. Header/Descriptor Robustness—*Results to be supplied.*

Grand Alliance laboratories are continuing work on the data tapes for the above two tests. Once completed, the data will be decoded by the Grand Alliance system and recorded as video and audio on high definition tape. This video and audio will be assessed and observations reported to the FCC Advisory Committee.

* * *

9.3. Compression Layer Interoperability

Note: These MPEG-2 compliance tests were carried out at Hitachi and IBM laboratories. This section was prepared by Frank Lane and Jill Boyce, *Hitachi America, Ltd.* and Inching Chen, *IBM.*

The purpose of the compression layer interoperability test was to verify interoperability of the Grand Alliance system at the bitstream level. To this end several samples of bitstream where recorded at the output of the transport encoder. At this point the bitstream should conform to a MPEG-2 Transport Stream as defined by ISO Standard 13818 and constrained by ATSC Standard "Digital Television Standard for HDTV Transmission."

The sampled bitstreams have been checked by software developed at Hitachi and IBM for MPEG-2 and ATSC syntax and semantic compliance. The syntax elements and semantic rules which are checked by the programs are described in this report as well as the performance of the Grand Alliance bitstreams. Note, the software can only detect violations of those elements which are examined within the bitstream samples acquired. Thus it does not verify a specific encoder is completely compliant under all coding conditions.

Bitstream Samples

Grand Alliance bitstreams were sampled from the encoder at the output of the transport encoder. The bitstreams were digitally recorded by D3 tape and transferred to 8 mm tape for distribution to Hitachi and IBM for verification.

A selection of scenes were used for the source material, and each selection was recorded as compressed in progressive and interlace formats. Table 9-1 below describes the video source material, Table 9-2 describes the audio source.

Table 9-1

Interoperability Compression Layer Source Video

Video Scene Description	Format	Duration	Time Code	
			Start/In	Stop/Out
1 Minute Sequence				
M43 Advisory Committee (Ducks)	720 P	15 secs	00:06:00.00	00:06:15.00
M43 Advisory Committee (Ducks)	720 P	15 secs	00:06:15.00	00:06:30.00
M48 Connections Graphic 30 fps	720 P	15 secs	00:06:30.00	00:06:45.00
M48 Connections Graphic 30 fps	720 P	15 secs	00:06:45.00	00:07:00.00
Gray	720 P	15 secs	00:07:00.00	00:07:15.00
4 - 15 Second Sequences				
M16A Rotating Pyramids	720 P	15 secs	00:07:15.00	00:07:30.00
Gray	720 P	15 secs	00:07:30.00	00:07:45.00
M11 Lamp	720 P	15 secs	00:07:45.00	00:08:00.00
Gray	720 P	15 secs	00:08:00.00	00:08:15.00
S1 Metal Table & Chairs	720 P	15 secs	00:08:15.00	00:08:30.00
Gray	720 P	15 secs	00:08:30.00	00:08:45.00
M45 Christa	720 P	15 secs	00:08:45.00	00:09:00.00
Gray	720 P	15 secs	00:09:00.00	00:09:15.00
Black	1035 I	1 sec	00:09:15.00	00:09:16.00
Gray	1035 I	14 secs	00:09:16.00	00:09:30.00
1 Minute Sequence				
M43 Advisory Committee (Ducks)	1035 I	15 secs	00:09:30.00	00:09:45.00
M43 Advisory Committee (Ducks)	1035 I	15 secs	00:09:45.00	00:10:00.00
M48 Connections Graphic 30 fps	1035 I	15 secs	00:10:00.00	00:10:15.00
M48 Connections Graphic 30 fps	1035 I	15 secs	00:10:15.00	00:10:30.00
Gray	1035 I	15 secs	00:10:30.00	00:10:45.00
4 - 15 Second Sequences				
M16A Rotating Pyramids	1035 I	15 secs	00:10:45.00	00:11:00.00
Gray	1035 I	15 secs	00:11:00.00	00:11:15.00
M11 Lamp	1035 I	15 secs	00:11:15.00	00:11:30.00
Gray	1035 I	15 secs	00:11:30.00	00:11:45.00
S1 Metal Table & Chairs	1035 I	15 secs	00:11:45.00	00:12:00.00
Gray	1035 I	15 secs	00:12:00.00	00:12:15.00
M45 Christa	1035 I	15 secs	00:12:15.00	00:12:30.00
Gray	1035 I	15 secs	00:12:30.00	00:12:45.00

Table 9-2

Interoperability Compression Layer Source Audio

Audio Scene				
Description	Format	Duration	Time Code	
			Start/In	Stop/Out
1 Minute Sequence				
#4 Tabernacle Choir "God Be With You"	5.1 channel	37 secs	00:06:00.00	00:06:37.00
#14 Clarinet and Rain	5.1 channel	20 secs	00:06:37.00	00:06:57.00
Silence	5.1 channel	18 secs	00:06:57.00	00:07:15.00
4 Short (12-15 second) Sequences				
#7 Indy II	5.1 channel	15 secs	00:07:15.00	00:07:30.00
Silence	5.1 channel	15 secs	00:07:30.00	00:07:45.00
#14 Clarinet and Rain	5.1 channel	15 secs	00:07:45.00	00:08:00.00
Silence	5.1 channel	15 secs	00:08:00.00	00:08:15.00
#19 Infinito	5.1 channel	16 secs	00:08:15.00	00:08:31.00
Silence	5.1 channel	14 secs	00:08:31.00	00:08:45.00
#20 Choir	5.1 channel	15 secs	00:08:45.00	00:09:00.00
Silence	5.1 channel	30 secs	00:09:00.00	00:09:30.00
1 Minute Sequence				
#4 Tabernacle Choir "God Be With You"	5.1 channel	37 secs	00:09:30.00	00:10:07.00
#14 Clarinet and Rain	5.1 channel	20 secs	00:10:07.00	00:109:27.00
Silence	5.1 channel	18 secs	00:10:27.00	00:10:45.00
4 Short (10 second) Sequences				
#5 Ornette Coleman	2 channel	10 secs	00:10:45.00	00:10:55.00
Silence	2 channel	20 secs	00:10:55.00	00:11:15.00
#7 Castanets	2 channel	10 secs	00:11:15.00	00:11:25.00
Silence	2 channel	20 secs	00:11:25.00	00:11:45.00
#8 Male Speech	2 channel	10 secs	00:11:45.00	00:11:55.00
Silence	2 channel	20 secs	00:11:55.00	00:12:15.00
#10 Haydn Trumpet	2 channel	10 secs	00:12:15.00	00:12:25.00
Silence	2 channel	20 secs	00:12:25.00	00:12:45.00

Elements Verified

The software will parse and report on syntax elements in the MPEG-2 Systems and Video layers. Some of the semantic constraints are tested in the programs and some can be verified by examining the reports generated by the programs and the decoded output. The list below represents the intersection of the set of elements detectable by the verification software and the set of elements present in the bitstream samples.

Transport Syntax

The following elements of ISO 13818-1 were tested in the bitstreams:

Video Elementary Stream Buffer Compliance
Audio Elementary Stream Buffer Compliance

Transport Packet Headers:
- sync byte
- transport error indicator
- payload unit start indicator
- transport priority
- PID
- transport scrambling control
- adaptation field control
- continuity counter

Adaptation Headers:
- adaptation field length
- discontinuity indicator
- random access indicator
- elementary stream priority indicator
- PCR flag
- OPCR flag
- splicing point flag
- transport private data flag
- adaptation field extension flag
- PCR
- PCR reserved bits
- adaptation header stuffing

PES Packet Headers
- packet start code prefix
- stream ID
- PES packet length
- PES scrambling control
- PES priority
- data alignment indicator
- copyright
- original or copy flag
- PTS DTS flag
- ESCR flag
- ES rate flag
- DSM trick mode flag
- additional info flag
- PES CRC flag
- PES extension flag
- PES Header data flag
- PTS
- DTS
- reserved bits