

Statistical Analyses. The primary purpose of the statistical analyses was to determine whether differences between Reference and Test were statistically reliable; that is, whether the observed differences could be attributed to chance variation or to actual differences in rated quality. ANOVAs assessed overall effects of Tape Order, Reference vs. Test, Replicate and Picture. Newman-Keuls tests assessed effects on a sequence-by-sequence basis.

Statistical analyses were conducted in three stages: 1) Comprehensive ANOVAs were conducted comparing Reference and Test for the five sequences (S1, M16A, M40, M43, M49) that were tested at all four InOut combinations; 2) Pairwise Newman-Keuls comparisons were conducted on Reference and Test for all sequences; 3) Pairwise Newman-Keuls comparisons were conducted on difference scores for all sequences. Details of these analyses are shown in Appendix N.

Comprehensive ANOVAs (Tape Order x Reference vs. Test x Replicate x InOut x Picture) showed the following main effects: Picture indicated that, overall, sequences were rated at different levels of quality; Reference vs. Test indicated that Reference sequences were rated higher than Test sequences; InOut indicated that the four InOut combinations were rated differently.

Comprehensive ANOVAs showed a two-way interaction between Reference vs. Test and Picture, which indicated that the magnitude of the difference in rated quality between Reference and Test varied with Picture. For example, the difference between Reference and Test for Metal Table and Chairs (S1) was smaller than for Dream Team (M40).

For Rotating Pyramids (M16A), Picnic with Ants (M49) and Dream Team (M40) viewers rated the unconverted sequences lower in the present test than in the Basic Received Quality tests. For M16A and M49, this occurred because more critical 10 second segments were used in the present test than in the Basic Received Quality tests. Lower ratings for M40 can be attributed to viewer variability and context effects. In general, viewer ratings may have been affected by the use of a relatively greater number of critical (and impaired) sequences in the present test than in the Basic Received Quality tests (Section 2.0).

Comprehensive ANOVAs showed a significant three-way interaction between Reference vs. Test x Picture x InOut, which indicated that the efficacy of conversion varied with Picture. For example, conversion resulted in a larger reduction in rated image quality for Rotating Pyramids (M16A) than for Metal Table and Chairs (S1). Other interactions were examined and deemed to have no important implications for evaluating receiver scan conversion.

Post hoc analyses comparing Reference and Test sequences were performed using the Newman-Keuls test. Significance levels are shown in Table 24. Statistically significant effects at $p < .05$ were observed at 1080I - 1080I for sequences M16A, M40, M43 and M49, at 720P - 720P for sequences M40, M43, M49 and M10, at 1080I - 720P for sequences M16A, M40, M43 and M49 and at 720P - 1080I for sequences M16A, M40, M43, M49, M6 and M10.

Post hoc analyses on mean difference scores (Test minus Reference) were performed on each sequence using the Newman-Keuls test, comparing rated image quality for each InOut

combination. Results are presented in Table 25 and statistically significant effects at $p < .05$ are shaded. The table permits the reader to perform detailed pairwise comparisons between arbitrary InOut combinations for each sequence.

TABLE 24
SUMMARY OF POST HOC TESTS
REFERENCE vs. TEST

NEWMAN-KEULS			
ID	PICTURE	IN - OUT	RECEIVER SCAN CONVERSION
S1	Metal Table & Chairs	1080 - 1080	.77
S1	Metal Table & Chairs	1080 - 720	.99
S1	Metal Table & Chairs	720 - 720	.98
S1	Metal Table & Chairs	720 - 1080	.99
M16A	Rotating Pyramids	1080 - 1080	.00
M16A	Rotating Pyramids	1080 - 720	.00
M16A	Rotating Pyramids	720 - 720	.99
M16A	Rotating Pyramids	720 - 1080	.00
M40	Dream Team	1080 - 1080	.00
M40	Dream Team	1080 - 720	.00
M40	Dream Team	720 - 720	.00
M40	Dream Team	720 - 1080	.00
M43	Ducks	1080 - 1080	.00
M43	Ducks	1080 - 720	.00
M43	Ducks	720 - 720	.00
M43	Ducks	720 - 1080	.00
M49	Picnic With Ants	1080 - 1080	.00
M49	Picnic With Ants	1080 - 720	.00
M49	Picnic With Ants	720 - 720	.00
M49	Picnic With Ants	720 - 1080	.00
M6	Den	720 - 720	.10
M6	Den	720 - 1080	.00
M10	Woman And Room	720 - 720	.00
M10	Woman And Room	720 - 1080	.00
S14A	Cheshire Cat	1080 - 1080	.27
S14A	Cheshire	1080 - 720	.34

Significance levels $p < .05$ are shaded.

TABLE 25
RECEIVER SCAN CONVERSION
NEWMAN-KEULS PAIRWISE COMPARISONS

Metal Table & Chairs (S1)	Mean Difference Score / (In - Out)			
	-1.8 / (1080I - 1080I)	-0.4 / (1080I - 720P)	-1.4 / (720P - 720P)	-0.6 / (720P - 1080I)
-1.8 / (1080I - 1080I)	---	---	---	---
-0.4 / (1080I - 720P)	.95	---	---	---
-1.4 / (720P - 720P)	.89	.93	---	---
-0.6 / (720P - 1080I)	.93	.88	.89	---

Rotating Pyramids (M16A)	Mean Difference Score / (In - Out)			
	-6.7 / (1080I - 1080I)	-11.5 / (1080I - 720P)	-0.3 / (720P - 720P)	-6.8 / (720P - 1080I)
-6.7 / (1080I - 1080I)	---	---	---	---
-11.5 / (1080I - 720P)	.15	---	---	---
-0.3 / (720P - 720P)	.00	.00	---	---
-6.8 / (720P - 1080I)	.91	.16	.00	---

Dream Team (M40)	Mean Difference Score / (In - Out)			
	-13.2 / (1080I - 1080I)	-18.5 / (1080I - 720P)	-11.4 / (720P - 720P)	-14.2 / (720P - 1080I)
-13.2 / (1080I - 1080I)	---	---	---	---
-18.5 / (1080I - 720P)	.01	---	---	---
-11.4 / (720P - 720P)	.68	.00	---	---
-14.2 / (720P - 1080I)	.51	.02	.45	---

Ducks (M43)	Mean Difference Score / (In - Out)			
	-9.5 / (1080I - 1080I)	-9.6 / (1080I - 720P)	-7.5 / (720P - 720P)	-9.9 / (720P - 1080I)
-9.5 / (1080I - 1080I)	---	---	---	---
-9.6 / (1080I - 720P)	.93	---	---	---
-7.5 / (720P - 720P)	.31	.51	---	---
-9.9 / (720P - 1080I)	.97	.88	.59	---

Picnic with Ants (M49)	Mean Difference Score / (In - Out)			
	-31.4 / (1080I - 1080I)	-27.9 / (1080I - 720P)	-43.1 / (720P - 720P)	-44.6 / (720P - 1080I)
-31.4 / (1080I - 1080I)	---	---	---	---
-27.9 / (1080I - 720P)	.06	---	---	---
-43.1 / (720P - 720P)	.00	.00	---	---
-44.6 / (720P - 1080I)	.00	.00	.32	---

Significance levels $p < .05$ are shaded.

TABLE 25 (Continued)
RECEIVER SCAN CONVERSION
PAIRWISE COMPARISONS

Den (M6)	Mean Difference Score / (In - Out)	
	-2.4 / (720P - 720P)	-12.6 / (720P - 1080I)
	-2.4 / (720P - 720P)	---
-12.6 / (720P - 1080I)	.00	---

Woman and Room (M10)	Mean Difference Score / (In - Out)	
	-5.1 / (720P - 720P)	-7.4 / (720P - 1080I)
	-5.1 / (720P - 720P)	---
-7.4 / (720P - 1080I)	.20	---

Cheshire Cat (S14A)	Mean Difference Score / (In - Out)	
	-2.4 / (1080I - 1080I)	-1.7 / (1080I - 720P)
	-2.4 / (1080I - 1080I)	---
-1.7 / (1080I - 720P)	.67	---

Significance levels $p < .05$ are shaded.

4.4 Comparative - Receiver Scan Conversion

Target Specifications. To facilitate evaluation of the *digital* HDTV Grand Alliance System, the observed performance of the System compared against the target specification obtained from the "Grand Alliance HDTV System Specification" manual (Chapter 9, version Dec. 7, 1994).

The target specification is shown in Table 26. This indicates the maximum value of the mean difference score, that is, the maximum amount by which the average rating of the Test sequences can fall below the average rating of the Reference sequences. By comparing the mean difference scores with the target specification, it is clear that in both cases the *digital* HDTV Grand Alliance System exceeded the target specification by a wide margin.

TABLE 26
RECEIVER SCAN CONVERSION
TARGET SPECIFICATIONS

TEST SEQUENCE	1080I - 720P (TEST minus REF.)	720P - 1080I (TEST minus REF.)	TARGET SPECIFICATION ²²
S1	-0.38	-0.64	
S14A	-1.66	----	
M6	----	-12.59	
M10	----	-7.44	
M16A	-11.46	-6.82	
M40	-18.54	-14.19	
M43	-9.57	-9.90	
M49	-27.88	-44.63	
MEAN	-11.58 (± 10.93)	-13.74 (± 13.24)	

²² The target specification is reported in units, where 20 units = 1 grade.

²³ Corresponds to ≤ 1.0 grade.

5.0 AUXILIARY DATA TRADEOFF

Auxiliary Data Tradeoff was an optional test, to be performed only at the recommendation of the Task Force on Digital Specific Tests (SSWP2). The objective was to assess the subjective quality of image sequences that were encoded, modulated, transmitted, demodulated and decoded by the *digital* HDTV Grand Alliance System at reduced bit rates.

None of the sequences recommended in the "Grand Alliance System Test Procedure" (SSWP2-1306, "Test Plans") for the Digital Specific test on Auxiliary Data showed sufficient effect to warrant non-expert testing. The requirement for an ATEL Auxiliary Data Tradeoff was therefore waived by the Digital Specific Task Force.

The Task Force also examined Dream Team (M40), a sequence considered to be more challenging but still realistic. For further details refer to the report of the expert observers of the SSWP2 Task Force on Digital Specific Tests on Auxiliary Data Tradeoff.

6.0 COMMENTS BY THE GRAND ALLIANCE

6.1 Introduction

The Video Subjective Test Plan, which calls for judgements by non-experts, is intended to provide data on system performance that complement the objective measurements and expert observations called for under the Transmission and Objective Test Plan, the Digital-Specific Test Plan, and the Cable Television Transmission Test Plan.

The following sections present comments by the Grand Alliance concerning the results of tests carried out at the Advanced Television Evaluation Laboratory under the Video Subjective Test Plan. When appropriate, however, the comments draw readers' attention to relevant results generated in response to the other test plans.

6.2 Basic Received Quality

Judgements by non-expert viewers confirmed the excellent compression performance of the system in both 1080-line and 720-line modes (see Tables 4-6 and Figures 5-7). In both modes, judgements of the compressed pictures were equivalent statistically to those of the uncompressed reference for most test pictures (*i.e.*, for 19, or 73%, of 26 pictures in 1080-line mode and for 21, or 81%, of 26 pictures in 720-line mode).

For the remaining pictures, judgements of the system were inferior statistically to those of the uncompressed reference. However, in most cases, the reductions in judged quality, which reflected slight levels of compression artifacts and direct and indirect consequences of source noise (the latter particularly for the 1080-line mode), were not sufficiently large to be of practical significance.

The system showed quality reductions of any note only for two pictures, *Dream Team* and *Picnic with Ants*. *Dream Team* was particularly challenging for compression as it involved rapid and complex motion, multiple scene cuts, and frequent luminance changes due to camera flash guns. *Picnic with Ants* was even more challenging. Designed to test the limits of the compression algorithm, this scene involved progressive encroachment of artificially generated, high-amplitude luma/chroma noise over a still picture. Although the system was judged appreciably worse than the reference in this case, it did maintain viable video, confirming its robustness in the face of limit-case material.

Overall, the video performance of the system was considerably better than the Advisory Committee's target specifications for all categories of test material. In no case did the system's performance require more than 50% of the tolerance allowed in the relevant specification (*e.g.*, ≤ 0.1 grades below reference for basic material rather than the ≤ 0.3 grades allowed, ≤ 0.5 grades below reference for Noise & Cuts rather than the ≤ 1.0 grades allowed, and even better otherwise.). Based on these results, the Alliance feels that the system, not only meets acceptance criteria, but also offers the assurance of high-quality HDTV services for entertainment and other applications.

6.3 Interference to NTSC

The Plan identifies 3 subjective tests of Interference to NTSC: Co-Channel Interference, Lower Adjacent-Channel Interference, and Upper Adjacent-Channel Interference. Only the results of the Co-Channel and Lower Adjacent-Channel tests are reported here; results of the Upper Adjacent-Channel test were deemed invalid as the receiver used to record material for non-expert tests was deemed not representative of the sample of receivers used for expert judgements and no more suitable receiver could be found (see Appendix D for details). For information on Upper Adjacent-Channel Interference, the reader is referred to Part I, Section 3.

In the test of Co-Channel Interference, progressive increases in level of the interfering signal from the Grand Alliance system introduced gradually increasing impairment to the NTSC signal over a range of about 20 dB (see Figures 13 and 15 and Table 18). Judgements confirmed that the degree of impairment introduced in the -55 dBm NTSC signal was less than that allowed in the Target Specification (*i.e.* judgements were above CCIR Grade 3 at the designated D/U of 36.5 dB).

In tests of Lower Adjacent-Channel Interference, increases in level of the interfering signal from the Grand Alliance system introduced gradually increasing impairment to the NTSC signal over a range of about 15 dB for both -35 dBm and -55 dBm desired signal levels (see Figures 12 and 14 and Table 16). Judgements confirmed that the degree of impairment introduced in the -55 dBm NTSC signal was appreciably less than that allowed in the Target Specification (*i.e.*, judgements were appreciably above CCIR Grade 3 at the designated D/U of -14.5 dB).

Based on these results, the Grand Alliance concludes that the performance of the transmission system, meets Advisory Committee performance specifications, warranting its ability to co-exist with transmitted NTSC services.

6.4 Receiver Scan-Conversion

Judgements by non-expert viewers confirmed the excellent performance of the prototype scan-converter. For reasons of efficiency, the Task Force on Digital-Specific Tests selected, for non-expert testing, only those sequences that showed effects of scan conversion. Further, to provide the most revealing test possible, they chose the most challenging portions of two of the test sequences. Despite this, however, scan-conversion performance was well above Advisory Committee specification, with 1080I-to-720P conversions less than 0.6 grades below reference and 720P-to-1080I conversions less than 0.7 grades below reference (target specifications called for 1.0 grade, or less, below reference).

Both the measured values and the Target Specifications given here reflect the combined effects of scan conversion and conversion. For that reason, it is instructive to examine performance for a 1080-line source displayed on a 720-line display rather than a "matching" 1080-line display and a 720-line source displayed on a 1080-line display rather than a "matching" 720-line display. The results indicates that the "costs of conversion" were 0.18 grades for 1080-line sources and 0.18 grades for 720-line sources.

From these results, the Grand Alliance concludes that it is feasible for broadcasters to use the flexibility allowed by the different video formats supported in the system to optimize for different kinds of source material. The consequence to the viewer of converting from the format transmitted to the native format of the receiving display is likely to be minor.

6.5 Video Quality/Auxiliary Data Tradeoff

This non-expert test principally was intended to confirm that the system could maintain satisfactory quality as the bit budget for video was progressively decreased in favor of auxiliary data services. Whether or not the test should be done was left to the discretion of SSWP2's Task Force on Digital-Specific Tests. After they had completed their expert review, the Task Force decided that non-expert testing in this area was not needed.

The Task Force found the performance of the system to depend on scene content. Most scenes showed little or no artifact at the full video rate and showed little or no increase in artifacts as the rate was decreased by as much as 3 Mbps from the nominal, 18.4 Mbps rate. When the rate was reduced by 4Mbps, however, the more challenging of these scenes showed an increase in visible artifacts. In contrast, one very challenging scene exhibited slight artifacts at the full, 18.4 Mbps rate. For this scene performance visibility deteriorated as the video data rate was decreased (see the report of the expert observers of the SSWP2 Task Force on Digital Specific Tests on Auxiliary Data Tradeoff.)

From these results, the Grand Alliance concludes that the flexibility in assigning capacity permitted by the design of the system will afford useful opportunities to the broadcasters. Depending upon the program material in an HDTV service, it will be possible to offer additional, auxiliary service(s).

6.6 Conclusions

Results of the video subjective tests confirmed the excellent performance of the system. In tests of Basic Received Quality, judged quality of the system in both 1080-line and 720-line modes exceeded all Target Specifications, verifying that the system will deliver high-quality video for entertainment and other applications. Tests of Video-Auxiliary Data Tradeoffs with non-experts were deemed unnecessary, but expert observations confirmed that the video compression algorithms have sufficient headroom that it is viable to exercise the flexibility inherent to the system to carry auxiliary data services. In tests of Receiver Scan Conversion, judged quality of the system exceeded Target Specifications, confirming the feasibility of multiple video modes in the transmission of ATV services. And, finally, in tests of Interference to NTSC (Co-Channel and Lower-Adjacent Channel), the system performed well above the Target Specifications and even matched the performance of the best round-one systems, verifying its suitability for the mixed transmission environment that will exist after the introduction of advanced television service.

6.7 Acknowledgments

The Grand Alliance expresses its appreciation to the Advanced Television Evaluation Laboratory for its efforts in carrying out the Advisory Committee's video subjective tests. The Alliance also expresses its appreciation to the Advanced Television Test Center, which supported the expert observations and other preparations that enabled this work. The Alliance further acknowledges contributions by Advisory Committee participants in developing and refining the test procedures and contributions by expert observers and members of the Digital-Specific Task Force in carrying out the basic work to support the video subjective testing. And, finally, the Alliance expresses its appreciation to the Advisory Committee and, in particular, to Mark Richer, Chairman of SSWP2, for their effective management of the test program.

APPENDICES

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APPENDIX A

ATEL EXPERT TECHNICAL REVIEW OF

BASIC RECEIVED QUALITY TEST MATERIAL

**ATEL EXPERT TECHNICAL REVIEW OF
1080I BASIC RECEIVED QUALITY TEST MATERIAL**

A) General comments:

All 1080I TEST sequences contain incongruous picture information in the first line of the active picture portion. This line of video information appears to be drawn from approximately 40 lines lower. This may be the result of the conversion from 1080 lines to 1035 lines.

A slight reduction in image crispness has been noted for almost all of the TEST pictures.

Where moderate luminance noise is present in a TEST picture, this noise can be seen to pulsate.

B) Colorimetry of Pixar stills:

An alternate tape source was used to supply the Pixar generated stills. The colorimetry of these images is inconsistent with that of the Pixar stills from Round 1 of testing, exhibiting a moderate shift in color towards red. The colorimetry is, however, consistent within any given trial since the same picture source was used both as Reference image and as input to the GA system. The following pictures are affected:

S1	Metal Table & Chairs	S5	Tulips
S6	Sculptures	S8	Toys
S9	Girls with Toys	S7	Fruits and Vegetables (demo)
S10	Memorial Arch (demo)		

The image 'Picnic with Ants' is not affected, having been generated from the original, and not the alternate, source tape.

For further details see Appendix D, document SSWP2-1465.

C) Picture specific comments:

	ID	NAME	1035I REF.	1080I TEST
1	S1	METAL TABLE & CHAIRS	-alternate colorimetry.	-alternate colorimetry. -this test image seems very slightly sharper than the reference.
2	S5	TULIPS	-alternate colorimetry.	-alternate colorimetry. -mild edge artifacts observed along petals, leaves and stems.

3	S6	SCULPTURES	-alternate colorimetry. -mild noise observed in high color frequency areas (fine color dots on certain animals).	-alternate colorimetry. -slight overall reduction in image crispness, primarily visible in stripes of bathing suits.
4	S7	FRUIT AND VEGETABLES	-this is a demo picture. -alternate colorimetry.	-alternate colorimetry. -very minor edge artifacts.
5	S8	TOYS	-alternate colorimetry.	-alternate colorimetry. -mild edge artifacts visible around red Lego blocks. -minor levels of 'red noise'.
6	S9	GIRLS WITH TOYS	-alternate colorimetry.	-alternate colorimetry. -minor edge artifacts around book titles. -minor 'red noise' observed. -minor busyness in carpet.
7	S10	MEMORIAL ARCH	-this is a demo picture. -alternate colorimetry.	-alternate colorimetry.
8	S14A	CHESHIRE CAT	-short green/white static 'streaks' observed between vases.	-visibility of static 'streaks' very slightly reduced. -second line of picture (in overscan) is black. -slight overall reduction in picture resolution.
9	M1	WINDOW	-mild to moderate camera noise.	-increased visibility of luminance noise in sink and bottoms of hanging pots.
10	M2	FAX MACHINE	-moderate luminance noise. -camera 'burn in' of text.	-luminance noise is somewhat more visible. -luma noise clearly observed to pulsate. -minor decrease in crispness of text.
11	M4	MANNEQUINS	-mild level of camera noise. -mild horizontal 'banding'.	-increased visibility of noise. -clearly visible busyness at edges of stars in backdrop.
12	M5	LIVING ROOM	-moderate level of camera noise. -moderate motion blur. -camera flare from spine of book.	-increased visibility of noise. -blocking and edge artifacts observed on book cover and shelves. -mild reduction in overall picture resolution.

13	M6	DEN	-this image is slightly soft.	-mild increase in visibility of noise.
14	M10	WOMAN AND ROOM	-mild to moderate level of camera noise. -horizontal luminance bands clearly visible on face.	-increase in visibility of noise. -red spine of book at start of sequence is very noisy.
15	M16A	ROTATING PYRAMIDS	-interlace twitter on scrolling text.	-clear decrease in picture resolution. -high chroma noise in red and magenta. -second line of picture (in overscan) is black.
16	M35	CROSSWALK	-mild camera mis-registration.	-some coding activity obvious on center manhole cover, and green dress of pedestrian, vending machines and store window. -green fringing slightly enhanced.
17	M36	AX MURDERER (G.T. LOOP)	-mild level of camera noise. -some green lag observed along vertical edges of coach windows. -increase in overall picture brightness about 7 seconds into sequence.	-busyness observed in ribbing of coach. -mild increase in visibility of noise in background. -green lag seems mildly accentuated. -same increase in brightness.
18	M37	BUCKINGHAM PALACE	-multiple camera flares from bright buttons and medals. -heat 'shimmer' in background.	-blocking visible in red uniforms, medals of stationary soldier, and in feet and shadows of marchers. -moderate to high 'red noise' level.
19	M38	SNOW TIRES / TREES	-notable absence of camera noise.	-mild blocking over surface of water as seen through small panning branches. -larger trunks show some blocking. -general mild decrease in overall resolution.
20	M39	END ZONE	-this sequence is soft and 'hazy'.	-small reduction in overall image crispness. -mild blocking in distant spectators during camera motion.

21	M40	DREAM TEAM	<p>-rapid camera motion causes area of spectators to occasionally blur.</p> <p>-large instantaneous changes in luminance levels caused by frequent photo flashes.</p> <p>-several lingering camera burn ins, also caused by photo flashes.</p>	<p>-blocking clearly visible over large areas of screen, and particularly in reds, in periods of high motion.</p> <p>-blocking is frequent in response to photo flashes.</p>
22	M41	GOLF	<p>-mild interlace twitter in scoreboard.</p>	<p>-reduced crispness on surface of water.</p> <p>-slight increase in visibility of background noise.</p> <p>-mild blocking on tee-off green.</p>
23	M42	ROLLER COASTER	<p>-this demo is slightly soft.</p>	<p>-mild blocking observed on flat rooftops.</p>
24	M43	DUCKS	<p>-mild green fringing visible.</p>	<p>-minor edge artifacts along necks of swans.</p> <p>-minor loss of resolution at surface of water.</p> <p>-green fringing somewhat enhanced.</p>
25	M44	MIRROR	<p>-moderate levels of film noise.</p>	<p>-slight decrease in resolution noticeable on lettering of invitation card.</p>
26	M45	CHRISTA	<p>-mild judder.</p> <p>-moderate to high level of film noise, primarily 'black noise' with occasional white sparkle.</p>	<p>-no differences noted.</p>
27	M46	FOUNTAIN	<p>-absence of any significant film noise.</p>	<p>-very slight loss of resolution.</p>
28	M47	CLOCK #1	<p>-this image exhibits aliasing due to low resolution rendering.</p>	<p>-no differences noted.</p>
29	M48	CONNECTIONS	<p>-computer graphic with video overlay</p>	<p>-mild edge artifacts around red dots on map.</p> <p>-slight reduction in overall crispness noted during the video insert overlay.</p>
30	M49	PICNIC WITH ANTS	<p>-still image with encroaching noise.</p>	<p>-blocking artifacts are clearly visible as the noise content is increased.</p>

**ATEL EXPERT TECHNICAL REVIEW OF
720P BASIC RECEIVED QUALITY TEST MATERIAL**

A) General comments:

All GA processed images exhibit a slight color shift towards yellow/green.

All GA processed images appear to have approximately 2.5% of the image clipped along the right hand side.

A cluster of faint horizontal lines has been observed traveling upwards in the pictures 'Girls with Toys', 'Den', 'Tulips', 'Living Room', 'Connections' and 'Window'.

Faint 'sparkle' observed in all Test versions of the pictures 'Connections' and 'Woman in Room'.

A 3 frame difference in video content exists between all occurrences of the Reference and Test cases of the picture 'Dream Team'.

A 2 frame difference in video content exists between the second occurrence of the Reference picture 'Buckingham Palace' at time code 24:18:00 of Order 1A, and all other Reference or Test presentations.

The Reference picture 'Buckingham Palace' at time code 23:52:00 of Order 1A (first presentation in this trial) actually starts 16 frames late (23:52:16 to 24:02:16). The sequence content is correct, but the grey period following the sequence is shortened by 16 frames.

The Reference picture 'Woman and Room' at timecode 09:50:00 contains a single field recording error, perceived as a chroma flash when played back in real time. This error occurs at timecode 10:05:03, and may be corrected by engaging the VTR's conceal function during the playback of this specific sequence.

No accurate match is possible with respect to display size and positioning for the images 'Cheshire Cat' and 'Rotating Pyramids'.

The direct rendered images 'Connections' and 'Clock' exhibit some horizontal squeeze.

Where moderate luminance noise is present in a TEST picture, this noise can be seen to pulsate.

B) Delay Compensation in the Overscan Setup for Playback of the GA 720 BRQ Ratings Tapes

Two pairs of display setups for the Hitachi C-65 were maintained at the ATEL for the display of 720 GA rating tapes. The first pair (low gang) presented images in either 1035I (Reference) or 720P (Test), using a strict 5% overscan setup. The second pair (high gang) used an identical 1035I (Reference) setup, but incorporated a vertical adjustment in the 720P (Test) setup to compensate for a 6 line displacement, as well as for a vertical 'stretch' introduced in the conversion of certain 1035I images into the 720P format. Additional compensation was required in the 720P format of both display pairs to neutralize the effect of horizontal delays in the Test images relative to the Reference images.

The following table contains the values used for both projector setup pairs, based on best visual match of picture content.

LOW GANG (normal)				
	Top (line)	Bottom (line)	Left (sample)	Right (sample)
1125	54 (616)	544 (1107)	244	2068
720	67	760	246	1480

HIGH GANG (for transconverted images)				
	Top (line)	Bottom (line)	Left (sample)	Right (sample)
1125	54 (616)	544 (1107)	244	2068
720	73	771	250	1468

Notes:

Line values are +/- 1

Sample values are +/- 4

1125 values are standard 2.5% overscan.

Picture 'Sculptures' used for LOW GANG visual match, horizontal.

No vertical match required for LOW GANG.

Picture 'Crosswalk' used for HIGH GANG match, horizontal.

Pictures 'Crosswalk' and 'Mirror' used for HIGH GANG match, vertical.

Source tape for pictures is GA 720BRQ 1B.

C) Picture specific comments:

	ID	NAME	1035I REF	720P TEST
1	S1	METAL TABLE & CHAIRS	-a small piece of red tape on the arm of one chair appears only on the Reference version of this picture; based on interfield differences, this may represent a data conversion error.	-slight shift in color noted. -this image appears slightly crisper than the Reference version.
2	S5	TULIPS	-still image with highly saturated colors.	-moderate edge artifacts observed along petals, leaves and stems. -some blocking clearly visible in petals of tulips.
3	S6	SCULPTURES	-mild noise observed in high color frequency areas (fine color dots on certain animals).	-mild to moderate edge artifacts around all objects. -color of background shelves is slightly greener than Reference.
4	S7	FRUIT AND VEGETABLES	-this is a demo picture.	-very minor edge artifacts. -some busyness on surface of watermelon and sliced orange.
5	S8	TOYS	-assorted toys over a grey ramp.	-edge artifacts and mild blocking visible around red Lego blocks and checkerboard. -edge artifacts visible along most fine detail. -moderate noise in reds.
6	S9	GIRLS WITH TOYS	-still image with high peripheral content.	-carpet looks slightly greener than Reference version. -minor edge artifacts around book titles. -minor 'red noise' observed. -moderate busyness in carpet.
7	S10	MEMORIAL ARCH	-this is a demo picture.	-slight shift in color noted.
8	S14A	CHESHIRE CAT	-short green/white static 'streaks' observed between vases. -because of differences in background pattern, vases appear both larger and nearer than in Test case.	-visibility of static green/white 'streaks' somewhat reduced. -a variety of speckles are visible in blue striped vase. -overall reduction in picture resolution.
9	M1	WINDOW	-mild to moderate camera noise.	-increased visibility of luminance noise in sink and bottoms of hanging pots, dish rack.

10	M2	FAX MACHINE	-moderate luminance noise. -camera 'burn in' of text.	-luminance noise is somewhat more visible. -luma noise clearly observed to pulsate. -decrease in crispness of text due to edge artifacts.
11	M4	MANNEQUINS	-mild level of camera noise. -mild horizontal striations visible in various areas of picture.	-increased visibility of noise. -clearly visible busyness at edges of stars in backdrop.
12	M5	LIVING ROOM	-moderate level of camera noise. -moderate motion blur. -camera flare from spine of book.	-increased visibility of noise. -blocking and edge artifacts observed on book cover and shelves. -mild reduction in overall picture resolution.
13	M6	DEN	-this image is slightly soft.	-mild increase in visibility of noise. -busyness in wicker furniture and wallpaper.
14	M10	WOMAN AND ROOM	-mild to moderate level of camera noise. -horizontal luminance bands clearly visible on face.	-increase in visibility of noise. -red spine of book at start of sequence is very noisy. -busyness in wicker furniture and wallpaper.
15	M16A	ROTATING PYRAMIDS	-interlace twitter on scrolling text.	-clear decrease in picture resolution. -increased chroma noise in red and magenta. -fringing artifacts around characters of scrolling text. -second line of picture (in overscan) is black.
16	M35	CROSSWALK	-mild camera mis-registration.	-some coding activity obvious on center manhole cover, and green dress of pedestrian, vending machines and store window. -blocking clearly visible on asphalt between painted lines of pedestrian crosswalk. -green fringing slightly enhanced.

17	M36	AX MURDERER (G.T. LOOP)	<ul style="list-style-type: none"> -mild level of camera noise. -some green lag observed along vertical edges of coach windows. -increase in overall picture brightness about 7 seconds into sequence. 	<ul style="list-style-type: none"> -busyness observed in ribbing of coach. -occasional blocking in trees and rocks. -some edge artifacts observed along edges of fine branches. -green lag seems mildly accentuated. -same increase in overall picture brightness.
18	M37	BUCKINGHAM PALACE	<ul style="list-style-type: none"> -multiple camera flares from bright buttons and medals. -heat 'shimmer' in background. 	<ul style="list-style-type: none"> -blocking visible in red uniforms, medals of stationary soldier, and in feet and shadows of marchers. -moderate to high 'red noise' level.
19	M38	SNOW TIRES / TREES	<ul style="list-style-type: none"> -notable absence of camera noise. 	<ul style="list-style-type: none"> -mild blocking over surface of water as seen through small panning branches. -larger trunks show distinct blocking. -general mild decrease in overall resolution.
20	M39	END ZONE	<ul style="list-style-type: none"> -this sequence is soft and 'hazy'. 	<ul style="list-style-type: none"> -reduction in overall image crispness. -mild blocking in distant spectators during camera motion. -high level of busyness along surface of track.
21	M40	DREAM TEAM	<ul style="list-style-type: none"> -rapid camera motion causes area of spectators to occasionally blur. -large instantaneous changes in luminance levels caused by frequent photo flashes. -several lingering camera burn ins. also caused by photo flashes. 	<ul style="list-style-type: none"> -blocking clearly visible over large areas of screen, and particularly in reds, in periods of high motion. -blocking is frequent in response to photo flashes.
22	M41	GOLF	<ul style="list-style-type: none"> -mild interlace twitter in scoreboard. 	<ul style="list-style-type: none"> -reduced crispness on surface of water. -slight increase in visibility of background noise. -mild blocking on tee-off green when camera is zooming out.