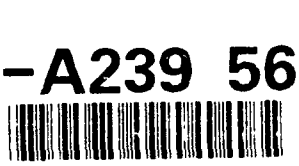

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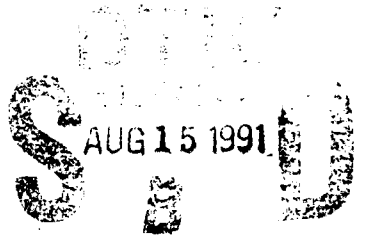
NCS TIB 90-7

NATIONAL COMMUNICATIONS SYSTEM

TECHNICAL INFORMATION BULLETIN 90-7

DEVELOPMENT OF A VIDEO TAPE TO CORRELATE SUBJECTIVE AND OBJECTIVE TESTING OF TELECONFERENCE SYSTEMS



MAY, 1990

OFFICE OF THE MANAGER
NATIONAL COMMUNICATIONS SYSTEM

WASHINGTON, D.C. 20305

May 1990 Final

Development of a Video Tape to Correlate Subjective and Objective Testing of Teleconcerence Systems

C-DCA100-87-C-0078

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300 Welsh Road
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National Communications System
Office of Technology & Standards
Washington, DC 20305-2010

NCS TIB 90-7

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Teleconferencing
Full motion codecs

Unclassified Unclassified Unclassified Unlimited

NCS TECHNICAL INFORMATION BULLETIN 90-7

DEVELOPMENT OF A VIDEO TAPE TO CORRELATE SUBJECTIVE AND OBJECTIVE TESTING OF TELECONFERENCE SYSTEMS

MAY 1990

PROJECT OFFICER

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APPROVED FOR PUBLICATION:

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Assistant Manager
Office of NCS Technology
and Standards

FOREWORD

Among the responsibilities assigned to the Office of the Manager, National Communications System, is the management of the Federal Telecommunication Standards Program. Under this program, the NCS, with the assistance of the Federal Telecommunication Standards Committee identifies, develops, and coordinates proposed Federal Standards which either contribute to the interoperability of functionally similar Federal telecommunication systems or to the achievement of a compatible and efficient interface between computer and telecommunication systems. In developing and coordinating these standards, a considerable amount of effort is expended in initiating and pursuing joint standards development efforts with appropriate technical committees of the Electronics Industries Association, the American National Standards Institute, the International Organization for Standardization, and the International Telegraph and Telephone Consultative Committee of the International Telecommunication Union. This Technical Information Bulletin presents an overview of an effort which is contributing to the development of compatible Federal, national, and international standards in the area of Video Teleconferencing. It has been prepared to inform interested Federal activities of the progress of these efforts. Any comments, inputs or statements of requirements which could assist in the advancement of this work are welcome and should be addressed to:

Office of the Manager
National Communications System
ATTN: NCS-TS
Washington, DC 20305-2010

DEVELOPMENT OF A VIDEO TAPE TO CORRELATE SUBJECTIVE AND OBJECTIVE TESTING OF TELECONFERENCE SYSTEMS

May 18, 1990

SUBMITTED TO:
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Office of Technology and Standards
WASHINGTON, D.C. 20305

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SECTION 1 - INTRODUCTION AND SUMMARY

This document summarizes work performed by Delta Information Systems, Inc. for the National Communications System, Office of Technology and Standards. This office is responsible for the management of the Federal Telecommunications Standards Program, which develops telecommunications standards, whose use is mandatory for all Federal departments and agencies. This study was performed under task order number 87-011 of contract number DCA100-87-C-0078.

This report covers the design and production of two video tapes for testing full motion codecs. It is part of a program for comparative evaluation of motion codecs used for teleconferencing at a wide range of bit rates. The specific purpose of the subjective tape is to provide pictorial material which may occur during both government and commercial teleconferences and related applications which simultaneously stresses the capabilities of each codec sufficiently so that differences in performance will become apparent. The choice of material must lead to a completely impartial evaluation without favoring any particular algorithm, and should not be constrained by limitations in encoding and transmission.

The objective motion test tape provides a means to develop a numerical score describing the motion performance of a codec

under specific test conditions. This is a new endeavor which required a considerable amount of design and experimentation which was performed as part of Task No.87-010. The finally produced tape is based on the results of these experiments and is usable for testing video codecs over the full range of bit rates.

Section 2 of this report covers the background material on which this task was based and gives an overview of all the interrelated activities which were performed to establish an integrated program for the evaluation of video teleconferencing codecs. Details of the test tapes which were prepared for objective and subjective testing are given in Sections 3 and 4. A brief conclusion and recommendations for future efforts are contained in Section 5.

SECTION 2 - BACKGROUND AND OVERVIEW

This effort is closely related to two previous tasks within the same overall program. They are Task No. 87-007, Development of a Video Tape to Test Video Codecs Operating at 64 Kbps, and Task No. 87-010, Standardization of End-to-End Performance for Full Motion Video Teleconferencing. Both these tasks in turn use background material prepared in previous years as parts of other NCS programs.

The video test tape developed for testing low bit rate codecs (NCS Technical Information Bulletin [TIB] 89-2, Development of a Video Test Tape to Test Video Codecs Operating at 64 KBPS - Final Report, February, 1989) used much previously prepared material. Scenes of highest technical quality, described in TIB 85-2, Development of a Video Tape to Test Teleconferencing Codecs, August 23, 1985, which had proved their usefulness during previous subjective codec tests (TIB 85-5 , Test and Evaluation of Teleconferencing Video Codecs Transmitting at 1.5 MBPS, August 23, 1985) were incorporated, including both people and graphics. Additional material was produced, covering both videophone scenes and graphics. The final tape is divided into three parts, namely:

Part A: Still Graphics

Part B: Motion Graphics

Part C: Limited Motion

While the contents of Part C are deliberately limited to be used for subjective testing of low bit rate codecs (below 384 Kbps),

the graphic material is applicable to all codecs, regardless of bit rate. Therefore, Parts A and B will also be used with the full motion test tape produced under the present task which is designated Part D. The anticipated application of all these tapes is given on Table 2-1. The bit rates given for Tapes C and D are typical examples and fit into the subsequently established CCITT hierarchy of P x 64 Kbps.

The purpose of the standardization task is to establish performance requirements and objective test methods for video teleconferencing systems. It requires adaptation of conventional analog tests for use with digital systems and development of novel techniques for evaluation of motion performance. Since the use of high quality video tapes has long been the standard method for testing the performance of digital video systems it was attempted to record the required test signals on 1" video tape. However, the recording process caused too much distortion of the highly critical test signals, therefore this approach could not be recommended.

The major effort of the standardization task was the development of a methodology for objective testing of the motion performance of video codecs. This required a completely new approach by means of a series of computer generated test patterns with accurately controlled motion. An experimental tape containing such patterns was processed through 3 different codecs operating over the full range of conventional bit rates. The processed tapes were viewed on a waveform monitor and the thus

TAPE DESIGNATION	TYPICAL SCENES	BIT RATE	APPLICATION (%)		
			FACE-TO-FACE VIDEOPHONE	ROOM-TO-ROOM TELECONFERENCING	TRAINING (BROADCAST)
A. STILL GRAPHICS	-CHARACTERS -DIAGRAMS -CHARTS -SCHEMATICS	64Kbps THRU 1.544Mbps	EQUAL		
B. MOTION GRAPHICS	-POINTER -ZOOM, PAN -NO PEOPLE	64Kbps THRU 1.544Mbps	EQUAL		
C. M x 64Kbps M = 1, 2, 4	-MOVING PEOPLE; LIMITED MOTION	64,128,256 Kbps	60	20	20
D. N x 384Kbps N = 1,2,3,4	-MOVING PEOPLE; UNLIMITED MOTION	Nx 384 Kbps	15	65	20

TABLE 2 - 1. SUBJECTIVE TEST TAPE APPLICATION

obtained data evaluated to produce numerical results. These results showed general consistency and good correlation with the various codec and test pattern parameters and also with known subjective evaluations. This proved the validity of the general approach and made it possible to use the experimental tape as source material for a motion test tape which can be used to establish correlation between subjective and objective codec performance tests.

The overall objective of the present program together with the two just described previous tasks is an integrated approach to testing complete video teleconferencing systems over the full range of generally used bit rates. Figure 2-1 schematically shows the interrelation of the various steps taken in the implementation of each of the three tasks. The result will be performance and test standards for all video teleconferencing systems and the ability to develop performance specifications in accordance with system requirements.

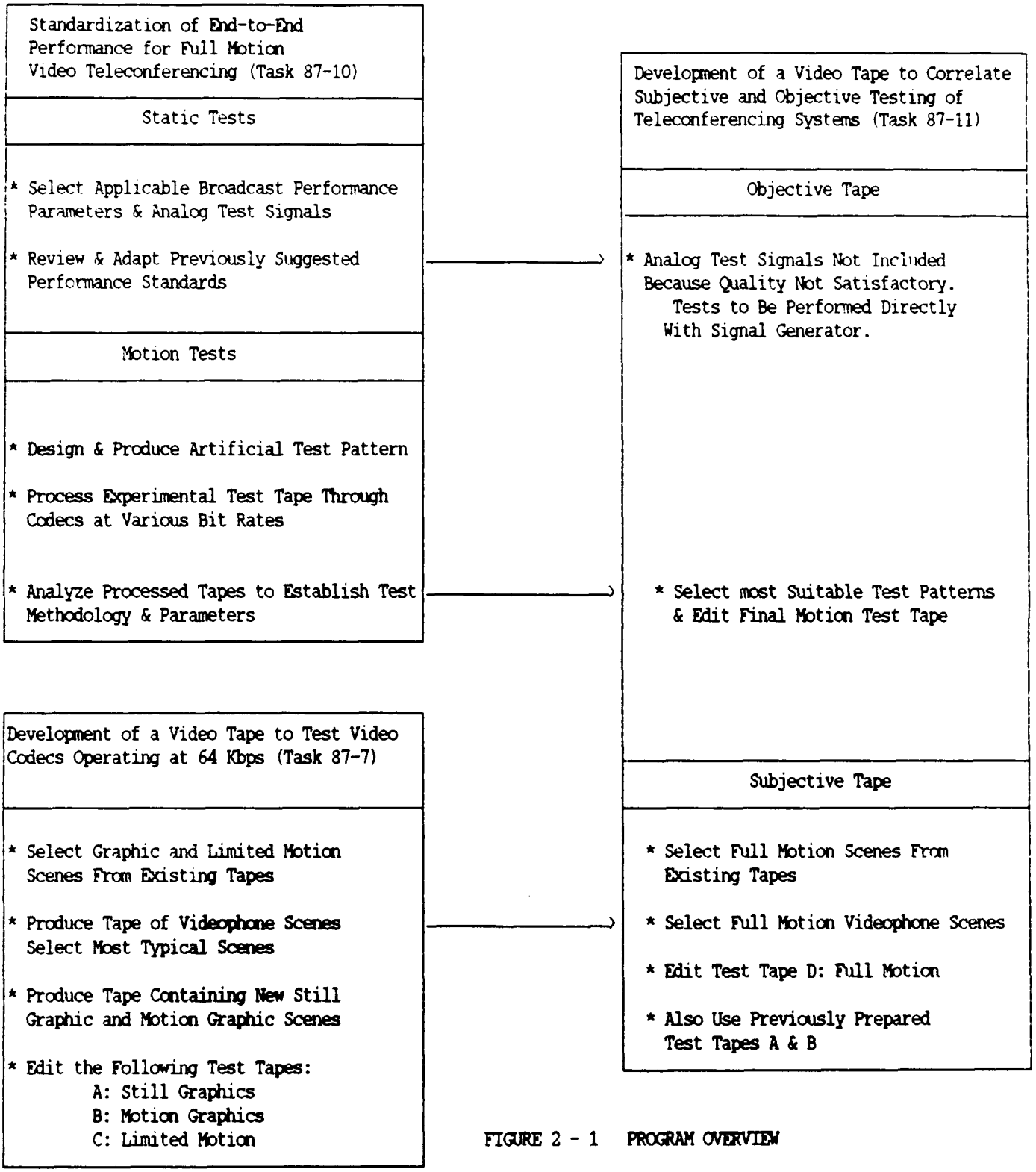


FIGURE 2 - 1 PROGRAM OVERVIEW

SECTION 3 - OBJECTIVE TEST TAPE

3.1 Still Picture Analog Tests

Analog performance standards covering mostly the same parameters as conventional broadcast performance specifications have been developed previously in Task 87-010 and are shown in the subject final report on Table 3-3. The applicability and numerical specification for each parameter still have to be verified by system tests. The original intent of this program was to record the required analog test signals on video tape and thus produce an integrated objective codec test tape. However, previous tests have shown that the taping process itself produces distortions which are significant enough to make it impossible to obtain valid performance data.

The only practical way to obtain dependable results is to have test equipment directly at the teleconferencing system terminals. Not long ago that could have been quite awkward but modern high performance compact equipment make such an arrangement practical. The Tektronix 1910 Test Signal Generator and VM-700 Video Measurement Set (both available at Delta Information Systems) are ideally suited for the purpose. They provide a large variety of digitally generated test signals and both waveform and vector displays for precision measurements in addition to the capability of direct numerical printout of selected lists of performance parameters. These equipments satisfy present and future test requirements of video

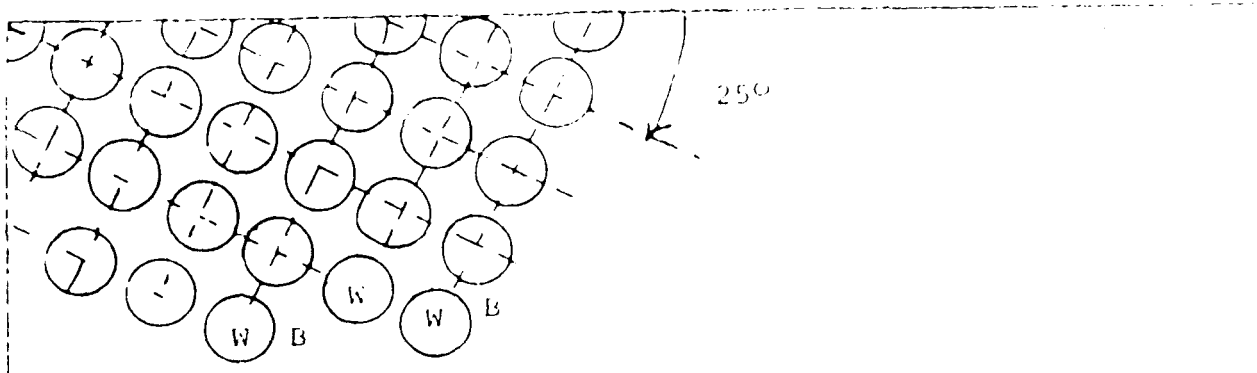
teleconferencing systems.

3.2 Motion Tests

The experimental motion test tape which was prepared as part of Task 87-010 contained two different types of artificial motion. The simplest approach uses a scene cut by switching between a pattern of white circles and a black field as shown in Figure 3-1. The more complex pattern, a sample of which is shown in Figure 3-2, provides actual motion implemented by black spokes rotating over a background consisting of white and colored areas. Both patterns produce an exactly definable and easily calculated amount of pixel change per frame. This amount can be changed by varying the detail in the picture (such as size and spacing of circles or number and width of wheel spokes) and by changing the speed of switching or rotation. These two types of pixel change can be combined into the common parameter of temporal frequency.

Extensive tests with the experimental tape showed that both methods of producing artificial motion were usable. The rotating wheel yielded somewhat more consistent results. Furthermore, it may be possible to design a codec algorithm which responds well to a scene cut without having good performance with actual motion. Therefore, it was decided that using only the rotating wheel pattern was preferable and sufficient to test codec motion performance.

Originally, three spoke widths were arbitrarily selected to produce pictures with different amounts of detail; they were



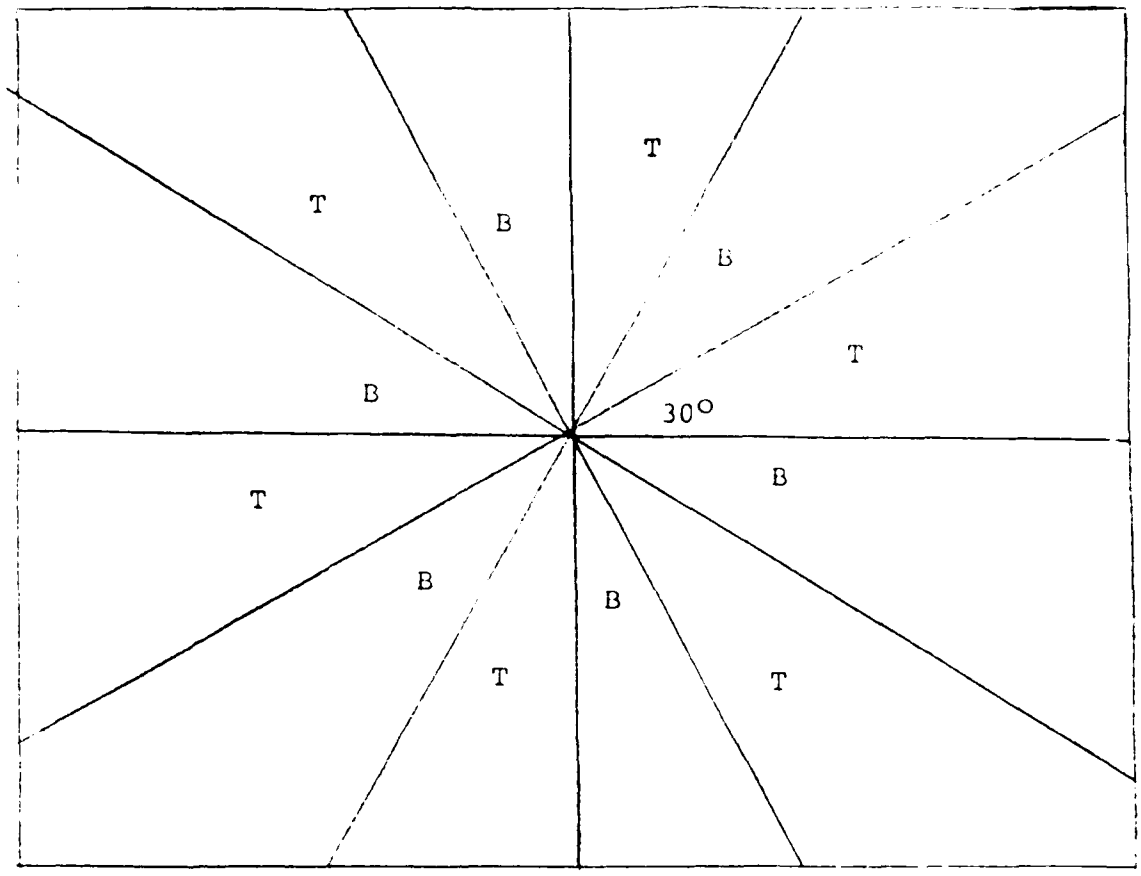
B = BLACK

W = WHITE

FIGURE 3-1 CIRCLE PATTERN

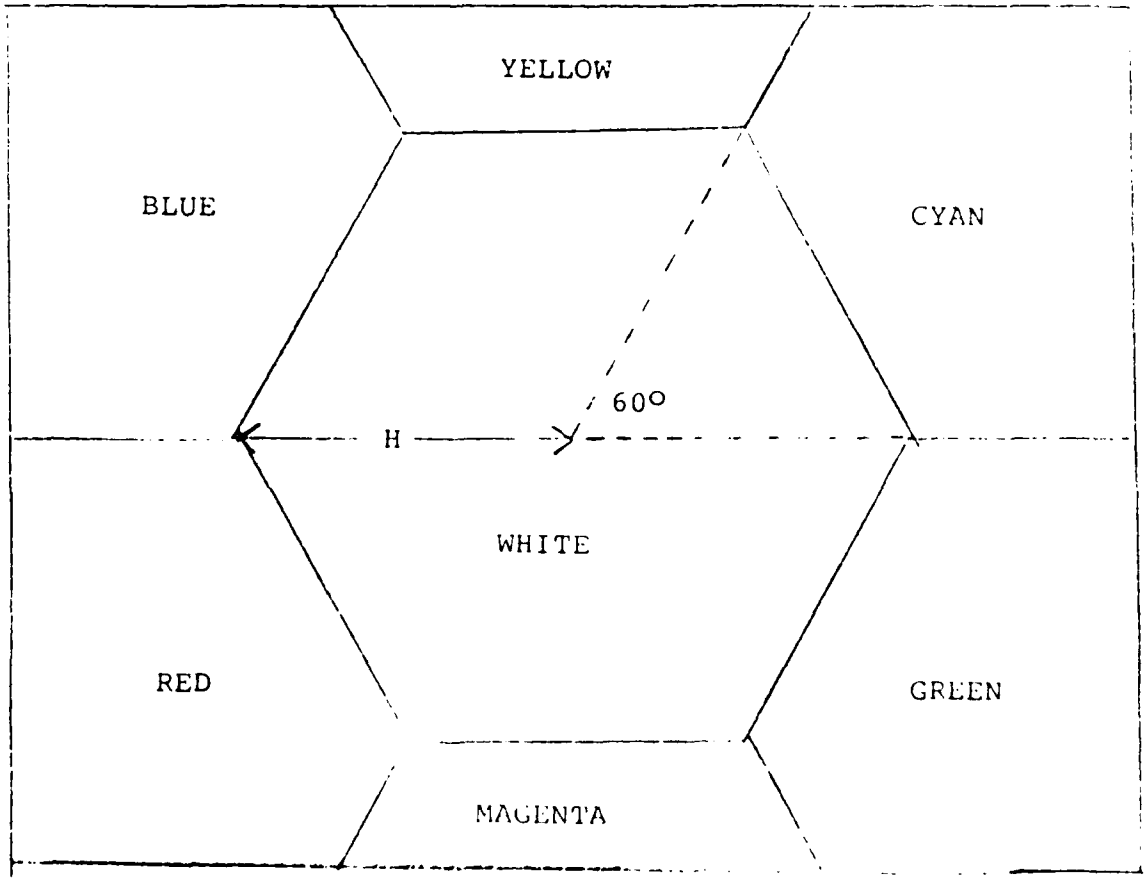
B = BLACK

T = TRANSPARENT



ROTATING OVERLAY

H = APPROX. 40% OF VISIBLE PICTURE HEIGHT



BACKGROUND

FIGURE 3-2: 30 DEGREE PATTERN

30, 18, and 10 degrees. The tests indicated that this choice was well made to cover the full range of codec bit rates. Testing 1.544 Mbps codecs required the use of the 10 degree spokes to sufficiently stress codec performance while at 64 Kbps mainly 30 degree spokes produced a temporal response curve with a significant range and slope. The 18 degree spokes were most desirable for testing 384 Kbps codecs. Using each pattern over the implemented range of rotation speeds resulted in one temporal response curve.

The preparation of the test tape was subject to some constraints imposed by the CUBICOMP computer animation equipment in use. The normal time increment for a picture change is one frame and rotation increments must be in full degrees. These factors can seriously limit the obtainable rotation speeds of the pattern but it is possible to use holding times of more than one frame and alternate both holding times and rotation increments between consecutive frames. This way a sufficient variety of rotation speeds can be produced.

Table 3-1 lists the patterns that have been implemented on the objective motion test tape. Following the spoke width it gives the rotation speed in two different terms. For compatibility with the CUBICOMP equipment it was first specified in frames per revolution but from the user's point of view degrees per second is much more descriptive. The following parameters are readily derived arithmetically from spoke width and rotation speed. Temporal frequency is the most useful

TEST PATTERN NO.	SPOKE WIDTH (DEGREES)	ROTATION SPEED FRAMES/ REVOLUTION	DEGREES/ SECOND	TEMPORAL FREQUENCY (CPS)	FRAMES/ SPOKE	% PIXEL CHANGE/ FRAME	% BLOCK CHANGE FRAME
1	30	540	20	0.33	45	2.2	18
2	30	360	30	0.50	30	3.3	
3	30	240	45	0.75	20	5.0	
4	30	180	60	1.00	15	6.7	22
5	30	144	75	1.25	12	8.3	
6	30	120	90	1.50	10	10.0	
7	30	90	120	2.00	7.5	13.3	34
8	30	72	150	2.50	6	16.7	
9	30	60	180	3.00	5	20.0	43
10	18	720	15	0.42	36	2.8	31
11	18	540	20	0.55	27	3.7	
12	18	360	30	0.85	18	5.6	
13	18	240	45	1.25	12	8.3	
14	18	180	60	1.67	9	11.1	42
15	18	144	75	2.10	7.2	13.9	
16	18	120	90	2.50	6	16.7	
17	18	90	120	3.30	4.5	22.2	57
18	10	720	15	0.75	20	5.0	50
19	10	540	20	1.00	15	6.7	54
20	10	360	30	1.50	10	10	
21	10	240	45	2.25	6.7	15	
22	10	180	60	3.0	5	20	70
23	10	144	75	3.75	4	25	75

TABLE 3-1: OBJECTIVE MOTION TEST TAPE

parameter to describe the motion response of a codec. The number of frames per spoke gives the period required for one spoke to pass a reference point in the picture. This is important in the case of low bit rate codecs which often use a high rate of vertical subsampling. If the number of frames per spoke approaches and finally becomes lower than the rate of vertical subsampling some spokes (both black and white) will be severely distorted and may actually be skipped completely. This leads to an effect which may be called temporal aliasing which produces false results. The percentage of pixel change per frame (computed as the percentage of the total area covered by the moving spoke during one frame) is a good measure of the stress imposed on the motion rendition capability of a codec. However, in the very common case of codecs using transform coding which divides the picture into blocks the percentage of block change per spoke is even more descriptive. This number is difficult to compute accurately but an approximate graphic method was used to come up with a sufficient sample of values. The last column of Table 3-1 shows a wide range of values with only little overlap between the three spoke widths. This is quite different from other parameters and also confirms the experimental result that all 3 implemented spoke widths are needed for full coverage. There would be no overlap of the block change percentage numbers if only 30 and 10 degree spokes were used.

On the edited motion test tape the time for each pattern was held to 20 seconds. This is shorter than on the original

experimental tape but based on early test results was deemed sufficient. The performed tests have shown that at low temporal frequencies only about 4 temporal cycles have to be examined to produce dependable results. The lowest temporal frequency on the tape is 0.33 cps which means that 12 seconds are required for 4 cycles. Therefore, a duration of 20 seconds is more than adequate. Even though at higher temporal frequencies it is desirable to examine more cycles, the measurement can be performed in a shorter time but for the purpose of uniformity the duration of 20 seconds was maintained for all test patterns. Preceding each pattern there is a title with the pertinent parameters which is held for 6 seconds. Including an introductory title results in a total tape length of just over 10 minutes.

SECTION 4 - SUBJECTIVE TEST TAPE

The large amount of already available test scenes made the preparation of new material unnecessary. Only selection of previously taped scenes and editing was needed to produce the final tape.

This subjective test tape contains only full motion scenes with people and is expected to be used at codec bit rates of 384 Kbps and above. It is designated Part D of a series of subjective test tapes which together are to be usable for all existing and future codecs. Part A, Still Graphics, and Part B, Motion Graphics, though previously prepared for use with low bit rate codecs, are equally usable in the higher bit rate range. Still graphics test both resolution and color rendition capability which are important for all codecs and are designed to be challenging in both freeze frame and motion modes. Motion graphics add the requirement to reproduce moving material, pointing and drawing, and camera zooming. These features stress codec capability at all bit rates, only settling time after motion becomes shorter and therefore less important at higher rates.

The scenerio of the full motion subjective test tape, designated Part D, is shown on Table 4-1. It consists of 18 sequences, separated by 10 seconds long scoring intervals. Including the introductory title results in a total tape length of about 15 minutes.

The highest quality scenes were selected from previously

TAPE SCENARIO

Sequ. No.	Source	Subject Matter	No. of People	Material Handled			Camera Motion			Duration (Sec.)
				Equ.	Phone	Papers	Marker/ Pointer	Pan	Zoom	
1	CCV	Introduction, 6 People	6 X 1			X		X		20
2	CCV	Girl at Marker Board	1				X	X	X	22
3	CCV	Equipment Demo	1	X		X				68
4	CCV	Man at Map	1				X	X	X	20
5	CCV	2 Groups of 3 People	2 X 3			X				30
6	CCV	Magazine Article	1			X				51
7	ISACOMM	Conference Introduction	6 X 1 2 X 2					X	X	41
8	CCV	Discussion at Map	2				X	X	X	35
9	CCV	Phone Call	1		X	X				64
10	CCV	Argument at Marker Board	2				X	X	X	27
11	CCV	Man at Desk	1		X	X			X	28
12	ISACOMM	Girl Talking	1							30
13	CCV	Sales Talk	1			X				57
14	CCV	Circuit Board Demo	1	X			X	X	X	49
15	CCV	2 Groups of 3 People (Stacked)	2 X 3			X				29
16	CCV	Equipment Demo	1	X		X				70
17	ISACOMM	Girl at Chalk Board	1				X	X		45
18	CCV	Man at Map	1				X	X		32

TABLE 4 - 1. VIDEO CODEC TEST TAPE PART D: FULL MOTION

produced tapes which had been proven to give good results in subjective evaluations. Most material was prepared at Center City Video (CCV) in Philadelphia but some scenes which were produced in the former ISACOMM (now US Sprint) Teleconference Room have been added. Several sequences consist of scenes which are typical for videophone. These sequences also include sound which may be important in the evaluation of some codecs. A few scenes which were judged to be useful to test some applications of codecs at all bit rates were repeated from the Limited Motion Test Tape C but occasionally with slightly modified editing. The resulting tape consists of scenes depicting the variety of applications of video teleconferencing codecs requiring good rendition of full motion.

SECTION 5 - CONCLUSION AND RECOMMENDATIONS

The output of this task consists of the two test tapes decribed in Sections 3 and 4. Both tapes were originally produced as 1" tapes. The objective motion tests do not require the highest resolution and color rendition capability, therefore it is recommended and expected that only 3/4" copies will be used for actual tests. The subjective full motion test tape is available in both tape sizes. For highest performance and precision 1" tape is very desirable but, if equipment availability and/or cost make this impractical, the use of modern high performance recorders makes 3/4" tape fully acceptable.

The next step in the development of codec testing is the use of the just produced tapes, together with the previously described tapes A and B for graphics (see Task 87-7) for correlation of subjective and objective test results on codecs operating at 384 Kbps and above. The same should be done on codecs operating below 384 Kbps - mainly at 64 Kbps - using tape C instead of tape D. The results of these tests are expected to confirm the validity of objective motion testing using the rotating wheel pattern.

Objective codec tests will be made using the just developed motion test tape for motion performance and standard analog test equipment for still picture performance. The results of these tests will indicate the degree of correlation between subjective and objective testing. They will also show the relevance of the various analog perfomance parameters and probably lead to a

reduction of the number to be tested. More experience with the rotating wheel patterns may result in modifications of the pattern design and the required range of spoke widths, rotation speeds and temporal frequencies. The ultimate goal is elimination of the motion test tape by replacing it with a motion pattern generator and automatic analyzer. However, this can be achieved only after extensive use of, and experience with, the test material produced within the present task.