Government of Canada / Gouvernement du Canada

October 18-21, 1982
Ottawa, Ontario, Canada

High Definition Television Colloquium '82

Volume 2 of 2

Canada

1982 HIGH DEFINITION TV COLLOQUIUM

POSTCONFERENCE PROCEEDINGS

1. High Definition TV Colloquium (1982: Ottawa)

The Postconference Proceedings contains the summaries of the discussions in the Workshops and the papers that were not available at the time of printing of the Preconference Proceedings.

Additional copies of the Colloquium Proceedings are available at $25.00 Canadian per two volume set. Please make cheques or money orders payable to CBC, HDTV Colloquium '82 and send your request to:

Elmer H. Hara
Chairman,
HDTV Colloquium Program Committee

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300 Slater Street, Ottawa, Ontario,
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The French language version will be available in early 1983.

1982 HIGH DEFINITION TV COLLOQUIUM

October 18 to 21, 1982

Holiday Inn, Kent Street,
Ottawa, Canada

CHAIRPERSON

Mr. D.F. Parkhill, Assistant Deputy Minister Research

Department of Communications

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Government of Canada — Department of Communications (DOC)
Department of Industry, Trade & Commerce (IT & C)

Canadian Broadcasting Corporation (CBC)

Teleglobe Canada

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HDTV COLLOQUIUM

Holiday Inn
Commonwealth Ballroom South

PROGRAM

Monday, October 18, 1982

	0930–0945	OPENING ADDRESS *D.F. Parkhill, Assistant Deputy Minister Research, DOC, Canada*

Session 1 – SYSTEMS (Chairperson: C. Siocos, CBC)

1.1	0945–1005	HDTV IN THE COMMUNICATIONS ENVIRONMENT OF THE 80's *Robert O'Reilly, CBC, Canada*
1.2	1005–1035	HIGH DEFINITION TV AND ITS ALTERNATIVES *Ian Childs, BBC, England*
	1035–1055	*Coffee*
1.3 *	1055–1125	HIGH DEFINITION TELEVISION OF NHK *Takashi Fujio, NHK, Japan*
1.4	1125–1155	TELEVISION SYSTEMS FOR THE FUTURE *T.S. Robson, IBA, England*
	1155–1400	*Lunch (Rideau Room)*
1.5 *	1400–1430	TOWARDS IMPLEMENTATION OF A COMPATIBLE HDTV SYSTEM IN NORTH AMERICA *C. Rhodes, Scientific Atlanta, U.S.A.*
1.6	1430–1500	COMPATIBILITY ASPECTS OF HDTV *Kerns H. Powers, RCA, U.S.A.*

Session 2 – DELIVERY AND DISPLAY (Chairperson: B. Baldry, CBC)

2.1	1500–1530	NETWORKING ASPECTS OF HIGH DEFINITION TELEVISION *Arpad G. Toth, BNR, Canada*
	1530–1545	*Coffee*
2.2	1545–1615	BANDWIDTH REDUCTION FOR HIGH DEFINITION TELEVISION *John P. Rossi, CBS Technology Center, U.S.A.*
	Paper only	SIGNAL PROCESSING FOR COMPATIBLE HDTV SYSTEMS, FIRST RESULTS *B. Wendland, University of Dortmund, F.R.G.*
2.3 *	1615–1645	A FIBER OPTIC NETWORK FOR DELIVERY OF HDTV TO THE HOME *Elmer H. Hara, DOC, Canada*
	1830–1930	*Cash Bar (Commonwealth Ballroom)*
	1930	*Banquet (Commonwealth Ballroom)* *Guest Speaker: Norman Campbell, TV Producer, CBC, Canada*

Tuesday, October 19, 1982

2.4 **	0900–0930	IS HIGH DEFINITION HIGH QUALITY? *John D. Lowry, Digital Video Systems, Canada*
2.5	0930–1000	DIGITAL CODING AND PROCESSING OF HIGH-DEFINITION TELEVISION SIGNALS: PART I *B. Prasada, BNR, Canada*

* Manuscript was received after the deadline for the Preconference Proceedings and is therefore included in the Postconference Proceedings.

** Manuscript was not available at the time of printing of the Postconference Proceedings.

Tuesday, October 19, 1982

2.6 1000–1030 DIGITAL CODING AND PROCESSING OF HIGH-DEFINITION TELEVISION SIGNALS: PART II
E. Dubois, INRS-Telecommunications, Canada

1030–1045 *Coffee*

2.7 1045–1115 SYSTEMS CONCEPTS IN HIGH FIDELITY TELEVISION
R.N. Jackson and S.L. Tan, Phillips Research Laboratories, U.K. and The Netherlands

2.8 * 1115–1145 AVAILABILITY OF FREQUENCY SPECTRUM FOR HIGH-DEFINITION TELEVISION
S.N. Ahmed and M.J. Hunt, DOC, Canada

2.9 * 1145–1215 SPECTRUM AVAILABILITY FOR HIGH-DEFINITION TELEVISION IN THE BROADCASTING SATELLITE SERVICE
Robert R. Bowen, DOC, Canada

1215–1400 *Lunch (Rideau Room)*

2.10 * 1400–1430 HIGH DEFINITION TV AND ITS DISPLAY TECHNOLOGY
Takashi Fujio, NHK, Japan

Session 3 – APPLICATIONS: PROGRAMMING SERVICES AND PRODUCTION HARDWARE
(Chairperson: Marcel Bouchard, DOC)

3.1 * 1430–1500 PROGRAM, PRODUCTS AND SERVICES: AN OVERVIEW OF THE POTENTIAL IMPACT OF HDTV
Carrol Bowen and Michel Guite, Kalba Bowen Assoc., U.S.A.

3.2 1500–1530 SATELLITE BROADCASTING OF HDTV
G. Chouinard, DOC, Canada

1530–1545 *Coffee*

3.3 * 1545–1615 THE PRESENT STATE OF THE DEVELOPMENT OF HDTV EQUIPMENT AND PROGRAM PRODUCTION
Yoshinobu Ohba and Takashi Fujio, NHK, Japan

3.4 * 1615–1645 HIGH DEFINITION TV: BOOM OR BUST FOR CABLE TV
V.C. Reed, Skyline Cablevision, Canada

3.5 1645–1715 HIGH DEFINITIDN TELEVISION: SOME POSSIBLE CANADIAN APPLICATIONS AND BENEFITS
Joseph Koenig, Interactive Image Technologies, Canada

Wednesday, October 20, 1982

Session 4 – APPLICATIONS: NON-PROGRAMMING SERVICES (Chairperson: M. Sablatash, DOC)

4.1 ** 0900–0930 HDTV GOES TO THE MOVIES
William H. Hogan, Ruxton Limited, U.S.A.

4.2 0930–1000 DEVELOPMENT OF THE HIGH-RESOLUTION VISUAL SIMULATION SYSTEM
R.E. Barrette and B.L. Welch, CAE, Canada

4.3 * 1000–1030 HDTV AND VIDEOTEX/TELETEX SERVICES
B. Crozier and Keith Y. Chang, DOC, Canada

1030–1045 *Coffee*

Session 5 – STANDARDS (Chairperson: B. Crozier, DOC)

5.1 * 1045–1115 THE EVOLUTION OF STANDARDS; TRANSMISSION AND OTHERWISE
Western Vivian, University of Michigan and Kalba Bowen Assoc., U.S.A.

5.2 * 1115–1145 NATIONAL STANDARDS MECHANISMS AND ACTIVITIES
R. Amero, A.R. Bastikar and K. Richardson, DOC, Canada

5.3 1145–1215 INTERNATIONAL ASPECTS DF HDTV STANDARDIZATION
Donald G. Fink, SMPTE, U.S.A.

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HDTV COLLOQUIUM WORKSHOPS

SCHEDULE

Wednesday, October 20, 1982

1330–1500 *Commonwealth Ballroom South*

1. **SOCIOECONOMIC**

"HDTV: ELECTRONIC NIRVANA?"
Moderated by Robert O'Reilly, CBC

1500–1530 *Coffee*

1530–1700 *Commonwealth Ballroom South, North and Capital-Carleton Room*

2. **SOCIOECONOMIC**

"HDTV: COSTS, BENEFITS, AND OPPORTUNITIES"
Moderated by Robert O'Reilly, CBC

3. **TECHNICAL**

"PRODUCTION HARDWARE FOR HDTV"
Moderated by Marcel Auclair, CBC

4. **SOFTWARE**

"HDTV: PRODUCERS DREAM?"
Moderated by Harold Greenberg, Astro Bellevue Pathe

Thursday, October 21, 1982

0900–1200 *Commonwealth Ballroom South, North and Capital-Carleton Room*

0900–1015 **5a.** **APPLICATIONS**

"HDTV: A TECHNOLOGY IN SEARCH OF APPLICATIONS – PART A"
Moderated by E. Steele, CAB

6. **TECHNICAL**

"GETTING HDTV TO THE CONSUMER"
Moderated by A. Toth, BNR

7a. **POLICY & REGULATIONS**

"HDTV: KEEPING THE LINES STRAIGHT – PART A"
Moderated by Ken Wyman, CRTC

1015–1045 *Coffee*

1045–1200 **5b.** **APPLICATIONS**

"HDTV: A TECHNOLOGY IN SEARCH OF APPLICATIONS – PART B"
Moderated by E. Steele, CRTC

8. **TECHNICAL**

"CONSUMER HDTV EQUIPMENT"
Moderated by A.G. Day, CAB

7b. **POLICY & REGULATIONS**

"HDTV: KEEPING THE LINES STRAIGHT – PART B"
Moderated by Ken Wyman, CRTC

Thursday, October 21, 1982

1400–1600 *Commonwealth Ballroom South*

9. WIND-UP

10. PLENARY SESSION

OPENING ADDRESS

D.F. Parkhill

Assistant Deputy Minister Research

Department of Communications

On behalf of the Government of Canada and the organizers of this colloquium, I would like to welcome you to this rather cold and frosty October morning in Ottawa.

To the authors of the many excellent papers that are going to be presented over the next few days, I'd like to offer on behalf of everyone, our thanks for the time and effort that they have put into their preparation. To the participants in the program and the workshops, I'm sure that you will find the next few days most rewarding in improving the understanding of this new and exciting area of technology. To all of you, we believe that this first colloquium on the High Definition Television will offer a stimulating insight into the television systems of the near future and the many possibilities for their application.

It's clear, I think, already that High Definition Television and of course enhanced definition television of which we are going to hear a great deal over the next few days are important areas of develpment for researchers, manufacturers and for users, and that it will not be long before we find these new systems in every day use. As a result, we have an urgent need to understand the new technology and in particular what we are going to be able to do with it.

In the case of Canada, we have a special interest as it relates to our other high technology communications development programs in which the Canadian Government has been deeply involved. Programs like our domestic satellite system and of course Telidon that was referred to earlier. Now, this colloquium from the point of view of the Government of Canada, I'm sure will provide us with an unsurpassed opportunity to tap the brains of some of the world's experts and to become acquainted with the potential of these new technologies and their future directions. But before we turn to the future it might also be useful to refresh our memories and think back not too long ago, it was only about 32 years ago, back around 1950 that we were all busy arguing about the appropriate standards for colour television. Some of us can recall the days of the frame sequential systems, recall the CBS big colour wheel - it had a short-lived renaissance, I believe in one of the Apollo missions. The time that we are now entering, in many respects, is very similar to those days. We don't really know what the technologies that are going to be most appropriate for High Definition Television are going to be like. We have some general ideas on them, but I'm sure that there is a great deal of room for inventiveness, for genius before our existing systems which really have served us rather well over the past 30 years become totally obsolete.

Of course, over the last 4-5 years in particular since micro electronics technology has developed, the technology of television has progressed far far beyond the level foreseen in even the wildest of dreams of the authors of the current standards and of course the uses of television have multiplied enormously. It is not surprising accordingly that there are now arising demands from all sides for new forms of television that offer better quality pictures; pictures that are more satisfying esthetically, pictures that are bigger, brighter, more colorful, pictures that have a reality to them instead of the pic conventional picture in the box appearance and as in many other current high technology areas these days, Japan seems to have taken an early lead in this High Definition Television field and a great deal of pioneering work has been done in both quantifying the needs and in developing appropriate demonstration hardware which I am only too sorry we don't have with us to show you today. In particular, the scientisits at NHG, the Japanese Broadcasting Corporation have been doing some magnificent work and we are fortunate to have with us today Dr. Fujio and some of his team who will be discussing the field with us and their work in truly High Definition Television and their hopes for the future. I think it is fairly clear that our current television systems are based on a presumption that the signal form in the studio, in the transmission chain, in the recorder and in the receiver are identical. When you think about it, there is really no logical reason why they should be so given the current state of micro electronics. Although, of course, in the early days of television it made a lot of sense, but today we are in a situation where the necessary elements to process and perform complicated operations on a television picture are becoming relatively inexpensive and in the near future, as micro electronics develops, should become almost trivially expensive in the face of the cost of the overall system. As a result, we are not in a happy position of being able to look forward to the luxury of employing complex processing at a number of points in the television chain to optimize signal forms independently for the various parts of the overall system and to meet specific user needs. Thus, we can envisage a number, a family of enhanced television systems with qualities vastly improved over those currently available. But, again, if our projections of micro electronics technology are correct, and I notice there are a number of references to this in the proceedings we will still be fully compatible with existing systems.

Now, a number of researchers have been working in this area, and certainly will share their findings with us this week. The key questions in the introduction of any new technology though, I think, are first of all what can we use it for, what good is it? Secondly, how can we overcome the cost implementation barrier and get the system up and running, in the face of reasonably satisfactory existing systems, and finally, of course, who is going to be willing to pay money for the new service, who are the users and how much are they prepared to pay? Similar questions will certainly arise with High Definition Television and this colloquium again will be examining these various issues not only in the formal papers but hopefully within the workshops where all of us will have an opportunity to exchange our views and defend them before our colleagues. We are fortunate that we have represented at this colloquium a wide range of experts from research, industry, government and television users and this should make our workshop sessions uniquely valuable. Now the colloquium proceedings, the revised version of what you already have, will gather together all of this information and will provide a useful record of our deliberations here and I believe that it will be a significant contribution to the development of High Definition Television not only in Canada where we are just beginning, but everywhere in the world.

Now a conference of this nature is always a major challenge to the organizers and it would be appropriate to recognize the assistance that the organizing committee has received from the different sponsoring organizations: the Canadian Broadcasting Corporation, Teleglobe Canada, the Department of Industry, Trade and Commerce, and of course my own department, the Department of Communications, each of whom have provided staff and financial assistance to us. I'd like also to thank the participating organizations, the Canadian Radio-Television and Telecommunications Commission, the Ministries of State for Social Development, Economic Development and Science and Technology who have provided many valuable inputs to the planning process. We also gratefully acknowledge the help received from industry contributors, particularly Bell Northern Research Limited, SONY Canada Ltd., and Digital Video Systems Incorporated. We are all overjoyed to see so many of you here today and I hope that the next few days will be stimulating, enjoyable and represent an invaluable contribution to the future of this exciting new area. So, officially, the 1982 colloquium on High Definition Television is now open. Thank you.

OTTAWA, October 18, 1982

NHK

HIGH-DEFINITION TELEVISION SYSTEM OF NHK

by Takashi Fujio

NHK Technical Research Laboratories
Tokyo, Japan

1. INTRODUCTION

Television broadcasting, including the period of monochrome TV, has a history of forty years. During those years, electronic technology advanced at an enormous pace, and as the demand for information also grew at an equal rate, it steadily expanded, both in the volume and diversity of the information required. People of these days are no longer satisfied with simple information. They want something more. They are seeking various information from various aspects.

Forecasting the arrival of such an information society, NHK started in 1970, research and development of high-definition television appropriate for the creation of future video culture, which we labeled HDTV.

Prior to starting research and development of this TV system, extensive studies and tests were conducted regarding characteristics of the human visual system, physical requirements of the TV system needed to satisfy these characteristics, and the future television system expected and desired by viewers. Based on the results of this research, the provisional standards for high-definition TV were decided.

Since then, NHK's untiring efforts have led to a new pickup tube and CRT for the high-definition television system, a television camera, laser telecine equipment, wide direct-viewing and projection displays, video tape recorder, transmission equipment and receivers for satellite broadcasting, to name only some of the items. All of the equipment has been in operation since 1978. In 1980, a transmission test of high-definition television was made using Japan's experimental broadcast satellite, "Yuri". Recently, a variety of field transmission and recording tests have been made, including satellite transmission, by using these equipment to verify the program effect with a high resolution and wide screen. Efforts have been made to verify the effects and to develop a system with wide ranging future applications, including for general imaging systems.

The high-definition television system is capable of transmitting and reproducing video information with informative volume approximately five times that of the conventional television system. The system is an entirely new system with a wide picture screen (aspect ratio 5:3) having very fine texture. Reproduction of these pictures on a large screen imparts a sense of reality far exceeding that of conventional television.

The picture quality of the high-definition television system is equal or superior to that of 35-mm slide picture. When converting from video to film, an ultrafine grain film can be used regardless of the film sensitivity by utilizing a laser beam. This will permit efficient production of high-definition movies, that is electronic cinema.

Thus viewed, the high-definition television system will enable us to create all-imaging systems needed for future information society, systems diverse in nature, such as for cable television, movie production, printing, high-resolution document transmission, television conferences, and various simulation purposes, aside from applications in the field of broadcasting.

2. TELEVISION SYSTEM FOR THE FUTURE

2.1 Existing TV and Future TV

The existing TV system was established 40 years ago when a number of restrictions existed in radio-wave and hardware technology such as transmission lines, bandwidths, and display ability. Thus the system failed to attain the level at which the functions of the human visual system can be effectively utilized. This is why the existing color TV can not be compared with movies or printing in terms of picture clarity, impact, or immediacy. It cannot thoroughly provide high-level psychological satisfaction in terms of feelings and emotions.

For this reason, the TV system befitting a future information society will require taking out the frame-work of existing TV and overcome its limitations to find out an ideal TV system.

2.2 Stereoscopic TV or High-Resolution TV

Prior to starting research of the future television system, we discussed which system should be developed; a stereoscopic television or a high-resolution television.

A high-fidelity stereoscopic television was determined to be difficult to attain because of the transmission bandwidth and live camera it required, since it should be such system as that the concealed portions of pictures can be viewed even if the viewing positions are changed.

On the other hand, a high-resolution television was determined that it will not be accepted if a psychological effect can not be taken into account in addition to high resolution.

Through the above discussion, we decided to study and develop the high-resolution and large-screen television system which fulfills sharpness and psychological effect such as sensation of reality and powerfulness, that is High-Definition Television.

3. WHAT KIND OF HDTV WILL BE NEEDED IN THE FUTURE

3.1 High-definition TV System from the Perspective of Vision Characteristics

The TV system as the visual system of the future must be decided through consideration of information content to be transmitted and high level of psychological characteristics. The frequency characteristics of the eyes when viewing

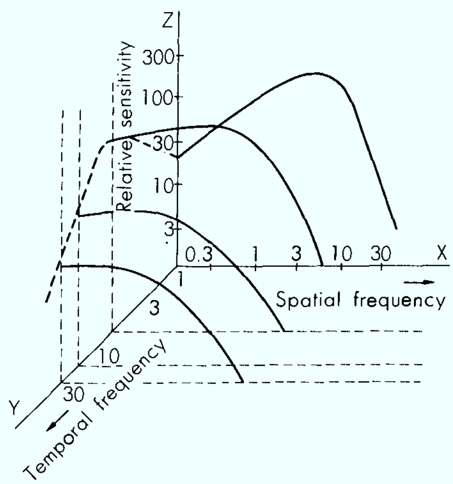

Fig. 1 Response of the human visual system.

Table 1 Required number of scanning lines as a parameter of viewing distance

Viewing distance (dH)	4H	3.3H	3H	2.5H	2H	7.2H
n (lines)	940	1125	1240	1480	1840	525
f_b (MHz)	11	16	19	27.5	42	2.8
Visual angle* (deg.)	23.5°	28.3°	31.0°	36.9°	45.2°	10.7°

when $a=5/3$, $\eta_v=0.935$, $\eta_h=0.835$
*Visual angle in horizontal direction viewed from optimum viewing distance of the system

television are LPF type as shown both spatially and temporally in Fig. 1, and are such that the eyes fail to detect fine detail and sense high speed flicker. For this reason, the framework for TV system standards such as the number of scanning lines, number of images per second, and signal bandwidth, can be calculated from the physical characteristics of the visual system once viewing conditions are determined (1).

Table 1 shows the specifications of the TV system that correspond to the visual system (2). The specifications show the TV standards required in terms of characteristics of the visual system, i.e., number of scanning lines (n) and signal frequency bandwidth (f_b), relative to various viewing distances from the TV. The viewing distances dH in the table are expressed by multiples of the screen height H. What is meant by 4 H is to watch TV at a distance four times the height of the screen. As this table shows, conventional TV is a video system with an optimal viewing distance of about 7 H. Watching the screen at a distance nearer than this, the viewer would find the picture coarse and blurred.

3.2 Desirable Viewing Distance and Future Television System

Television is a system for taking moving pictures such as those of sports athletes and flying objects. However, the visual system cannot follow when the object is too fast. When the viewer sees pictures moving at a high speed from a distance which is too close to the screen a dizziness and fatigue would be felt. A test with movie films and TV pictures to determine what would be the ideal distance to watch moving pictures has shown that the minimum viewing distance permitting the viewer to watch moving pictures for a long time without fatigue is about 4 H (3) (4) (5). As a result, the viewing distance for the future TV should be:

(a) A video system with a viewing distance of 4 H is recommended for movies, animation, and sports programs with quick movements.

(b) Pictures with fewer or slower movements are watched nearer to increase psychological effects such as immediacy, and the system should be such that pictures can be seen satisfactorily even at a distance of about 3 H[1].

This means that future TV systems will require 1200 scanning lines and a signal frequency bandwidth of about 20 MHz so that the picture quality does not degrade when watched at a viewing distance of at least 3 H.

3.3 TV Screen System that Satisfies Psychological Effects

We have already experienced with movies and other media that psychological effects such as immediacy and impact can be obtained by projecting beautiful, high-resolution picture on a large screen.

By displaying a clear picture in a wide visual field as explained above, the area of the picture display and the space conciousness of the viewer almost converge, and the sense of presence of the display system is reduced, while the pictures themselves are felt with depth, naturalness and reality.

To study the sensation of reality induced by a visual wide field display, subjectively induced tilt angle of the observer's coordinate axes when presented with a tilted stimulus display pattern has been evaluated using various picture displays on the hemispherical concave screen as shown in Fig. 2[6]. The value of subjectively induced coordinate axes tilt by the evaluation test is shown in Fig. 3. It was concluded from the results that the visual display with

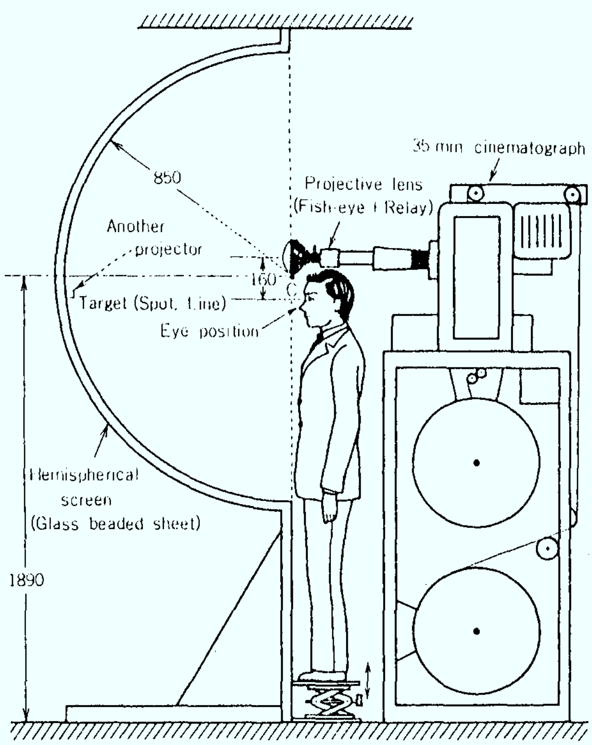

Fig. 2 Apparatus creating an experimental visual wide-field dispaly.

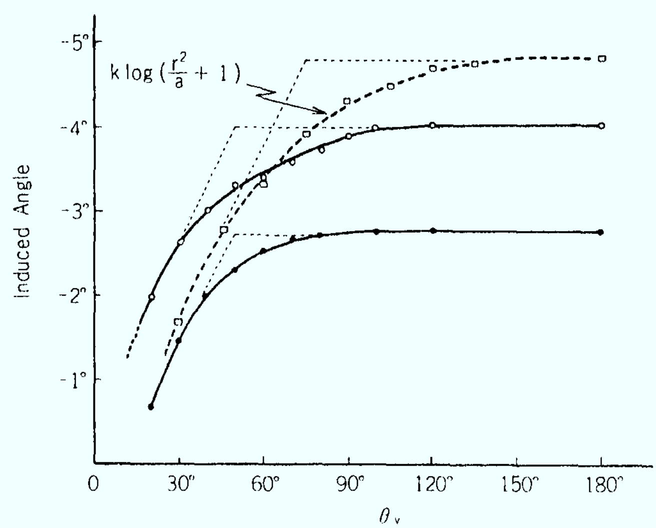

Fig. 3
Subjectively coordinate axes tilt as a function of display image tilt;
--◘-- grating pattern, tilted -17°;
—o— suspension bridge, tilted -10°;
—●— open landscape, tilted -10°.

viewing angles of 20° to 30° begins to produce psychological effect that gives a sensation of reality.

For this reason, the most effective technological means of producing psychological effects, such as immediacy and impact, with future television would be to widen the display screen. As shown in Table 1, the viewing angle at the optimal viewing distance of the conventional television system is up to 10°, and with these values pictures cannot be expected to be psychologically satisfying. To convert this system to a realistic future TV screen system with a viewing angle of at least some 30°, the viewing distance should be about 3 H, and the screen should be wider than the conventional screen. When the viewing distance is fixed, a large screen wider than that of the conventional television system will be required.

4. VIEWERS' REQUIREMENTS FOR FUTURE TELEVISION SYSTEM

In order to fix the parameters of a future television system, the following primary factors must be considered.

1) Picture format (standard picture size and aspect ratio).
2) Scanning standards (number of scanning lines, interlace ratio, and frame frequency).
3) Signal standards (signal type, bandwidth, and required S/N ratio).

To make these factors clear many tests were performed in respect to the items in Table 2 to seek the viewer requirements for future television systems. In these tests, 70mm movie films, simulation films, and experimental high-resolution television systems were used. The following results were obtained from a series of such tests.

4.1 Interlacing Scanning

Opinion differs as to the advantage of line interlacing and multiple interlacing. Tests were carried out on the line interlace effect and how line structure affects picture quality, by means of a high-resolution monochrome television system with a variable number of scanning lines up to 2125.

(1) It was found that a television picture having n scanning lines and a 2:1 line-interlace ratio has the same subjective picture quality as that of a transparency having 0.6n - 0.7n scanning lines[1]. This agrees well with other results obtained[7] from the test for interlace effects on picture-quality.

(2) The best line-interlace ratio is 2:1[7] [8]. In multiple line-interlacing with the ratio of 3:1 or 5:1, the vertical resolution measured by using a resolution pattern is improved slightly, but as scanning-line interference such as interline flicker and line crawling increases, the overall picture quality is no better than that of the 2:1 interlace system.

(3) In a television system with a 2:1 interlace and 30 Hz frame freqeuncy, 1600 scanning lines are sufficient to obtain satisfactory picture-quality[8] with no line flicker.

Table 2 Viewers' requirements and HDTV standards

Factors		Items		Equipment and systems used (※)	HDTV system
Viewing		Desirable viewing distance		Movie F, Slide F, Simulation F	HDTV Standard
Picture aspect		Aspect ratio		Slide F	
		Picture size		Slide F, Simulation F	
		Contrast and brightness		〃 〃	
Scanning system		Effect of interlace scan and nonlinear scan		Variable-scan TV, Simulation F	Quality factor (Q)
Picture information	Still picture	Y	n	ST-TV, HDTV, Variable-scan TV	
			f_b	HDTV, Simulation F	
		C	Transmission primaries	ST-TV, HDTV	Preferable color
			f_W, f_N	HDTV, Simulation F	Signal Standard
		Y⇄C crosstalk		ST-TV, HDTV	
	Moving picture	Smoothness, Tracking, Desirable resolution		16mm film, ST-TV	Frame frequency, Display system
	Noise impairment, Desirable S/N			ST-TV, HDTV	Broadcasting system, Size
Note	(※) Movie F : Movie films (35mm, 70mm) ST-TV : Standard TV system Simulation F : 4″×5″, 8″×10″ Simulated slide HDTV : HDTV system Slide F : 4″×5″ Slide				

4.2 Field Frequency

Field frequency is limited by consideration of flicker and smoothness of moving image. Field frequency of 45 Hz will be enough to give smoothness for moving image with 20 degree/sec., the highest tracking speed for movement of the human visual system. If a television display can be realized in which the luminescence of picture elements can be held for a field period, the required number of television field could be as low as 45 Hz [9]. It may, therefore, be possible to reduce the field frequency. For ordinary display, however, a field frequency of 60 Hz is suitable.

4.3 Aspect Ratio

A subjective evaluation test relating to picture size and aspect ratio have been performed by projecting large color transparencies onto a screen. The results of the test are shown in Fig. 4 [4].

In general, an aspect ratio of 5:3 is preferable to 4:3 for current television systems; as the picture becomes larger, the aspect ratio of 5:3 becomes more preferable. For sporting scenes and landscapes, the 2:1 aspect ratio is preferable. If the problems of home use display of wide screen, high brightness and high resolution can be solved, a television system with 2:1 aspect ratio is most suitable.

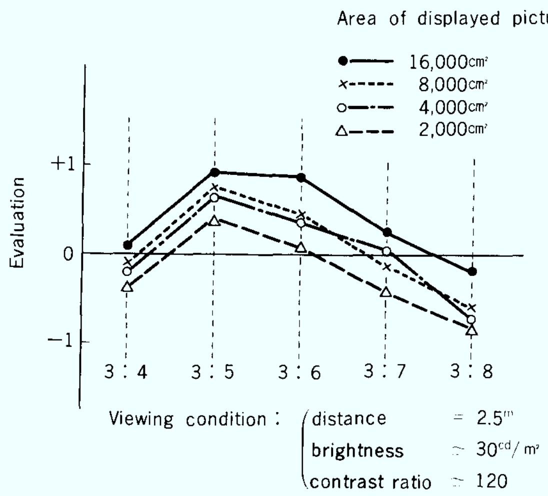

Fig. 4 Desirable aspect ratio.

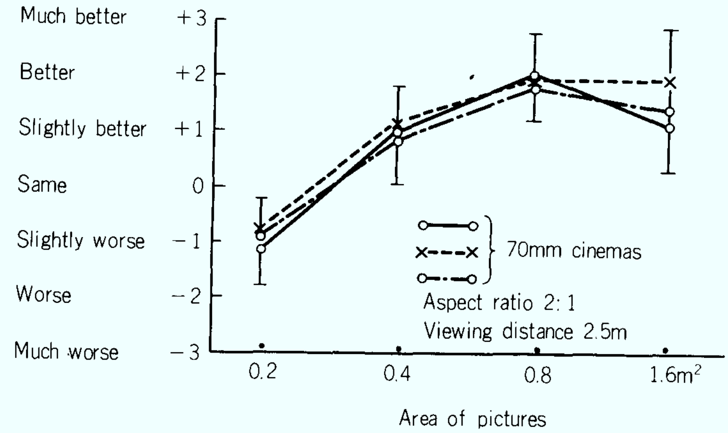

Fig. 5 Picture-quality as a function of picture size.

4.4 Picture Size

Subjective tests on the psychological effect of the screen size on the picture have been conducted by projecting 70mm movies and 4"x5" or 8"x10" color transparencies made by computer processing and a simulator (4) (5) (10).

Fig. 5 shows the relationship between the picture size and picture-quality. A picture size greater than one square meter will be desirable.

4.5 Picture Resolution

When picture size is made large, sharpness is an important factor for picture quality. Sharpness of a television picture depends upon resolution, brightness and contrast ratio.

Fig. 6 shows the relationship between the video bandwidth and picture-quality for the 1125 scanning lines system (11). It is obvious that a desirable signal bandwidth is 20 MHz for the system with an aspect ratio of 5:3. In this case, picture-quality deterioration is not perceptible even at a viewing distance of only 3 H.

In a 1125-line system with a 5:3 aspect ratio, desirable band-widths for wideband chrominance component and narrowband chrominance component are 7 MHz and 5 MHz respectively (12).

Through these tests, the author induced a quality factor Q defined by the primary factors of the number of picture elements (number of scanning lines), the display picture size, and the picture brightness. The value of Q gives the fineness of picture quality, and contains such effects as reality, presence, and the visual impact of large display pictures.

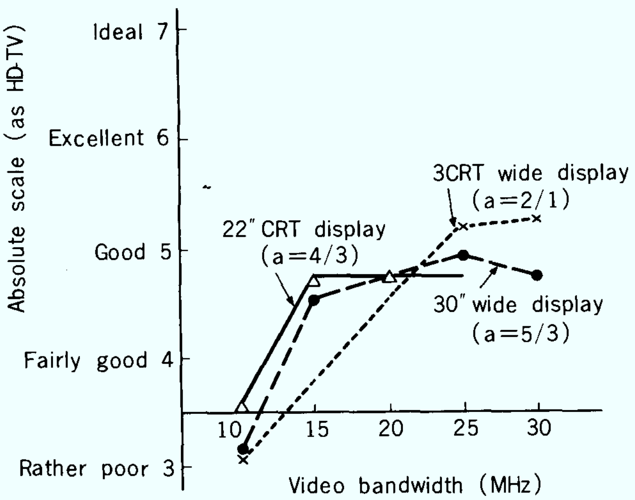

Fig. 6 Picture quality as a function of signal bandwidth.

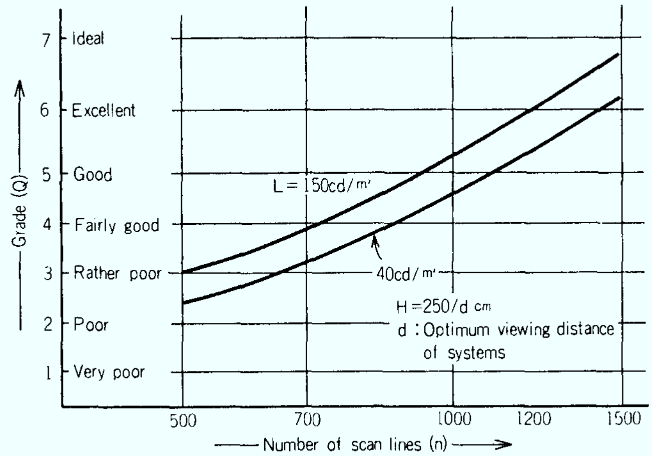

Fig. 7

System performance (quality factor Q) in various TV systems.

Fig. 7 gives the value of Q for television systems with various number of scanning lines and when the picture displayed in each system is viewed [13]. The picture size is derived from a fixed viewing distance of 2.5m, as the picture height H is equal to (2.5/d)m. From Fig. 7, it will be found that a television system matched to a viewing distance of 3 H will produce a subjective picture quality better by about 3 grades than that of a conventional 525-line television system.

5. PROVISIONAL STANDARD FOR HDTV

Based on the results above, the provisional HDTV standards were specified at NHK for further study as shown in Table 3 [14] [15]. Desirable bandwidths for the luminance (Y) and chrominance signals in the systems described in Table 1 are shown in Table 4. The number of scanning lines means this system has an optimal viewing distance 3.3 H when viewed with the vision characteristics shown in Table 1. However, when the bandwidth of the luminance signals is chosen as 20 MHz, the picture quality of this system does not degrade significantly. This system is considered to meet the requirements desirable for the future TV system [13].

Until recently, equipment for high-definition TV has been developed in accordance with the standard contained in Table 3. Furthermore, pickup, transmission, and other tests have been undertaken regarding the broadcasting system.

The High-Definition Television System which is being developed by NHK was designed not only for broadcasting but also for other applications to require high resolution. It has the following features:

1. The system is capable of reproducing video pictures of high resolution conveying five times the information of conventional television.

Table 3 Provisional standards for an HDTV experimented at NHK

Number of scanning lines	1,125
Aspect ratio	5 : 3
Line interlace ratio	2 : 1
Field repetition frequency	60 Hz
Video frequency bandwidth	
Luminance (Y) signal	20 MHz
Chrominance (C) signal	
Wideband (C_W)	7.0 MHz
Narrowband (C_N)	5.5 MHz

$$\begin{pmatrix} Y \\ Cw \\ Cn \end{pmatrix} = \begin{pmatrix} 0.30, & 0.59, & 0.11 \\ 0.63, & -0.47, & -0.16 \\ -0.03, & -0.38, & 0.41 \end{pmatrix} \begin{pmatrix} R \\ G \\ B \end{pmatrix}$$

Y : Luminance signal R : Red
C_W : C_W signal G : Green
C_N : C_N signal B : Blue

Table 4 Signal bandwidth for various HDTV

	n(lines)	935	1,241	1,481	951	1,125*2	1,351	1,601
Luminance signal f_Y(MHz)		14	24	34	15	19	28	40
Chrominance components	f_W(MHz)	5	8.5	12	5.5	7.0	10	14.5
	f_N(MHz)	4	6.5	9.5	4	5.5	7.5	11
	f_C*1(MHz)				4.7	6.5	9.4	13.3

*1 Bandwidth of line-sequential chrominance signal
*2 Provisional used system at NHK

2. Each television frame can transmit an 8-inch-by-11-inch page of words and pictures in fine detail.
3. The quality of the picture is equivalent to that of a 35mm transparency and is superior to that of 35mm motion picture film.

For these reasons, we feel certain that practically all types of video-imaging systems that are necessary for the information society of the future - the transmission of minute words and pictures, the wide-screen tele-conference, photography, printing and electrocinematography - will come to be created on the basis of the technologies of HDTV, or the high-definition video.

6. CONCLUSION

Since 1970, many efforts have been made at the NHK Technical Research Laboratories for research and development of a large-screen high-definition television system, in response to the expected demands of a future information society.

In conclusion, the future HDTV system should have 1100 to 1300 scanning lines and the acceptable picture size is more than 1 m^2 with an aspect ratio of 5:3 or 2:1.

When it seems likely that the information society of the future will be formed and operated on the basis of a progressing television technology, it is clear that the development of high-resolution and higher-quality television technologies is necessary. It is expected that standards will be unified and established in order to promote rapid development of high-definition television system. HDTV is a possible dream for broadcast engineers of the eighties, and the author looks forward to international understanding and cooperation towards its realization. It will be necessary to exchange views, opinions, and information on a world-wide basis in order to establish unified international standards for all imaging systems of the future.

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TOWARDS THE IMPLEMENTATION OF A COMPATIBLE HDTV SYSTEM IN NORTH AMERICA

by

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Part I-A

Compatibility of a New Service with the Existing Broadcast Services

With the exisiting TV channels so effectively used for 525 line NTSC broadcasting, we cannot expect that these channels would be used for HDTV broadcasting unless HDTV were receivable on NTSC color receivers without either adaptors of any sort or improved antennas.

The SPMTE HDTV Study Group's report (Journal of SMPTE, Feb., Mar., 1980) indicated that there was no new encoding concept by which NTSC receivers could be made to produce pictures in color from transmissions designed to produce HDTV pictures on HDTV receivers. This observation remains valid today. There is no doubt that further improvements in NTSC receivers will be introduced by the receiver manufacturers, but those improvements can be expected without any changes in the nature of the broadcast signal.

CBS has pointed out that UHF channels above say 45 remain under utilized. The reasons for which do not suggest that these channels might be well suited for HDTV.

It appears that only new broadcast frequencies are possible for a new service. These are SHF frequencies in the 12, 22, and 43 gigahertz bands. Primary interest is in the 12 gHz band because of the difficulties with the technology for the higher bands. Rainfall attenuation at 22 gHz. requires power increases of an order of magnitude over the power needed at 12 gHz. The directionality of antennas for these higher frequencies works against their practicality for home use.

As has been pointed out by the IBA (U.K.) the 12 gHz band is our opportunity for the introduction of HDTV as a new broadcast service. There is no reason why the NTSC video signal format should be used at 12 gHz. where FM, not vsb AM will certainly be used. The public will have to be equipped with 12 gHz. FM television receivers, not just down-convertors. As the baseband video signal is recovered from the discriminator, it is possible to consider alternatives to NTSC video for the baseband signal.

Here are the three possibilities:

1. Use NTSC, amplitude modulate a VHF carrier (vsb) to feed the antenna terminals of ordinary receivers, or feed baseband NTSC to those receivers which have baseband NTSC input.

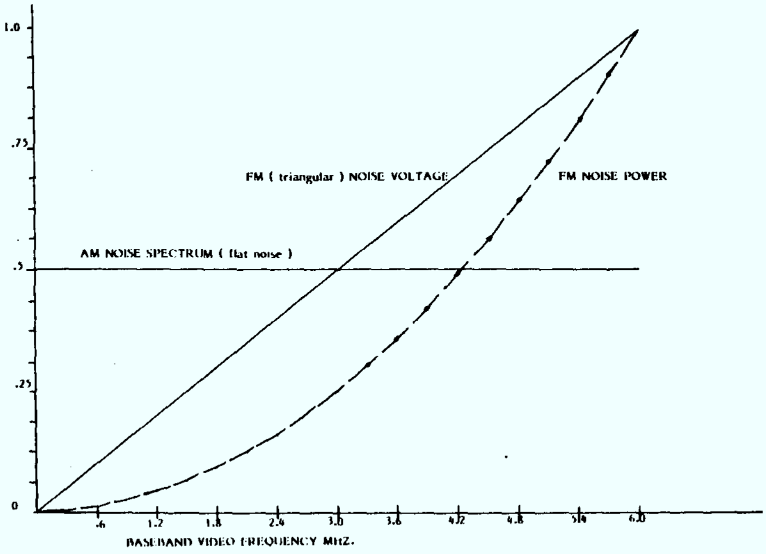
2. Use something other than NTSC, but better suited to FM transmission, and which can be converted to NTSC for display on new receivers having R-B-G baseband input, which are now marketed in Europe, and are being introduced to the North American market by an increasing number of manufacturers.

3. Use of a new baseband video signal format which is highly spectrum efficient so that the additional detail needed for HDTV pictures can be transmitted. Such a signal must be designed for FM transmission and it must be readily transcodable to NTSC within the 12 gHz FM receiver for compatibility with the present NTSC recievers.

Reception of super high frequency (SHF) transmission will require signal processing to bridge between the FM transmission signal and the VHF - vsb AM input of home receivers. The costs of the video signal processing will be small compared to the fixed costs of the SHF roof or pedestal mounted antenna, the low noise amplifier down-convertor, and the FM demodulator. The difference in signal processing cost between our options is small.

Part I-B
Compatibility Between NTSC Video and FM Transmission

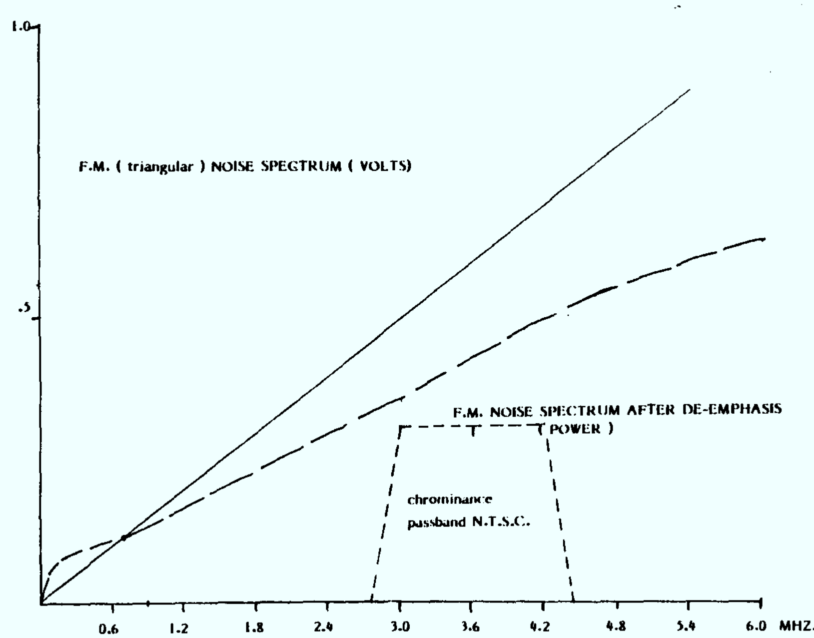
Composite color video signals, such as NTSC or PAL have a serious problem with "color noise" when transmitted by FM. The spectrum of the noise voltage in FM is triangular. The spectrum of the noise power is quadratic. These are shown in Fig. 1.



The NTSC chrominance information is transmitted by suppressed carrier amplitude and phase modulation of a 3.58 mHz color subcarrier. The chrominance information occupies the upper part of the video frequency band, 3.0 to 4.2 mHz. If we compute the integral of the noise power spectrum of Fig. 1, over the interval 0 to 4.2 mHz, we obtain the noise power which affects the luminance signal.

The effect of the higher frequency noise components is minimized by our reduced visual accuity to h.f. noise. This is the psycho-physical noise weighting effect. After noise weighting, triangular (FM) noise in the luminance channel is reduced 10.2 dB.

In an FM system, the noise power in the chrominance channel 3.0 - 4.2 mHz is 63% of the noise power in the 4.2 mHz luminance channel. The chroma channel noise spectrum is shown in Fig. 2, which gives both the voltage spectrum, and the power spectrum. In the synchronous detection process, the noise components (between 3.0 and 4.2 mHz) beat with the color subcarrier to form noise which is down-converted to the 0 to 0.6 mHz baseband frequencies of the color difference signals. The power of noise components equally above and below 3.58 mHz add directly. The spectrum of the noise power in the baseband color difference signals is shown in Fig. 3. Note that the triangular noise spectrum has now been converted to white noise.



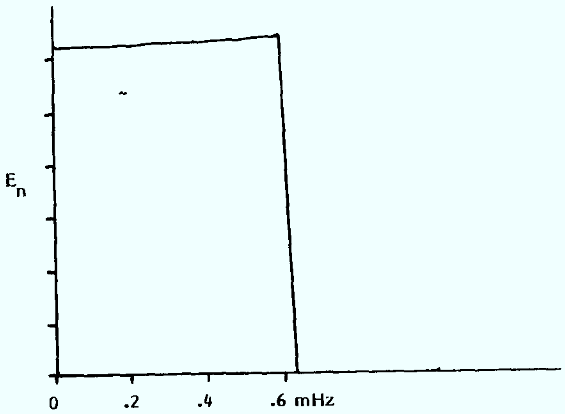


Fig. 3 Baseband Sprectrum of down-converted Chroma Noise after NTSC demodulation

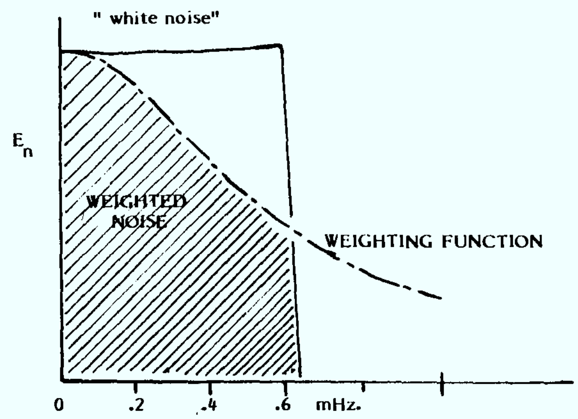


Fig. 4 Spectrum of chroma noise voltage after demodulation

Applying the same psycho-physical noise weighting to this "white" color noise, we find that very little improvement results, as shown in Fig. 4.

This is the paradox of the FM transmission of NTSC or PAL composite video signals. The use of FM is highly advantageous to the luminance signal because of noise weighting. The chrominance components are carried in the high noise portion of the spectrum yet weighting only slightly affects the resulting chroma S/N.

De-emphasis is used in FM transmissions. At most, it reduces chrominance noise 3 dB. The standard de-emphasis for 525/60 video is shown in Fig. 5.

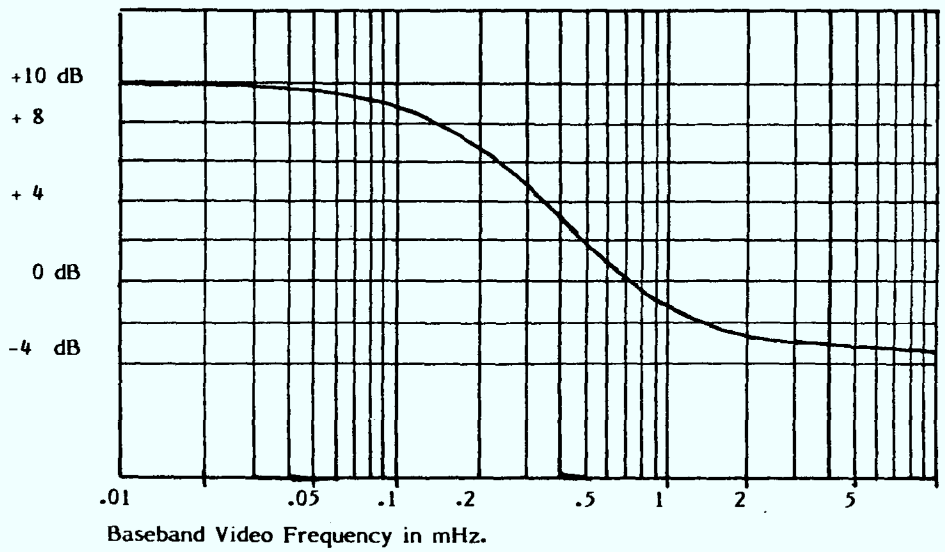


Fig. 5 FM DE-EMPHASIS FOR 525/60 systems (CCIR Rec. 405-2)

Human vision is much less sensitive to noise fluctuations which alter hue and/or saturation i.e., chroma noise than noise which affects luminance, this difference is said to be 8-11 dB. The NTSC System was designed in a manner which minimizes luminance noise. That strategy set up the luminance signal weightings to match the relative brightness of the original R, G, and B phosphors. Since then, very significant changes in phosphors have been implemented and today, the benefits of the constant luminance principle are not being fully realized. This should not be overlooked in planning a new TV standard.

Analysis of the weighted noise in FM systems indicates that chroma noise is the dominant source of picture impairment. Improved pictures can best be obtained by a reducing chroma noise.

A solution is to not transmit the chrominance information via a subcarrier near the noisy band edge.

Part II

Time Division Multiplexed Luminance and Chrominance Components

Time Division Multiplex (TDM) of luminance and chrominance components is a spectrum efficient technique by which we can avoid the pitfalls of Frequency Domain Multiplex systems such as NTSC and PAL.

Our present 525/60 system is inefficient in its transmission of information in that during 17.5% of each line which is horizontal blanking, no information is sent. The vertical blanking interval represents another 7% loss. It is now possible to make effective use of the horizontal blanking interval in the transmission system. The vertical blanking interval is now being used fairly efficiently for other information transmission purposes.

Chrominance information can be time compressed and transmitted within the horizontal blanking intervals.

Assume the chrominance bandwidth is 0.7 mHz, and the luminance occupies 4.2 mHz. The 52.44 uS of active line time per line carries the luminance information, and in .7/4.2 of 52.44 uS, chrominance could be time division multiplexed into the 4.2 mHz transmission channel. See Fig. 6.

This technique would accommodate one chrominance component per TV line, but not both.

The second chrominance component could be multiplexed during the next line. This would be a line sequential chrominance transmission system, as shown Fig. 7.

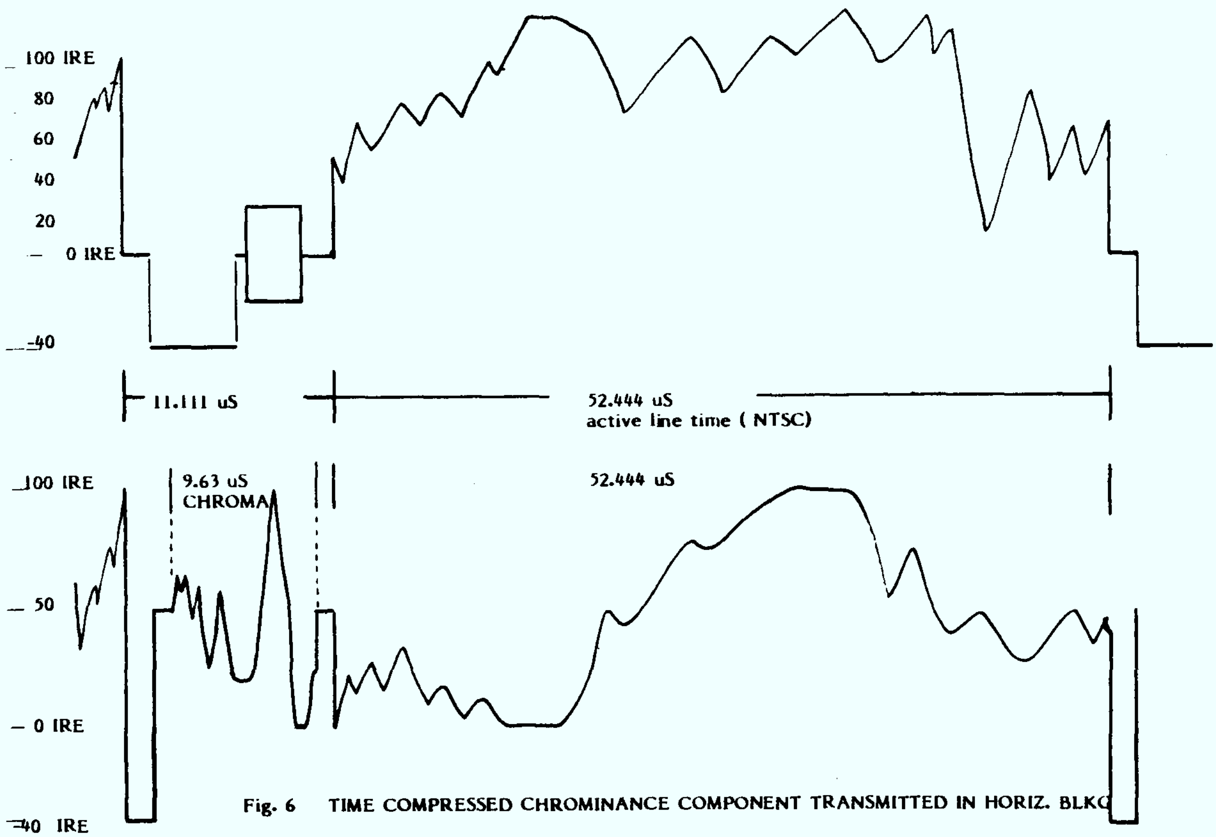


Fig. 6 TIME COMPRESSED CHROMINANCE COMPONENT TRANSMITTED IN HORIZ. BLKG

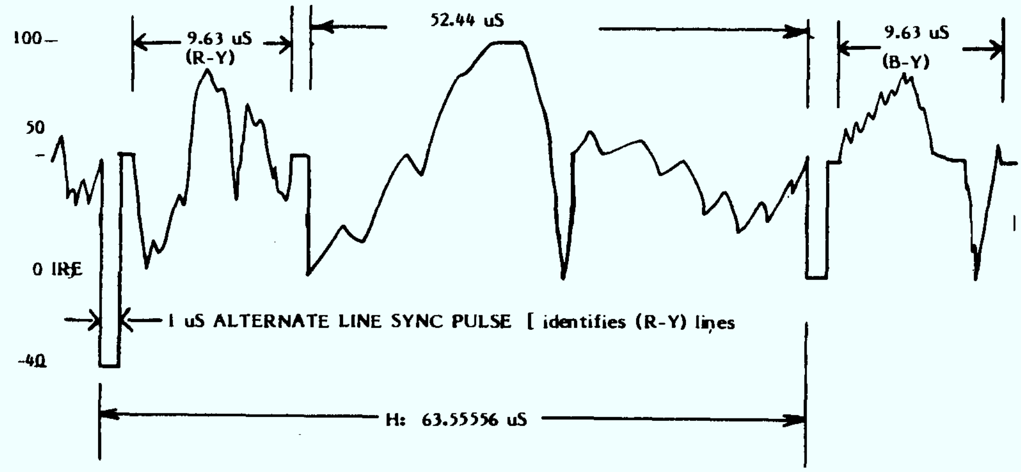


Fig.7 TWO CHROMINANCE COMPONENTS TRANSMITTED LINE SEQUENTIALLY IN HORIZ.BLANKING

The time compressed chrominance signal is treated in the same way as the luminance signal in the transmission system. A significant portion of the chrominance information is sent in the lower frequency part of the spectrum where it is but little affected by noise.

After transmission the chrominance is time-decompressed; its spectrum is 0 to 0.7 mHz. The noise voltage spectrum is triangular as shown in Fig. 8a. The noise is reduced by weighting, as is shown in Fig. 8b.

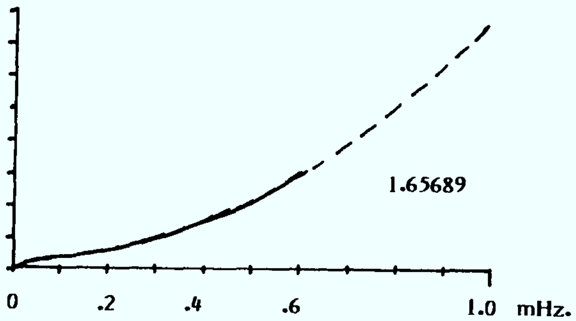


Fig. 8a FM NOISE SPECTRUM of chrominance after time de-compression [de- edmphasis incl].

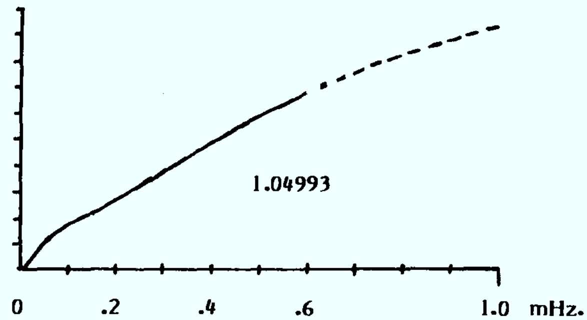


Fig. 8b FM NOISE SPECTRUM ,WEIGHTED, adter time de-compression [de-emph incl]

Time compression and decompression are signal processing functions which were not available when NTSC was developed. These processes are now easily implemented using digital techniques.

With a clock frequency of 2.1 mHz, the band-limited (0 - 0.7 mHz) chrominance signal can be sampled during the 52.44 uS active line time and converted to a digital signal in an analog to digital convertor (ADC).

In 52.44 uS, there would be 110 samples taken. Allowing some margin, there would be, say, 120 samples at the 2.1 mHz clock frequency.

The digital color difference signals would be written into a pair of digital line stores of 120 elements each at 2.1 mHz as shown in Fig. 9.

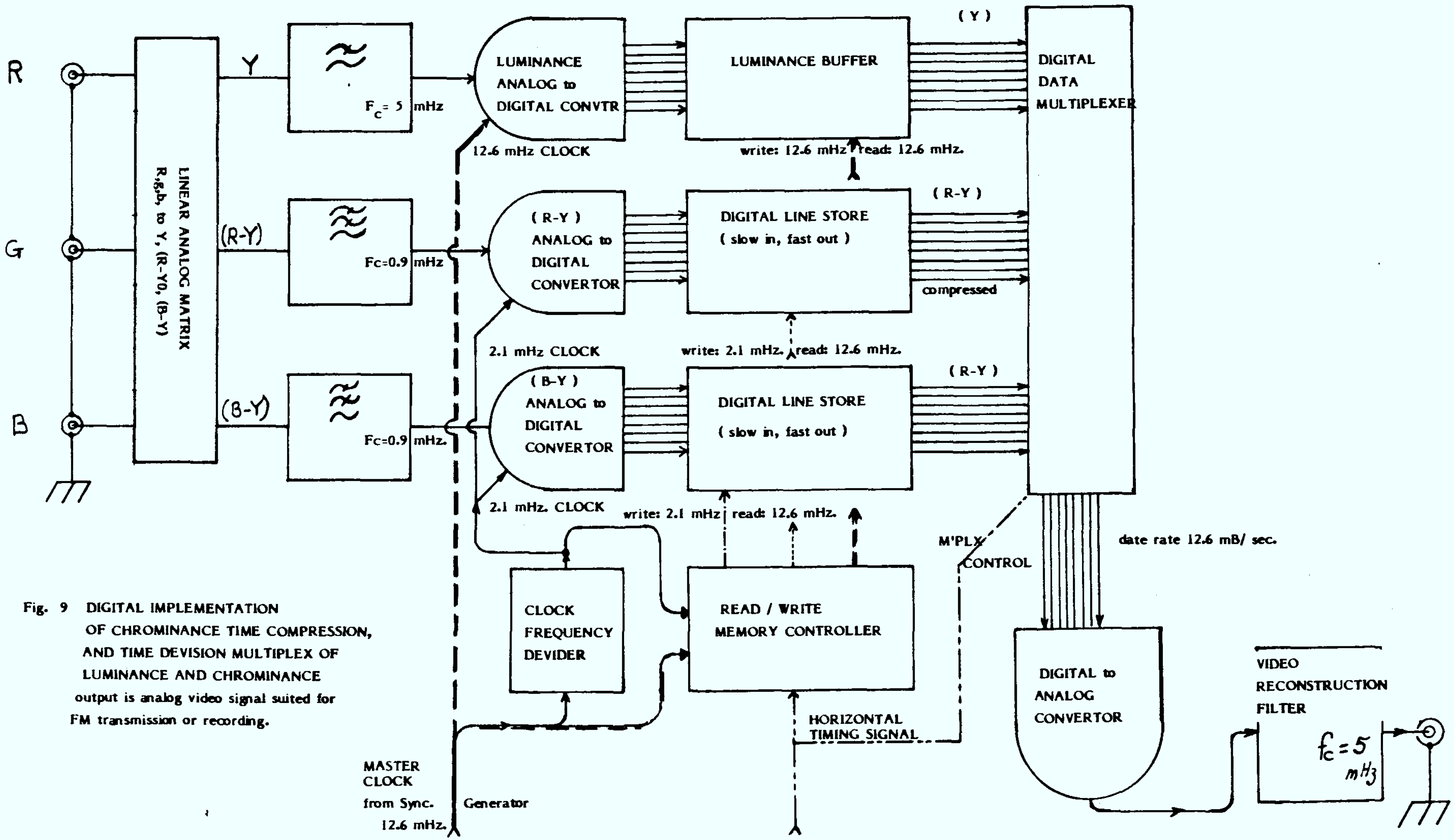


Fig. 9 DIGITAL IMPLEMENTATION OF CHROMINANCE TIME COMPRESSION, AND TIME DEVISION MULTIPLEX OF LUMINANCE AND CHROMINANCE output is analog video signal suited for FM transmission or recording.

When one of these line stores is read out using a read clock frequency of 12.6 mHz, the 120 elements are clocked out in 9.53 uS. The color difference memories are clocked out during alternate horizontal blanking intervals.

These 120 elements per line are converted back to analog form using a Digital-to-Analog Convertor (DAC) at the 12.6 mHz data rate. The analog signal is band limited to 4.2 mHz by the video reconstruction filter, which also removes the 12.6 mHz clock energy. The luminance signal is digitized at 12.6 mB/sec. and during each active line, it is clockled out of the luminance buffer at 12.6 mB/sec. Luminance need not be time compressed.

The unweighted S/N ratio for luminance is the same as if the channel were used for NTSC. The unweighted S/N for chroma is the same as for luminance. Of course, weighting is more effective for the wideband luminance signal, but even so, the weighted chrominance S/N will be better than if NTSC were used. This is because the chrominance noise remains triangular in the time compressed transmission scheme. Triangular noise is more affected by weighting than is flat noise.

It must be said that noise in chrominance will apppear as correlated noise in two time consecutive lines as a consequence of the line sequential nature of transmitting one chroma component per line. It should also be noted that the line sequential transmission of chroma reduces vertical color resolution 2:1. However, in NTSC, a 7:1 reduction of horizontal color resolution is taken. In the writer's opinion, from computer simulations, a 4:1 resolution ratio between luminance and chrominance horizonatal resolution and a 2:1 ratio vertically yields good results.

It is possible to increase chroma horizontal resolution by:

1. Taking advantage of the fact that receivers increase horizontal blanking 10 - 15% by over-scanning the screen. A slight increase of horizontal blanking duration to 14.5 uS would still provide 7% overscan in the receivers, and increase chroma transmission time by 40%, which can be used to increase chroma (horizontal resolution) bandwidth to at least 1 mHz, or to further reduce chroma noise, or both.

2. As in the proposal by the IBA, which is called MAC, time compress the luminance from 52 to 40 uS, thereby increasing by 12 uS the time available for chroma transmission.

Given such an increase in chroma transmission time, it can be used to increase resolution or to decrease noise, or some of both.

It should be noted that time compression of the luminance from 52 to

40 uS would increase the video signal spectrum by the same ratio to produce a video spectrum of 5.46 mHz in the FM transmission system.

The noise power in this wider spectrum is increased by: $(5.46/4.18)^3$ and the luminance signal to noise ratio is decreased proportional to $(5.46/4.18)^{3/2}$. The relationship between time used for transmission of Y and S/N reduction is shown in Fig. 10.

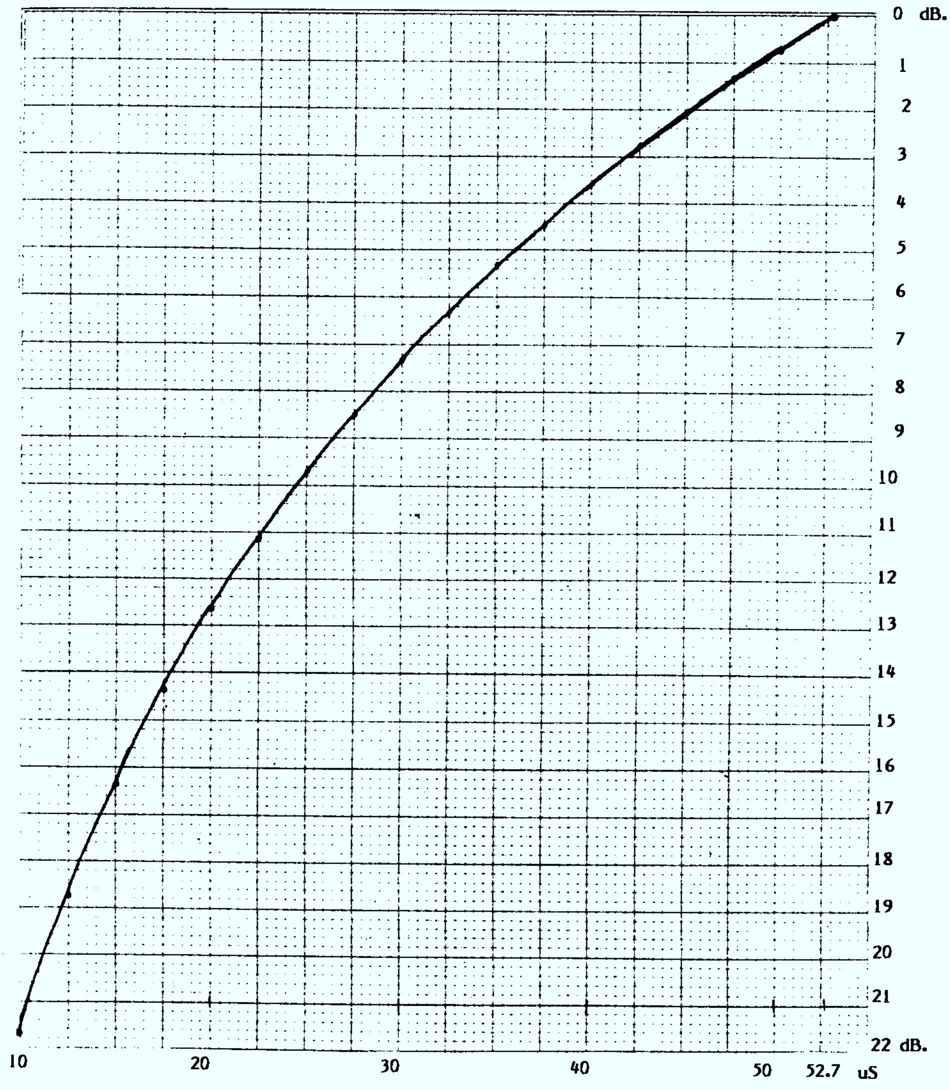


Fig. 10 Decrease in S/N as a function of time interval into which a component is compressed.

Another option available if Y is time-compressed would be to transmit both color difference components on each line.

It would be convenient to time compress both color difference signals by the same factor. This simplifies the clock recovery system in the receiver.

Of the alternatives outlined above, the choice is influenced by the channel width and satellite C/N and earth station G/T figures upon which the system design depends.

It is interesting to note that in a TDM system, the function of the chrominance bandpass filter in NTSC or PAL is fulfilled simply by a switch. It is the ability to perfectly seperate luminance and chrom ce in a TDM system which gives it an advantage over FDM systems. No FDM filter exhibits the ideal properties of the simple switch in FDM systems. Time compression and/or de-compression at the receiver can be carried out using digital techniques, or in the analog domain, charge coupled devices (CCD) may be used. The choice would be made by receiver designers. While the CCD approach is more cost-effective at present, the digital design will emerge within just a few years, once the standard is set.

TDM offers advantages over FDM in FM transmission both in S/N and in immunity to the effects of non-linear distortions.

With TDM it is impossible for inter-modulation between chrominance and luminance to occur. Thus the characteristics of the FM channel, gain/frequency ripple, delay/frequency ripple and discriminator linearity are less important.

These distortions cannot occur:

- Differential Gain
- Differential Phase
- Chrominance/Luminance Gain Inequality
- Chrominance/Luminance Delay Inequality
- Chrominance/Luminance Intermodulation

With no color subcarrier, intermodulation between the sound subcarrier and color subcarrier is precluded. This may in turn permit better FM-pre-emphasis/de-emphasis improvement in noise.

With NTSC, the FM channel is over-deviated by color bars greater than 75% amplitude. In particular, bright yellow or cyan, or saturated and vivid red may cause over-deviation.

It is possible to design a TDM system capable of transmitting 100% amplitude, 100% saturated color.

TDM offers also pictures entirely free of subcarrier caused artifacts:

dot crawl

cross color

sound-color beats*

In the writer's opinion, these are now the real limitations on NTSC picture quality. Both are more objectionable with today's improved cameras and picture tubes which more fully resolve the high frequency components which generate these artifacts.

The most important advantage of TDM over FDM is that it is the key to improving definition, and can lead to compatible HDTV.

*(920kHz) Ideally this artifact need not occur, but drift in receiver allignment, especially in AFT circuits frequently produces this problem.

Part III
Compatibility of Scanning Standards
HDTV and 525/60

Assuming the feasibility of a black box which can transcode the TDM video to NTSC at a cost which is a small part of the SHF antenna and receiver costs, it is essential that the transmitted signal conform to the 525/60, 2:1 interlaced raster of the present system.

Very few people have ever seen the latent picture quality of a 525/60 system. We tend to reject 525 lines as being wholly inadequate to provide sufficient vertical resolution.

This was proven invalid to this writer by photographing a 525/60 R-G-B display on a 26" high resolution monitor. The photograph was of a still picture. This allowed exposure for 1/15 sec. During this 4 field interval, the image was integrated on the film emulsion. The film image had no inter-line flicker and the moire generated by sub-Nyquist sampling of the vertical detail of the scene was also fully integrated out by the film.

The subjective picture quality of the image stored on the film is notably better than that observed on the screen from which it was photographed. The integration process in the film can be essentially perfect. The integration process in the human eye-brain system is imperfect over the frame interval of 1/30 escond.

This demonstrates that it is the interline flicker and vertical detail aliasing (moire) which are the main objections to 525/60 image quality.

Inter-line flicker results from the interlace of two fields in the display device. Given a frame store, it is possible to electronically de-interlace the present 525/60 broadcast picture. This has been announced by Sony and demonstrated recently by Philips. Digital frame stores are presently used by broadcasters for many purposes. With the present trend in digital memory costs, it is inevitable that TV receivers will have frame stores. Just de-interlacing the picture is not enough. The picture must be displayed at least 60 times per second to avoid large area flicker.

525 lines, refreshed at 60 Hz require a 31.5 kHz horizontal deflection in the display. To retain the resolution horizontally, the bandwidth of the video amplifiers following the frame store must be doubled. The A/D convertor writes into the frame stores at one rate, the D/A convertor receives the data at about twice the input rate. Fortunately, D/A convertors can operate faster than A/D convertors.

In this way, a 525 line display, refreshed 60 times a second can and will be realized in future home receivers, even in those designed for NTSC.

Sub-Nyquist sampling in the camera is responsible for the moire which is readily observed in test patterns where vertical detail is high (horizontal wedges near the center.) This is shown in Fig. 11a, 11b, and 11c.

We specify the horizontal resolution in "lines" which actually refer to the number of line pairs per picture width. This should be expressed in cycles per picture width (cpw). We can also specify the number of cycles resolved per picture height (cph). We know from Nyquist's famous criteria that we must have two or more samples to resolve a cycle of information.

The camera samples the vertical detail of the image. With 483 active lines per picture, we should be able to resolve up to 1/2 x 483 cycles of vertical information per picture height (cph).

However, with the camera interlaced, it samples only 241 lines per picture height and from this we see the broadcast camera cannot resolve vertical detail above 120 cph without aliasing.

In the case where we sample video to digitize it, we always pre-filter the video signal with a low pass filter, flat to at least 4.2 mHz. In the TV camera, there is no such low-pass filter. The result is aliasing of high vertical spatial frequencies, above 120 cph (vertical detail).

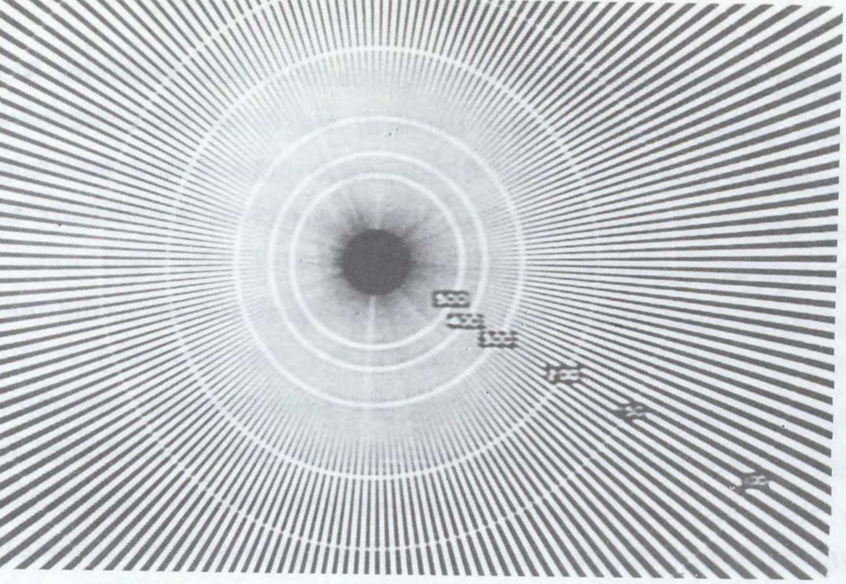
Fortunately, vertical spatial frequency components above 120 cph but below 240 cph generate a moire pattern in one field which is the opposite of the moire generated in the second field. In this way, through integration of the two fields, the perception of the aliasing is decreased. In the case of a picture recorded on film, the integration is perfect. Unfortunately, the integration time of human vision is less than 1/30 second so we do perceive these alias components as a flicker.

We could pre-filter the high vertical spatial frequencies before they can cause aliasing by increasing the effective spot size of the beam in the camera.

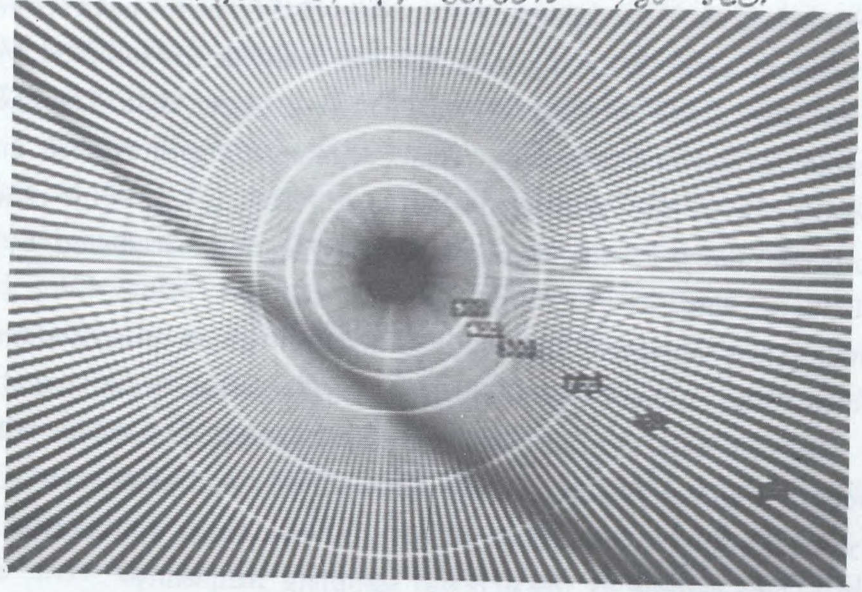
This would also reduce horizontal resolution. A better approach is to introduce astigmation in the camera beam, as it is focussed on the target. This is done in practice.

The shape of the camera beam at the target is more or less Gaussian. Thus, the filtering action due to the beam is more or less a Gaussian roll-off. For significant attenuation of the non-useful high frequencies, significant unwanted attenuation of the useful lower frequencies also occurs. This is offset in practice by the clever use of vertical aperture correction in the camera.

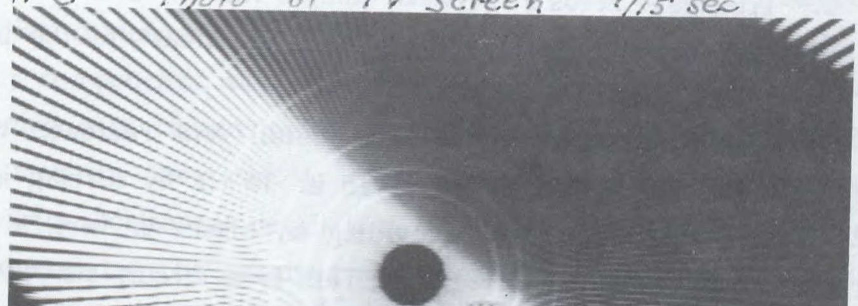
11a Radial TEST CHART



11b Photo of TV Screen 1/60 sec.



11c Photo of TV Screen 1/15 sec



With digital frame stores, another approach is now possible. Recognizing there is no need for interlace in the camera, we could scan the camera with a 1050 line raster at a 30 Hz rate. The camera tube would be designed with a much smaller effective beam height at the target. This would shift the aliased vertical spatial frequencies up in frequency.

We can filter out those high spatial frequencies in a digital filter at the studio.

The digital filter would have a sharper than Gaussian cutoff, and hence it would preserve the in-band components better and remove the out-of-band energy better than just the Gaussian characteristics of the camera beam shape.

In 1980, Professor Broder Wendland first proposed this scheme in a stat-egy to obtain a compatible HDTV system. The concept was also put forth in the IBA Experimental & Developement Report 112/81. Both have pointed out that the video signal after it is digitally filtered may be re-sampled by simply discarding every other line. This converts a 1050 line raster to a 525 line raster. It is also possible to convert the non-interlaced camera signal into an interlaced format to conform with the broadcast standards. This is done by reading out the even numbered lines in the frame store as a field, followed by reading out the odd numbered lines as a second field.

It is much less apparent that the down-filter which preceeds the down-sampling process, also imbeds vertical detail information from the 1050 line camera into the 525 line signal. This detail information survives the down-sampling process. Wendland also showed that these processes are reversible. The 525 line video signal can be processed after transmission as follows:

1. re-sample at the original sampling frequency
2. interleave zeros in between sample values
3. re-filter the signal with a filter identical* to the pre-filter

These processes un-bundle the vertical detail and recreate the 1050 line structure. Now this can be either displayed at 30 Hz by forcing interlace, or at 60 Hz. Forcing interlace means providing an offset in vertical position of one field, with respect to the next field. This is a circuit function in the display unit because the number of lines per field is an integer. From an eco-nomic standpoint, the 30 Hz interlaced display will be less costly. There are now color monitors available which are capable of both the higher horizontal scanning rate and the higher video bandwidth. Nothing is presently commercially

* This indicates the need for a standard filter algorithm.

available to display a 1050 line picture at 60 Hz refresh rate. This is mentioned only to illustrate the technical difficulties in such a display. Having observed 1125 line, interlaced pictures on a number of different kinds of displays, including 12' projection screens, there is not too much incentive to eliminate interlace from high line rate displays. The incentive is lessened by the way vertical detail is perceived. Dr. Fujio gave us a universal weighting characteristic, useful in designing any TV system. It is based on psycho-physical testing. From it, one can see that a HDTV system can actually tollerate a poorer S/N than can a broadcast system on the basis that the h.f. noise is less perceptible. Inter-line flicker is this sort of noise.

Not to lose sight of compatibility, the 525 line transmission signal could be viewed on existing receivers. However the picture should be in color. We cannot use NTSC with the resolution enhancement techniques described.

We will have to employ some kind of TDM scheme.

We must now extend the horizontal resolution of the system while not increasing bandwidth. Previously we have discussed the Nyquist Criteria. When we sample at least twice per cycle of the highest frequency to be transmitted, it is called super-Nyquist sampling. This produces no aliasing. The opposite is called sub-Nyquist sampling and it does produce aliasing. Normally, aliasing is unacceptable. Alias components are imbedded into the baseband signal spectrum. Their frequency is the difference between the video frequency which caused the alias and the sampling frequency. When there is no energy above one-half the sampling frequency, no aliasing occurs. Prof. Wendland proposed sampling the video signal at the upper video spectrum edge (8.4 mHz), not at twice that frequency. This is sub-Nyquist sampling. Spectral components above 4.2 mHz generate alias components in the spectrum between 0 and 4.2 mHz. Alias components at 5 mHz appear at 8.4 - 5= 3.4 mHz. Higher video frequency components, say 6 mHz appear as aliases at 2.4 mHz. Normally these alias components cannot be seperated out of the baseband spectrum. In the case of interest, they can. In transmission thru a 4.2 mHz channel, the information about horizontal detail (from 4.2 to 8.4 mHz) is interleaved with baseband components. The received signal can be re-sampled at the same sampling frequency. The spectrum of the re-sampled signal now has unfolded the alias components back into their correct frequencies 4.2 to 8.4 mHz. Unfortunately, the baseband components are now also present in the same frequency range. However if one looks carefully at the spectra, it can be seen that with the correct choice for the sampling frequency, it should be possible to comb out the new spurious components between 4.2 and 8.4 mHz. Properly combed, we have a spectrum identical to that before it was first sampled prior to transmission.

This scheme will require very careful developement. Of principal concern is the extent to which the aliased components in the 0-4.2 mHz region may affect present receivers. Also of concern is the aliasing of h.f. noise into l.f. noise. The reversibility of this scheme depends on the transmission channel having near ideal characteristics.

However this scheme is so promising that it deserves a very intensive development effort. That is already underway in several countries. It is not unreasonable to expect solutions to the problems, so great will be the reward when a compatible HDTV system can be defined and implemented.

There is today a need for studio production and post-production editing systems which are superior to NTSC, but must be compatible with it. The use of NTSC composite video in production studios has a number of attendant limitations or at least major inconveniences. The four field sequence of NTSC reduces the number of possible edit points to 15 sec. This makes editing the picture and editing the sound more difficult and time consuming. Video tape recording is essentially an FM process. We have already discussed how triangular FM noise is down-converted into very noticable color noise. Another source of color noise, peculiar to video recording is that residual time base errors produce subcarrier phase jitter which becomes a source of color noise. Much work has been done on developing the digital video tape recorder and most effort has recently been directed towards a digital studio standard involving components, not the NTSC composite signal. It appears to many, the writer included, that there is a lot to be gained from using analog components for the studio standard. It is only a small extension of this thought to see that the world will someday have a HDTV system. When that day arrives, how nice it will be if most of the more recent programs now archived on tape had been recorded in a way that made them suitable for HDTV transmission when that is a reality. These factors suggest the desirability of a component based 1050 line studio standard. With the color information so neatly kept seperate from luminance, by use of TDM, very much greater use of chroma key or colormatte can be made. This would allow use of these creative processes in the post-production process. It is possible that the higher costs of the equipment required can be justified by time savings which might be realized, together with the economics of program archiving on tape instead of film, in anticipation of

HDTV.

Considering the strong commercial appeal of such a studio standard, it is probable that such a system will be introduced within several years.

Part IV
Summary and Conclusions

An alternative to frequency domain multiplexing of luminance and chrominance, based upon digital signal processing techniques has been described. It eliminates the artifacts which are inherent in NTSC. The baseband signal spectrum of the TDM signal is well matched to the properties of FM transmission.

Chrominance and luminance components multiplexed and transmitted in this way can be displayed on the new kind of receivers now entering the marketplace. This only requires matrixing to R-G-B. Display on NTSC receivers is possible by modulating the chrominance information onto the NTSC subcarrier. This function may be accomplished digitally, or, as TV games and some personal computer do it, by analog means using purpose built I.C. devices. This relatively minor video processing step would be carried out within the satellite FM receiver unit, either in the home in the case of DBS, or at the cable system "head-end".

Extended definition in both horizontal and vertical directions is possible within the confines of our 6 mHz. RF channels and our raster scanning standards.

Three HDTV display formats are possible:

1. 525 lines, de-interlaced in the HDTV receiver, refreshed at 60 Hz.
2. 1050 lines, 2:1 interlaced
3. 1050 lines, non-interlaced, refreshed at 60 Hz.

Any of these formats can be created by digital signal processing in the receiver. Each is likely to find applications based on the screen size and cost considerations.

The present narrow horizontal blanking interval of our 525/60 system should be increased slightly to afford more chrominance transmission time. Home receivers cannot display the whole 52.44 uS of active line time due to their universal practice of over-scanning which is made necessary by the economics of long horizontal retrace time.

Future HDTV systems will have to compete with the NTSC system. To the extent that we meet the challenge of providing for compatibility, the new system will more rapidly gain acceptance. This will start, I beleive, in studios and post-production houses which produce broadcast material, presently in NTSC format.

There is little likelihood that a new system would be supported by revenues from advertising. More likely, a new service would involve pay-per-view. Encription of the program contents, both audio and video will be required. This reality must be taken into account in the developement of the new video signal standards. This is necessary to assure that the high picture quality is not compromised by the decription process, and to minimize the costs of the signal processor which does the de-encription.

Acknowledgments

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The views expressed are my own. Except for 1050, the numbers cited are not proposed values for a new system, but are given as examples only.

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A FIBER OPTIC NETWORK FOR DELIVERY OF HDTV TO THE HOME

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ABSTRACT

The broad bandwidth of approximately 30 MHz required for the transmission of analogue high definition television (HDTV) signals places a severe demand on the limited spectrum available in conventional transmission schemes to the home. The integrated broadband service network using optical fibers offering cable TV, telephone and data services on a centrally switched basis offers a solution to this problem because the switched star network configuration allows individual connection of a subscriber to many HDTV signals at the central switching office. The compatibility problem between HDTV and conventional TV formats is resolved readily by installing interstandard converters at the central switching office.

A demand access video service can be offered if a videodisc system is located at the central switching office. The random access nature of the videodisc will permit comparatively quick response to a request any time of the day with many playback heads installed on the videodisc player. Since selection of a program is on a switched basis following the request from a subscriber, the preference of various minority groups can be catered to and what is presently known as broadcasting service can be replaced by what might be called narrowcasting service.

Collection of subscription fees is a computer software problem and both the pay-per-channel and pay-per-program approach can be used. Although the technologies are ready, realization of the fiber optic integrated broadband network to the home in Canada depends very much on the resolution of regulatory and institutional problems.

1. INTRODUCTION

Fiber optic communications is growing rapidly into a mature technology. Most telephone companies will now choose fiber optic transmission systems for their interoffice and intercity trunk lines [1]. In the province of Saskatchewan, towns and cities with more than 500 households are being interconnected with a 12 fiber trunk line which carries digitized TV as well as digitized telephone and data signals [2]. The Edmonton Telephone System which is owned and operated by the City of Edmonton, is in the last phase of installing a fiber optic interoffice trunk network [3]. Recently, MCI of Washington D.C., announced that they have contracted with Northern Telecom Canada Ltd., for the supply of single mode fiber cables to be used in the long-haul telephone and data trunk lines from Washington D.C. to Chicago to Altanta. This is an indication that some satellite links may be replaced by fiber optic lines in the future. Indeed, Trans-Pacific and Trans-Atlantic fiber optic undersea cables are being planned today. Even the comparatively conservative cable TV companies are turning to fiber optics technology. In Houston, Texas, the distribution network to various hubs is through fiber optic trunk lines rather than through microwave links [4].

The advantage of fiber optic transmission systems for trunk lines arises from the broad bandwidth (∿1 GH.km), long repeater spans (∿10 km), small diameter (∿1 mm/plastic coated fiber) and immunity to EMI (electromagnetic interference). These advantages combine to make the initial cost of the fiber system comparable to systems based on copper wires. When maintenance costs and future expandability by use of WDM (wavelength division multiplexing) is taken into account, the fiber optic trunk line is significantly lower in cost such that copper wire systems become economically unattractive.

Whether the economic advantages in fiber optic trunk lines can be transferred to local subscriber service networks, is a moot point and a subject of on-going studies. It is significant to note that Times Fiber and Cable Inc. is scheduled to install a fiber optic network that will serve more than 24,000 cable TV subscribers in the Bay Area of San Francisco. This latest development is significant because the network is a centrally switched star configuration similar to that of the telephone subscriber network. Telephone service is not being offered but data communication services are included in the plans. Evolution towards a broadband integrated service where telephone, data, cable TV and pay TV services are offered through the same network, is but a short step away.

That the centrally switched fiber optic network capable of simultaneously delivering telephone, data, radio, and TV services is technically feasible, there is no question. Such an integrated broadband service is being tested right now in the rural setting of Elie, Manitoba [5]. Approximately 150 subscribers are receiving services where 9 TV channels, 7 FM radio stations, single party telephone and Telidon data services are being provided. The Elie Fiber

Optic Field Trial is one of the first of its kind to offer what might be termed "fibered city" services to the home. Similar field trials have been announced by France [6] and the Federal Republic of Germany [7] where national policies towards fiberization of the communication network appear to have a chance to be put into practice.

The integrated services in the "fibered city" should of course include HDTV (high definition television) in the future. The required transmission bandwidth is approximately 30 MHz for the analogue baseband format [8]. At least 80 MHz of bandwidth is needed for FM transmission of this signal [9] and about 400 MHz will be required by the digitized signal if no processing is used [9]. Broadcasting many HDTV channels in the conventional sense therefore appears impractical because of the lack of spectrum space. The DBS (direct broadcasting satellite) promises delivery of a number of channels to the home but the maximum number is limited by the availability of spectra and compression of the signal to conserve bandwidth defeats the original concept of providing a high quality video picture.

The problem of delivering multiple HDTV channels to the home might be solved by coaxial cable TV systems supported by magnetic video tape recorders and a satellite distribution network. However, the shortage of spectrum space in existing coaxial cable systems caused by the introduction of pay TV will make it difficult to allocate five standard NTSC channels per HDTV channel. Even if spectrum space is available, the CNR (carrier to noise ratio) may not be maintained for the HDTV signal because the coaxial cable system is designed for NTSC signals with 5 MHz bandwidths. The intermodulation products generated among the NTSC signals as well as those produced between the HDTV and NTSC signals may also significantly degrade the signal quality of both.

The centrally switched star network of the "fibered city" system can have the capacity to provide many HDTV signals on a switched basis because each fiber optic subscriber line has ample transmission capacity to carry an extra 30 MHz of information. In the following sections, the centrally switched fiber optic star network is first described and the provision of HDTV service is considered.

2. CENTRALLY SWITCHED FIBER OPTIC STAR NETWORK FOR BROADBAND INTEGRATED SUBSCIBER SERVICES

Figure 1 shows the basic outline of a centrally switched fiber optic star network. A large number of TV programs are made available at the

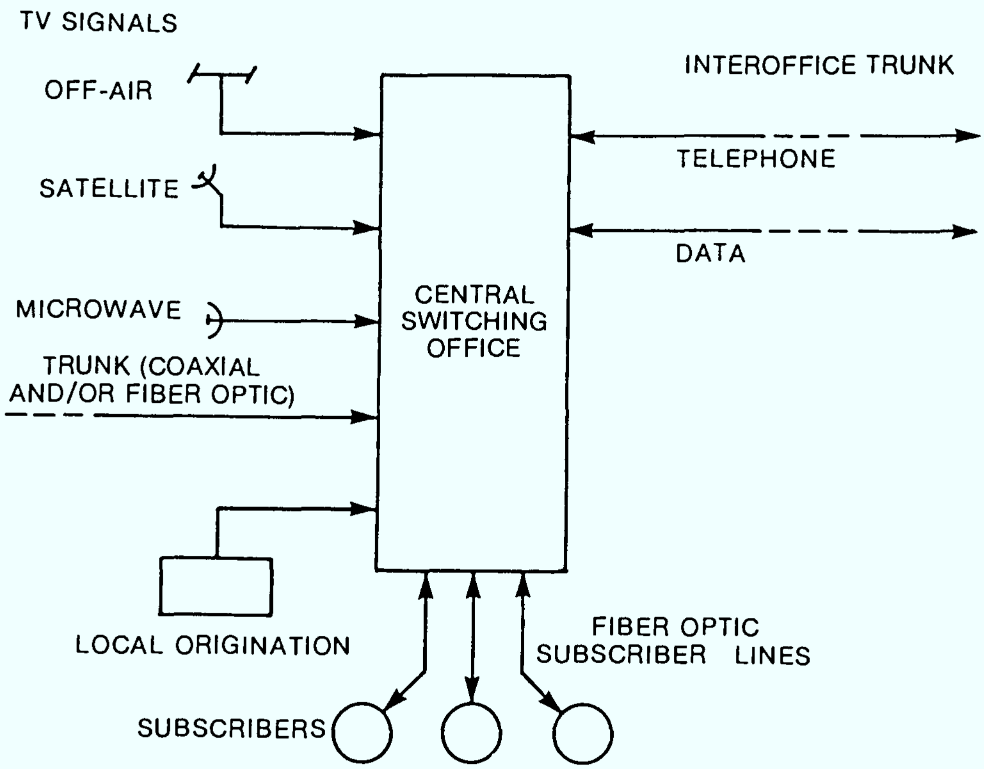

Fig. 1 CENTRALLY SWITCHED STAR NETWORK

A subscriber is connected to one of many TV signals available at the central switching office by sending a selection command. Other narrowband services such as telephone and data are provided simultaneously over the same fiber optic lines.

central switching office where selection of a TV program is performed in response to a command signal received from a subscriber. Since fiber optic transmission lines have more than sufficient bandwidth, cable TV, pay TV, telephone and data (e.g. Telidon) services can be provided simultaneously to a subscriber over the same fiber optic line. Field trials such as those at Elie, Manitoba and Biarritz, France follow this configuration.

One possible signal transmission format to the subscriber is shown in Table 1. Two TV channels are provided to allow simultaneous use of two TV sets and standard broadcast frequency allocations are selected to eliminate the need for RF converters at the subscriber terminal.

A block diagram of the subscriber terminal is shown in Fig. 2. Channel selection is performed on a keypad and an encoded signal is sent back to the central switching office by using one of the narrowband channels. Optionally, a TV signal can also be transmitted on a RF subcarrier (e.g. 55.25 MHz).

The interfacing at the central switching office between the switching system and the subscriber line is shown schematically in Figure 3. The TV selection codes are received by a CPU (central processing unit) and appropriate control signals are transmitted to the TV switching system. The system is constructed so that a subscriber may choose any one of the programs without disturbing other subscribers. All subscribers, therefore, can be connected to the same program at the same time.

The switching system may consist of digitally controlled VCO (voltage controlled oscillator) converters identical to the cable TV converters on the market today. Switching for TV is accomplished by such a system in the Elie Fiber Optic Field Trial. Another approach is described schematically in Figure 4. The TV signals from various program sources are converted to CH-2 (channel 2) and CH-3 (channel 3) frequencies and supplied to the switching matrices. Switching is performed at the CH-2 and CH-3 VHF frequencies and the selected signal is supplied to a combiner which combines the TV_1 (CH-2), TV_2 (CH-3) and narrowband service signals to produce the FDM (frequency division multiplexed) signal. By performing the switching at standard VHF frequencies, the extra expense of two modulators (converters) per subscriber line is avoided.

The difficult task of designing a switching matrix capable of switching broadband VHF signals has been solved recently by using the principle of optoelectronic switching [10]. The following section describes the optoelectronic matrix switch and discusses its merits.

SERVICE	FREQUENCY (MHz)	MODULATION
TV_1 VIDEO AUDIO (NTSC FORMAT)	55.25 59.75 (CH-2)	AM FM
TV_2 VIDEO AUDIO (NTSC FORMAT)	61.25 65.75 (CH-3)	AM FM
TELEPHONE DATA TELIDON SECURITY	BASEBAND (64 kb/s PER SERVICE)	TDM

Table 1 RF SUBCARRIER FREQUENCY ALLOCATION

Standard broadcast frequencies are used for the simultaneous transmission of two TV channels to the subscriber. Baseband frequencies are used to provide narrowband services such as fire-burglar alarm, data and telephone.

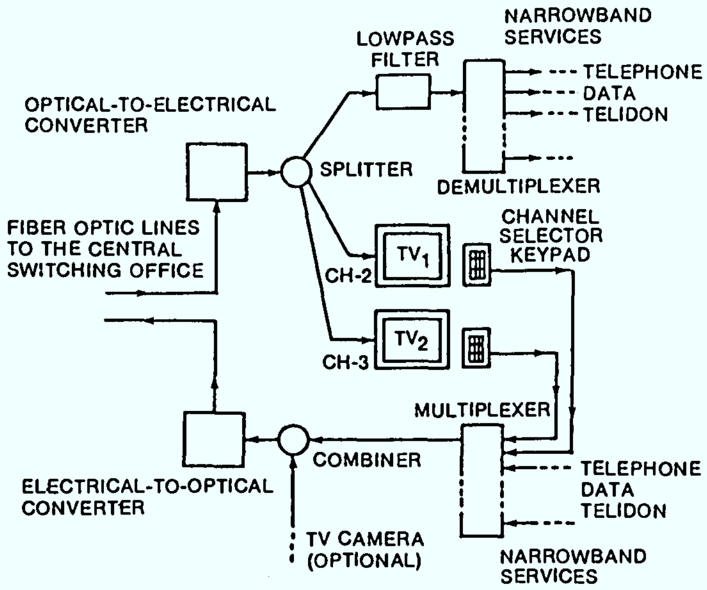

Fig.2 SUBSCRIBER TERMINAL

The TV signals are connected directly to conventional TV sets which have the channel selectors set at CH-2 or CH-3. Program selection is done by using the channel selector keypad to send a command to the central switching office. A standby battery power supply maintains telephone service during power failures.

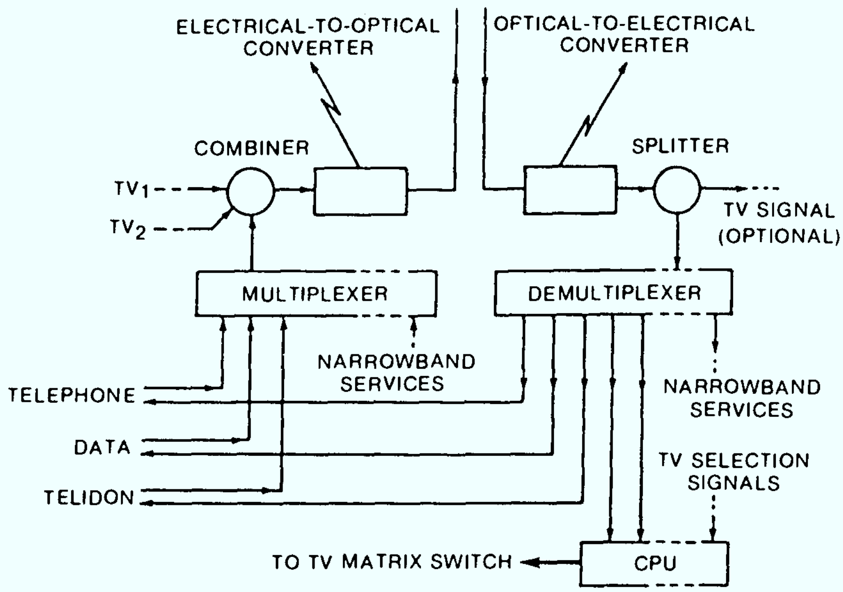

Fig. 3 SUBSCRIBER LINE INTERFACE

The TV channel selections are directed to the CPU whicn controls the TV matrix switch. Narrowband services are connected to their respective switching systems.

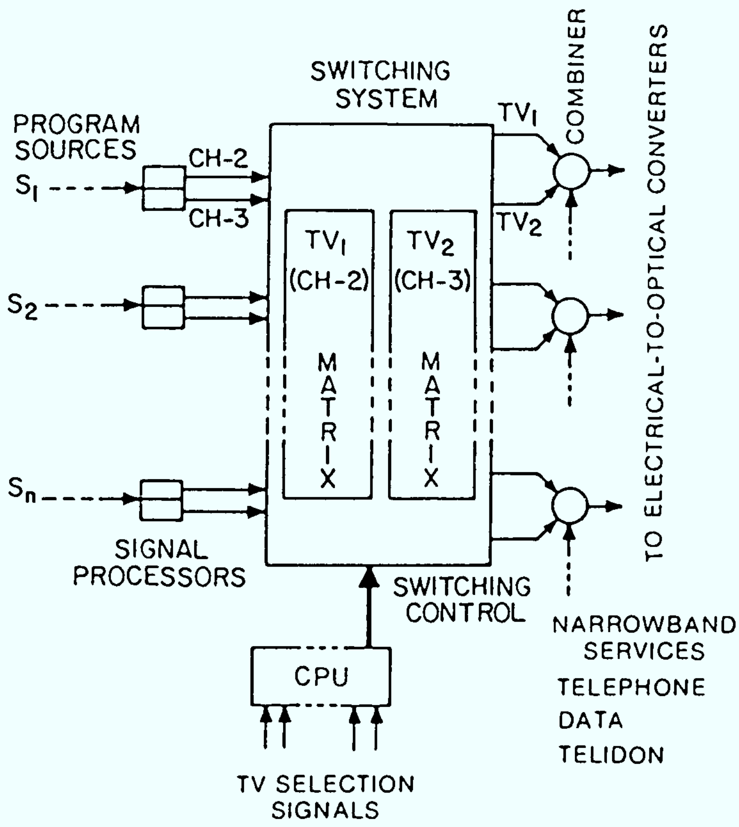

Fig. 4 VHF MATRIX SWITCHING

Switching is carried out at VHF frequencies (CH-2 & CH-3) by a matrix switch to eliminate the need for modulators in the subscriber lines. High isolation and low crosstalk levels are required for such matrix switches.

2.1 Optoelectronic Matrix Switch

A conceptional design of an optoelectronic matrix switch is shown in Figure 5. The optical output of a LED (light emitting diode) is modulated by the source signal carried on a suitable RF subcarrier such as 55.25 MHz (CH-2). The modulated output is delivered to photodiodes that act as switching elements at the matrix crosspoints under the control of the CPU. Distribution of the optical signal can be achieved by using biconical fused star couplers [11] or by using a suitable combination of lenses.

The switching action of the optoelectronic switch is obtained by reverse or forward biasing the photodiode which may be a standard PIN photodiode or an APD (avalanche photodiode). Under reverse biasing, the RF output signal across the load resistor R_L is that carried by the optical signal. Under forward biasing, no output signal is observed because the photodiode acts as a low impedance element and short circuits R_L to ground through the bias power supply. In the case of an APD, the off-state is reinforced by the gain factor going to zero during forward biasing [12]. The biasing circuit required for the optoelectronic switch is simple and an example using a PIN photodiode is shown in Figure 6. Reverse biasing is applied through a high resistive element and forward biasing is achieved through a switching transistor. Performance of the circuit is shown in Figure 7. We can see that a frequency response in excess of 200 MHz and isolation better then 80 dB can be obtained from a PIN photodiode.

The advantages of the optoelectronic matrix switch are its high isolation and low crosstalk levels. The latter arises from the use of optical means to distribute the signal to the crosspoints. Isolation of the input and output line ground planes becomes possible because of the opitcal distribution and this reduces crosstalk levels significantly. Also, there is no crosstalk among the optical lines themselves, nor is there crosstalk between the optical lines and electrical output lines. In addition, there are no switching transients that might disturb other output lines because the electrical state of the photodiode does not significantly affect its optical state. Therefore, no transient optical reflections are generated.

A prototype version of a 6 input by 7 output matrix switch with isolation and crosstalk loss of 80 dB, capable of switching baseband signals of 100 MHz is being offered commercially now [13]. We can see from Fig. 7 that switches capable of switching baseband signals in excess of 200 MHz bandwidth can be constructed. This means that HDTV signals, whether it be the baseband 30 MHz signal or the same signal on a FM VHF carrier, can be switched readily by an optoelectronic matrix switch. The following section discusses how the HDTV signal might be transmitted to the subscriber through the fiber optic line.

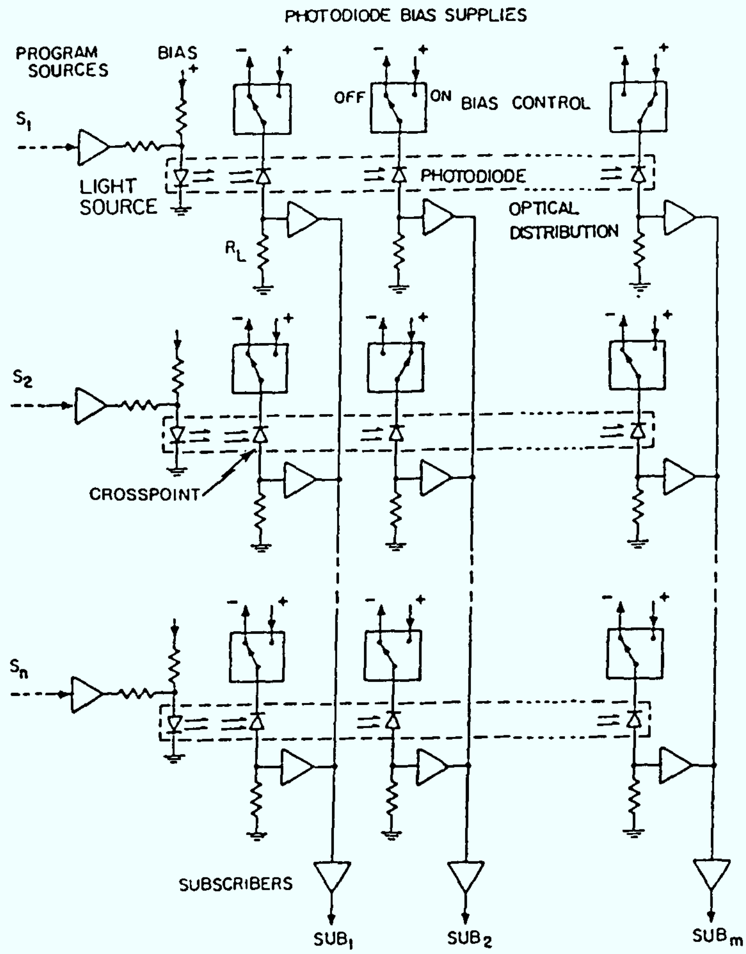

Fig. 5 OPTOELECTRONIC MATRIX SWITCH

The RF signals modulate the light source's output power which is distributed to the matrix crosspoints by optical means. By using such a distribution method, low crosstalk levels are acheived. The crosspoint switches are photodiodes that are turned on and off by changing their bias conditions.

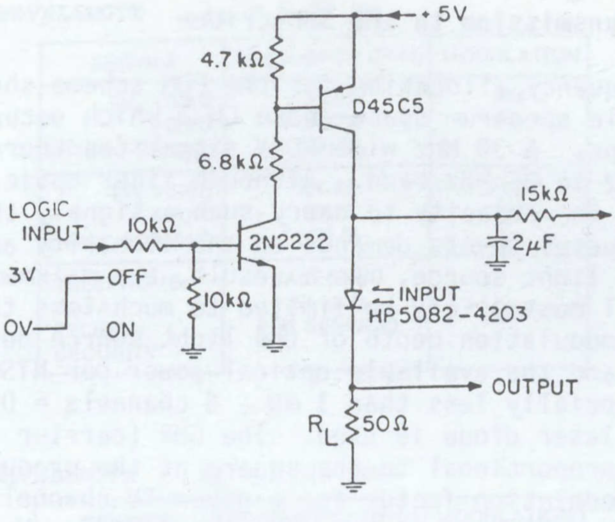

Fig. 6 **OPTOELECTRONIC SWITCH**

The photodiode is reverse biased when the switching transistor (D45C5) is biassed off by the logic input. The input optical signal is then detected and on RF output signal obtained. When the logic input is low the photodiode is forward biased and the RF output is shorted to ground.

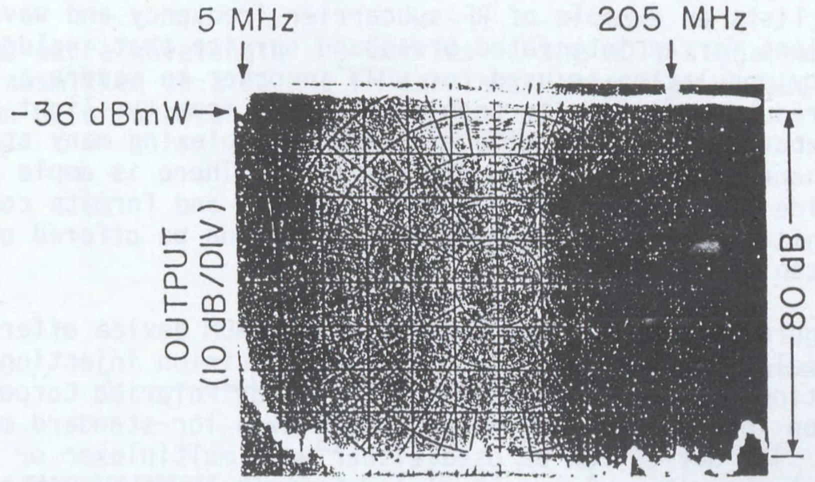

Fig. 7 **OPTOELECTRONIC SWITCH PERFORMANCE**

The upper trace shows the on-state response which extends well beyond 200 MHz. The lower trace shows the off-state response and we see that 80 dB of isolation (on-off power ratio) is obtained over most of the frequency range. The incident optical power was 0.091 mW and the modulation factor was 0.83.

2.2 HDTV Transmission to the Subscriber

The frequency allocation for the FDM scheme shown in Table 1 provides ample spectrum space above CH-3 which occupies the 60 MHz to 66 MHz band. A 30 MHz wide HDTV signal can therefore be placed in the 66 MHz to 96 MHz band. Although fiber optic transmission systems have the capacity to carry such a signal, the extra bandwidth imposes severe demands on the linearity and optical output power of the light source. As a result, the maixmum transmission distance will most likely be limited to much less than 5 km because the overall modulation depth of the light source must be kept low (e.g. 50%) and the available optical power per NTSC TV channel will be small, typcially less than 1 mW ÷ 6 channels = 0.17 mW/channel, even when a laser diode is used. The CNR (carrier to noise ratio) is directly proportional to the square of the product $m_{SC} \cdot P_0$ where m_{SC} is the modulation factor for a given TV channel and P_0 is the optical power delivered to the subscriber [14]. We can see that limiting the modulation factor to reduce intermodulation and cross modulation products caused by the nonlinear response of the light source will restrict the maximum transmission distance significantly.

A solution to this limitation can be found in WDM (wavelength division multiplexing) techniques were light sources emitting at different wavelengths are used to transmit signals on a single fiber. It is equivalent to the FDM method used in the RF domain. Table 2 lists an example of RF subcarrier frequency and wavelength allocations for an integrated broadband service that includes HDTV. Frequency modulation is used for HDTV in order to assure a good CNR and to reduce nonlinearity problems arising from the light source. The baseband is used for time division mulitplexing many stereo audio channels, which are in digital form. There is ample bandwidth to provide six or more stereophonic channels and formats compatible with digital optical audiodiscs that will soon be offered on the market can be considered.

Figure 8 shows the block diagram of a WDM device offered commercially by GTE [15]. By utilizing precision injection molded collimating connector lenses manufacutred by Polariod Corporation, insertion losses less than 4 dB are achieved for standard multimode fibers. The device can be used either as a multiplexer or demultiplexer. By using such devices, a single fiber can be used as if two fibers were available by using two different wavelengths, λ_1, and λ_2 on the same fiber.

A subscriber terminal capable of receiving HDTV service in addition to NTSC TV, telephone, and data is shown schematicaly in Fig. 9. The HDTV signal which is on an FM carrier is carried on λ_2 together with the digital audio signal. The remainder of the services are carred on λ_1. The WDM demultiplexer separates the two wavelegnths and the two groups of signals are processed separately. After photodetection by the optical-to-electrical converter, the FM HDTV signal is demodulated and displayed on the set for HDTV while

WAVELENGTH $\lambda_1 = 0.85\ \mu m$

SERVICE	FREQUENCY (MHz)	MODULATION
TV_1 VIDEO AUDIO (NTSC FORMAT)	55.25 59.75 (CH-2)	AM FM
TV_2 VIDEO AUDIO (NTSC FORMAT)	61.25 65.75 (CH-3)	AM FM
TELEPHONE DATA TELIDON SECURITY	BASEBAND (64 kb/s PER SERVICE)	TDM

WAVELENGTH $\lambda_2 = 1.33\ \mu m$

SERVICE	FREQUENCY (MHz)	MODULATION
HDTV	60±50	FM
AUDIO CHANNELS	BASEBAND (64 kb/s PER SERVICE)	TDM

Table 2 WAVELENGTH DIVISION MULTIPLEXED INTEGRATED SERVICE

The extra wavelength λ_2 carries the HDTV signal which is transmitted on a 60 MHz FM carrier. Many digital audio channels can be offered on a TDM basis.

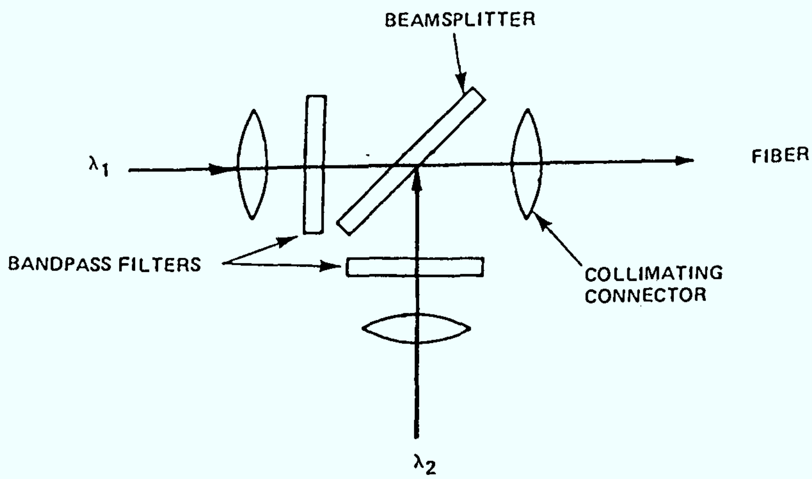

Fig. 8 WDM MULTIPLEXER/DEMULTIPLEXER

The beamsplitter is a dichroic mirror that reflects λ_2 but is transparent to λ_1. Insertion losses less than 4 dB can be achieved with such a design. The same device can be set either as a multiplexer or demultiplexer.

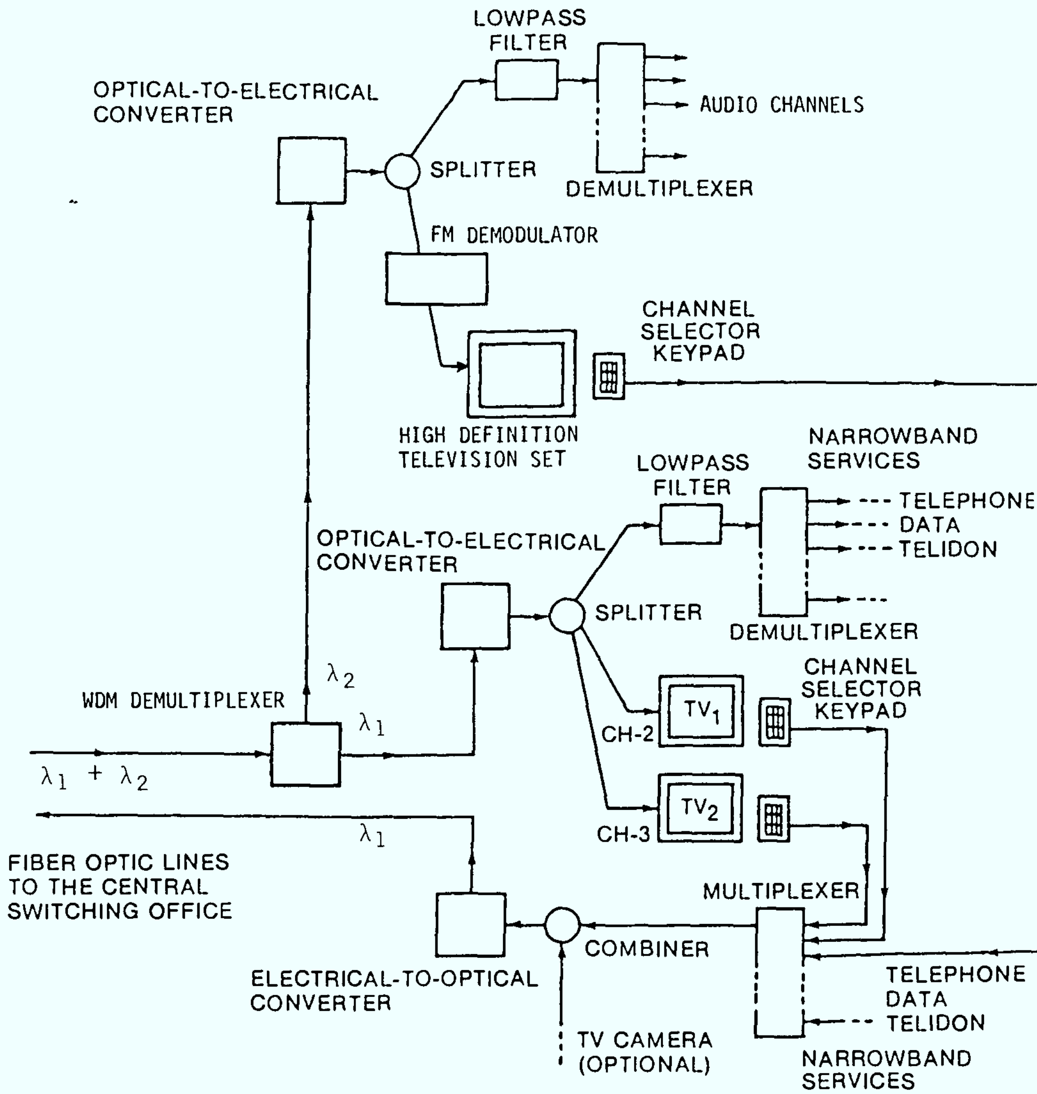

Fig. 9 WDM SUBSCRIBER TERMINAL

The HDTV signal carried by λ_2 is demultiplexed and converted to a RF signal. The audio channels are separated out by the digital demultiplexer while the FM demodulator recovers the analogue HDTV signal. The channel selection signal for HDTV is carried back to the central switching office by one of the data channels.

the audio signals are extracted by the digital demultiplexer. Channel selection for HDTV is carried out in the same manner as that for NTSC TV.

Figure 10 shows the subscriber line interface at the switching office. A WDM multiplexer is used to combine λ_2 which carries the FM HDTV and digital audio channel signals, with λ_1 which carries the NTSC TV and other service signals to the subscriber. The switching of the FM HDTV signal and digital audio signals can be performed by an optoelectronic matrix switch under the control of the CPU which receives selection signals from a subscriber through the return fiber.

A schematic diagram of the switching system for HDTV and NTSC-TV is shown in Fig. 11. In order to eliminate the need for separate FM modulators on each subscriber line, the HDTV signal is placed in the FM format first and then supplied to the switching system together with the digital audio signals.

By using WDM techniques, the incremental cost of adding HDTV service to an existing fiber optic integrated broadband service should be much less than the original cost of providing the delivery network. One problem that will need to be solved is securing the delivery of HDTV program sources. The topic is discussed in the following section.

2.3 HDTV Program Sources

A satellite can support a national network that delivers HDTV signals to each central switching office. In densely populated areas, single mode fiber optic transmission systems [16] can be used to interconnect central switching offices. In such cases digitized HDTV signals can be used to ensure a high signal quality. The signals can share the same fiber on a WDM basis with other common carrier signals such as telephone and data.

One problem that must be faced is the provision of many HDTV programs to satisfy the demand created by HDTV set owners. Some form of delayed broadcasting using record/playback techniques would appear to be the best solution. A VTR (video tape recorder) designed for HDTV can be used for that purpose and taped programs can be delivered to the central switching office through satellite and fiber optic tansmission systems. For some programs, the postal service should be satisfactory.

A HDTV videodisc playback system would be more attractive than a VTR not only because it has few mechanical wearout problems, but it is also a random access recording device. By placing multiple readheads on a single disc, demand access video service becomes possible. The following section discusses this concept.

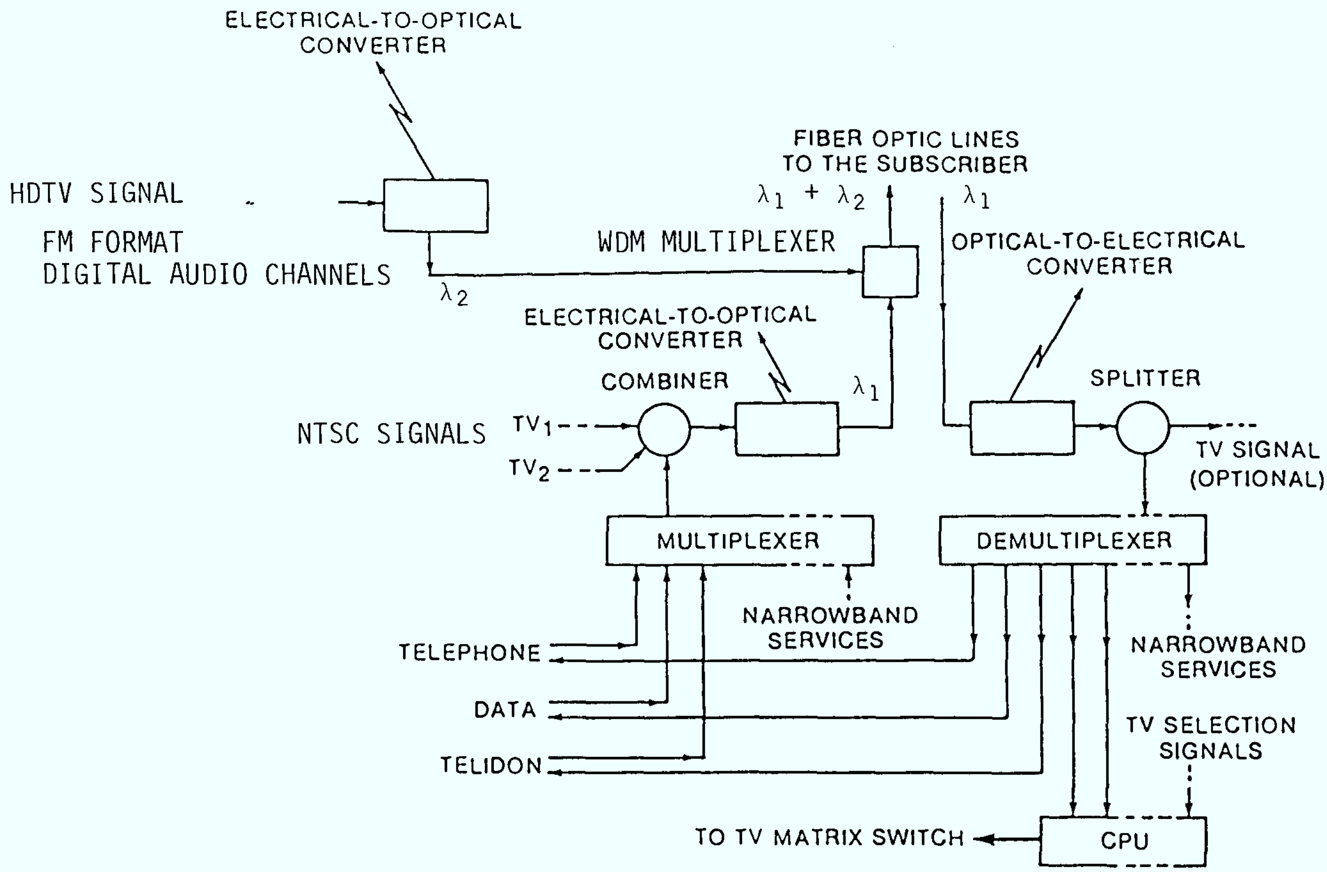

Fig. 10 WDM SUBSCRIBER LINE INTERFACE

The HDTV signal is carried by λ_2 and combined with λ_1 by the WDM multiplexer and fed into the subscriber line. The NTSC TV, telephone, data and Telidon services are carried by λ_1. The return signals from the subscriber can also utilize λ_1 because a separate return line is used.

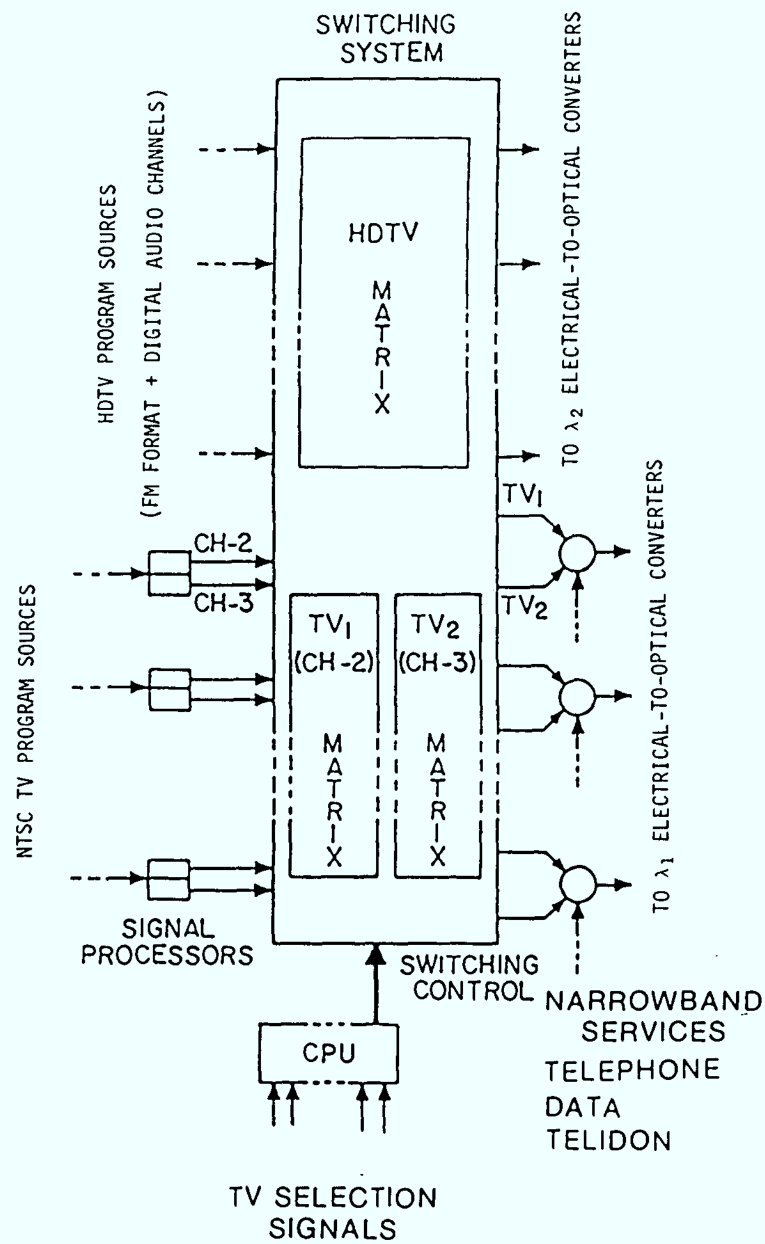

Fig. 11 CENTRAL SWITCHING OFFICE

The HDTV video and audio signals are placed first in the format listed in Table 2 and supplied to an optoelectronic matrix switch. The program selected by the subscriber is connectd to the electrical-to-optical converter which transmits at the wavelength λ_2.

2.4 Demand Access Video Service

A typical 30 cm video disc can store a 30 minute NTSC TV program on one side. By placing a number of playback heads on the disc, sequential playback in time becomes possible. For example, a one-hour program can have starting times every 7.5 minutes if four playback heads are used. Starting times will vary with the length of the program. An 8-minute program will have a starting time every minute with eight playback heads. A similar system for HDTV can also be considered.

Fig. 12 shows a schematic diagram of a demand access video system placed at the central switching office. Each signal from a playback head is modulated onto to a suitable R.F. carrier and then supplied to a matrix switch which allows a subscriber to choose any of the starting times T_1, T_2, T_3, or T_4 from any of the videodisc programs P_1, P_2, ... P_i, ... P_m. Since the matrix switch allows simultaneous connection to other subscribers, any program is available to all subscribers on an equal basis, 24 hours a day. A stacked-disc videodisc player with multiple playback heads is yet to be developed but the task is a straight forward application of known technology, and no problems are expected. The matrix switch discussed earlier can be used as the switch.

If a frame storage device is made available at the subscriber terminal, provision of still-picture services becomes possible. In otherwords, images such as those of classical paintings stored on a HDTV videodisc can be transmitted to the subscriber's storage device in a matter of seconds and displayed for appreciation on a HDTV receiver set. Such a service is a natural extension of the present Telidon service and avoids the traffic congestion problem which can occur when copper wire telephone transmission lines are used for Telidon.

Recent developments in write-read videodisc systems [17] can increase the attractiveness of the demand access video service by allowing delayed broadcasting of popular TV programs. For example, aside from sports programs, news telecasting can be made available to the subscriber on a 24-hour basis and frequent updating during the 24-hour day will further enhance its appeal. Table 3 summarizes the types of demand access services that might be offered. Preforming arts events occuring at important centres such as the National Arts Centre can first be recorded on a HDTV videodisc and then distributed nation-wide to make these centres truly national establishments. The National Art Gallery collection can also be offered for viewing in the home on a HDTV still-picture service.

The centrally switched star network allows this flexibility of offering demand access video services, either in the NTSC TV or in HDTV formats. This network configuration also has additional advantages when interstandard compatibility is considered.

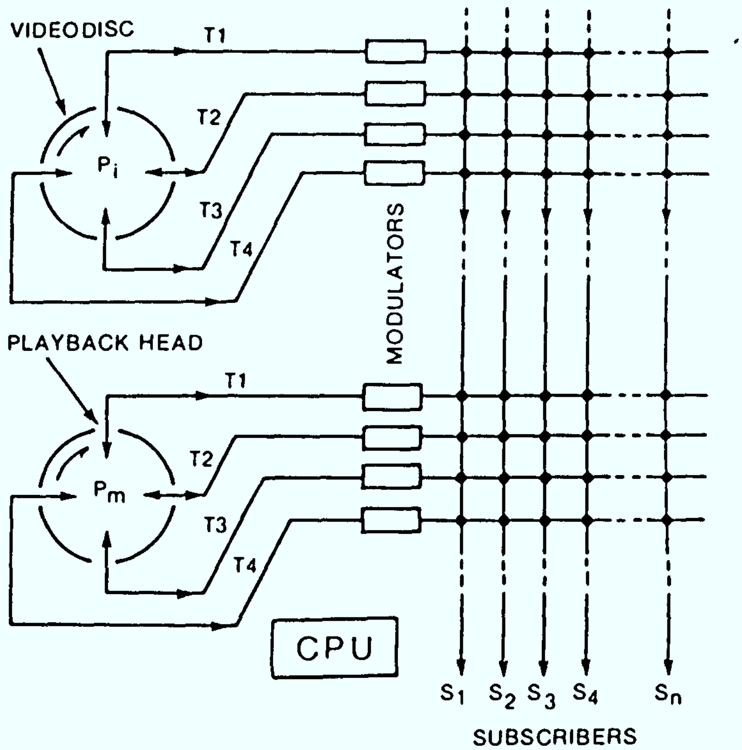

Fig. 12 DEMAND ACCESS VIDEO SYSTEM

Each videodisc is played back through multiple heads. Many discs can be stacked on a single drive shaft to reduce equipment cost. Crosspoints of the matrix switch are controlled by the CPU which receives program selection signals from subscribers.

<table>
<tr><td colspan="5">TV SERVICE</td></tr>
<tr><td rowspan="2">SUBSCRIPTION OPTIONS</td><td colspan="2">PER "CHANNEL"</td><td colspan="2">PER PROGRAM</td></tr>
<tr><td>ADVERTISEMENT</td><td>NO ADVERTISEMENT</td><td>ADVERTISEMENT</td><td>NO ADVERTISEMENT</td></tr>
<tr><td>SUBSCRIPTION COST</td><td>LOW</td><td>MEDIUM</td><td>MEDIUM</td><td>HIGH</td></tr>
<tr><td>PROGRAMS</td><td colspan="4">DELAYED "BROADCAST", CINEMA, SPORTS, PERFORMING ARTS, SPECIAL EVENTS, HDTV</td></tr>
<tr><td colspan="5">STILL-PICTURE SERVICE</td></tr>
<tr><td rowspan="2">SUBSCRIPTION OPTIONS</td><td colspan="2">PER "CHANNEL"</td><td colspan="2">PER PAGE</td></tr>
<tr><td>ADVERTISEMENT</td><td>NO ADVERTISEMENT</td><td>ADVERTISEMENT</td><td>NO ADVERTISEMENT</td></tr>
<tr><td>SUBSCRIPTION COST</td><td>LOW</td><td>MEDIUM</td><td>MEDIUM</td><td>HIGH</td></tr>
<tr><td>MATERIAL</td><td colspan="4">COMPUTER-AIDED INSTRUCTION, TELIDON, LIBRARY, FINE ARTS, ARCHIVES</td></tr>
</table>

Table 3 DEMAND ACCESS VIDEO SERVICE

The term "channel" refers to a class of video services because the computer program can readily specify whether a source is to be connected to a subscriber on a per channel basis or a per program (page) basis. Television programs can be offered on a delayed basis by using a DRAW (direct-read-after-write) videodisc.

3. COMPATIBILITY

If HDTV service is to be offered to the public, compatibility with existing NTSC TV sets must be considered so that HDTV programs might be viewed on standard NTSC TV sets. Ideally, compatibility should be bidirectional, upwards compatible from NTSC TV to HDTV and downwards compatible from HDTV to NTSC TV. If MAC (mutilplexed analogue component) TV [18] is also to be offered, we would need to consider the three-way compatibility between NTSC TV, HDTV, and MAC TV.

To require such compatibility in consumer TV sets will most likely make the sets prohibitively expensive, and to demand that downward compatibility to NTSC TV be built into the HDTV format may compromise the video quality that might be achieved otherwise. The centrally switched network configuration offers a solution to this problem. whenever compatibility is desired, an interstandard converter can be placed at the central switching office and the converted signal offered to the subcscribers on a switched basis. For example, an HDTV program received from a satellite can be down converted to an NTSC TV signal through a converter which might be a digital processor. Both signals are then made available to subscribers through the appropriate matrix switches. The subscriber need only select the proper signal by using the channel selector keypad.

Placement of the interstandard converter at the central switching office allows all subscribers to share the cost of the converter, thereby keeping the cost per subscriber to a minimum. We can see that the centrally switched star network has a number of advantages. Their impact is considered in the following section.

4. DISCUSSION

Since provision of services is under the control of a computer at the central switching office, various subscription charges can be managed readily by a suitable computer program. It should be noted that the question of scrambling a pay TV channel will not arise in the star network discussed here because connection of a signal is controlled at the central switching office by a computer. Theft of pay TV services therefore becomes extremely difficult.

Insertion of an advertisement is also easily manipulated by the computer software and the subscriber may have the option to avoid advertisements by paying a slightly higher premium as shown in Table 3. Separate videodiscs, one for programs with advertisements and one for programs without advertisements will be used for such a service. Accurate statistics can be kept on subscriber preferences and the information used to expand a popular market as well as set charges that will maximize return on an investment. For example, foreign movies for minority ethnic groups might prove so popular that close to 100% penetration might be achieved and provide a high return. Special fees can be charged for HDTV services too. The types of entertainment that might be offered profitably is limited only by the imagination of the entrepreneur and his diligence in uncovering or creating a demand among subscribers.

By the middle of this decade, it is estimated that the cost of digital fiber optic system for telephone and data only will be lower than that of a copper wire system [19]. Addition of video services to the telephone and data services should prove attractive to business users at about the same time [20]. If such integrated service and demand access TV is provided to all subscribers, economy-of-scale should be achieved and profitability realized. Since the delivery system is broadband and centrally switched, HDTV services can be added readily and the incremental cost to provide other new services such as electronic mail and facsimile newspaper should be small. Addition of new services will provide a broader economic base on which to support the network.

In order to attract investment to HDTV technology, we might consider allowing cable TV licence holders to offer HDTV service on a pay TV basis with minimum of restrictions as to rates and content. Since there are no commercial products available today, such an approach might stimulate the equipment manufacturers as well as the program production industry.

Because all communication signals are routed under computer control in the centrally switched system, accounting of usage is a straight forward computer programming problem and appropriate tariffs can be established for use of the transmission facility. If needed, generation of program production funds can be achieved by differential taxing on the usage according to message content.

The delayed videodisc offering of TV broadcast programs and videodsic versions of the performing arts will open a revenue base heretofore unavailable to the program production industry. That is, the CPU controlled centrally switched delivery system can collect copyright fees from each individual viewing, thereby ensuring the income of the program producer as well as that of the performer.

The impact of the fiber optic broadband subscriber system is wide-ranging such that it deserves the concentrated attention of the industry. If an early start is made to establish such a system on a wide scale, Canada may become a dominant force in fiber optics technology in terms of component and systems production. A lead can also be gained in HDTV tennology as well. At the same time, the Canadian program production industry may receive a substantial benefit by gaining a larger audience and financial base. We look forward to future developments.

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AVAILABILITY OF RADIO FREQUENCY SPECTRUM FOR HIGH DEFINITION TELEVISION

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1. INTRODUCTION

Other authors submitting papers to this colloquium have addressed the subject of the characteristics and the possible means of delivery of High Definition Television (HDTV). Proposals include systems that are intended to be compatible with conventional TV as well as those that are optimized to meet the perceived requirements for HDTV.

The purpose of this paper is to investigate the potential radio frequency bands in which radio transmission might be utilised for the delivery of HDTV. In many instances, the technical and systems parameters of such delivery systems for HDTV are not yet fully formulated. Consequently, a general approach has been taken in order to review the likely provisions for frequency spectrum that might be utilized. At this stage of the development of HDTV this paper should be viewed as a part of an ongoing iterative process.

2. BACKGROUND

The availability of radio frequency spectrum is affected by several considerations. The first of these is the International Radio Regulations which define the allocations of frequency spectrum to the various radio services ranging from Broadcasting through to Fixed Satellite. In many instances, several radio services are allocated internationally to the same segment of the frequency spectrum. Many administrations such as Canada and the United States produce a domestic Table of Frequency Allocations by selecting among the internationally permitted services for each segment of the spectrum, those which best suit the current and potential needs of their countries. In the process of such a selection technical considerations, to ensure that sharing problems between the selected services are kept to within acceptable limits, often have an important influence.

It is important to realize, however, that the frequency allocations are for specific radio services as defined in international or domestic radio regulations. These definitions are general. One example is the "Fixed Service" category which covers the transmission between fixed locations of one or many multiplexed telephone channels or on the other hand the transmission of television. This transmission could use a variety of modulation techniques. As another example, definition of the Broadcasting Service can include various types of radio communications provided it is intended for reception by the general public. As such there is no need to obtain specific provisions for spectrum for delivery for HDTV, but rather to ensure that prospective requirements can be accommodated within the frequency bands allocated to the various radio services.

A second consideration is that for the segments of frequency spectrum, allocated to a given service, those segments (frequency bands) for which appropriate and economically viable RF technology already exist, are more likely to be well subscribed. As a simplification one could say that the higher the frequency band being considered, the more likely it is to accommodate a new mode of transmission for the allocated service. Of course, associated with such ease is an economic cost.

Thirdly, some consideration must be given to certain other activities of the International Telecommunications Union, that can affect the availability of frequency spectrum for specific uses. These include planning conferences, such as the upcoming Regional Administrative Radio Conference on Broadcasting Satellites in 1983, which evolve plans for the allotment of frequency channels (and orbital positions) based on the perceived needs of administrations and on the best available assumptions of the characteristics of the radio systems judged likely to meet the perceived needs. Such assumptions may preclude certain other types of radio systems if their characteristics are not as fully defined at the time of the conference.

3. POSSIBLE APPLICATION OF HDTV THAT MAY REQUIRE USE OF FREQUENCY SPECTRUM

High definition T.V. is but one manifestation of Television. Admittedly, it holds the promise of an increase in the quality of Television. Implemented in its most sophisticated form, the quality improvement represents a quantum jump from current generally available levels for colour T.V. and Video display of information. If past experience of the introduction of similar innovations in communications is a guide, one could surmise that the introduction of HDTV will also follow an evolutionary path to its final manifestation. Currently one can discern certain discrete fields of application in which such an evolution is taking place. And one approach to the topic of the potential availability of radio Spectrum for HDTV is by categorising the foreseen applications of HDTV and identifying those which have a potential need for the use of the Spectrum.

3.1 HDTV Application in Film and T.V. Program Production

The prime objective in such applications is to store, and subsequently easily edit photographic quality pictures on tape. The characteristic of this type of application is that the system components are relatively close to each other and can be interconnected by cable or fibre optics. These latter are confined transmission media. Radio spectrum allocations, in the context of this paper, for such applications are not relevant, and no specific needs have been identified. One could, however, conceive of such a need in certain specific circumstances. This may well arise when portable camera units covering for example activities on a convention floor or special outdoor events communicate with fixed video tape units. Any radio links established for such purposes will be typically temporary, unidirectional, low power to cover short distances and most likely in the higher portion of the frequency spectrum to ensure portability as well as wide bandwidth of transmission.

3.2 HDTV Distribution

If program material suitable for HDTV already exists and is to be displayed at remote locations various means of distributing it can be conceived. The suitability of any given means of distribution depends on the nature of the application including the number of remote locations to be served, their geographical spread and the need or otherwise for time coincidence at each of the locations. Two categories of such distribution can be easily identified. The first one is exemplified by direct to home distribution. Typical characteristics of this category are very large numbers of locations simultaneously served and which are randomly and often times unevenly spread. The second category is one in which the number of locations to be served is not large, but which may themselves form the hubs of local distribution to homes. The generalised characteristic of networks serving this category is that they are optimised for delivery of point to point or point to multipoint signals.

3.3 Distribution of HDTV direct to home:

Two traditional means of distribution of conventional TV to homes exist - Terrestrial Broadcasting and Coaxial Cable. Two new entrants are direct to home Broadcasting Satellites and fibre optics. Terrestrial Broadcasting as well as Broadcast Satellites need spectrum for their operation while as the Cable and fibre optics being guided wave media do not require specific allocations of spectrum in the context of this paper.

Terrestrial Broadcasting of HDTV signals falls within the definition of the Broadcasting Service. However, its entry into those bands which are heavily utilised by conventional TV will be constrained by the need for compatibility with the existing broadcasting system. The potential of the use of spectrum at higher frequency bands, allocated to the terrestrial Broadcast Service, for direct to home HDTV is somewhat unknown.

Broadcast Satellites can be utilised for the delivery of TV signals direct to home in the frequency bands allocated for this Service. Once again, HDTV, being a subset of TV, could be transmitted in the same bands. The area coverage characteristics of geostationary satellites, the fact that the geostationary orbit and the frequency spectrum must be shared by all countries often leads to complex trade-offs. In the 12 GHz Satellite Broadcasting band where the exploitation of Satellite Broadcasting appears most imminent, such trade-offs have received particular attention in the development of positions for the 1983 Regional Administrative Radio Conference for ITU Region 2 covering the Americas. Being the first band planned for the implementation of Broadcast Satellites, the largest requirements stem from conventional TV whose characteristics are also well defined thus removing uncertainty in one of the parameters of the trade-off.

3.4 HDTV carriage for redistribution:

Another application of the use of radio spectrum in the delivery of HDTV could be the transmission of program material from the production or distribution center to redistribution points. These point to point or point to multipoint requirements may be accommodated in either the Fixed or Fixed Satellite Bands. Extensive networks of this nature already exist for the networking of conventional TV.

4. AVAILABILITY OF FREQUENCY SPECTRUM

4.1 Fixed Services

The choice of frequency bands for the Fixed Service is particularly affected by the present usage of these bands, domestic policy and the established channelling arrangements. The choice of appropriate frequency bands should be based on a number of considerations including but not limited to the following:

- Number of HDTV channels required
- Spectral signature of a typical TV channel
- Modulation charactristics of the transmission scheme
- Bandwidth
- Susceptibility to interference
- Distances to be traversed
- Points of origin and destination

REVIEW OF SELECTED FREQUENCY BANDS FOR FIXED SERVICES IN CANADA

BAND	POSSIBLE APPLICATION FOR HDTV DELIVERY	COMMENT
2500 MHz	Point to multipoint	Narrow channel spacing envisaged (6 MHz)
4000 MHz 6000 MHz	Long haul point to point	Presently utilized for telephony and conventional television transmission. RF channel bandwidth of 20 and 29 MHz respectively.
6590-6770 MHz 6930-7125 MHz	One hop point to point	Extensively used for temporary pickups and studio transmitter links for conventional TV. Channel bandwidth restricted to 20 MHz.
8275-8500 MHz	Medium distance point to point	Extensively used for transmission of conventional TV. Channel spacing restricted to 18.75 MHz.
12.7-12.95 GHz	Short distance point to point and multipoint	Presently used for transmission of conventional TV. Restricted bandwidth. Affected

REVIEW OF SELECTED FREQUENCY BANDS FOR FIXED SERVICES IN CANADA (cont'd)

BAND	POSSIBLE APPLICATION FOR HDTV DELIVERY	COMMENT
		by present domestic policy on use of the 12 GHz band
14.5-15.35 GHz	Short to long haul point to point	This band is presently lightly used, although the prospect for future usage is high. The possibility exists for accommodating High Definition TV by pairing RF channels together.
17.7-19.7 GHz	Point to point	Canadian frequency plans for this band have not been fully developed. Possibilities for HDTV exist.
21.2-23.6 GHz	Point to point	Frequency plans have not been developed. Possibilities for HDTV exist.
Frequency Bands above 30 GHz	Point to point	Could hold potential for HDTV when allocated to the Fixed Service. Propagation variances unknown at present.

4.2 Availability of Spectrum for Fixed Satellite Services

As for the Fixed Services, the current use of the Fixed Satellite Services is forcing new use to higher frequency bands, primarily due to frequency and orbital usage in the 4 and 6 GHz bands. The considerations which must be addressed prior to implementation of HDTV distribution by means of a Fixed Satellite Service include the following:

- Number of HDTV channels required
- Spectral Signature of a typical HDTV channel
- Modulation characteristics
- Bandwidth
- Susceptibility to interference
- Points of origin and destination

REVIEW OF FIXED SATELLITE SERVICE BANDS IN CANADA

BAND	POSSIBLE APPLICATION FOR HDTV DELIVERY	COMMENT
4 and 6 GHz	Point to point and multipoint distribution	Channelization in Can/US based on 40 MHz separation. These frequency bands are extensively used and earth station antenna costs are significant.
12 and 14 GHz	Point to point and multipoint distribution.	Rapidly becoming congested. Earth station antenna costs are lower
17.7-21.2 GHz	Point to point and multipoint distribution.	Channel plans not yet defined. Earth station antenna costs likely to be still lower.

4.3 Availability of Spectrum for Terrestrial Broadcasting Services

As is well known, currently all television broadcasting is either in the VHF or UHF bands channelized in 6 MHz segments in North America. T.V. channel allotment plans to accomodate foreseen requirements for conventional T.V. to the end of the century have been developed for Canada as well as the U.S., based on current T.V. receiver designs. The VHF spectrum is essentially saturated in urban areas given today's receiver technology. The UHF spectrum also is well subscribed in the larger urban centres of Canada. Any proposed usage of these bands for HDTV distribution to the home would be constrained by the need for mutually interference-free operation with existing conventional T.V. use, and agreed T.V. allotment plans. Such plans are based on well known taboos associated with current designs of T.V. receivers, and demonstrate a domino effect to change. In view of this it is very likely that any introduction of HDTV in these bands in the next decade would need to fit in with the existing channel spacing of 6 MHz.

Certain frequency bands above 10 GHz have been allocated to Terrestrial Broadcasting as well as the Satellite Broadcasting Service. However, sharing by these two services on a co-channel basis in the same geographical area does not appear feasible.

The characteristics of Terrestrial Broadcasting Systems that would affect the choice of frequency spectrum for HDTV include among others:

- Size of service area
- Cost of receivers
- Modulation employed
- Bandwidth required
- Desired quality and reliability of service
- Compatibility needs for the reception of HDTV transmissions by conventional T.V. receivers.

TERRESTRIAL BROADCASTING (television)

BAND	POSSIBLE APPLICATION	COMMENT
470-608 MHz 614-806 MHz	direct to home	-many assignments to conventional TV -channel spacing restrictions
12.2-12.7 GHz	direct to home	availability of spectrum affected by decisions of the RARC concerning Broadcasting Satellite
40.5-42.5 GHz	direct to home	feasibility and limitations practicality unknown
84-86 GHz	direct to home	feasibility and limitations practicality unknown

4.4 Availability of Spectrum for Broadcasting Satellite

The use of the Broadcasting Satellite service has received particular attention to date, as a means of delivery of HDTV. Several frequency bands are allocated to the Broadcasting Satellite Service, such as 2500 MHz, 12 GHz, 20 GHz, 40 GHz and 80 GHz. Initial interest has been addressed towards the use of the 12.2-12.7 GHz band due to the preparations for the Regional Administrative Radio Conference on Broadcasting Satellite. The availability and suitablity of spectrum for Broadcasting Satellite is discussed in detail in a companion paper by R. Bowen.

5. CONCLUSIONS

Possible frequency bands for the delivery of HDTV have been examined. It is evident that the spectrum requirements for HDTV need to be constrained if the delivery systems are to fit within currently used frequency bands. Failing this, opportunities exist at higher frequency bands. The characteristics and requirements for HDTV need to be more closely defined and transmission standards established before a definite indication can be given as to which frequency bands would best accommodate the delivery of HDTV. The process is expected to be iterative over the next few years.

Spectrum Availability for High-Definition Television
in the Broadcasting Satellite Service

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1. Introduction:

High-definition television signals may be delivered to the ultimate user either in recorded form or in "real time". In the latter case they may be transmitted either in a "guided-wave" mode, likely either copper coaxial cable or optic fibre, or broadcast over an area in an "unguided" mode except for limited guidance through the directivity of a transmitting antenna. It is only in this broadcast mode that use of the radio spectrum is required. The transmission may be in the broadcasting service from a site on the ground or from a permanent structure. Or transmission may be from a satellite in geostationary orbit, in which case the transmission is said to be in the broadcasting satellite service. These modes of delivery are discussed in more detail in the companion paper by S.N. Ahmed and M.J. Hunt.[1] This paper concentrates on the spectrum available in the broadcasting-satellite service. A general review of the relative advantage of the different broadcasting-satellite frequency bands is in section 2. A closer examination of the 12GHz band, and the planning of the use of that band at the 1983 Region 2 Broadcasting Satellite Regional Administrative Radio Conference, ('83RARC), is given in Section 3. The problems of sharing a given band between HDTV signals and conventional television signals, and the alternatives, are discussed in section 4.

2. Frequency Bands Available to the Broadcasting-Satellite Service:

Based on the decisions of the 1979 General WARC, i.e. on the Radio Regulations as of January 1982, there are now six bands allocated to the broadcasting-satellite service. These are, in order of increasing frequency:

- the 700 MHz band,
- the 2.5 GHz band,
- the 12 GHz band,
- the 23 GHz band,
- the 41 GHz band, and
- the 85 GHz band.

Each of these bands has certain advantages and disadvantages for delivery of high-definition television signals to the ultimate user or viewer, with some bands being more appropriate than others. The different bands are considered below in terms of:

- bandwidth available,
- sharing considerations,
- propagation factors, and
- availability and maturity of equipment.

2.1 The 700 MHz Band.

The band 620MHz to 790MHz is available in the ITU table of allocations through Footnote 693, although it is not in the current Canadian Allocation Table. The bandwidth available is only 170MHz, which, although over 20% of the carrier frequency, is rather narrow for delivery of a significant number of HDTV signals. The allocation is on a "subject-to-agreement" basis, and is constrained to systems which transmit at levels less than -129dBW/m^2 in adjacent service areas. This limits the systems to those with fairly large receiving antennas. The major problem in use of this band is of course the need to share the band with UHF terrestrial broadcasting systems.

Rain attenuation is not a problem on such low frequencies, although Faraday rotation effects would suggest that circular polarization be used.

From a system technology viewpoint, the low frequency involved would indicate that unfurlable spacecraft antennas would have to be used unless the coverage area were very large.

In summary, this band is not considered a good candidate for HDTV transmission because of the narrow bandwidth, low frequency, and the problems of sharing with terrestrial services.

2.2 The 2.5 GHz Band:

This band, 2500MHz to 2690MHz, 190MHz wide, is available world-wide on a primary basis, and is being used by such systems as INSAT for delivery of standard television programs. Such systems must share the band with fixed, fixed-satellite, and mobile systems, which may present problems in some areas. The most serious problems with use of this band are the narrow bandwidth available and the need to transmit at power levels not greater than -152 dBW/m^2/4KHz at low elevation angles to -137dBW/m^2/4KHz at high elevation angles, primarily to protect terrestrial systems. These low levels, again, would require use of fairly large earth station antennas. Thus the 2.5GHz band is not considered a prime candidate for HDTV delivery, for much the same reasons as the 700MHz band.

2.3 The 12GHz Band:

The "12GHz band" is different in different parts of the world, but in all cases is between 11.7GHz and 12.75GHz. In Region 1 it is the band 11.7 to 12.5GHz and has been planned in detail at the 1977 Broadcasting-Satellite WARC. A number of uplinks are possible, including the 17.3-18.1GHz band. In Region 3 the band is 11.7GHz to 12.2GHz, planned at the '77 WARC, plus the band 12.5-12.75GHz for lower-powered systems.

In Region 2, the Americas, the ITU Table of Allocations between 11.7 and 12.7GHz is rather complex. The band allocated in the Table to the broadcasting-satellite service is the upper part of the band, from somewhere in the 12.1GHz to 12.3GHz range to an upper limit of 12.7GHz. (It will be assumed in the remainder of this paper that the band is 500MHz wide, from 12.2GHz to 12.7GHz.) This band will be planned at the 1983 Region 2 Broadcasting-Satellite RARC (See section 3.) As well, the band

11.7-12.2 GHz can be used by lower powered systems with an EIRP of not more than 53dBW per television program at the spacecraft, through Footnote 836.

The bandwidth available, 500MHz in each of two adjacent bands, would seem adequate. Sharing is required with Fixed and Mobile terrestrial systems, and with other broadcasting satellite systems carrying conventional television programs. (See section 3.) Rain propagation is a factor at 12GHz, but is not a major factor except in very heavy rainfall areas or with systems requiring very high reliability. Propagation margins in the 2dB to 5dB range are typical. Satellite systems have been developed at 12GHz in many countries, including Canada, the United States, Europe, and Japan. Thus, in many respects, the 12 GHz band is a good candidate for delivery of HDTV programs. However, the sharing with other satellite systems, in some cases planned, has to be considered (see section 3).

2.4 The 23 GHz Band:

The 23 GHz band, 500 MHz wide from 22.5 to 23GHz and with corresponding uplink from 27.0 to 27.5 GHz, is available in Regions 2 and 3 only. There are no power-flux density limitations on satellite transmission in this band, but assignments are on a subject-to-agreement basis. Since it is a new satellite allocation in Region 2 there are no orbit congestion problems in the band, nor any immediate actions to plan use of the band. Propagation through rain is more of a problem at 23GHz than at 12GHz, but is a manageable problem under most meteorological and reliability situations. Larger earth station antennas can be used if required. Satellite system research and development work is underway in several countries in this band and in the adjacent 20/30GHz band. For these reasons the 23 GHz band and its corresponding feeder links in the 27GHz band should be considered seriously for HDTV broadcasting-satellite system of the 1980's and 1990's.

2.5 The 41GHz and 85GHz Bands:

The 41 GHz band and the 85GHz band are each 2GHz wide, capable of carrying a large number of HDTV signals. There are no power-flux-density constraints on satellite use of these bands, which leaves options open for whatever system characteristics are required. These attractive features are offset by the fact that rain propagation losses are considerably greater at these frequencies, and system design work is at a very early stage. Thus these bands are not prime choices in the immediate future, but will likely be used in the longer term.

2.6 Summary of Appropriateness of Available Bands:

It would seem that the 12GHz and 23GHz bands should be seriously considered in any immediate HDTV system design considerations, with the 41 and 85GHz bands as possible alternatives in the longer term. The planning of the 12GHz band, discussed below, puts some constraint on use of that band for HDTV broadcasting by satellite.

3. Planning of the 12GHz Broadcasting-Satellite Band:

The 12GHz band (see section 2.3 above) was planned at the 1977 WARC for Regions 1 and 3. Region 2 decided to delay planning of the band until 1983; this will be done at the 1983 RARC, scheduled to take place in Geneva for five weeks in June and July of 1983.

The '77 WARC Plan for Regions 1 and 3 was a detailed rigid a-priori one, in which five channels were allotted to each service area in the two regions. The Final Acts of that conference, now Appendix 30 of the Radio Regs, specified the channel frequencies, polarizations, EIRP levels, coverage areas, satellite orbital positions, channel bandwidths, and a large number of other technical parameters of the broadcasting-satellite systems permitted under the plan. A significant parameter of the plan is that 27MHz radio-frequency bandwidths are to be used. The plan is a very rigid one in that according to Article 3 of Appendix 30 "the members of the Union shall adopt for their broadcasting-satellite space stations....the characteristics specified in the Plan for those Regions". If an administration wishes to put in orbit some other system it may do so by requesting a " modification to the plan" that would put its planned system in the Plan. However, in some crowded portions of the orbit such as 19°W it may not be possible to have a moficiation agreed to by all affected administrations and at the same time have that modification extensive enough to permit operation of a high-definition television system.

The situation is obviously different in Region 2, in that our plan is not yet completed. However, any deviation from the course followed by Regions 1 and 3 will have to take into account that as well as possible HDTV requirements there are also extensive requirements for the delivery of conventional television programs by satellite. It is not possible to determine the sharing considerations between HDTV and conventional TV at the present time, because HDTV systems have not been defined in precise terms. Thus to develop a plan with a precise mix of HDTV and conventional TV assignments is not feasible. Nor is it possible to divide the band between HDTV and conventional TV assignments at this time, because the relative spectrum requirements of the two media are not known at this time, although much more is known quantitatively about the demand for conventional TV delivery than for HDTV delivery. Thus the development of a mechanism to allow the introduction of HDTV systems into the Region 2 plan is somewhat of a problem.

Fortunately, the problem is eased somewhat by the foreseen need to have the Region 2 plan more flexible than that of Regions 1 and 3. Two such planning approaches have been proposed at the Conference Preparatory meeting (CPM) of the CCIR in June 1982 for planning at the RARC. One such planning approach, called the Block Allotment Planning Approach, (2) has been proposed by the United States. Another, called the Flexible High Capacity Detailed Planning Approach, (3) has been proposed by Canada. As a result of discussions at the CPM and other such fora it is seen that there are many similarities between these two approaches, although on initial examination they may seem somewhat different. (4) Under each approach planning would be based on a very specific "standard" broadcasting-satellite system. This standard system would be a conventional television DBS one for delivery direct to the home. It would be assumed that the "standard" signal would be an analog video television signal with audio subcarriers, frequency modulated into an r.f. carrier and with a necessary bandwidth in the order of 18 to 24 MHz. The resulting plan would not be a description of system technical characteristics as was done in the Regions 1 and 3 plan, however. Rather, it would be a description of the permissible interference levels between pairs of systems in the plan. If, for instance, an administration wished to implement an HDTV system, and if that system did not impose any more subjective interference to any other standard system in the plan than did its own plan entry, nor requested any more protection, then that HDTV system would be permitted under the plan. For systems as different as conventional TV and HDTV the amount of subjective interference that one imposes on the other has not yet been determined. It has been suggested that this work be done by the CCIR before HDTV systems are implemented.

There are still differences between these Canadian and US approaches which need to be resolved. Further, there is no certainty that either approach with the above common characteristics will be used as a basis for planning at the RARC. However, from discussions at the CPM, at meetings of the Permanent Technical Committee II/III of CITEL, and at meetings of the ITU '83 RARC Panel of Experts, it would seem that the planning approach used will have the above general characteristics. How an administration uses the frequencies assigned to it in the plan would be a domestic decision, within the above general sharing rules. That administration would have to decide how much of its assigned resource it wished to use for the transmission of HDTV programs, and how much it wished to use for conventional TV transmission. Thus, the decision whether to implement HDTV in the 12GHz band by a given administration can probably be made after the 83 RARC.

4. Choice of Frequency Band for HDTV Delivery:

As seen above in section 3 it will probably be possible to use the 12GHz band for HDTV delivery. It is likely, but not certain, that the planning approach to be used at the 83 RARC will permit later introduction of HDTV delivery systems, subject to interference limits that are not yet specified and will not likely be specified explicitely at the RARC.

The alternative to following this route, i.e. in a band that is being planned flexibly but in detail, is to go to the higher 23GHz band where there are far fewer interference constraints. It is unlikely that the 23GHz band will be utilized in the near future for broadcast of conventional television programs. It may be possible to utilize the 23GHz band primarily as a band for delivery of HDTV programs. If so, it would seem that there would be no immediate shortage of spectrum or orbit, and that satellite system development could proceed in parallel with 18/30 GHz fixed-satellite development at about the same pace as other aspects of the HDTV concept.

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NHK

HIGH-DEFINITION TV AND ITS DISPLAY TECHNOLOGY

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1. INTRODUCTION

In a television system, the final interface with the viewer is a display equipment. The performance of the display equipment determines the evaluation of the entire television system. High-definition television must include a system for displaying television pictures on a large and wide screen in order to attract viewers and convey a sense of reality not easily achieved by existing television systems. To achieve a practical HDTV broadcasting service, the development of a high-resolution large-size display is indispensable. As it is considered that flat panel displays are most promising for future large-size high-definition displays, research into color gas-discharge panels is now in progress at the NHK Laboratories. However, at present, the development of a high-resolution CRT is the shortest cut to an HDTV display. NHK has been developing HDTV dispaly of with 5:3 aspect ratio of 1.125 scanning lines.

2. PERFORMANCE REQUIRED FOR HDTV DISPLAY

HDTV display device is required to have following performances[1] :

(1) Picture size of 1.4m(width) x 0.8m(height) to produce realistic and powerful picture.

(2) Brightness of at least 30ftL for a displayed picture. When the picture brightness was increased from 10ftL to 20ftL, subjective of the picture quality was improved by about half grade on a seven-grade evaluation scale.

(3) Resolution more than 1000 TV lines.

3. CRT DISPLAY

Based on the technology established in manufacturing color receivers for the conventional standard television system, a direct-viewing CRT display was developed for high-definition television pictures on a screen of up to 45 inches. Table 1 shows the types and performances of the high-definition CRT displays developed by NHK.

3.1 22-inch Display

In 1970, NHK started to develop a high-resolution 22-inch color CRT. The resolution of a shadow-mask type CRT is determined by spatial sampling[2] , by shadow-mask holes, and by spot size of electron beams. First an enhancement of the resolution was attempted by reducing the shadow-mask hole pitch to 310 μm, about 1/2 compared with the mask pitch used on conventional color CRT. A high-resolution electron gun was devel-

Table 1 Specifications of high-definition CRT displays

	Displays	27-inch Black & White	22-inch HDTV	45-inch Wide-screen	30-inch Wide-screen	26-inch HDTV
Number of scanning lines		2,125max	1,125	1,125	1,125	1,125
Frame frequency		30~500	30	30	30	30
Line-interlace ratio		1:1~9:1	2:1	2:1	2:1	2:1
Screen size (H×Wcm)		45×60	34×44	50×100	38×63	31×52
Screen area (cm²)		2,700	1,400	5,000	2,250	1,620
Aspect ratio		4:3	4:3	2:1	5:3	5:3**
CRT	Size	27-inch	22-inch	26-inch×3 tubes	30-inch	26-inch
	Mask aperture* spacing (μm)	—	310	440	340	370
Video bandwidth (MHz)		120	30	30	30	30
Peak luminance (cd/m²)		150	50	70	100	150
Zoom control		Without	Without	Without	With	Without
Year of developmed		1975	1973	1975	1978	1979

* The typical mask-aperture spacing for conventional tubes is 660 μm.
** 4:3 is also possible.

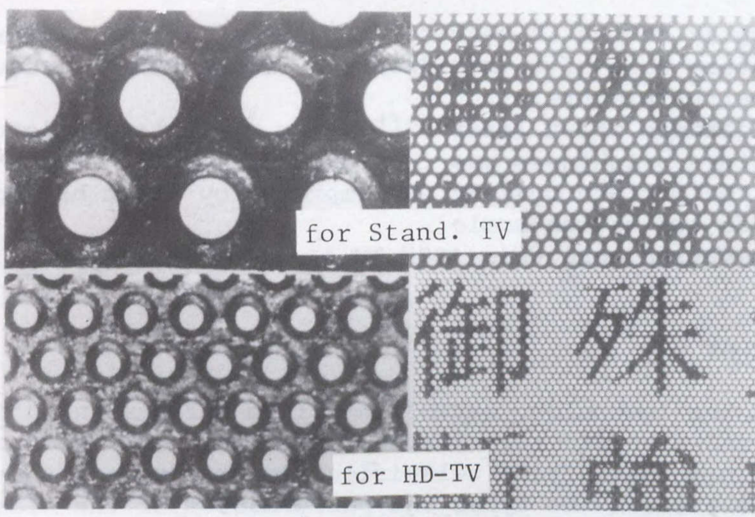

Fig. 1 Difference in shadowmask form and appearance of characters.

oped to reduce the size of the electron beam spot. Figure 1 shows the difference in profiles of shadow masks for the high-definition and conventional television displays and how Chinese characters looked through these shadow mask. The number of picture elements in this 22-inch high-definition CRT is about four times that of a conventional CRT tube, and very fine pictures can be displayed. This display has a limiting resolution of greater than 1,000 TV lines.

3.2 30-inch Wide-screen Display

In 1977, a 30-inch high-definition television CRT with an aspect ratio of 5:3 was developed to obtain as large as possible a screen on one CRT[3] [4] with an assistance of Matsushita Electronics Corporation and Matsushita Electric Industrial Company. This color CRT has twice the screen area and about six times the picture elements (2.6 million) of a conventional 20-inch CRT. As the phosphor surface is of a black-matrix structure, the picture contrast is improved. Mask pitch was 340 μm, and a new high-resolution electron gun was developed, to increase the brightness and to obtain a resolution in excess of 1,000 TV lines.

Figure 2 shows an external view of the display. The viewer can increase magnification of (zoom up) any portion of the high-definition TV picture up to four times, and this indicates one possible direction for a high-definition home entertainment television receiver.

Recently, 26-inch CRTs with 370 μm mask pitch were developed and used as an HDTV monitor. These tubes are using conventional glass valve.

3.3 Future of CRT Display

Figure 3 shows the beam response characteristics of the high-definition television displays developed in the past. These response characteristics are suppressed by beam response characteristics and are lower than the limiting resolution determined by mask pitch. An improvement regarding this point will be needed together with further enhancement of the picture brightness. As a direct-viewing display for the high-definition TV, the realization of a large-screen display of about 40 inches in diagonal dimension has been desired.

Recently, several Japanese manufacturers have started to develop CRTs for high-definition television. These CRTs have already been used as computer output displays. It is hoped that a large-screen, high-resolution, and high-reliability CRT will be developed for the benefit of future high-definition TV display for home entertainment.

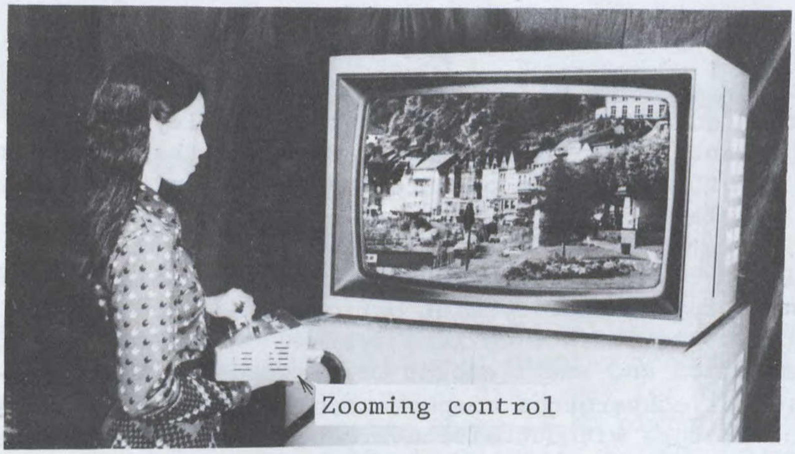

Fig. 2 External view of 30-inch wide-screen display.

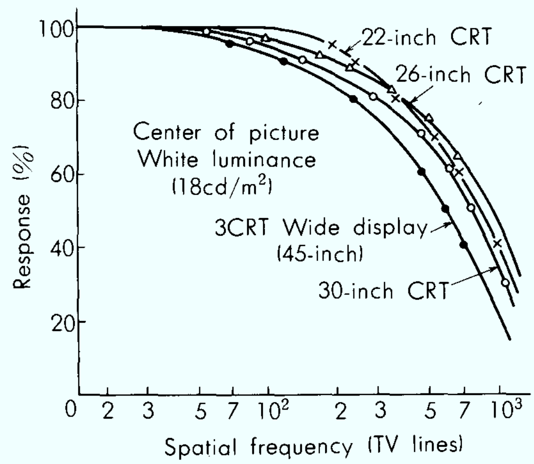

Fig. 3 MTF of the high-definition CRTs.

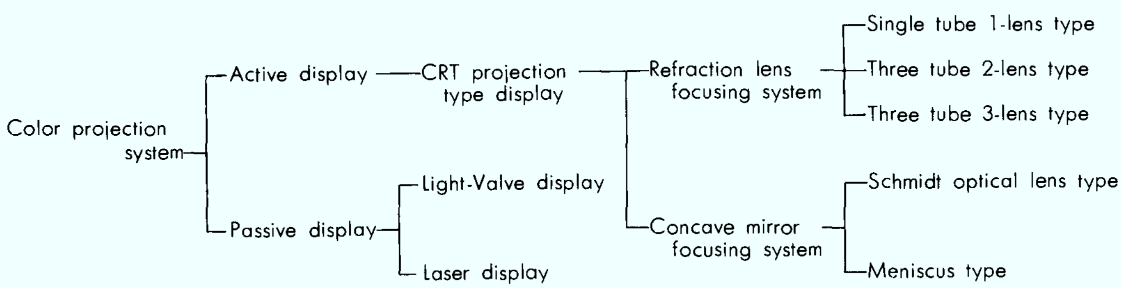

Fig. 4 Classification of projection-type TV displays.

4. PROJECTION-TYPE DISPLAY

Projection-type displays for TV pictures can be classified as shown in Fig. 4. The main advantage of projection-type displays is that large screens are easily achievable with CRT displays. However, their resolutions and picture contrasts are insufficient, and picture quality is not satisfactory for high-definition TV display.

NHK developed two kinds of HDTV projection type display for home use. One is a 55-inch projector of Schmidt optical lens type and the other is a 65-inch projector using refraction lens system. Especially, a 65-inch projector has a good resolution and small amount of disturbance by flare. In these HDTV projectors, digital convergence compensation system[5][6] was used to reproduce high resolution picture without misconvergence over the entire areas of display picture.

Fig. 5 shows the MTF characteristics of the various projectors [4]. As shown in this figure, performance of the projectors are considerably lower than those of direct-viewing type CRT display. A further improvement in resolution and decrease in flare are required.

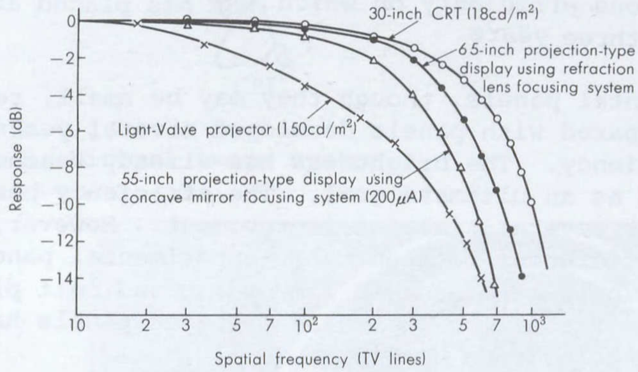

Fig. 5 MTF of high-definition TV display.

Home application of HD-TV projector

5. PANEL DISPLAY

We who are in charge of development of HDTV believe that the future high-definition television display will be a panel display (and hence great efforts are being made to study gas discharge panel displays) for the following reasons: panel displays do not occupy much space; there is no picture distortion; there is no out-of-focus problem, even in the highlights; a luminosity-hold-type display is available; and panel display television is attractive as a commodity [7].

Two experimental color panel displays were developed for conventional television. One is a 10-in (25.4 cm) color panel [8] utilizing many arrangements of positive columns as picture elements. The picture brightness was 36 cd/m^2, the contrast ratio 36:1, and the luminous efficiency 0.065 lm/W. Other is a 16-inch color panel utilizing a negative glow. The brightness of these panel dispaly is not sufficient as yet for a target value of HDTV display. The most important problems for realization of HDTV panel display are the improvement of brightness and luminous efficienty on which NHK has placed an emphasis during the past two to three years.

In recent experimental panels, though they may be small, remarkable progress [9]~[11] has been made compared with panels developed several years ago, especially in brightness and efficiency. The brightness has already reached the level which can be considered as an ultimate goal. The efficiency has also reached the level requiring just several times of improvement. However, it is clear that there are great differences between these experimental panels and high-definition TV displays in terms of screen dimensions and cell pitch. NHK will continue the research in the belief that gas-discharge panels have full potential as high-definition television displays.

6. ANOTHER DISPLAY FOR HDTV

6.1 Light-Valve Display for HDTV [4]

As a large screen display for the conventional standard television system, Light-Valve type projectors are utilized extensively. NHK remodeled this display in 1980 in accordance with HDTV standards in order to attain a high level of brightness and resolution. A high-resolution anamophic lens was used for a conversion of projected pictures into an aspect ratio of 5:3. By this remodeling, a screen brightness was achieved of more than 100^{ftL} on a 67-inch screen. But the fineness of displayed picture is not sufficient.

6.2 Virtual Image Display Using Concave Mirror [12]

As to other applications of the picture tube, an enlarged virtual image display was developed (Fig. 6). This device is a combination of a 30-in picture tube and a large concave mirror; because a magnified image can be produced at a remote point, a stereoscopic feeling can be attained.

The feature of this system is that, unlike projection type display, the screen brightness does not decrease even when the screen size is enlarged. As viewable range is narrow, this system will be suitable for personal use (Fig. 7).

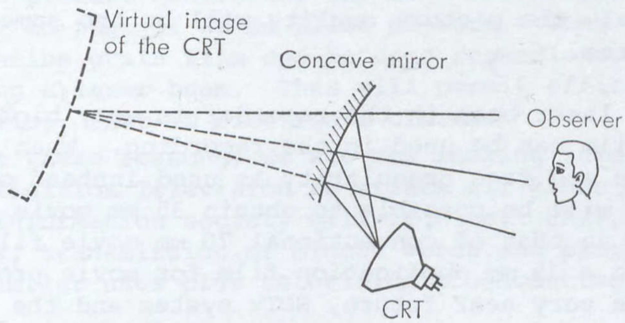

Fig. 6 Virtual image system

Fig. 7 A fabricated mirror.

7. ELECTRONIC CINEMATOGRAPHY BY HDTV SYSTEM [13]

The high-Definition Television System which is being developed by NHK was designed not only for broadcasting but also for other applications which require high resolution. The quality of the picture is equivalent to that of a 35 mm transparency and is superior to that of 35 mm motion picture film. Therefore it can be used for high quality motion picture production.

NHK developed a laser beam recorder which records television picture directly on film by using laser beams modulated by conventional television signal. This technology can be applied to movie film production by using HDTV system. In order to produce a motion picture film by the laser beam recorder, recording should be made on 35 mm color negative film to enable printing of color release prints. When conventional color negative film is used for laser beam recording of HDTV signal, the picture quality will be the same as that of conventional motion pictures.

However, as intensity of the laser beam in the recorder is very high, low sensitivity but high resolution film can be used in the recording. When duplication film having high resolution and fine granularity is used instead of conventional color negative film, it will be possible to obtain 35 mm movie film with as excellent picture quality as that of conventional 70 mm movie film. Fig. 8 shows a picture recorded on a 35 mm duplication film for movie production by using HDTV signal. In the very near future, HDTV system and the recording technology will be used to produce movies.

Fig. 8 A picture recorded on a 35 mm cinefilm using a laser beam recorder for HDTV.

8. CONCLUSION

The high-definition television system which is being developed at NHK is capable of transmitting and reproducing video information with informative volume approximately five times that of the conventional television system. The system is an entirely new system with a wide picture screen (aspect ratio 5:3) having very fine texture. Reproduction of these pictures on a large screen imparts a sense of reality far exceeding that of conventional television.

The picture quality of the high-definition television system is equal or superior to that of 35 mm slide picture. When converting from video to film, an ultrafine grain film can be used regardless of the film sensitivity by utilizing a laser beam. This will permit efficient production of high-definition movies, that is electronic cinema.

For these reasons, we are now looking into the possibility of using this High-Definition Television to create all kinds of imaging systems that the future information society will require: CATV, motion picture production, videotex, transmission of minute words and pictures, tele-conferencing and other similar uses plus television broadcasting.

At present, we at NHK are engaged in studies whose main purpose is to ensure effective application of High-Definition Television to broadcasting. Among those are studies on band compression technology, a display device with new capabilities, and a television-to-film conversion device using laser technology. In addition, we are conducting, in close cooperation with our engineering colleagues of the world, studies with the ultimate aim of achieving global unified specifications for High-Definition Television.

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PROGRAM, PRODUCTS AND SERVICES: AN OVERVIEW OF THE POTENTIAL IMPACT OF HDTV

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Good afternoon. We have here a fairly busy session. We'll try to match the quality of the previous session. This session, which is going to run for the rest of the afternoon, is particularly interested in application, programming services, and production hardware.

We will start immediately with the first paper, which is an overview of the impact of High Definition Television, and it is to be given by two authors, Carroll Bowen and Michel Guite of Kalba Bowen Associates.

Mr. Bowen, Carroll Bowen, is the Executive Vice President of Kalba Bowen Associates, and has directed cable TV planning and franchising consultancies in Boston, Chicago, and many other locations in the USA. He has also specialized in the implications of the new communication media for broadcasters, program producers, and sports organizations including copyright and pay TV aspects. Prior to cofounding Kalba Bowen Associates in 1973, Mr. Bowen was director of the MIT Press and Senior Fellow of the MIT Center for Advanced Engineering Studies.

Mr. Michel Guite received a Ph.D. from Stanford in 1977 and is currently Vice-President of Cable America, a cable company owned by Cable Casting of Toronto which operates in Atlanta and Los Angeles. His interests are principally in Satellite Communication, Internatonal Communications, and Pay Television Communication Applications. I understand that the work to be described this afternoon is based on a study which was performed on behalf of CBS. Mr. Bowen will give the introduction to the study, Mr. Guite is going to give the technicalities and the implications, and, I believe that Mr. Bowen is going to end with an analysis of policy decisions related to High Definition Television marketing and the concluding remarks.

I recommend that questions be asked at the end of the overall presentation. Mr. Bowen, the floor is yours.

Mr. Bowen: It's a speaker without fear that follows that particular bit of technologic introduction. When Mr. Bachard called last June, I told him I would be pleased to prepare an extended essay or brief monograph on the subject of new markets for enhanced video products, services, and programs. In August, Mr. Hara was told by me that I would be very pleased to prepare a brief essay on the subject of new markets for enhanced video products, programs, and services. As this day has drawn closer, I was reduced to tendering an outline for new markets, enhanced video products, programs, and services. Today I would like to offer to you on behalf of Michel Guite and myself, notes toward an outline toward an essay on new markets for enhanced video products, programs, and services.

I trust you will bear with us also as to the parochial substance of our presentation. Kalba Bowen Associates is a small, relatively young, Cambridge, Massachusetts firm which has spent the last decade investigating the impact of new communication media on traditional markets, products, and communication services. Our introduction to High Definition Television as a subject matter was not exclusively through the CBS project. We began looking at DBS first for the National Association of Broadcasters in the United States in 1979, and thereafter followed the entrants as they announced their market positions and strategies for the DBS allocations down there. CBS' Network Engineering Division, very sensibly when confronted with a request both by the FCC and CBS Corporation for prognosticating dimensions of a market in circumstances of very high uncertainty, chose the manly way and hired consultants. We were the consultants that worked with them through this period, measuring the High Definition Television market, and it has led to further work in the field. In our thirty minutes today, you will have something less than a feast, a rather longish invocation on my part leading to the rather gritty meal of slightly warmed over American data which may give you some insights into at least our perception of market potential for selected video products.

The field of High Definition Television applications is much broader than our earlier focus of the single mode of High Definition Television distribution by DBS, and it is on that theme that I wish to speak for a few minutes. The motivation for research that led to improved quality in television viewing did not focus, nor should it now focus exclusively, on an improved resolution. The work in improved video quality has been multifaceted and sequential over the history of television. Some research has been ergonomic in character, addressing human factors of viewing. One might reasonably classify much of this work sensory research, rather than video research. What are the products of such work? We have seen relatively little improvement in the audio of television sets, though now at last it's coming; however, we have seen very substantial picture improvement. We have also gained diversity in screen size. Perhaps more important than cumulative changes in the set is a much greater awareness of the role of the viewer in video perception. The proposed change in aspect ratio of the High Definition Television picture is simply another integer of this.

I was much taken by the NHK summary referring to the history of perceptual or visual research relating to television: "Such research has been much more significant than any single improvement in resolution in terms of producing an image, a sensation that would be seen as better by the conventional television viewer."

Now, in setting a context and a delivery in which High Definition Television might be measured as a market entry, bear in mind that we have two different worlds. (See Chart A: The Context and Delivery of High Definition Television.) We have a world in which DBS is very visible in Europe, the western Hemisphere, and Asia. We also have on the horizon a world in which cable television may or may not be present in substantial numbers. Today, Japan has roughly 10 percent penetration, while the U.K. has 14 percent cable penetration. On the other end of the scale, Canada has 60 percent, and the U.S. has 30 percent penetration. Germany, at 35 percent, is somewhere in the middle.

In each of these worlds, however, DBS promises to make its appearance before 1987. So in the short term we're looking at co-axial and microwave or tape delivery of High Definition Television, but by 1986 or 1987, DBS delivery. Fiber optical delivery does not appear in that time horizon.

As to the pace of High Definition Television, I found inspiration in a quote by the late Vanover Bush, who said: "We always overestimate the impact of a new technology in the short term and underestimate its impact in the long term."

We need very long time frames for fundamental communications innovations, substantially longer than we remember. Innovations in communications persistently have taken ten years to achieve modest penetration, 10-20 years to achieve as much as ten percent, and up to 30 years to achieve as much as 30 percent. The particular illustration I'll offer here is from the advent of FM broadcast and manufacture in the United States. (Chart B: Factory Reduction FM Radios.)

The first FM radio sets were offered in experimental mode only in 1935. In the 15 post-war years of 1950-1965, we got up to about 15 percent penetration. It took almost another decade to double, and, in the United States, finally in the next five years, 1975-1980, did it rise to the level of penetration we see at the bottom of the chart, 76.8 percent.

By 1980 FM or AM/FM radio purchases dominated 78 percent of all radio unit sales, or 29 million of the approximately 38 million radios sold. The period from initial introduction of the service to full integration into the market was 35 years. In 1965 the FCC issued its first rule making mandatory a percentage of non-duplication between FM and AM radio programming. The period from 1965 to FM dominance of the market in 1980 was 15 years. By 1973, the earliest year for which data is available, FM radio had captured 28 percent of the total radio listening audience of 12 years and over. By 1981 FM radio's share of the total audience was 59 percent.

I might add that this pace is also true for cable television. Our master antenna systems in the United States began in the late 1950s. It took us 15 years, and the introduction of pay television, to get us up to 20 percent, and now we've had an additional ten percent gain in the last five years. (Chart C: Growth of Cable TV Industry, 1960-1982.)

The pace of color television is again similar. (Chart D: Color Television as a Percent of U.S. Households.) Michel Guite will speak directly about the speed of this particular innovation because our extrapolation for our High Definition Television work was heavily based on the analogy of the introduction of color television sets and their acceptance.

I've dealt so far with possible delivery modes for High Definition Television and with the pace of similar communications innovations. As important as technology to communications innovations is regulatory environment. In general the less one has to alter existing institutional arrangements, the faster the accomplishment of innovation. For example, pay television might have unfolded rather more in the U.S. scenario than it has in Canada, if the regulatory climates in the respective countries had been similar.

Last, communications innovations almost always require special circumstances. Characteristically, they take place in small markets with very high unit prices in the context of as little regulation as possible, and with as much institutional substitutability as possible. We can speculate on how this will begin to operate in the context of several markets. (Chart E: Potential High Definition Television Products and Markets.)

CHART A

THE CONTEXT AND DELIVERY OF HDTV BY COUNTRY

	UCR/VTR	CATV	DBS	VHF/UHF Broadcast Spectrum
Japan	3% + 1-1/2%/yr	10%	1987	very congested
USA	2% + 2%/yr	30%	1984	VHF congested UHF partial avail.
Canada	2% + 1%/yr	60%	1983	available
Germany or		35%	1984-5	very congested
UK or	3% + 2%/yr	14%	1986-90	congested
Australia	5% + 2%/yr	10%	1985	available

Dominant mode of HDTV delivery

DBS where geography dictates

CATV

Microwave

Fiber Optical

CHART B

ANNUAL FACTORY PRODUCTION OF RADIO BY TYPE AND MODEL (Thousands of Units) UNITED STATES, 1960-1980

Year	AM	FM/AM-FM	Total	FM/Total Radio Production
1965	35,389	6,337	41,726	15.2%
1970	23,095	21,332	44,427	47.3%
1973	26,174	24,042	50,198	
1974	17,862	26,130	43,992	
1975	12,095	22,420	34,151	65.0%
1976	17,828	26,273	44,101	
1977	18,048	34,878	52,926	
1978	15,988	32,047	48,035	
1979	12,583	27,446	40,029	
1980	8,752	28,974	37,726	76.8%

Source: Electronic Market Data Book, 1981 Edition, Electronic Industries Association, 1981, p. 17

CHART C

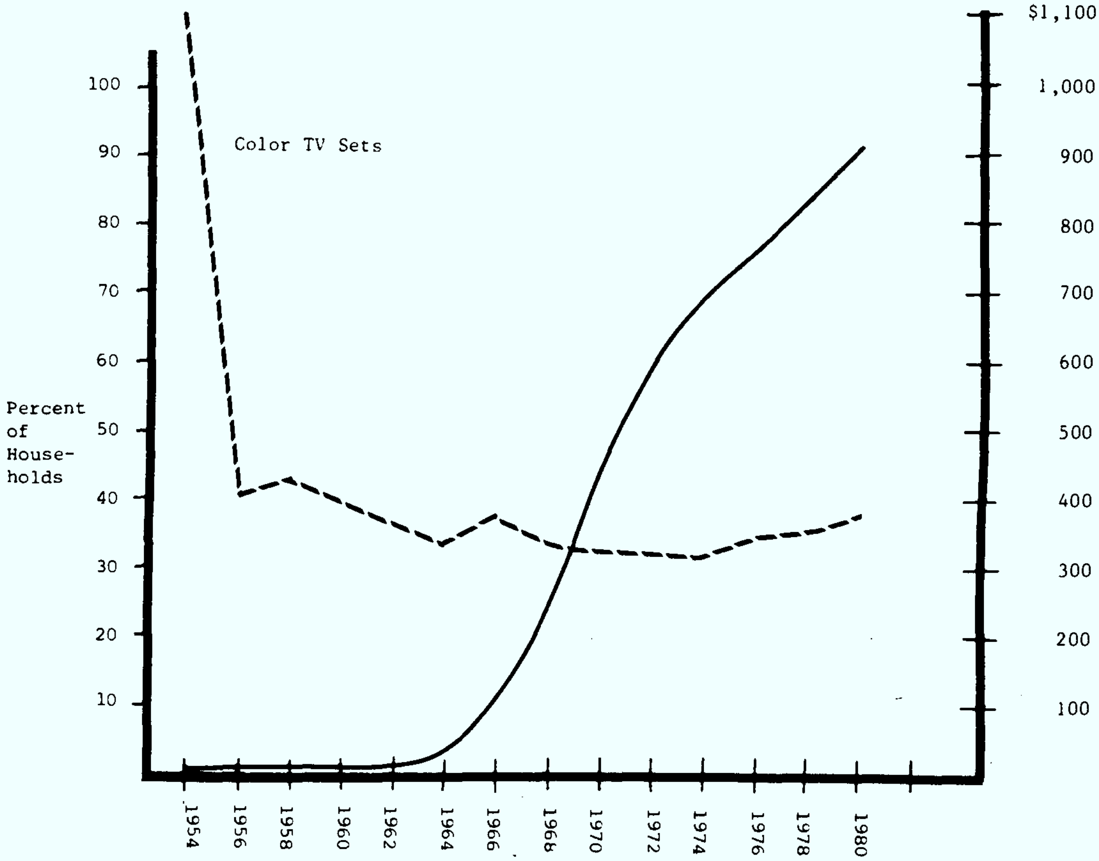
GROWTH OF CABLE TV INDUSTRY (1960-1982)

Year	No of Cable systems	No of Sub-scribers (000)	US TV households	% of TV house-holds w/cable
1960	640	650	45,200	1.4
1965	1,325	1,275	53,800	2.4
1970	2,490	4,500	59,389	7.6
1975	3,506	9,800	68,771	14.3
1976	3,681	10,800	70,573	15.5
1977	3,832	11,900	71,556	17.3
1978	3,997	13,000	73,307	17.7
1979	4,100	15,000	76,300	20.0
1980		18,000	77,700	23.8
1981		21,600	79,100	27.3
1982		24,900	80,700	30.9

Source: The Emergence of Pay Cable Television, Technology and Economics, Inc., July 1980, and Cable Television 1981, Donaldson, Lufkin and Jenrette, February 1981.

CHART D

COLOR TELEVISION AS A PERCENT OF U.S. HOUSEHOLDS
COMPARED WITH THE AVERAGE COST OF A COLOR TV SET 1954-1980



*Nominal dollars

Source: The Mass Media, p. 372

Years
1954 to 1980

Cost average color TV set
Color TV as a % of U.S. Households

CHART E
POTENTIAL HDTV PRODUCTS AND MARKETS

1. The Consumer Market

   --Enhanced TV sets (less than full HDTV)
   --HDTV sets
   --HDTV Projectors
   --HDTV videodisc players
   --HDTV TVRO antennas
   --HDTV video games

2. The Exhibition Market

   --Video games arcades
   --Movie theatres
   --Bars, hotels, etc.
   --Commercial exhibits
   --Retail exhibits
   --Closed circuit applications (airline, medical, etc.)
   --Teleconferencing

3. The Production Market

   --Feature films (cameras, recorders)
   --TV programs (cameras, recorders)
   --Transfer systems
   --Duplication systems

4. The Transmission Market

   --Broadcasting
   --Cable TV
   --Microwave
   --Satellite (Fixed)
   --Satellite (Broadcast)
   --TVRO antennas

5. The Terminal Market

   --Computers
   --Videotext
   --Special applications (automated banking, POS)

6. The Peripherals Market

   --HDTV tapes
   --HDTV cassettes
   --HDTV discs
   --HDTV printers
   --HDTV cables, etc.

7. The Components Market

   (Specialized parts required by one or more of the above segments e.g., HDTV signal processors, projection components, etc.

This array of markets is far broader than DBS applications. I'll say nothing more about Number 1, the consumer market, except to observe that this is far from a complete list; we need to add all the interface equipment that might connect High Definition Television receivers to additional gear in the home.

In Number 2, the exhibition market, there is general agreement that this will be an early entry, particularly as substitute distribution techniques for film. A critic of the early advent of High Definition Television, July Barnathan of ABC, was quoted in Broadcasting Magazine as saying that the first appearance of High Definition Television will almost certainly be in large screen projection in motion picture complexes.

Pressure for High Definition Television games is very strong in arcade set- tings. There are two modal aspects to games in an arcade. One is the so-called promotional aspect in games whose High Definition Television aspect provides a high visual attraction, but which are also programmable. This promotional element, which manufacturers are keenly interested in, requires a much better graphical base than current games have right now. The other aspect, the play mode of arcade games, can accept lower definition.

The initial entry in Number 3, the production market, is almost certainly going to be electronic editing equipment and electronic cameras. Neither are experimental now, and both are available in early purchase modes. Their use is eliminating some of the transfer and duplication costs. One of our other speakers makes the point that elimination of the transfer alone would reduce video production costs overall by perhaps five percent. Duplication costs currently amount to ten percent of total motion picture release costs.

In Number 4, the transmission market, the order of entry almost certainly is going to be the reverse of its array there. We put broadcast transmission at the bottom, for some obvious reasons. It's the most regulated, it's the most constrained by practice and tradition, and it certainly has the largest consumer investment in existing sets. Our probable order is tape and disk, then cable and microwave, then DBS, and last, terrestrial broadcasting.

On Number 5, my colleague Wes Vivian can offer comment. We see videotext as an early entrant coincident, perhaps, with home computers.

In regard to Number 6, the High Definition Television peripherals and com- ponents depend largely on products arrayed in Numbers 1-5.

Having reviewed these prospective High Definition Television products and markets at high speed, let me offer this market summary: We would expect High Definition Television to conform generally to the rules for communications innovations. One, it will be offered first to small markets; two, it will be offered at a relatively high unit price; three, it will serve business or institutional users who can afford the high cost; four, it will use unregulated modes of transmission, that is, non-broadcast transmission; and five, High Definition Television products and services, in our judgement, will build, wherever possible, on existing communications technologies: games, VCR's-disks, projection, and TV.

I will now turn the presentation of the Kalba Bowen Associates High Definition Television market study for CBS over to my colleaue, Dr. Michael Guite.

Dr. Guite: The conclusion I'm going to get us to is how many sales of High Definition Television sets in the U.S. can we expect in ten to fifteen years, and at what production costs.

U.S. consumers confronted an alternative, similar to what they may see with High Definition Television, in the 1940's with FM radio and in the 1950's with color TV. In the case of FM radio, the similarity was that electromagnetic spectrum taken up for higher quality programming was substantially more than the spectrum space needed for traditional AM programming. In the case of color television, the spectrum allocation was unaffected, but introduction of color radically altered the design of the TV receiver; consumers had to invest in expensive receivers to view color TV. In both instances, with FM radio and color TV, innovators sought to replace the standard of the day with a technology which significantly improved the delivered quality of broadcast programming.

Color TV, when first introduced, offered an enhanced picture quality at a substantially increased extra cost. Chart D shows that it took at least ten years for color TV to begin to make significant progress compared to black and white in numbers of units bought by dealers. It took 18 years to 1971 for color TV to penetrate over 50 percent of all U.S. households. It's taken almost 30 years for color TV to fully dominate the market.

In 1953 the wholesale price of a color TV was $1,100, compared with the average wholesale price of a black and white TV of $150. By 1962 this difference was reduced to $352 versus $128.

The conclusions that I draw from looking at the experience with FM and color TV that may be relevant to High Definition Television are as follows:

First of all, that in the early stages of any of these new technologies, a small and consistent proportion of consumers have been willing to innovate for improved programming, viewing, or listening quality even at relatively high cost, <u>but most consumers have not</u>.

Second, entrepreneurial risk takers seeking to offer a new service that offers improved program quality may be embarking on an undertaking of some six to twelve years before it becomes clear whether their technology will achieve a takeoff stage plus 15 to 25 years before their technology, if it proves highly successful, becomes dominant.

Third, U.S. consumers have been willing to pay significant extra costs for enhanced reception of radio and TV broadcasts. Consumers, in the case of color TV, have proven willing, since 1965, to pay an average price of three to four times greater for a color TV, compared to the price of an average black and white TV.

Will HDTV succeed?

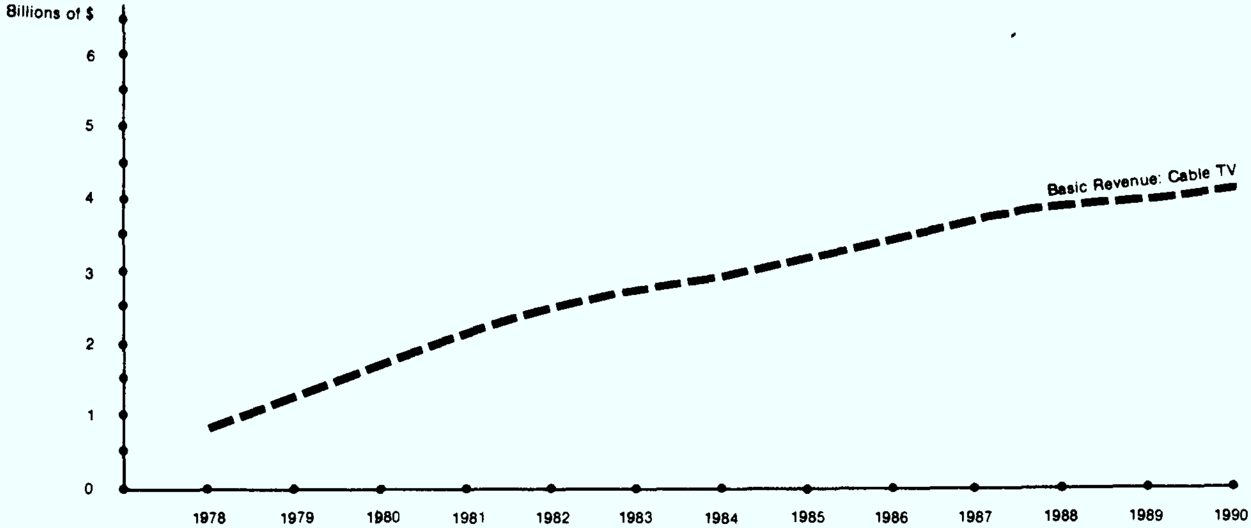
Will High Definition Television be in the category of a successful innovation or not? Let's look at a different set of projections. Following is a set of tables of existing communications technologies for home entertainment and information. These tables project consumer spending for these technologies over the next 10 years.

Tables 1 to 9 demonstrate the relative volume of U.S. consumer spending for major components with a home information/entertainment environment relevant to High Definition Television. Notes that accompany each table explain the assumptions used for each table. In all cases where publically available sources have been used for projections,these sources are cited; the notes form an important part of these Tables. Although the projections are for the U.S. only, U.S. development of each of these technologies will have some impact on Canadian developments. The tables illustrate the substantial investment consumers will make for home video entertainment services, either with High Definition Television or without. Table 9, a summary, projects total consumer spending per household for TV set and home computer purchases, cable TV and pay TV, and related home video products and services.

Our projections show that the average spending per TV household on all home video servces will rise from $128 per year in 1981 to $194 in 1985 and $259 in 1990. Total spending for these same categories for all TV households will rise through the same period in cost and dollars from $10.3 billion in 1981 to $16.8 billion in 1985 to $29.9 billion in 1990.

I should tell you as an aside that there's some evidence of consumer expenditures for information and entertainment for the last forty years have, on the average, remained constant as a proportion of total consumer spending, i.e. between 3 and 4 percent of annual personal income. Because we project that this same upper limit of 3 to 4 percent will continue, it means that someone's ox has to be gored. If more money is being spent on the services we're looking at here, the money has to be reallocated out of other categories of spending. That may be from books,

Table 1: Cable TV: Basic Service Revenues



Projections	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Total US households to 1990 [1]	76.0	77.3	79.3	80.7	82.1	83.5	84.9	86.3	87.5	88.7	89.9	91.0	92.3
Households w/TV sets (MM) [2]	74.2	75.6	77.7	79.1	80.7	82.2	83.7	85.2	86.3	87.5	88.7	89.8	91.1
Households w/TV sets (%)	97.6	97.7	97.9	98.1	98.3	98.4	98.5	98.6	98.6	98.6	98.6	98.6	98.6
Households passed by CableTV [3]	27.3	29.3	32.8	40.7	47.1	53.7	60.3	65.8	70.2	73.5	75.7	77.9	80.1
% of all TV households	36.7	38.7	42.2	52.4	58.4	65.3	72.0	77.2	81.3	84.0	85.3	88.0	88.0
Households subscribing to cable TV (MM) [4]	9.3	13.9	18.0	21.6	24.9	28.3	31.9	35.3	38.5	41.2	43.4	45.6	47.9
% of all TV households	19.0	20.5	23.8	27.3	30.9	34.4	38.1	41.4	44.6	47.1	48.9	50.7	53.0
% of all households passed by cable	51.7	43.0	56.4	53.1	53.0	52.7	52.9	53.6	54.8	56.1	57.3	58.5	60.0
Projected basic service revenue, per subscriber for non-Pay TV service [5]	7.26	7.56	7.85	8.20	7.95	7.72	7.48	7.26	7.26	7.26	7.26	7.26	7.26
Projected basic service revenue, for all subscribers, for non-Pay TV (MM)	810	1261	1695	2125	2375	2621	2863	3075	3354	3589	3781	3972	4173

1. Based on Section D projections of U.S. Bureau of the Census, using weighted averages to integrate trends from 1964 to 1978 with actual proportion from 1978. See Statistical Abstract of the U.S., 1980, U.S. Bureau of the Census, Washington, D.C.

2. Based on A.C. Nielsen and Company data to 1980, and based on discussion with A.C. Nielsen personnel for projections to 1990.

3. Based on cable industry operating data from 1978 to 1981; and on Cable Television - 1981 (Donaldson, Lufkin, & Jenrette, February 1981, for projections from 1981-1990).

4. Based on cable industry operating data from 1978 to 1981; and on Cable Television - 1981 (Donaldson, Lufkin, & Jenrette, February 1981, for projections from 1981-1990).

5. Based on cable industry operating data from 1978 to 1981; and on Cable Television - 1981 (Donaldson, Lufkin, & Jenrette, February 1981, for projections from 1981-1990).

6. Based on cable industry operating data from 1978 to 1981. These operating results show cable TV basic rates rising at approximately 4.3% during a period when the Consumer Price Index has risen at more than double that rate and economic indices for other entertainment services have risen at approximately 6.9% per year. For monthly basic cable TV service, we have projected a 3% per year drop in constant dollars from 1982 through 1985 with the charges remaining constant from 1986 to 1990.

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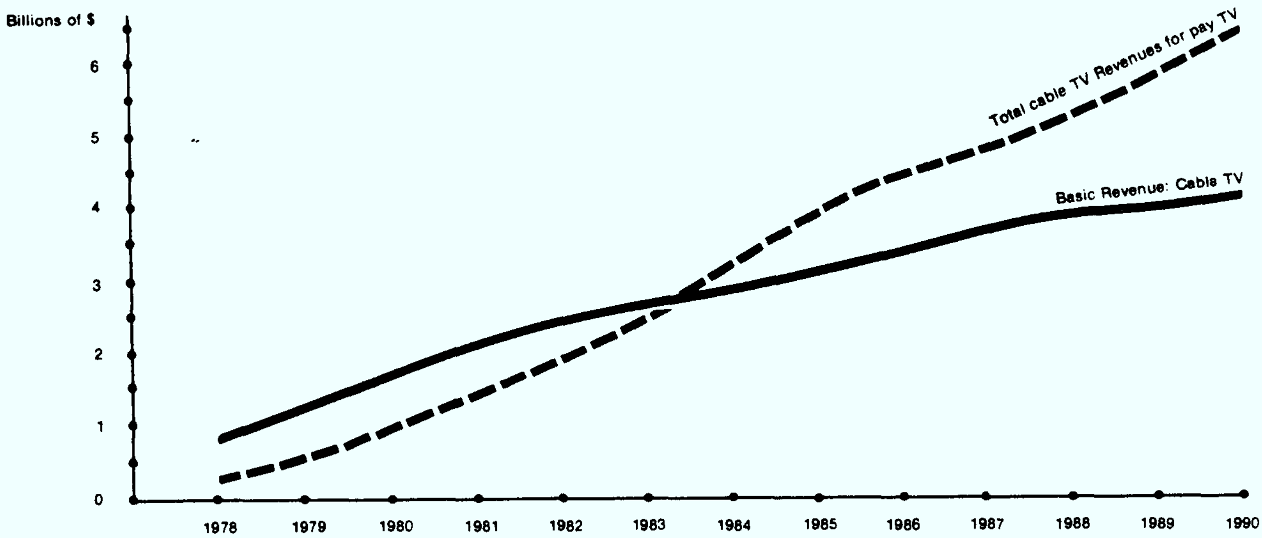
Table 2: Cable TV: Pay TV Revenues



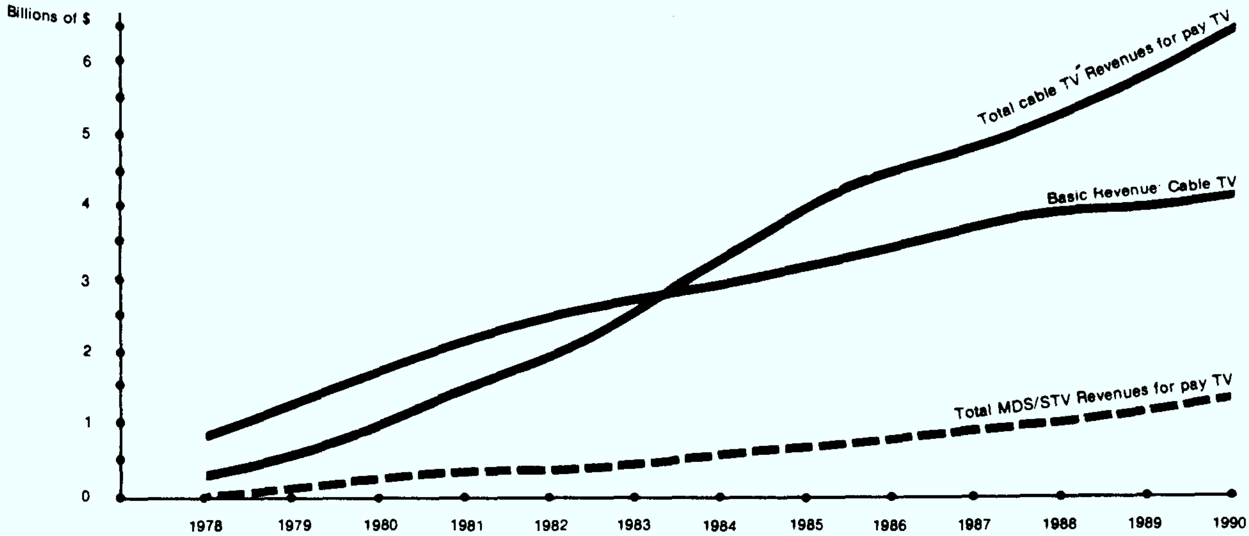
Projections	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Households w/TV sets (MM)	74.2	75.6	77.7	79.1	80.7	82.2	83.7	85.2	86.3	87.5	88.7	89.8	91.1
Households subscribing to cable TV (MM)1/	9.3	13.9	18.0	21.6	24.9	28.3	31.9	35.3	38.5	41.2	43.4	45.6	47.9
Households subscribing to pay TV	3.3	5.7	8.8	12.2	14.4	16.9	20.0	23.6	25.1	26.6	28.3	30.0	31.9
% of all TV homes	4.4	7.5	11.3	15.1	18.1	20.6	23.9	27.7	29.0	29.9	31.9	33.4	35.0
% of homes subscribing to cable TV	35.5	41.0	48.9	56.1	57.8	59.7	62.7	66.9	65.2	64.6	65.2	65.8	66.6
Pay TV services/subscribers2/	1.0	1.0	1.0	1.1	1.2	1.3	1.4	1.4	1.5	1.5	1.6	1.6	1.7
Monthly cost per pay TV services 3/	8.09	8.44	8.80	8.85	8.95	9.15	9.45	9.80	9.80	9.80	9.80	9.80	9.80
Total Cable TV Revenues for pay TV (MM)	320	577	929	1425	1855	2412	3175	3885	4422	4695	5321	5650	6377

1. Based on cable TV industry operating data from 1978-1981. Cable industry Pay TV projections commonly use Pay TV subscriptions instead of subscribers as the basic unit of measurement. Because of considerable uncertainty about the future of Pay TV services and about per-program Pay TV, Pay TV teletext services, Pay TV multi-tiered rates and the like, all projections are speculative. We have made a conservative estimate of 13.4 million Pay TV subscriptions and an estimated 1.1 Pay TV services per Pay TV subscriber for estimated 12.2 million homes taking at least one Pay TV service via cable TV. For 1982-1985, we have increased Pay TV households by 18% per year. For 1986-1990, we have reduced this growth to 6.2% per year.

2. Cable TV Multiple System Operator projections for major new urban markets in 1980 and 1981 generally showed an anticipated 1.6 Pay TV subscriptions per basic cable service subscriber. Although some MSOs have used higher or lower projections, a ratio of1:1.6 has been used in cable TV proposals in Dallas, Portland, Omaha, Atlanta, Los Angeles and elsewhere.

3. Pay TV average subscription charges for 1978-1980 are based on industry reports from The Pay TV Census - 1980 (Paul Kagan Associates Inc., Carmel, California, 1981). Pay TV rates increased 4.33% from 1978-1979 and by 4.27% from 1979-1980. These represent reductions in constant dollars for each year and we considered continuing this trend. However, increased competition among programmers for Pay TV production will likely increase wholesale costs charged to cable TV operators.

Table 3: MDS, STV Revenues



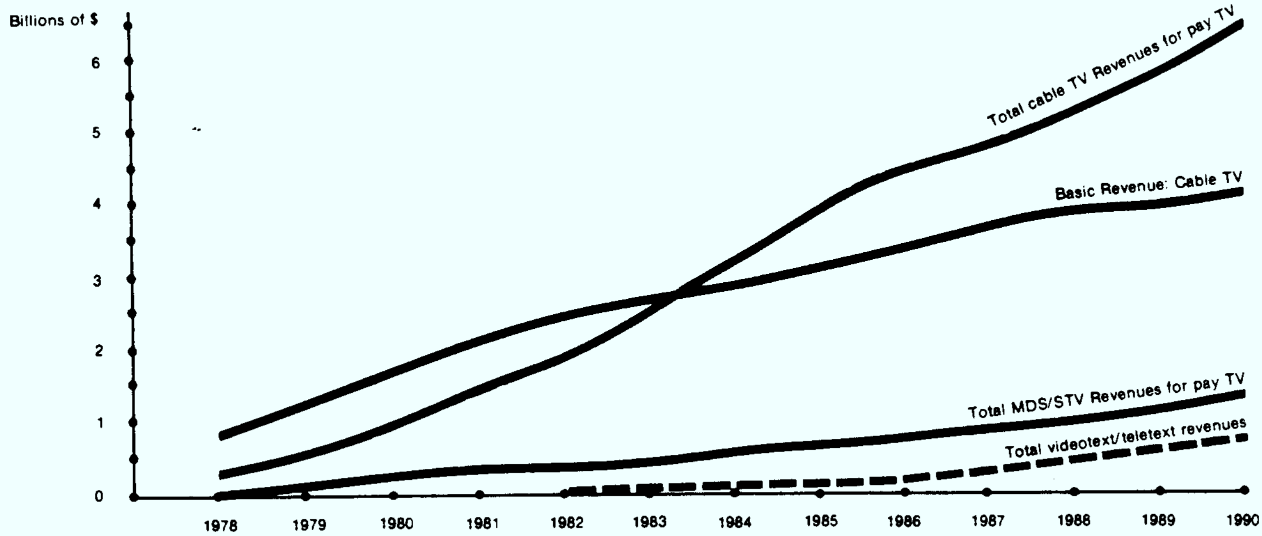
Projections	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Households with TV Sets (MM)	74.2	75.6	77.7	79.1	80.7	82.2	83.7	85.2	86.3	87.5	88.7	89.8	91.1
Households where MDS/STV is available (MM) 1/	6.3	16.9	24.5	27.6	31.1	35.1	41.0	81.0	82.0	83.0	84.0	85.0	86.0
Households subscribing to MDS/STV (MM) 2/	.3	.7	1.3	1.5	1.7	2.1	2.4	2.8	3.3	3.9	4.6	5.4	6.4
% of all TV households	.4	.9	1.6	1.8	2.1	2.4	2.8	3.3	3.8	4.5	5.2	6.0	6.9
Pay TV services per Pay TV subscriber	1.0	1.0	1.0	1.0	1.0	1.0	1.1	1.1	1.1	1.2	1.2	1.2	1.3
Monthly cost per Pay TV channel 3/	14.53	17.27	17.84	17.84	16.69	15.62	12.00	10.00	9.80	8.82	8.82	8.82	8.82
Total MDS/STV revenues from Pay TV (MM)	50	140	267	314	346	382	518	571	737	825	973	1143	1354

1. Based on MDS & STV industry operating data for 1978-1981 as reported in The Pay TV Census 1981 (Paul Kagan Associates, Carmel, California, 1981).

2. The long-term impact of MDS & STV competition with cable TV for Pay TV subscribers is only partly known. With two-channel MDS now being implemented on a experimental basis, the possibility of multi-channel MDS being discussed, and with two-channel STV also now being introduced, these technologies offer a strong prospect for vigorous competition with cable TV for non-interactive pay TV services.

3. Actual STV average monthly rates fell from $19.58/month in 1979 to $19.37 in 1980. MDS charges in the comparable period increased from $14.24 to $15.08. Because of competition from DBS cable TV, we anticipate STV & MDS rates to drop to totals comparable with DBS & cable television. We project monthly costs will drop to the average per pay cable channel charge in 1986, and will remain at 10% below this charge for 1987-1990.

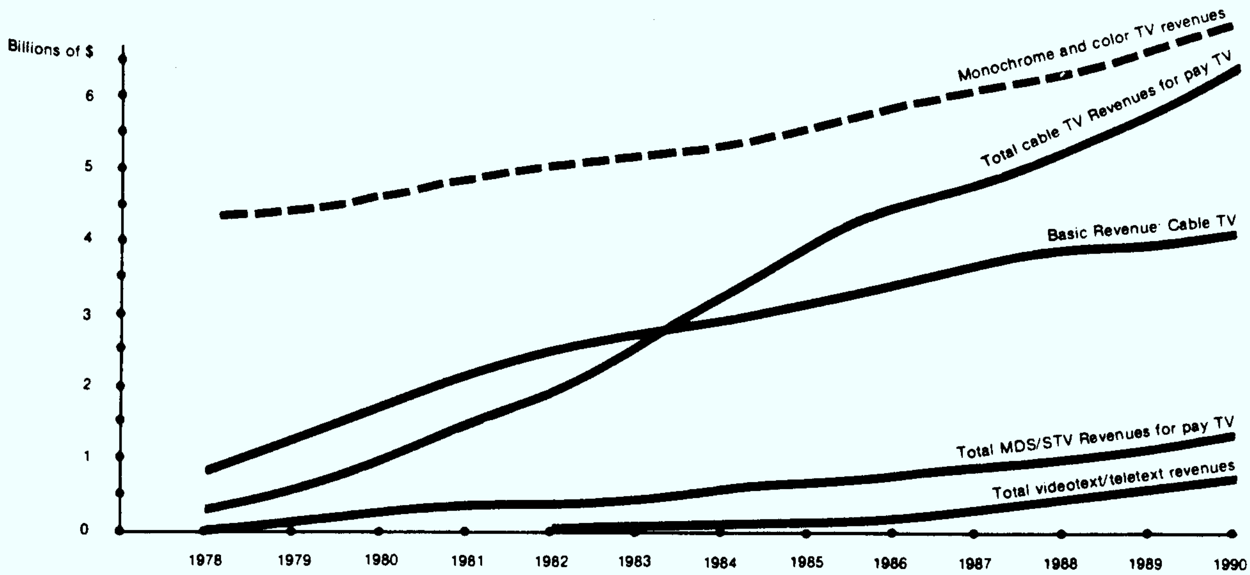
Table 4: Video/Teletext Revenues



Projections	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Households with TV Sets (MM)	76.0	77.3	79.3	80.7	82.1	83.5	84.9	86.3	87.5	88.7	88.9	91.0	92.3
Households subscribing to cable TV (MM)	9.3	13.9	18.0	21.6	24.9	28.3	31.9	35.3	38.5	41.2	43.4	45.6	47.9
Households subscribing to Pay TV (MM)	3.3	5.7	8.8	12.2	14.4	16.9	20.0	23.6	25.1	26.6	28.3	30.0	31.9
Households subscribing to MDS/STV (MM)	.3	.7	1.3	1.5	1.7	2.1	2.4	2.8	3.3	3.9	4.6	5.4	6.4
Households subscribing to videotext/teletext via cable MDS/STV & over-the air TV & telephone (MM) 1/	--	--	--	.02	.05	.1	.5	1.5	3.0	5.0	7.0	10.0	14.0
Average revenue/ subscriber/month	--	--	--	--	3.00	3.0	3.3	3.5	3.8	4.0	4.3	4.5	4.8
Total Revenues (MM)	--	--	--	--	.04	3.6	19.5	63.0	135	240	357	540	798

1. These projections are more conservative than those commonly made in the videotext/teletext industry. For example, Viewdata Report, May, 1981, 1:34, projects 2.5 million videotext/teletext homes by 1985 and we project 1.5 million. A range of sources project from 25% to 90% of TV homes in the U.S. using electronic home information services by 1990 and we project 16%. IRD News of March 14, 1980, p. 4, projects $500 million in direct fees and $2.75 billion in advertising revenues for teletext & videotext services, for a total of $3.5 billion.

Table 5: Monochrome & Color TV Consumer Spending

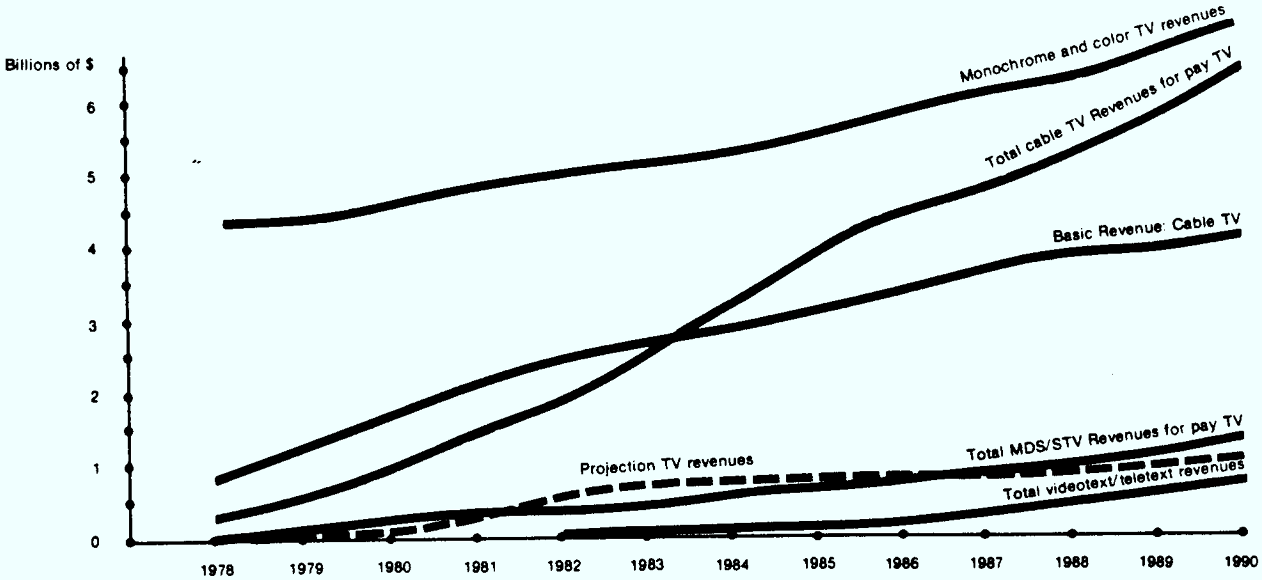


Projections	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
No. of all monochrome TV sets sold (MM) 1/	6.4	6.5	6.6	6.6	6.6	6.6	6.5	6.5	6.5	6.4	6.4	6.4	6.3
No. of color TV sets sold (MM) 1/	10.5	10.2	10.6	10.7	10.7	10.8	10.9	11.0	11.2	11.3	11.4	11.6	11.7
Total sets (MM)	16.9	16.7	17.2	17.3	17.3	17.4	17.4	17.5	17.7	17.8	17.8	18.0	18.0
Average price/set 2/	$249	253	262	272	283	294	306	319	331	344	358	373	387
Total sales (MM)	4223	4245	4532	4705	4896	5116	5324	5582	5859	6123	6372	6714	6966

1. TV sets sold for 1978-1980 are from Electronic Market Data Book 1981, Electronic Industries Association, 1981. Projections for monocrhome sales are based on continuation of 1955-1980 patterns. Projections for color sales are based on continuation of the 1973-1980 pattern. Projections for color TV sales do not include sales of projection TVs. An RCA Household Inventory of TV sets in 1981 showed a projected figure of over 43 million color TV sets in for U.S. Over 6 years old and that will need replacement. Our estimates are conservative compared with a projection this finding would indicate.

2. We project that the internal electronics package for current TV sets will drop in price by some 30%, and that increases to the degree that they occur, will result from consumer preference for better quality audio, and for microcomputer memory and display capability for text services. The principal component in the 4% annual average TV receiver price increase shown here is the increase in color TV sets sold as a proportion of the total TV sets sold.

Table 6: Projection TV Consumer Spending

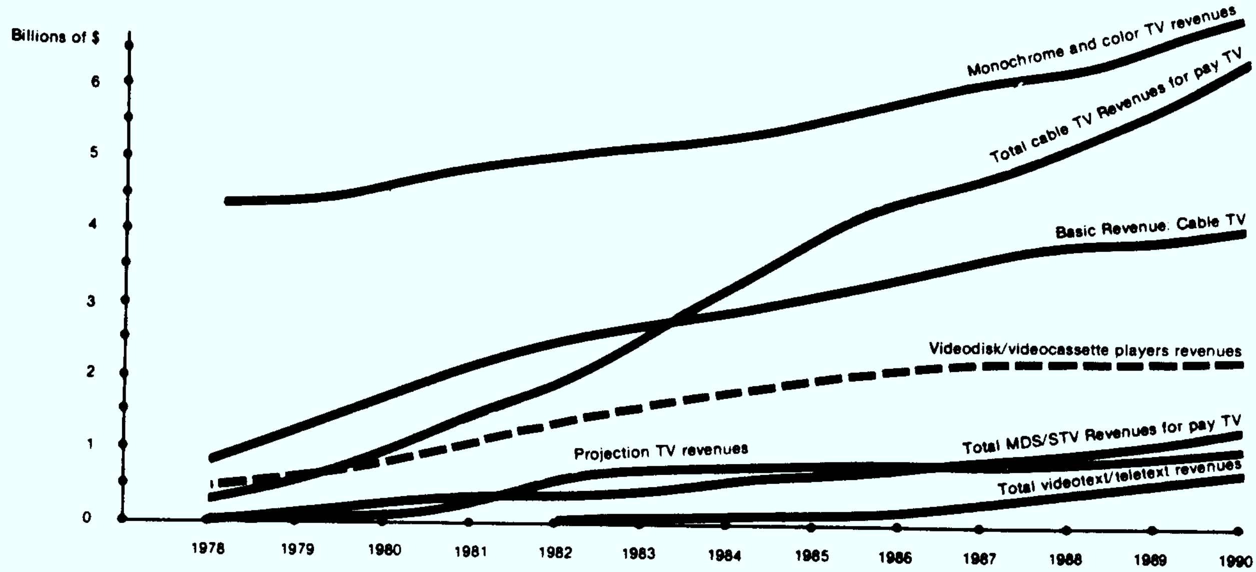


Projections	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Total Non-projection TVs sold (MM)	16.9	16.7	17.2	17.3	17.3	17.4	17.4	17.5	17.7	17.8	17.8	18.0	18.0
Projection TVs sold (MM)1/	.015	.026	.057	.118	.244	.260	.280	.300	.320	.340	.360	.380	.430
Average price/projection TVs 2/	2400	2640	2904	2760	2620	2490	2420	2370	2350	2320	2300	2280	2220
Sales of all projection TVs (MM)	36	69	166	326	639	647	677	711	752	789	828	866	955

1. Projection TVs sold from 1978 through November 1981 are actual figures reported to Electronic Industries Association. Figures shown for 1981 includes 8.33% increase for December. Prior to introduction of High Definition TV, we assume that unit sales of projection TVs sales will remain in the range of 1.5%-2.0% of non-projection units sold, with (constant dollars) sales volume of between 13% and 14% of non-projection TV.

2. For average projection TV prices, we assume here a production learning curve of 5%. Using average 1981 prices for a baseline, each doubling of cumulative production volume causes a 5% reduction in costs per unit.

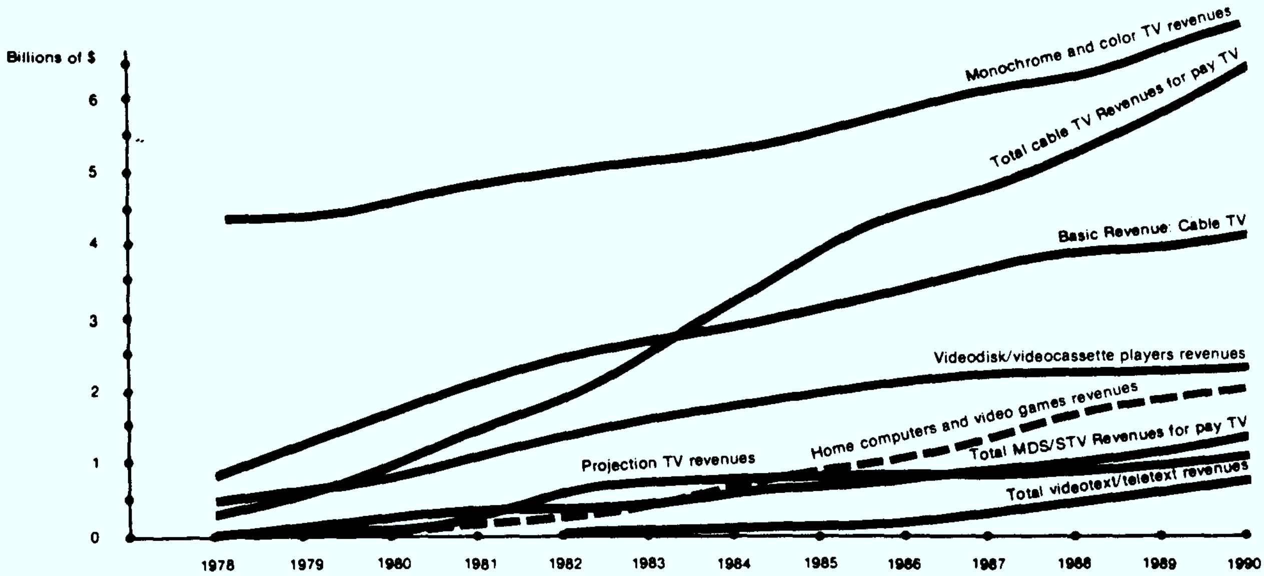
Table 7: Video/Videocassette Players Consumer Spending



Projections	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Households with TV sets (MM)	74.2	75.6	77.7	79.1	80.7	82.2	83.7	85.2	86.3	87.5	88.7	89.9	91.1
VCR/disc units sold (MM) 1/	401	475	875	1290	1690	2050	2480	3000	3383	3505	3632	3763	3900
Average price/unit 1/	1160	1077	1000	922	850	784	723	667	650	634	621	608	596
Total volume (MM)	465	511	875	1189	1436	1607	1793	2001	2198	2222	2255	2288	2324

1. Unit sales for 1978-1980 are based on VCR sales only. Prices and projected unit sales for 1981-85 are based on The Emerging Video Disc Market," Argus Research, 1980. Projections to 1990 assume a 5% learning curve. We have also assumed that after VCR videodisc player unit sales equal one third of color TV unit sales, then growth of the former will parallel growth of the latter.

Table 8: Home Computers and Video Game Consumer Spending

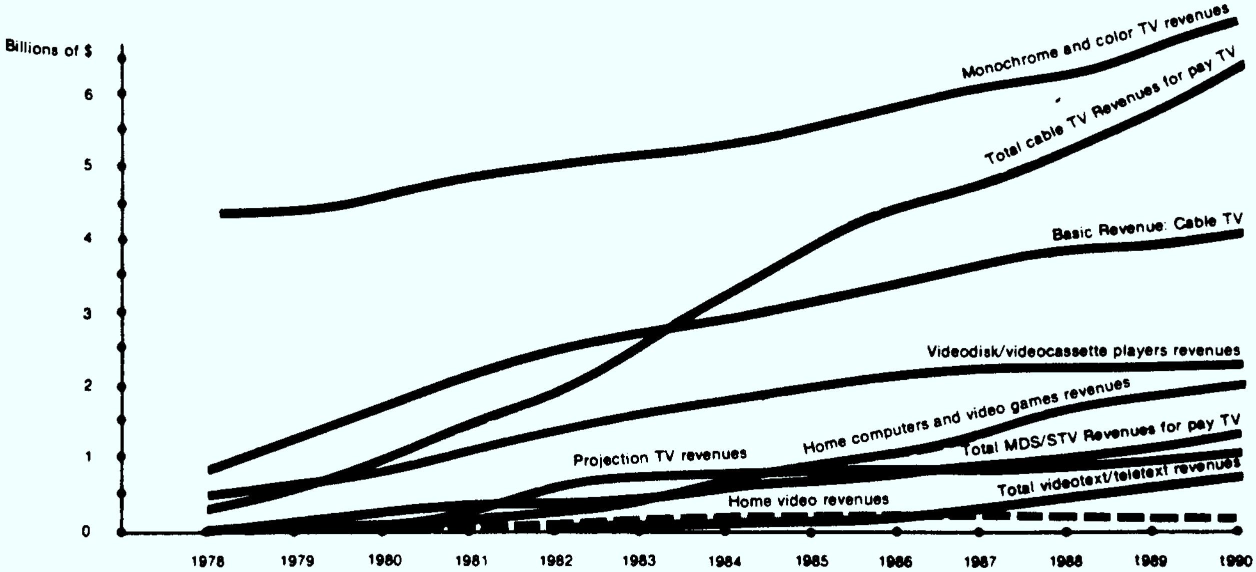


Projections	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Households with TV sets (MM)	74.2	75.6	77.7	79.1	80.7	82.2	83.7	85.2	86.3	87.5	88.7	89.0	91.1
Total personal computers and videogames for home use (MM) 1/	.020	.075	.124	.222	.398	.713	1.27	1.76	2.45	3.41	4.07	4.87	5.82
Cost/unit 2/	1893	1576	1312	1117	940	792	666	561	472	452	434	416	400
Total Sales (MM)	37.9	118	162	248	374	565	846	987	1156	1541	1766	2026	2328

1. Sales of computers in the "Personal Computer" category totalled 250,000 units in 1979, 400,000 units in 1980 and 600,000 units in 1981. These numbers include "small computers" for use in business, education and engineering. Approximately 31% of personal computer sales are for personal home use (see Preliminary Prospectus, Apple Computer Inc., Morgan Stanley and Company, December, 1980; Electronic News, September 7, 1981, p.4). We project continued high growth of personal computers for in-home use for games and text services with interconnection to data bases via cable TV or telephone lines, as receive-only or MDS or DBS as over-the-air broadcasting frequency transmission.

2. Two broad tiers of home computers have been grouped together. The sophisticated tier is made up of individuals purchasing computers for primary information functions, spending $1500-$4000 on hardware and software. The less sophisticated tier consists of users who primarily want entertainment, typically spending in the $200-$500 range.

Table 9: Summary of Home Video Consumer Spending



Projections	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Basic revenues from cable TV (MM)	810	1261	1695	2125	2375	2621	2863	3075	3354	3589	3781	3972	4173
Pay TV revenues from cable TV (MM)	320	577	929	1425	1855	2412	3175	3885	4422	4695	5321	5650	6377
Pay TV revenues from MDS/STV/DBS (MM)	50	140	267	314	346	382	518	571	737	825	973	1143	1354
Videotext/Teletext revenues (MM)	--	--	--	--	.04	3.6	19.5	63.0	135	240	357	540	798
Monochrome & color TV sales (MM)	4223	4245	4532	4705	4896	5116	5324	5582	5859	6123	6372	6714	6966
Projection TV sales (MM)	36	69	166	326	639	647	627	711	752	789	828	866	955
Videocassette/videodisc player sales (MM)	465	511	875	1189	1436	1607	1793	2001	2198	2222	2255	2288	2324
Home computer & video game sales (MM)	379	118	162	248	374	565	846	987	1156	1541	1766	2026	2328
Total	6,748	6,921	8,626	10,332	11,921	13,354	15,215	16,875	18,613	20,024	21,653	23,199	25,275
Total TV households (MM)	76.0	77.3	79.3	80.7	82.1	83.5	84.9	86.3	87.5	88.7	89.9	91.0	92.3
Average spending/TV household on home video services/year	88.8	89.5	108.9	128.0	145	160	179	195	213	226	241	255	274

newspapers, theatre attendance, or from categories that we haven't yet thought of.

Let's turn to Table 9. Table 9 shows the ratio of each of these spending categories to each other. What do these nine tables tell us? 1) That the range of entertainment and communication services available to consumers is projected to increase rapidly through 1990 by new technologies such as cable TV, pay cable, STV, MDS, home video, cassette recorders, disk players, teletext, video text, etc. 2) That consumer spending for information will double in the decade between 1980 and 1990, while total consumer expenditures for all communications services will remain. 3) High Definition Television offers potential expanded market opportunities for virtually every one of these categories of technology and service. What we've looked at now is only what happens without High Definition Television. Now let's look at what could happen when High Definition Television comes in and how we would see it come in.

HDTV TV set costs and sales

We had to go from the nine tables you see to try to make a projection for what's going to happen to High Definition Television set sales. To some degree, I suppose that Tables 1 to 9 are a kind of protective foliage for making the leap to saying "now how many sets are going to be sold." As you can see from Table 10, from the years 1984 and 1985, we're projecting High Definition Television sets sold for use with cable television and video cassette and video disk players. We're not assuming any over the air or DBS transmissions.

During the years from 1986 to 1991, we continue to break out High Definition Television sets sold for use in each of these categories and with direct broadcast satellite. In fact, the High Definition Television set designs we anticipate would be usable with each of these technologies. From 1990 onward, we do not differentiate between the High Definition Television sets for DBS, cable TV, or video cassettes and disks. Our cost projections, you see these over on the right, assume a 10 percent learning curve for production of High Definition Television components through 1990 and an 8 percent learning curve thereafter. In other words, each doubling of total volume of sets produced causes a 10 percent reduction in cost per component, and then after 1990 an 8 percent reduction.

Our DBS High Definition Television channel projections are broad estimates which demonstrate that we see the need

Table 10

	DBS/HDTV Channels[1]	Cumulative Total of HDTV Sets Sold/Rented (000)				Cost of HDTV Set		
		DBS Sets	CATV Sets	Disc/ Cassette Sets	Total Sets	HDTV Display Unit(s)[2]	HDTV Receiver[3]	Total Cost[4]
1984	—	—	5	2	7	1700	700	2400
1985	—	—	20	10	30	1400	400	1800
1986	—	—	85	40	125	900	100	1000
1987	3	20	160	80	260	810	90	900
1988	3	80	320	160	560	730	80	810
1989	4	120	440	260	820	680	75	755
1990	4	160	640	320	1120	650	70	720
1999	12–18	—	—	—	29720	435	45	480

NOTES:

1. This does not include analog fixed satellite service transmission to cable systems or theatres, or other cable, videocassette, or videodisc services.
2. HDTV display unit includes frame store.
3. HDTV receiver is a tuner to convert DBS or Cable TV signal to digital input to frame store of display unit. For 1986 and 1987, prices shown are for prototype quantities. Actual prices will vary by volume.
4. Outdoor electronics for DBS reception are not shown here. Cost is approximately the same for HDTV DBS or NTSC DBS. We project these costs per year, using volume production corresponding to years shown above at: $1,000, $700, $500, $450, $400, $360, $330, $300, $275, $240.

for a minimum number of differentiated channels as a critical mass to stimulate consumer interest in high definition TV. The current home video environment has radically altered the consumer's expectations regarding TV programming. Consumer expectations for home video have dramatically increased both in terms of quality and diversity. We estimate a minimum of three high definition channels will be required for consumers to be sufficiently exposed to high definition TV to stimulate initial demand.

As an alternative projection of High Definition Television sets, we took the growth curve of color TV sets in the U.S. 1954 to 1969 and let that curve stand for the growth of High Definition Television equipped sets in U.S. households in 1984 to 1999. Results are shown in the right-hand column of Table 11.

Table 11

Comparisons of Two Projections for HDTV

	Total HDTV Sets Projected in U.S. in Our Scenario (000)	**HDTV Househojds in U.S. Extrapolated from U.S. Color TV Households 1954–1959** (000)
1984	7	8
1985	30	17
1986	125	43
1987	260	175
1988	560	355
1989	820	539
1990	1,120	637
1991	—	831
1992	—	1,125
1993	—	1,810
1994	—	2,997
1995	—	5,199
1996	—	9,661
1997	—	16,479
1998	—	24,829
1999	29,720	33,472

As an alternate projection of HDTV sets, we took the growth curve of color TV sets in the United States, 1954–1969, and let that growth curve stand for the growth in HDTV equipped sets in U.S. households in 1984–1999. Results are shown in the right-hand column of the following table. The purpose was to get a sense of how our scenario projections for HDTV growth compared to actual U.S. color TV growth.

Mr. Bowen: In concluding this presentation, one might reasonably ask what is missing from the scenario. First and foremost, national policy is absent. The strategic national interests of two countries, the United States and Canada, are not necessarily well-served by the development of High Definition Television at the present time. True, both countries are rich in transmission capabilities, which will become the delivery mechanisms for High Definition Television products and services. But both countries are in the position of having to import an entire technical base and industrial capability in order to gain the full benefits of the High Definition Television revolution.

For Japan right now, strategic national interests in High Definition Television are clear. NHK began with consumer concern for better video perception and reception. MITI began with the relationship between industrial policy and government policy, and, though they have yet to take a position on High Definition Television, they will almost certainly relate it to a world market for High Definition Television sets and Japan's role in producing them.

For the United States, we would argue, the use of High Definition Television so far has been for product differentiation within a specific delivery technology, such as CBS exercised in its DBS application; for major production houses to reduce their production costs; and last, for selected video production equipment manufacturers to provide peripherals and components. For Canada and Western Europe, the situation is more bleak.

In conclusion, I suggest that four concerns be born in mind in a scenario for High Definition Television. I would suggest that regulatory constraint is perhaps the most important. For both the United States and for Canada, for High Definition Television to develop, it must be relatively free from regulation, rather than being constrained the way that the Canadian pay television industry has been constrained for the past decade.

Also, the United States and Canada, who are rich in transmission potential, should exploit their transmission advantage, particularly in cable and satellite, while it lasts. The programming capability in each of these countries for using High Definition Television is very strong, both in video and film. Our video programming will benefit worldwide.

But ultimately, strategically and economically, the High Definition Television prospect for both the United States and Canada is poor unless we can capture our domestic High Definition Television set market. Thank you very much.

Thank you Mr. Bowen and Mr. Guite. We have time for two short questions before we go to the next decision.

George Kenney, Phillips Laboratories, North American Phillips: I was quite interested in your analysis of the zero sum game for the dollars spent. I'd ask you the same question about time. Are we in fact not competing for the consumer's time--aren't we competing for his tennis game, or his skiing, or for the video games of home computers? How are we going to attract people to the High Definition Television television set. Are we going to re-sell old movies with twice as many lines?

Mr. Bowen: Let me answer in terms of minutes watched. The Japanese use a different measure, a per set measure of time spent watching television. But it aggregates to something about an hour more per television household than ours in the U.S. I'm sorry to say that I don't know what it is in Canada. Our average television viewing in the United States is 6 hours and 40 minutes currently. Those are hours of sets on. I think what you're probably going to find is a differentiated use. The KBA judgement is that the U.S. television set is on a great many more hours than it is in fact actively viewed.

We also are mindful of other measurement techniques coming along which are determining program satisfaction and qualitatively segmenting the viewing hours. If there is softness in the viewing measurement numbers now, there will continue to be softness in the measurement numbers. But the number of hours the set is going to be on has not diminished and is not likely to diminish in the USA, Canada, or Japan.

Mr. Guite: When you segment people by education and by socio-economic background, and then you take that category within each group that looks at more TV and looks at less TV, you find that those who look at more TV are less likely to vote, less likely to have participated in any activity related to government, and less likely to have recently attended a family event. There is no question that TV viewing time comes out of a limited budget and it's reallocated from our personal lives.

Bob Barrett, CAU Electronics: In your projections, you compared High Definition Television to the introduction of FM and color TV, both of which were major expansions on an existing system. FM added stereo and high fidelity, color TV added color. The same with video disks, etc., High Definition Television devices are devices that were not available before; they are completely new. Isn't there some fear that

High Definition Television will be looked on by the average consumer, who is probably quite satisfied wth the present TV set, as just an extra frill, much like quadrasonic sound was in the 1970's?

Mr. Guite: You're right about what you're saying. What was of special interest to us in looking at FM and color TV, was the extraordinary length of time it took for both those innovations to become successful, assuming that they really were major steps forward. So that High Definition Television won't likely occur on a faster time frame, if it's a little bit less dramatic. It might occur on a much longer time frame, if it's a little less dramatic. CBS was worried about the consumer acceptance issue, so they funded research in several cities where High Definition Television demonstrations were presented. The results have become available. The object was to see what kind of value the consumer puts on High Definition Television reception compared to something else.

Mr. Bowen: I would add that their specific research results showed that over 80 percent of those who saw the High Definition Television demonstrations at three regional sites said they would pay up to twice what they're presently paying for current color televison sets to receive high definition images such as they had just seen in the demonstration.

Thank you, Mr. Bowen and Mr. Guite. I guess that this question raises more questions than this time would allow to answer, and again, workshops will probably be the right place tomorrow and the day after to answer and ask those questions.

NHK

THE PRESENT STATE OF THE DEVELOPMENT OF HDTV EQUIPMENT AND PROGRAM PRODUCTION

by

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and
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1. INTRODUCTION

NHK has been making every effort to develop a high-definition television equipment of 1125 scanning lines system. At present, various experimental equipment have been developed, such as TV cameras, Laser Telecine for 70 mm movie film, VTR, color encoder and receiver for satellite FM transmission, display devices and high-resolution color monitors, in cooperation with several manufacturers of Japan. These equipment are used effectively to further progress the study of HDTV broadcasting system in the test program production, field pickup tests and signal transmission tests to ensure the effect of immediacy due to high-resolution wide-screen pictures.

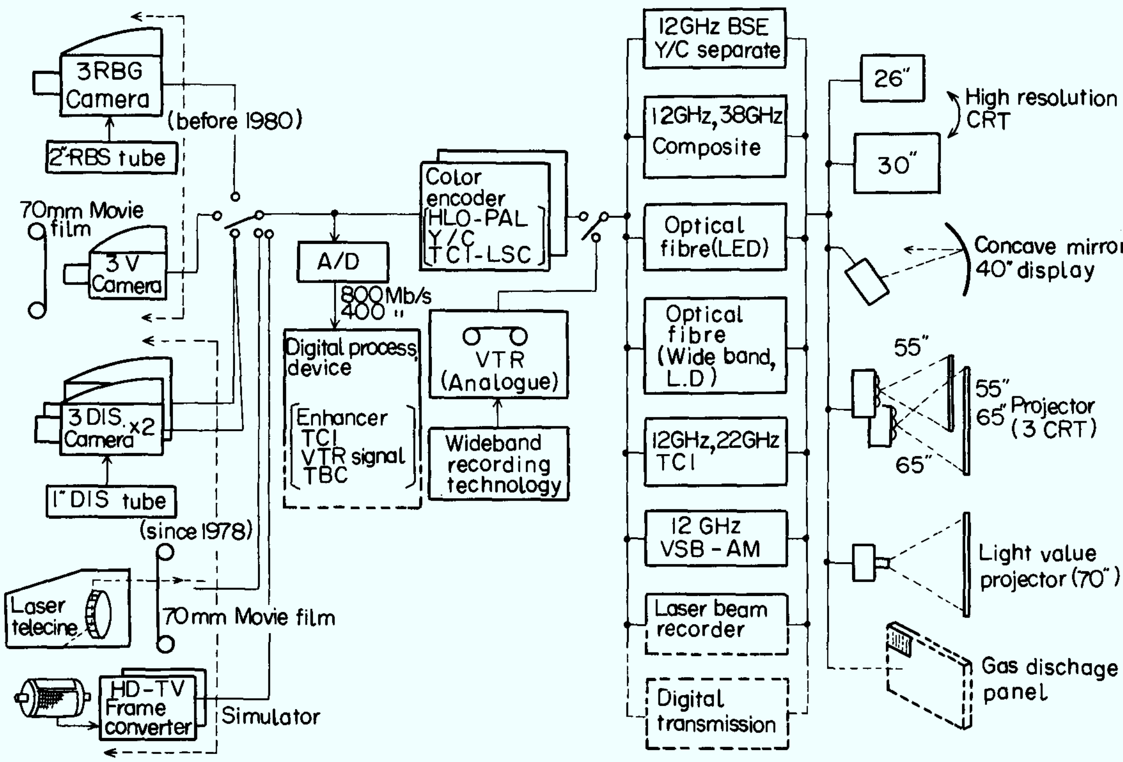
2. DEVELOPMENT OF HDTV EQUIPMENT

Almost all of the HDTV equipment have been developed at NHK and they are operated under the NHK's provisional standard as shown in Table 1 and Fig. 1.[1]

2.1 Camera

HDTV cameras were taken up work from the beginning of HDTV research in 1973. In the early stage of the research, an RGB three-tube color camera[2] was produced on a trial basis using a 1.5-inch electrostatic-focusing vidicon (8480).

In the second step, a high-resolution 2-inch return beam Saticon (RBS) tubes and camera were developed from the viewpoint that high resolution would be the most important factor for the camera. The camera had sufficiently good resolution compared with the characteristics of the system other than the camera. It was very useful as a signal source in evaluation tests. A variable scanning line monochrome camera[3] capable of operating up to 2125 scanning lines was also developed using an RBS. The camera had a



Solid Line : Completed
Dotted Line : Under development

Fig. 1 Various HDTV equipment already developed.

Table 1 HDTV equipment developed by NHK

	Scanning specifications	Cameras	Display devices	Encoders, Transmission equipment
Monochrome	265~2125 lines 50/60 fields 1 : 1~5 : 1 interlace ratios	2-inch RBS camera 1-inch DIS camera	27-inch CRT (4:3 aspect ratio)	Composite signal (NTSC, PAL, SECAM HLO-PAL Linear gamma system
Color	1125 lines 50/60 fields 2 : 1 interlace ratio f_y : 19~20MHz f_w : 7.0MHz f_N : 5.5MHz	Live cameras 2-inch 3 tube RBS 1-inch 3 tube DIS Film cameras 1.5-inch 3 tube vidicon 70mm 2-3 pulldown movie projector Laser FSS (continuous running)	Laser display 22-inch CRT (a=4:3, P=310μm) 26-inch CRT×3 (0.5m×1.0m size) 30-inch CRT (a=5:3, P=340μm) 55-inch projector (3 tubes) Light-Valve 26-inch CRT (a=5:3, P=370μm)	Y-C separate transmission device Wideband FM modulator, demodulator Optical fiber transmission devices VTR (analogue)

Note RBS : Return Beam Saticon, DIS : Diode-gun Impregnated-cathode Saticon,
a : Aspect ratio, P : Shadow mask

video signal band greater than 100 MHz and is contributing to the research[4] of scanning systems in combination with a 27-inch monochrome monitor.[5]

However, the capacitive lag of an RBS is so large that an RBS is not suitable for picking up moving pictures. After that, efforts were made to develop a pickup tube with high resolution and low lag, resulting in a 1-inch diode-gun impregnated-cathode Saticon (DIS).[6] A three-tube color camera[7] was developed using this DIS. The camera permitted live picking up of moving pictures with high resolution and low lag for the first time, and a good prospect of developing a practical camera could be obtained. The camera and displays were first shown at the open house of the NHK Technical Research Laboratories in 1980, and also at exhibitions throughout Japan and a demonstration in the United States in 1981, and 1982. At all of these demonstrations, the system was highly evaluated.

The features of this camera are as follows.

(1) Nearly similar mode to that of a camera for practical use
(2) High accuracy registration
(3) Emphasis on preventing oscillation and on enhancement of stability

The principal characteristics of this camera are shown in Table 2. The scanning size of the DIS can be set about 10 % larger than the regular size of a 1-inch tube. The resolution is close to that of a 3 RBS camera (see Fig. 2). In fact, there is no difference between the two cameras when pictures by these cameras are shown on 30-inch CRT display.

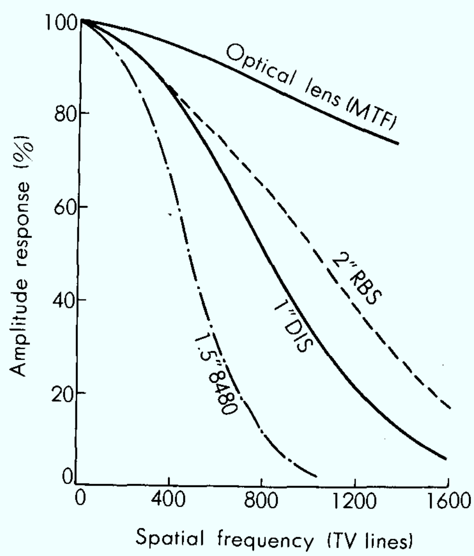


Fig. 2 Amplitude response of various pickup tubes.

Table 2 Specifications of various cameras

Camera		3 RBS	3 DIS	1 RBS
Year of development		1975	1980	1974
Number of scanning lines		1125	1125	($\leq$ 2125)
Video signal bandwidth (MHz)		50	60	110
Pickup tube		2-inch RBS	1-inch DIS	2-inch RBS
Optical lens		85mm, F4	14 times zoom, F2.1	55mm, F3.5
Sensitivity		2000lx, F5.6	2000lx, F2.8	1400lx, F8
Limiting resolution (TV lines)	center	more than 1500	1600	more than 1600
	edges	more than 1000	more than 1200	more than 1200
Signal-to-noise ratio* (dB)		38	39	36
Lag** (%)		about 30	below 1	—
Misregistration (%)	80% circle	less than 0.1	less than 0.03	—
	Outside the circle	less than 0.2	less than 0.03	—

* Signal-to-noise ratio of luminance signal for video bandwidth of 30MHz
** After 3 fields for standard signal current

Lag is very small, and blur by an integration effect is more noticeable in picking up moving pictures than blur by the lag characteristic. Because the resolution is high, the difference between still picture portions and moving picture portions is sometimes large, giving an unnatural impression. This will be a problem requiring future study in relation to the overall system.

At present, the sensitivity is lower compared with those of conventional standard cameras because of a large signal current (0.5 μA) to secure the required S/N ratio and because of the poor light utilization factor caused by an aspect ratio of 5 : 3, among other reasons.

As there is room for study regarding the present standard signal current, and there is possibility of improvement in sensitivity by one lens stop. Registration can be obtained nearly completely in the entire picture area. Recently, several Japanese manufacturers, following the NHK, have also developed cameras of 1125 line system using Plumbicons, or magnetic focusing and static deflection (MS) Saticons.

In foreseeing the future of the pickup device of a high-definition television system, a solid-state pickup device such as a CCD would be desirable in a long-range outlook. However, at the present, there is no alternative but to depend on a pickup tube. Characteristics of a pickup tube naturally have to be enhanced.

2.2 VTR[8]

For more than ten years, the NHK Technical Research Laboratories have been working on the wideband magnetic recording from a variety of aspects such as the tape head, tape running mechanism, and signal processing. Based on the research on the magnetic recording and signal processing, a prototype VTR for the high-definition television using analog (FM) recording (to be referred to as high-definition VTR) has been constructed (Fig. 3).

The modified 1-inch type C machine was used as the mechanical system, by making use of the up-to-date technology in the rotary head mechanism. To record the wideband signals of high-definition television, the rotating speed of the head drum was doubled and the head trackwidth was arranged to increase the tape running speed two times that of a standard 1-inch type C machine.

The wideband recording head with the high resonance frequency (60 MHz) is used with the combination of (Co)γ-Fe_2O_3 coated tape. The recording signal is the Y-C separate signal and Y-part and C-part are recorded on the two

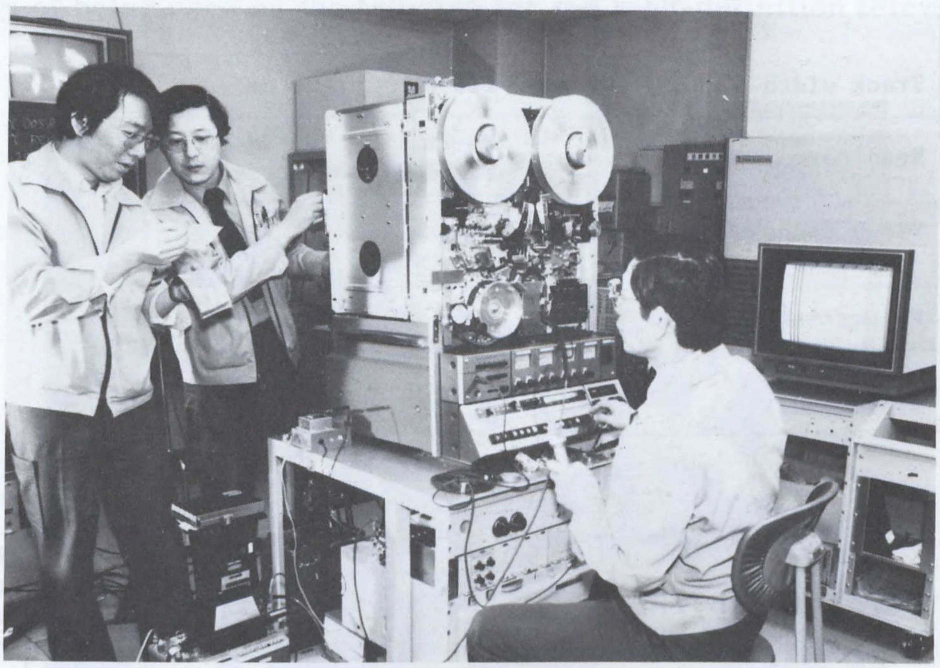


Fig. 3 HDTV VTR.

tracks of the tape after FM modulation. The specifications of the prototype VTR are summarized in Table 3. To increase the demodulated S/N ratio in a limited C/N ratio of the RF signal, a new playback equalization technique was applied.

The time base error corrector (TBC) was constructed by using the high-speed digital technology including the A/D-D/A converter for the high-definition television signal. The overall video signal performance of the VTR is shown in Table 4. The playing time is 48 minutes with the tape of 10.5'' reel size.

The high definition VTR was developed by getting various factors into a condition of balance based on theoretical analyses and test results. The VTR was tested in the field and satisfactory picture quality was obtained, and it is used for HDTV test program production.

Table 3 Specifications of the prototype VTR

Mechanical system	Modified 1" type C	
Writing speed	51.7 m/s	
Tape running speed	48.8 cm/s	
Tape used	(Co) γ-Fe_2O_3 coated	
Recording signal	Y/C separate	
	Y	C
Track width	110 μm	50 μm
Head core	Mn-Zn Ferrite	Mn-Zn Ferrite
Video bandwidth (MHz)	20	7 (line seq.)
FM carrier (MHz)	30 ∿ 40	12
Maximum deviation, video (MHz)	10	3

Table 4 Overall performance of the VTR

Signal	Bandwidth (MHz)	SN Ratio (dB) unweight	Moire (dB)	Residual timebase error (nS)
Y	20	42	<-40	2nS
C	7	45	<-40	

2.3 70 mm Film Laser Telecine[9]

Theatrical films, beautiful and full of force, are important and attractive program sources for high-definition television. In order to convert film pictures into high-definition television signals without degrading the picture quality, high-quality film transmission equipment, telecine equipment, is necessary.

The NHK has been conducting research and development of such telecine equipment for transmitting 70 mm film, the highest quality among theatrical films. Its outer appearance is as shown in Fig. 4.

At first, a prototype 3 V telecine was produced combining a 3 V camera using three high-resolution vidicons and a 70 mm movie projector.[10] However, resolution and S/N ratio were not satisfactory for a high-definition television system.

Under these circumstances, the development began for an entirely new telecine using a laser beam. This new telecine effectively utilizes the properties of a laser beam, and in principle, a high resolution and high S/N ratio can be obtained. Furthermore, continuously moving film images are read in a lap-dissolve fashion, so that the telecine permits a free selection of the film running speed and television scanning specifications. A laser telecine has many advantages in terms of performance and functions, and has a large possibility of being used as the telecine for the high-definition television system.

Fig. 4 Laser Telecine equipment.

The basic principle of a laser telecine is to read images by directly scanning film surfaces using a laser beam which excels in the directivity, luminous intensity, and monochromaticity. A picture quality excellent in resolution, S/N ratio, and color reproducibility can be obtained.

Three laser beams for R, G, and B are combined into one beam, and a raster is formed through horizontal and vertical deflection. This raster is focussed on a film plane through a rotating polygonal mirror for frame synchronization ensuring phase lock between the film frame frequency and the television frequency. The laser beam passing through the film is decomposed into R, G, and B components, each of which is converted to an electrical signal using a photomultiplier.

The raster change from one frame to the next frame in the continuous moving film is performed in a lap-dissolve fashion by utilizing beam spliting by ridge edge between sides of a rotating polygonal mirror for frame synchronization.

Fig. 5 shows the construction of the Laser Telecine and Table 5 lists the specifications of the equipment. The aperture response of the scanning laser beam is about 50 % in a green channel with 1000 TV lines. The signal-to-noise ratio is about 44 dB (unweighted) in a green channel for a video bandwidth of 30 MHz. With this Laser Telecine, lustrous pictures excellent in resolution, signal-to-noise ratio and color saturation are reproduced. With respect random noise in particular, system noise produced in the equipment is extremely small and for a fine grained slide reproduction, random noise including the granurality noise is almost unrecognizable on the CRT display.

Table 5 Specifications of Laser Telecine equipment

Laser F.S.S.	Horizontal deflection	25-sided rotating polygonal mirror (81,000 r.p.m.)
	Vertical deflection	Galvanometer
	Laser R G B	He-Ne (632.8nm) 15mW Ar^+ (514.5 //) 5 // He-Cd (441.6 //) 10 //
Film transport		Continuous
Frame read-out		Lap-dissolve system by means of 48-sided rotating polygonal mirror
Ability	Color registration	Negligible small over entire picture area
	Aperture response	> 1,000 TV lines (−10dB)

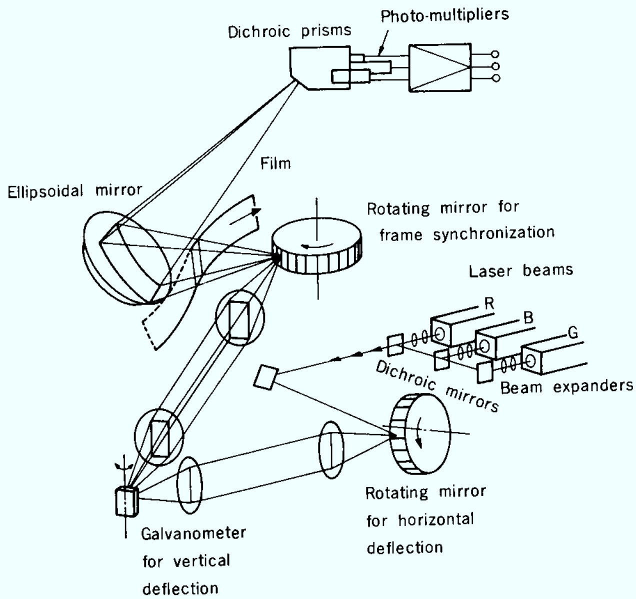


Fig. 5 Optical layout of 70 mm Laser Telecine.

2.4 Transmission Equipment(11) ~ (18)

In addition to the HDTV equipment mentioned above, we developed many other equipment which have been used for various HDTV transmission experiments.

(a) a color encoder which converts TV camera output signals to broadcasting signals, and a color decoder which decodes the received signal to RGB primary color signals, and a PCM sound signal multiplexer
(b) a wideband FM modulator and demodulator for HDTV transmission
(c) a wideband HDTV transmission system using optical fiber
(d) a microwave transceiver for the transmission tests at the SHF and EHF bands

3. EXPERIMENTAL TESTS TOWARDS HDTV SERVICE

3.1 Transmission Experiments of HDTV Signal

The Japanese experimental broadcasting satellite "YURI" (BSE) was launched in April 1978. The HDTV transmission experiments via the BSE were performed three times at NHK Technical Research Laboratories with the cooperation of the Japanese Ministry of Posts and Telecommunications.(19)

As the transmission power of the BSE is low, the Y-C separate transmission system in which luminance signal and line-sequential chrominance components were transmitted through individual FM channel was used for efficient transmission of the signal with low transmission power.

The experiment showed that picture quality with good signal-to-noise ratio could be obtained when received with a 1.6 m diameter antenna.

For HDTV broadcasting system, it will be necessary to develop new transmission media and new frequency band. Application of millimeter band (into the field of HDTV transmission) has been studied. A transmission equipment with 400 mW IMPATT power amplifier of 38 GHz band for HDTV has been developed and HDTV signal transmission tests were carried out between the NHK Laboratories and the NHK Broadcasting Center in Tokyo. It was made clear through these tests that HDTV signal (HLO-PAL) with the S/N ratio of threshold detectability could be transmitted at a distance of 8 kilometers and with the rainfall of 5 mm/hour when 40-cm diameter antennas were used both at the transmitting end and the receiving end.

3.2 Field Pickup Tests and Test Program Production

In order to ensure the effect of the sensation of reality due to high-definition large-screen television display, the HDTV system was used last year (1981) on a trial basis for the origination of sports-events programs outside the studio. (Fig. 6) The system including a camera, a VTR and display systems worked out satisfactorily.

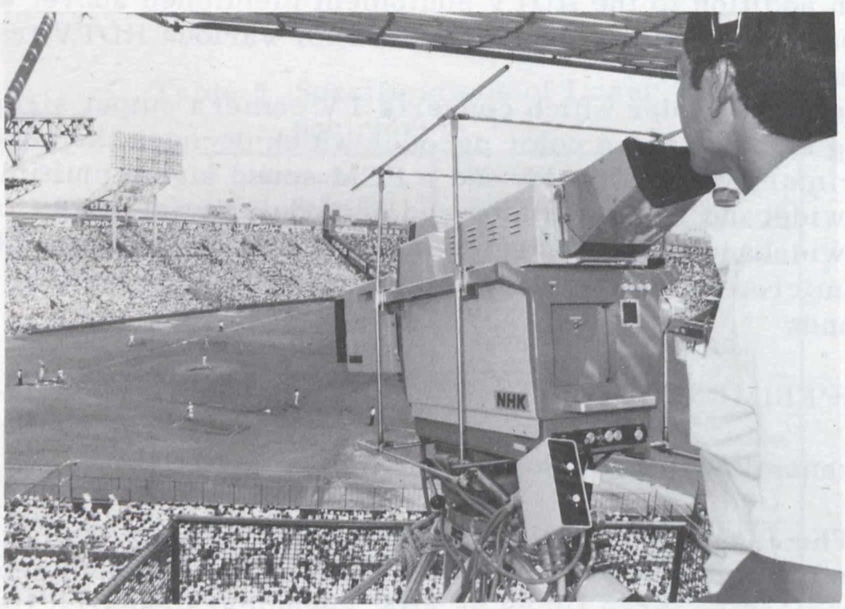


Fig. 6 Field test of HDTV camera.

The reproduced pictures were quite superior to existing television, and the sensation of reality was very impressive together with the stereo sound.

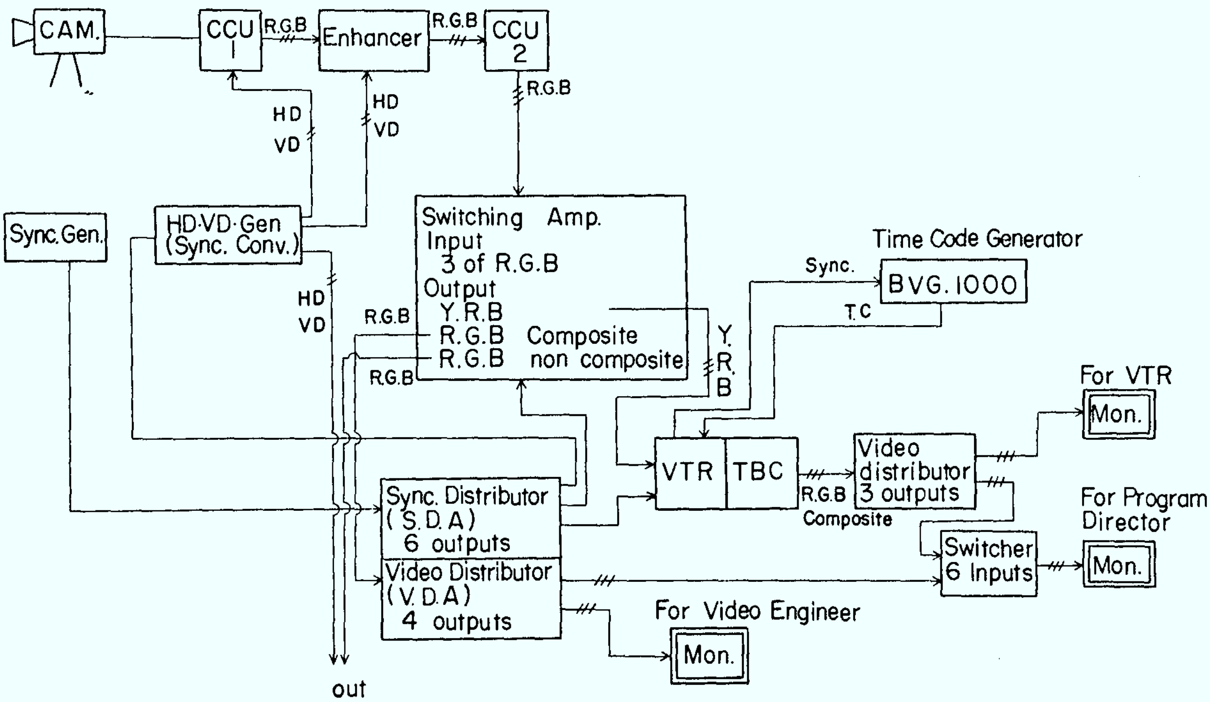
In October 1981, a special HDTV program was experimentally produced by specially organized production crew of NHK. They visited various parts of Japan in order to pick up typical Japanese scenes to depict the beauty of Japan – tranquility and dynamism. The program was turned out very attractive and highly evaluated both in picture quality and the sensation of reality by everybody who saw it. Especially, the program producers were enchanted by the force of HDTV and said how excellent it was.

(1) "I have never got tired whenever I looked at the pictures in which the birds were having water bathing in the mountain stream with the leaves scattered over the water. I could always find out a fresh discovery and an amazement in looking at the every part of pictures. In comparing with the conventional TV pictures, there was much difference in picture quality as if the conventional TV camera was in out of focus. I was always anxious about it."

(2) "The high-definition TV gives you a feeling of clearness or a kind of different nature which the present printing pictures never give. When you look at it, you feel the conventional TV picture leave something to be desired. I wish to take something like a traditional picture scroll in the future. I think it is quite satisfied to depict the traditional Japanese culture because of the size of picture frame or the power of expression. Looking at the high-definition pictures on the 65-inch display developed for home use, I feel the large display gives you more forceful impression and the sensation of reality than those of the conventional TV pictures even in watching the same movie film. The aspect ratio of 5 to 3 is also quite satisfied by taking baseball games or horse races. I feel something mystery the conventional 4 to 3 TV picture makes us feel boorish after looking at HDTV pictures."

Fig. 7 is the video and sync block diagram of HDTV OB van.

Fig. 7 Video and sync block diagram of HDTV OB van.



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HIGH DEFINITION TV: BOOM OR BUST FOR CABLE TV

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If a high resolution television system is to be developed in Canada it will have to follow a profile that is different from any previous historical course in the introduction of a new technology in the television industry. For example, when colour was introduced it was both upwards and downwards compatible with the monochrome system. The system allowed the receiver to receive the colour transmission on a black and white set and a monochrome transmission on a colour set and it, therefore, became an easy step to introduce new technology in the form of colour transmission.

However, with the introduction of a high definition TV system especially if the aspect ratio of the system is changed, then it will be difficult to get any compatability. However, a downward compatability should be strived for. Perhaps putting it a different way it is necessary in my opinion for a New High Resolution receiver to receive not only the transmission designed for the set but to also receive the present transmissions that are currently the transmission standard of that country. People will just not have two display devices in the same room to watch television and for that reason for any high resolution system to be successfully introduced the monitoring device must be downward compatible. Upward compatability would be considerably more difficult. It would require a modified transmission system and also a line conversion, demod, remod device to be attached to the conventional receiver. Upward compatability should not be just written off and does require a great deal of resource and effort to determine its practability.

One thing that can however be dismissed without any further consideration is the transmission and distribution of all services in both systems or even the duplication of the national service in both systems for any length of time.

How then might a high definition system then develop in Canada? Firstly, it has to be allowed to develop without further extraction of a "social dividend" and without roadblocks by bureaucratic agencies. There has to be room for a number of people to make a number of mistakes. Different things must be tried, some of which will succeed and some will fail, but there has to be reasonable rewards for the successful and an opportunity to try again for the failures.

One of the first to use this new technology will be the movie industry and not the broadcast industry. They will use it in the production of movies. These will be replayed in an entirely different type of theatre than we know today. It will be a small intimate area holding about 15 to 20 people in each room and it will be either a dinner theatre, a lounge theatre or a pizza theatre, showing first run movies along with meals, drinks or just pleasant surroundings and carrying a cover charge to pay for the movie. I believe there will be an opportunity for a centralized distribution system rather than video equipment at each location.

With high resolution TV, the potential exists for electronic billboards. This will be ideally suited to shopping malls and eventually used outdoors. This system would best function with a forward and store system connected between the cable system and each location.

Of course, the obvious application for high definition TV on cable is for a Pay TV channel. The success of this is completely dependant on the poliferation to high definition receivers and this would be directly proportional to whether or not the receiver is downward compatible.

It is highly unlikely, with the state of the economy in Canada, that it would be a politically sound decision to introduce a tax supported high definition television system and because of declining revenues in the advertising supported television system it is equally unlikely that we will have a national network of any sort with a new system.

Therefore, it would seem that in the foreseeable future the only way for a high definition television system to develop here in Canada is by cable distribution and local originations through cycled tapes.

But what about the problems of distribution of HDTV on cable? Let me say that they are numerous and will require a substantial amount of innovative research to solve the transmission problem.

Firstly, there is going to be a noise problem. It would appear that the minimum overall band width on the cable would be 30 MHz, perhaps more. To maintain the same perceived horizontal resolution of about 400 line resolution on a new monitor with the aspect ratio of five by three instead of four by three would require an additional 100 lines of resolution or another 1/5 more band width. Also, just to maintain the present perceived resolution and increase the number of vertical lines from 525 to 1125, over twice as much, will require a doubling of the band width of the transmission system. So, to maintain the same perceived horizontal resolution in the system, with no improvement whatsoever in resolution, requires about two and one half times the band width or approximately 10 MHz of luminance band width. For each additional 100 lines of horizontal resolution in a 1125 vertical line system with a three by five aspect ratio, the band width required is approximately 2.25 MHz. The proposed NHK system from Japan uses a luminance channel of 20 MHz. The signal to noise ratio is 55 db. Unfortunately, cable systems are not noise free devices. To maintain a carrier to noise ratio to produce the signal to noise ratio over this band width alone may in fact not be achievable with standard practices. The second major problem is third order distortion products appearing in the pass band when this broadband signal is transmitted over cable with twenty to thirty standard NTSC signals. These beats may in fact be a greater problem than the carrier to noise problem.

There is no point in trying to minimize the problems. They are indeed very real and very large in magnitude. There are solutions, some of which may not be economically practical but I am quite confident that acceptable solutions can be found if there are reasonable incentives to find solutions.

The cable industry in Canada cannot be considered as the fair haired prodigy of specific government departments or its regulatory agencies. In fact, technology and opportunity have been continually denied the cable industry over the years. The cable industry in Canada realized the opportunities to develop Pay TV long before it was introduced in the U.S. Next February it will be introduced into Canada with the cable industry's only involvement being that of a non exclusive carrier and long after it was introduced into the U.S.

In the development of High Definition Television, if the cable industry found that it was to be the transmission medium for a national system or for someone else's service then there will undoubtedly be a lack of enthusiasm to spend large quantities of money and effort to develop a transmission system on cable. The cable industry would not be opposed to carrying these signals provided these channels were leased from the cable companies.

There is here, in this newly developing technology, the opportunity for substantial co-operation in developing policy and perhaps an industry. Representatives from Government, the Regulatory Agencies, and Industry must first of all develop a policy toward High Definition Television. This policy must be defined in absolute terms and done now - not later. For example, for the time being if there is no policy and in a few years it is announced that we will have a national high definition TV network distributed direct to home by satellite, then the cable industry would only respond by saying "Weren't we clever by not doing anything because we knew that government policy would again try to exclude cable systems from this new technology".

That is a very plausible scenario of how the policy toward this new technology could develop and we all recognize it as such. So unless there is a conscious effort to bring all of the interested groups together, then it is highly likely that each group will chose a path over which it has control of the eventual outcome.

In the newly developing high definition television technology we could see industries such as the telephone companies, cable companies or new entrepeneurs developing a completely closed system outside the regulatory environment to deliver the theatre of the future to the home and business along with a multitude of other non-broadcasting services. The choice is really in the hands of the policy makers and tomorrow is too late to start formulating that policy.

HDTV AND VIDEOTEX/TELETEXT SERVICES

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Telidon, like other videotex systems in the world, is a rapidly evolving medium, but unlike most other videotex systems, Telidon will readily accept high resolution displays systems, and will in fact facilitate the coming of digital TV.

Telidon is a communication code which was conceived at the Communications Research Centre (CRC) of the Canadian Government, in the 1970's. It has only been implemented outside of the laboratory, during the last 5 years. In that time, it has seen growing international interest and involvement, which has in turn led to its adoption as the North American and as an International Standard, the development of a new industry, and the commercial availability of Telidon equipment and services. Conservative forecasts have predicted between 250,000 and 400,000 Telidon terminals in Canada by 1985, and the potential of a multi-billion dollar national and international market has led Canadians to invest an estimated $90 million in this new medium.

This paper will introduce you to the world of videotex and in particular, Telidon. It will describe the characteristics of Telidon so that you might better understand it, and in so doing be able to judge for yourselves, the potential of some specialized applications which I believe need both Telidon and high resolution displays. In closing the paper I will comment on the impact of Telidon as a frame storage/processing system for Digital TV.

VIDEOTEX

Videotex is a communication medium which has only evolved within the last decade. The term Videotex is generic for computer information systems which are able to use a TV set as the display device. Britain developed the first videotex System - Prestel, in the early 70's and that service has grown to hundreds of thousands of pages of information, and over one hundred thousand terminals (users). Prestel, along with the French system - Antiope, and the Canadian system - Telidon are the three videotex standards which are recognized internationally (C.C.I.T.T./C.C.I.R.). As of June 1982, the Canadian Standards Associaton (CSA) and the American National Standards Institute (ANSI) have jointly adopted Telidon as the basis for the North American Videotex Standard - "North American Presentation Level Protocol Syntax". The establishment of international standards and the evolving videotex markets, will within a decade serve to place Telidon in the homes and the offices of the future.

TELIDON:
- a unique computer graphic based videotex system
- a communication protocol (code) for the efficient exchange of graphics between computer terminals over narrow band communication lines
- an extension of the ASCII code table to define graphics
- electronic publishing
- a user controlled entertainment/information medium
- It is all of these and more.

Telidon differs fundamentally from the earlier European systems in its method of coding and presentation of graphics information. It employs a coding scheme commonly known as alpha-geometric. In comparison to the European method of piecing together a picture with mosaic blocks (80x60 pels), a Telidon picture is constructed from a set of geometric primitives which are transmitted from the database to the decoder terminal in the form of a picture description instruction (PDI) code. The decoder, which contains a microprocessor and memories, will then decode the PDI's, and decide what to draw and where to draw it on the screen.

With PDI codes, the amount of data required to describe a picture is minimized, reducing both the computer storage and the transmission requirements. The actual amount of required data depends on the level of graphics detail. A typical Telidon graphics page may contain, for example, 500 bytes of data.

Telidon involves the encoding, transmission, and decoding of a text/graphic frame as digital information. The heart of Telidon is the Picture Description Instruction (PDI); instruction codes which allow a computer to define a geometric element (point, line, arc, rectangle and polygon) using a minimum of information. A particular frame can be composed as a series of any number of geometric elements as well as text. The attributes of a particular element being simply defined by its location, shape, and colour in relation to the overall frame. Further features include overlays, animation, blinking, and flexible choice of colours and fill patterns, along with photographic quality pictures. Photographic pictures are produced using the 'incremental point' PDI and in a manner similar to facsimile whereby, an image is displayed point-by-point and line-by- line, resulting in a highly-detailed, photograph-like picture.

In decoding the PDI's, a microprocessor in the Telidon terminal recognizes the geometric shape to be drawn and using the appropriate algorithm overwrites the reconstructed image onto a bit map plane memory (representative of the TV raster) which in turn causes the screen image to change.

One of the most important characteristics of the Telidon coding scheme is that it is terminal independent. Information encoded as PDI's today is compatible with colour and black and white TV's, and low, medium or high resolution displays, thus making it compatible with future display technology enhancements. This versatility is attributed to the method of defining graphics, and to the intelligence of the decoder terminal to adapt the presentation to the characteristics of the display medium. The location and shape of geometric elements are not defined in absolute coordinates, but relative to an abstract, unitary, two or three-dimensional coordinate space. (0-1, 0-1, 0-1).

For example, a rectangle centered in this coordinate space might be defined, by its' diagonally opposite corners, as being at 0.25,0.25 and 0.75,0.75. In regenerating this rectangle a Telidon decoder will adapt the rectangle to the resolution of the bit map planes (TV raster), with the object always taking up the same percentage of the overall screen. Present terminals operate with bit map planes of 200 by 256 elements, but as need and economics dictate, these can be expanded to higher resolutions to allow 'crisper' definition of diagonal or curved lines. The code can presently support resolutions of more than 250,000 by 250,000 pels.

Telidon Today

There is presently a Telidon network which extends across Canada and internationally. This network involves access to local, national and international computer databanks via telephone, coaxial cable and fibre optics, as well as access to Telidon information from TV broadcasting stations and satellites (Teletext). The services involved cater to specific business groups as well as educational groups and the general public. Present functions include access to up-to-date information retrieval (living encyclopedias), interactive programs (analysis/computation), inter-user messaging, electronic funds transfer (business transactions) and computer games. From the usage statistics to date, it appears that each user accesses in the order of 30 frames (pages) of information each day.

The demand and interest in Telidon is ever increasing. Even in these times of economic restraint, the number of companies or groups directly involved in providing Telidon services has grown in the past 3 years, to well over 100. In the United States, Telidon is supported by the standards association (ANSI) as well as such companies as AT & T, Time Inc, Times Mirror, CBS, NBC, and Apple computers. Its presence as a picture and graphics code, can only serve to enhance the introduction of computer services to the home and office (a picture is worth 1,000 words).

Applications

Telidon can be applied to specialized applications where there is a need to create or communicate, detailed pictures which may require editing or processing. Telidon as graphics (PDI's) can be associated with basically one thing; computer generated "soft-pictures." Soft-pictures are what I would like to call a Telidon page because it is dynamic in its presentation - one essentially sees the graphics appear in the order that the artist, or whoever, created them, and because the picture is a series of independent elements, it can easily be modified. The Telidon code permits the pre-programming of delays into the presentation of a picture, it allows labelling of a series of independent elements as an object, which can be scaled, rotated, animated, and modified. The resolution and processing speed are not presently a limitation. The fact is, that Telidon will readily accept faster micro-processors, faster algorithms and higher resolution. When the economics, transmission systems and market can support higher resolution, Telidon will be there.

Engineering or design drawings is one area where there is a tremendous opportunity for Telidon and high resolution displays. The professional community has already accepted computer aided design (CAD), but are restricted in communicating these graphics across the border let alone throughout their international offices. Telidon, because of its efficiency and the fact that it is an international standard is ideal for this. It is based upon the same computer graphic primitives as CAD and can supply cost effective storage, transmission and display of precision drawings for: semiconductors, manufacturing, construction, and even systems control. In Manitoba, Canada, the provincial telephone company is using Telidon to monitor their entire system. As a result of faults within their telecommunications network, a computer program generates the appropriate "alarm" graphic and system layout information. This is automatically displayed in the system control centre, and can be called up by managers and technicians at other locations.

Office automation and productivity are probably the most discussed topics of today. For the first time ever, the clerk represents the largest percentage of the workforce. We are rapidly moving from an industrial society to that of an information society. The two factors which are driving us in this direction are the global expansion of business into multi-national companies, and the introduction of automation and robotics into the manufacturing line.

We have introduced minor changes into the office environment in the way of calculators, electric typewriters, copier machines and word processors, but the increases in efficiency have not been that great. These minor innovations in automation will become integrated with computers and telecommunications, eventually characterizing the office of the future by a highly versatile, multifunctional work station which can communicate throughout the world.

Telidon, which marries pictures, computers and telecommunications, will naturally play a significant role in this office automation process. Indeed, many services envisaged in the office of the future are already available in many of the present Telidon systems. These services include access to business and other information databases, computational programs, electronic funds transfer, messaging, and other forms of electronic mail services, etc. Bell Canada presently offers an executive work station that combines a telephone, an alphanumeric terminal and a Telidon videotex terminal in a single compact unit, called the Displayphone. This is indeed a flexible, multifunctional office communication unit which puts information directly at the hands, and in the control of the end user. It is hoped that with the automated distribution of information, the office worker will have more time for creativity.

As this automation progresses, the need for higher resolution terminals is arising. The ultimate system will also have to be able to create, store and distribute the standard 8½" x 11" letter, and accomodate teleconferencing, and facsimile transmission.

Other applications for Telidon and high resolution displays come to mind in the areas of specialized training or analysis. Since life is a continual learning process, there will always be a demand for effective training methods. Computers are becoming recognized as a useful instruction tool, and accessibility to learning packages is crucial to their effectiveness. These factors along with the fact that we think in images, lead us once more to Telidon.

Learning through simulation has many applications, and these can only be effective if they incorporate computers and detailed graphics. Just as nothing is written in stone anymore, simulation programs must be easily modified to adapt to change. One of the initial study areas for Telidon involved use of a common visual space, whereby a number of individuals located anywhere in the world would be able to interact with, and modify, the same graphic, program, or situation. Such a system has enormous potential in military, corporate, and institutional training.

There are many other applications which require the ability to create or communicate detailed pictures which may require editing or processing. It is just a matter of need and economics before Telidon is applied to medicine, cartography, satellite surveillance and navigation. The availability of high definition displays will be advantageous, and in some cases important, for the development of these applications.

Telidon and High Definition TV

When I talk about Telidon facilitating the introduction of high definition and digital TV, the following 3 things come to mind:

(1) All of the high resolution systems proposed, mention the use and benefits of digital frame storage at/in the receiver.
(2) Telidon is anticipated to capture a significant market and is being introduced as a component for your T.V.
(3) As required, Telidon will readily support high resolution displays.

In effect, Telidon is essentially putting in place the receiver end of a digital TV system.

The benefits of frame storage are well recognized, it allows image processing to code (Telidon), update, and restore/enhance images, while providing perceived resolution 30% higher than the actual bit plane size.

Telidon and the Japanese "Captain" videotex system (not yet fully described internationally) are both based on the principle of storing a frame in bit map plane memory. With the head start of these technologies over high definition TV, and the market projections, these videotex technologies will supercede high definition TV's acceptance by the marketplace and essentially put in place the receiver end of a digital TV system.

Telidon will not be used to geometrically describe the content of video frames, but its photographic and updating capabilities, along with speech synthesis are presently being studied for a 512 by 512 bit plane memory with 8 million colour shades by Dr. S. Schlien of our Communications Research Centre. The one point I would like to emphasize with respect to the imminent introduction of digital TV, is that since bit map planes are based upon the binary number system, the most probable size would be 1024 by 512 which would provide a perceived resolution of over 1300 by 660 and the desirable wider aspect ratio of 2:1. In identifying a compatible high definition system we must look to the future and not compromise digital TV.

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The Evolution of Technical Standards for HDTV, Particularly Transmission Standards

by
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20 October 1983

Introduction

Each manufacturer who delivers early-generation HDTV camera, recording, transmission, or display equipment to producers or others will attempt to provide equipment designed to create and reinforce user need for his brand rather than any competitor's brand. Not one but several de facto worldwide equipment performance standards likely will evolve. From these de facto standards, each nation will likely choose as its national standard the one which best supports its manufacturers and/or program producers.

Engineers' professional societies in some nations, and some multinational manufacturers which are interested in aggregating a world-scale market, desire that not several but one worldwide standard emerge and that this standard emerge quickly so that minimum private investment and public wealth will be wasted on abandoned designs.

A beneficial, enduring worldwide recording and display standard well may evolve this decade. A worldwide transmission standard may also, but if a transmission standard is adopted too soon, which I fear, the standard likely will be outdated before any significant percentage market penetration could occur, or worse, much transmission bandwidth likely will be allocated unnecessarily and unproductively, diminishing both the number of satellite broadcast channels available per nation and raising transmission costs for all of the media.

I'll review today (1) the scope of HDTV standards I see needed; (2) the perceptions of various stakeholders as to an appropriate pattern and pace of evolution of HDTV standards; (3) current efforts to initiate or delay establishment of HDTV standards, de jure or de facto; (4) ways of accommodating within transmission standards the compression algorithms which now slowly are evolving; (5) the consequences of analog versus digital implementation; (6) current non-HDTV recording, transmission and display standards which I think might be extended to encompass higher definition; (7) those which I think should not be extended or even kept; and (8) a suggestion for an interim transmission "standard."

Topic 1 <u>Scope of Standards Needed</u>

Figure 1 illustrates today's standards context. The words used in the Figure all are very familiar to you.

Figure 2 and Figure 3 illustrate the standards context which I think will be relevant by the end of the decade, a context deriving from two assumptions: (1) by then, every new high-quality TV will contain a frame store, and (2) the transmission standard will be formulated within the International Standards Organization (ISO) Open Systems Interconnection conceptual framework, rather than the past NAB conceptual framework. In the ISO framework, whatever recording and editing standards evolve will constitute protocol level 2 through level 6 standards. Whatever transmission standards evolve will constitute protocol level 1 through level 5 standards. Certainly the transmission level 1 standards, as before, will include spectrum parameters for a carrier frequency, for modulation, and for inter-channel interference; but will not, I hope, include parameters for chrominance carrier, nor audio carrier, nor teletext carrier, nor frame sync, because these, I hope, will not exist. I expect the transmisson level 2 through level 4 standards instead will include new elements: data format sync, the current number of programs in time multiplex, the identity of the current compression algorithm for each of these programs, and perhaps a transmitted word bit energy weighting. That is, tomorrow's HDTV standards context will be very different from yesterday's NTSC, PAL, or SECAM context. The "multiple analog components" (MAC) transmission proposed by the U.K. Independent Broadcast Authority (UK/IBA) is an in-between context.

Topic 2 Perceptions of Various Stakeholders as to an Appropriate Pattern and Pace of Evolution of these Standards

Adventuresome theater film producers like Coppola say HDTV is a great new tool, exciting, to be used in the studio as soon as available. They want to work cooperatively now with manufacturers to set camera and recording performance guidelines.

The theatre owners to whom the producers will send their works of art show little interest in HDTV.

The Japanese manufacturers eagerly developing HDTV cameras and recorders, and who have done initial HDTV DBS broadcast testing, are emphasizing the value of HDTV to viewers and are very busily preparing for their next HDTV DBS test a few years hence, but are saying little about standards. I think they are trying to not antagonize anybody's FCC.

The prospective U.S. and Canadian manufacturers, looking at the Japanese, are saying among themselves, "Until we figure out how to move production back from Japan to here, we don't want any HDTV standards of any variety".

Of the U.S. TV networks, CBS has applied to the FCC and obtained authorization from it for a costly, comprehensive HDTV DBS pilot service. CBS is pressing the FCC to allocate a wide band at 12 Ghz to HDTV. That's what CBS wants right now. Today, like the Japanese manufacturers with whom CBS works, CBS is emphasizing the value of HDTV to viewers. Because CBS now delivers NTSC TV to its audience through its many affiliate stations who rely on terrestial propagation, and because CBS doesn't want to frighten all those affiliates, CBS also is testing terrestial propagation of HDTV. CBS does plan to start archiving programming for HDTV, recording programs now for use years hence. So CBS does desire to accelerate development of HDTV recording standards. (If HDTV recording standards could be agreed to internationally, international commercial exchange of these programs would be facilitated.) CBS will discuss transmission and modulation options, but does not appear ready to press for specific long term transmission standards.

The affiliate stations of CBS and the other U.S. networks are apprehensive, neither hostile nor favoring. They don't yet see quite what their role will be. Because they've prospered in the world of the past, they'd like to block change. But ratings are drifting down. They're afraid CATV may overpower them, with or without HDTV. While they fear that HDTV might aggravate this situation, it isn't a central concern.

The U.S. engineering societies are glad to have occasion to work on and shape a brand new TV standard. The effort, then the outcome, both create high paying, fascinating jobs for their members.

The U.S. Federal Communications Commission, the Canadian Department of Communications, and other nations' spectrum allocators don't like the voracious spectrum appetite which HDTV exhibits. But a short year hence these spectrum allocators have to participate in a RARC proceeding at which HDTV must be discussed. They must allocate spectrum. They must allocate orbital slots. They'd like by then to have enough policy developed to be able to walk in and say something plausible, whether optimum or not. Something beats nothing.

The UK/IBA is pushing its MAC approach. BBC is resisting. MAC offers performance better than NTSC, PAL, or SECAM, but not as good as the Japanese prototype HDTV.

In summary, manufacturers and producers will press increasingly for standards for cameras, recorders, editors, and displays, and let transmission standards follow. Conversely, spectrum regulators and prospective broadcasters will press for some initial spectrum allocation, but a flexible one, confident that early transmission and equipment standards will follow.

What about compatibility with NTSC? The need is declared, with fervor, at every meeting. But no one has an efficient approach. Nor does anyone want to be known as the culprit who killed compatibility. When the need arises we'll all discover some defenseless scapegoat upon whom we can deposit the blame.

Topic 3 Current Efforts to Initiate or Delay Establishment of HDTV Standards, De Jure or De Facto

A prior speaker today outlined the recent activities of the JCIC committee considering this subject, the role of the new NAB committee, and the concerns of CCIR and of SMPTE.

For quite some time CMTT, a joint endeavor between CCIR and CCITT, has been reviewing standards for teleconferencing, including possible high-ratio compression standards. But because image motion is more important in HDTV broadcasting than in teleconferencing, standards for the two applications likely will be different. Neither the Electronic Industries Association nor the National Cable Television Association appear to be focussing on HDTV. A few days ago I asked a pertinent FCC representative whether any formal FCC or other U.S. government HDTV standards authority had been established to date. The answer, no.

It is quite clear that the UK/IBA, to support its MAC approach, cannot evade opposing standards more advanced than MAC. Yes, IBA's efforts may delay something better.

Some say CBS, very subtly really, is working to delay HDTV standards by pushing so hard for the impossible that nothing ever will happen. Perhaps someone in CBS is. But not CBS's Joe Flaherty. I believe he wants HDTV to be his mark on history.

Topic 4 Ways of Accommodating Within Standards the Compression Algorithms Which Now Slowly Are Evolving

NEC and now GE have offered products for sale which utilize low-ratio algorithms. Higher ratio algorithms are being tested in R&D labs. Yesterday, CBS's John Rossi showed the redundancy probability distributions, frame to frame, for several series of TV frames he considered representative. Those distributions confirm what we have known intuitively for years: that most pixels of a TV image change little, that most of the information capacity available in the bandwidth and dynamic range of NTSC transmission is unused. Certainly TV, including HDTV, can be transmitted with very high accuracy within a bandwidth far less than the current NTSC channel. Someday (several decades hence?) NTSC television may be transmitted worldwide reasonably well through the 256 kilobit per second Integrated Services Digital Network (ISDN) telephone circuits now being readied by the major telephone companies. These telephone companies, deeply interested in regaining their past overlord role in telecommunications, will work indefatigably on compression technology.

As bandwidth compression algorthms improve, how can systems designers, spectrum allocators, and standards designers accommodate the slow evolution?

Suppose each year, or two, or three, a better algorithm is proven and is offered for sale and use.

Option one, broadcasters could be awarded channels of fixed bandwith and then be required to transmit over these thereafter exactly as initially operated.

Option two, broadcasters could be required to periodically reduce bandwidth. For certain applications, periodic reduction could be economic. For example, my associates and I believe the first HDTV users will be commercial entertainment establishments such as bars and restaurants which offer group viewing. Because the equipment is there not just to inform or amuse the owner but to attract customers, the owner will desire to have as stunning, up-to-the-moment performance as feasible. If each few years the IF amplifiers and expanders of their receivers must be replaced by the next version (the display, the expensive part of the equipment, need not be), the owner will write off the replacement cost loss with little more than a whimper.

Option three, broadcasters could be awarded channels of fixed bandwidth, yet the transmission standards for the bandwidth would be defined only in terms of (1) a bandwidth reservation and accompanying cross-channel interference levels, (2) parameters for a multi-phase, multi-level digital-modulated single-carrier transmission signal, and (3) parameters for an alternative, optional analog "AM sample" transmission signal instead. (Up to the transmitter modulator, and beyond the receiver demodulator, all HDTV standard signals might be multiline or serial digital, but, to minimize transmission bandwidth demand, from the modulator through transmission to the demodulator the signal would be as close to analog AM as possible.) The channel licensee would be free to transmit within the licensed bandwidth not only one but up to several time-multiplexed independent programs, completely independent programs, each using some one of whatever set of compression/expansion algorithms were encoded within the receivers. The choice of algorithm for each or any program might change from hour to hour or from minute to minute, depending upon the pace of image change in the specific programs being transmitted at that moment.

That is, in option three the decision as to what subjective value a specified level of resolution offers to viewers, is not resolved in advance in the engineers' laboratories nor in the regulators' conference room, but is resolved at time of use in the producers and the sponsors marketplace, by people whose goal is to attract, please, and serve the human market. Let them decide, day by day, program by program, the technical parameter mix they desire, just as they now decide what program content mix they desire. For dramatic newsflash pictures and for football games, they likely would choose lots of megahertz. For the soap operas, somewhat less. For the newscasters, few megahertz. Current over-air TV spectrum allocation practices allow no freedom to marketers. This situation benefits few viewers, I believe. Just as telephone and data channel technical parameter mixes have become more flexible, and CATV channel mixes soon will be as the newly-developed compression/expansion converters come into use, so also should over-air television, HDTV as well as NTSC.

In order that the HDTV market can be entered at low entry cost, the HDTV bandwidth reservation should be set sufficiently large as to permit analog AM transmission of one non-compressed HDTV program with no receiver frame storage. The 30 megahertz proposed by CBS to the FCC should suffice. Perhaps some lower bandwidth based on the UK/IBA MAC approach would be better.

Topic 5 What are the Consequences of Analog Versus Digital Implementation

When used inside a microprocessor chip, in a frame store, in a compression/expansion processor, and perhaps on video disk or in a trans-ocean fiber optics cable, digital implementation is great. It offers enormous dynamic range. Stable calibration. It's regenerable; for copy after copy after copy, copying error can be reduced to near zero. Error analysis algorithims are available and widely used which recognize and correct isolated errors.

But for over-air transmission of wide band HDTV, digital is not so great. Basically digital implementation simply converts amplitude dynamic range into bandwidth. For over-air transmission about this planet, where bandwidth is a scarce commodity, that's going in the wrong direction.

By use of multi-phase coding and multi-level coding certainly it is possible to reduce the bandwidth of digital transmission. But when energy per bit in the signal is weighted for minimum end error (that is, the most important bits are sent with the most energy and the least important bits with the least), such coding produces signals exhibiting analog-like spectrum distribution.

Provided frequent calibrating signals are interspersed, as in NTSC today, and frame stores are used, simple AM analog over-air transmission can accommodate the program time multiplexing I mentioned earlier; it can accomodate flexible scanning, which I'll come to in a minute; also scrambling in time position as well as in frequency and amplitude; and coherent linear integration is feasible. Don't underestimate this old method.

Topic 6 What Current Standards Might be Extended to Encompass HDTV

For this question I will consider here only video recorder standards, the key to all non-transmitter questions.

The 1982 February CCIR Recommended AA/11 Standard for digital interconnection betweeen cameras, recorders, and displays probably will be adopted worldwide very soon. Although this standard as written would not suffice for HDTV, certainly it can be extended to do so. The sampling rates stipulated in Recommendation AA/11 can be raised from, say, 13.5 megahertz for luminance and 6.75 megahertz for chrominance, to about 70 megahertz and 35 megaghertz, respectively, to accommodate first the increase for HDTV of four to one (2 x 2) in resolution, and second the increase of five to four in aspect ratio. Yesterday Kerns Powers of RCA Corp. discussed some of the pertinent considerations, and soon today Donald Fink will also.

A standard for HDTV digital recording probably does need to be set soon. Fortunately, we in the U.S. or Canada may not need to exert much effort to accomplish this. NHK and its Japanese cohorts soon will set a *de facto* standard as they design and produce equipment to satisfy the first large orders for HDTV camera, recording, and display equipment, and interactive HDTV video disk equipment. Of course we in the U.S. and in Canada could set a de jure standard different from whatever the Japanese deliver. But our standard likely would be irrelevant, just as any new U.S. local data network bus de jure standard likely will be irrelevant if is does not encompass IBM's prospective new ring product. To the best of my knowledge no U.S. manufacturer is preparing to match production volume with the Japanese. So we probably can save time and trouble by accepting early on whatever de facto recording standard the Japanese choose, because we're probably going to have to do so in the long run anyway.

Topic 7 What Current Standards Should not be Extended to Encompass HDTV

For this next question I will consider here only transmission standards, having discussed recorder standards a moment ago.

First, I think we should scrap all standards requiring a full video picture per field. That is, we should scrap NTSC, PAL, and SECAM, and also UK/IBA's MAC (even though I like it). Why? Because all these, formulated before frame storage became feasible, stipulate that irrespective of what extent of visual change may have happened the last tenth second or last few seconds, nevertheless in every next incremental field time interval, a full field must be sent. Using frame storage, a full field may not need be sent so often; certainly once, at the beginning; certainly soon after a drastic camera image change; perhaps thereafter only incrementally at quiet instants when little change has been detected over several seconds.

Second, I think we should scrap all the standards calling for separate audio carriers, or for biphase video carriers. During the past two days here you've heard the reasons why. The HDTV video signal chrominance information, luminance information, the HDTV audio, and all teletext should be encompassed within one serial data stream, not frequency and phased multiplexed as now. UK/IBA MAC sends chrominance serially after luminance.

Third, HDTV needs to be able to serve personal computers well, just as interactive videodisk will. Within the next few years far more high definition displays will be sold for personal computers than for HDTV. So part of the market for higher quality presentation already will have developed and will be ready for a next step. For example, a plug-in, 1,024 line by 1,024 line, 3-bit level, 8 color frame store is available today to retail computer customers for about $1000 (specifically, for the Nippon Electric Corp. 1982 model Advanced Personal Computer; only any 512 line by 512 line quarter of that frame is showable in the display window) (the Corvus Concept personal computer, the Xerox Star personal computer, and the prospective Apple Lisa personal computer all have comparable displays). Many such frame stores are being purchased. Within a few years the price for such frame stores likely will drop to half the above.

Topic 8 A Suggestion for an Interim Transmission "Standard"

We need to allow for transmission field scan geometries much more flexible than the rectangular camera raster scan with which we are so familiar. In Figure 4 the scan lines in scan zone 1.1 to 1.4 constitute an ordinary rectangular raster scan over a part of the total image. The scan lines in zone 2.1 thru 2.4 continue with a trapezoidal scan. Notice that each successive scan line within this trapezoid requires a longer scan time. The scan lines in zone 3.1 to 3.4 continue with a trapezoidal scan, degenerated to a triangle. Zones 4.1 to 4.4, 5.1 to 5.4, then 6.1 to 6.4 follow. Why this complexity? Because virtually all camera image sequences are composed of a number of separate localized subimages, large and small, which remain relatively stationary, but which over short periods move with near-uniform relative motion relative to each other. The next image of such a sequence can be efficiently generated from the previous image, using predictive extrapolation, linear or non linear, by defining the zones moving, the motion, the edge detail, and the residual differential change within each zone. Transmission scans such as are shown in Figure 4 facilitate this. (Neither the camera nor the receiver display need scan this way; only the transmitter.) The compression analyzer calculates the zone choices. The zone pattern itself is sent to the receiver. The transmitter encoder scans the input frame storage as instructed. The receiver decoder interprets the signal according to the zone pattern.

Such flexible scanning does not vitiate downward capability of HDTV to NTSC. It does not vitiate use of a time-multiplexed low-pass/high-pass spectrum split, as mentioned by several speakers here. But it does require use of a frame store as the intermediary between HDTV and NTSC. No other intermediary black box makes as much sense.

Thus, I suggest the fundamental interim transmission "standard" which could be adopted is: set aside a generous band, but one not wider than simple analog; assume a single serial data stream will be used; set ISO/OSI specifications for the transmitted data stream; assume non-rectangular scanning may be used; allow program suppliers to market as many programs as they can fit in the band. Don't hurry to set any rigid, detailed standards.

The hardware and software components needed for development of such a system are materializing extremely fast. For example, at AT&T a Josephson junction digital multiplier now is being developed for use specifically in video compression which is expected to provide an 8-bit by 12-bit multiply in two nanoseconds. For example, at NEC a full megabit memory chip now is being developed.

Do hurry to think up new compression algorithms. Do hurry to identify early markets.

Thank you for your attention.

Figure 1: Standards Needed: Today's Context

Create Image "C" (camera; scanner)	Record & Edit "R" (tape; disk)	Deliver "DL" (terres. or geosat. bdcast; CATV; fiber)	Display "DS"
	Items from Column C, plus:	Items from Column R, plus:	Items from Column DL+ plus:
H bandwidth	RGB or composite	channel spectrum	receive sensitivity
V lines number, length, & interlace	composite modulation phase reference phase stability	carriers spacing & crosstalk & modulation (l,c,a,tx)	registry
aspect ratio		teletext modulation	
	error buildup		
scan rate			
synchronization frame, line			
intensity range			

Figure 2: Standards Needed: Frame Store Context

Create Image "C"	Record & Edit "R"	Deliver "DL"	Display "DS"
Items from prior page Column C, Plus:	ISO protocol specifications for:	ISO protocol specifications for:	Items from Column DL, plus:
resolution gradient (center to edges)	max. bit rate	channel spectrum spacing & crosstalk	receive sensitivity
sampling pattern (H,V,T)	bit synchronization	carrier & modulation (one only)	store logic
	word synchronization	bitword energy distribution	registry
	store logic	format sync	multipath cancellation algorithim
		number of programs	
		identity of each	
		compression algorithm for each	

Figure 3: ISO/OSI PROTOCOL LAYERS

7. APPLICATION

6. PRESENTATION

5. SESSION

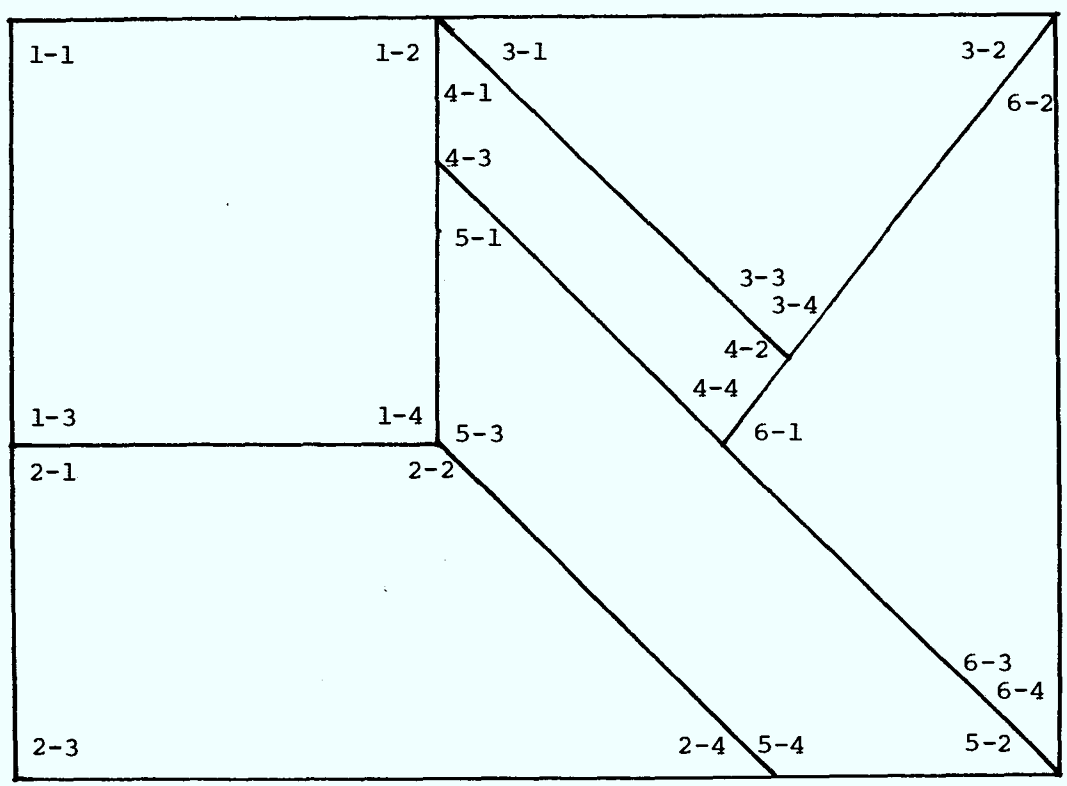
4. TRANSPORT (MESSAGE)

3. NETWORK (PACKET)

2. DATA LINK (FRAME)

1. PHYSICAL (BIT)

FIGURE 4: Non-conventional Field Scan (One Option, Trapezoidal)



CANADIAN STANDARDS MECHANISMS AND ACTIVITIES RELATED TO HDTV

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ABSTRACT

The tremendous efforts we experience today to improve the signal quality of television video and the emerging proposals developed on HDTV and EDTV lead to the question on how these new services are to be introduced. It is essential that widely-accepted standards are developed in a timely fashion with due consideration for compatibility with the existing systems as well as the rapid acceptance of the advanced technology. In order for a standards writing body to function, the various mechanisms and associated activities must be in place. Included in its development are the regulatory aspects as applied nationally and internationally. Manufacturers benefit from standards, so do the users of new services and the service provider.

1. INTRODUCTION*

The complacency of noticeable improvement of the display quality of video on NTSC, PAL and SECAM standards during the past couple of decades is now ending. Today we are experiencing tremendous efforts to improve the production, transmission and storage of television and film. We are becoming aware of advanced proposals on high definition television (HDTV) and enhanced definition television (EDTV). The impact of this new television format on basic technology and application is so far reaching that administrative planning for its introduction must be prudently carried out with the highest priority. Crucial to this planning are mechanisms established to deal with the effects that the potential applications will have on current standards and regulations and the changes and development of these elements with the provision of new services. This paper will review the Canadian standard-setting process.

2. PURPOSE OF STANDARDS

A growing need for standards always exists when technological advances enables the availability of new communication services, and when some socio-economic change occurs that affects or alters our

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* This paper draws upon the findings of a contract done for the Department of Communications, National Telecommunications Branch, by Philip A. Lapp Limited (Reference 1).

** The views expressed in this paper are solely those of the authors.

consumer habits such as affordability, changes in regulations, buying trends, novelty, a new status symbol, etc. Within the administrative plans to introduce a new service, such as HDTV, consideration must be given to two schools of thought; either take a quantum jump to the full HDTV and accept the consequences of incompatability with existing systems or maintain compatability with existing systems for a certain period while enhanced receiver, network designs, programming etc. are developed. Such development would continue until a time when a reasonable portion of the industry has accepted the new technology and the severance from the existing technology will not fragment the industry.

The success of either route chosen would depend upon the standards developed to support these systems.

Obviously from a manufacturing point-of-view a standard with wide geographical acceptance will mean a larger market for a specific product. For the service providers, optimum network design, maintenance procedures and operating functions can be developed and whose cost can be spread across a wider network or amongst a number of networks encompassing a larger cross section of the population. The production and distribution cost of programming and non-programming services can be shared among the networks in the same way. Standards for users could mean a set of specifications upon which request for tender for user terminals are based. Generally a widely accepted standard means multiple sources for user equipment. The ease of mobility of user and user terminals is preserved when standard operating procedures by the users and compatability of the terminals are governed by set standards.

In the case of HDTV, there are no internationally-accepted standards except that being proposed by NHK, Japan. The concepts and technology are changing rapidly. Canadian manufacturers in particular have the opportunity to capture a good share of the potential HDTV market through the use of high technology devices if the mechanisms can be established to develop initial service and equipment standards.

The choice of a particular standard can have a significant impact on the cost of the service and its availability. From a consumer's point of view, new standards frequently necessitate a change of equipment to meet the new standard. In the television area, this impact on the consumer has greatly affected the choice of standards and the introduction of new standards. Public pressure and momentum has limited the freedom to diverge on a totally new path.

The following sectionsdiscuss the present arrangement for establishing standards in Canada.

3. STANDARDS IN CANADA

Most industries and commercial operations use standards of one form or another. These are often internal standards developed and used by a single company or manufacturer, or industry standards developed by an industry association for use by members. In Canada, the standards are all too frequently developed by foreign manufacturers and imposed on Canadians by the simple fact that the products or goods are sold within Canada.

As it developed, this fragmented structure of standardization militated against the root objective of standards: that is to provide a widely acceptable norm for goods and services to facilitate trading on a national and international basis.

3.1 The Standards Council of Canada and the National Standards System

To bring order to the standardization process, the Standards Council of Canada (SCC) was created by Act of Parliament in October 1970, as the National Co-ordinating Institution for voluntary standardization in Canada. The SCC operates a National Standards System (NSS) which is made up of organizations concerned with voluntary standardization. The System was created to provide a medium through which Canadian organizations involved in such activities may operate and cooperate to recognize, establish and improve standardization. It was designed to provide a comprehensive standardization capability to meet both national and international requirements and responsibilities.

The System now consists of the Standards Council, five accredited standards-writing organizations (SWOs), two Canadian National Committee structures concerned with international standardization, one certification organization, and several advisory and co-ordinating committees. A limited program of accreditation of testing organizations is underway.

Of the accredited standards-writing organizations of the National Standards System, the one most concerned with communications standards is the Canadian Standards Association (CSA).

Within its overall programme each standards-writing organization operates in an agreed group of designated subject areas from which it may submit its standards to the Standards Council for approval as National Standards of Canada (NSCs), the prime output of the National Standards System. The description of standards as National Standards of Canada is essential for international recognition and for effective Canadian participation in the development of international standards. Ability to trade beyond a local market is thus greatly enhanced.

The SCC is currently conducting a thorough review, in conjunction with the SWOs, of the whole process of development and approval of NSCs with the aim of streamlining the process. It is anticipated that eventually there will be several thousand NSCs satisfying a major part of the Canadian requirements for standards. Progress towards this objective has to date been slow, but is expected to improve now that the accredited standards-writing organizations have adopted policies to process the bulk of their standards as NSCs.

3.2 International Standards

As, by its very definition, telecommunications is concerned with distance communication, it is to be expected that international operation, and standards for such operation, are fundamental to the industry. Canada participates in the development of international telecommunications standards through the International Standardization Branch of the SCC and by membership in the International Telecommunication Union (ITU).

The International Standardization Branch of the SCC is responsible for the general administration of the Canadian National Committees of two major international standards-writing organizations, the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC).

3.3 The International Organization for Standardization (ISO)

ISO is a specialized agency for standardization which was created in 1946 in London at a meeting of the United Nations Standardization Coordination Committee and 25 national standardization organizations. The object of the ISO is to promote the development of standards with a view to facilitating international exchange in goods and services, and to develop cooperation between nations in the sphere of intellectual, scientific, technological and economic activity. National standardization organizations may belong to ISO, but a country may be represented by one organization only.

The Canadian National Committee for the ISO (CNC/ISO) is responsible, through the Standards Council of Canada, for the general supervision and direction of Canada's participation in the work of the ISO. Accredited standards-writing organizations are encouraged to use recognized international standards as a basis for national standards whenever Canadian practices and conditions permit.

3.4 The International Electrotechnical Commission (IEC)

The International Electrotechnical Commission, which was created in 1906, does similar work to that performed by the ISO, but confines its activities to the electrotechnical field. Since April 1972, Canada has been represented on the IEC by the Standards Council of Canada.

The Canadian National Committee of the IEC (CNC/IEC), which is similar in structure to the Canadian National Committee on the ISO, is responsible to the Council for the general supervision and direction of Canada's participation in the work on the IEC.

3.5 SCC's Management of Canadian Participation in ISO and IEC

The International Standardization Branch of the SCC is responsible for the general administration of the IEC and ISO standardization work in Canada and provides the secretariat for the CNC/ISO and CNC/IEC.

The work of international standardization is carried out by the two organizations through ISO and IEC technical committees and their subordinate sub-committees and working groups.

Canadian participation in this work is performed by Canadian Advisory Committees (CACs) in the case of ISO work and by Canadian sub-committees (CSCs) in the case of IEC work. There is a CAC or a CSC, for every international technical committee whose work is of interest to Canada. The members of the CACs and CSCs participate directly in the work of international standardization carried on by the associated technical committee, and consist of individuals, producers, users and others according to the subject under consideration.

For some years, the SCC has been endeavouring to reduce duplication or overlap of national and international standardization work. This effort has been two-fold: improving communication between the organizations responsible for writing standards in Canada and those individuals participating in international standards work - thereby permitting Canadian organizations to take into account the results of international standardization work; and promoting Canadian standards as international standards, where appropriate.

In 1977, the SCC set up an Advisory Committee on International Standardization. This Committee, formed of members of the Executive Committees or other persons of appropriate background and interests, provides a forum for discussion of problems common to both national committees.

3.6 <u>The International Telecommunication Union</u>

The ITU is a body created in 1932 by a merger of organizations previously concerned with international telephone, telegraph and radio regulations. A single convention, signed by 80 countries, was drawn up with three sets of regulations attached: one for radio, one for telegraph and one for telephone. Currently, 157 countries are members of the Union.

Telecommunications Conventions are agreements of the nature of a treaty between governments. Their objective is to facilitate relations and cooperation between countries by means of efficient telecommunications services while fully recognizing the sovereign right of each country to regulate its telecommunication. The International Telecommunications Convention, which is in effect at this time, is a sort of constitution of the Union, which specifies the internal organization of the ITU and sets forth general principles governing telecommunications.

The ITU is dedicated amongst other things to maintaining and extending international cooperation for the improvement and rational use of telecommunications of all kinds.

The Union, in particular, is responsible for:

- effective allocation of the radio frequency spectrum and registration of radio frequency assignments in order to avoid harmful interference between radio stations of different countries; and,

- coordination of efforts with a view to harmonizing the development of telecommunications facilities, notably those using space techniques, with a view to full advantage being taken of their possibilities.

The ITU consists of four permanent organizations: the General Secretariat; the International Frequency Registration Board (IFRB); the International Radio Consultative Committee (CCIR) and the International Telegraph and Telephone Consultative Committee (CCITT).

The latter two organizations, commonly called CCIs, permit four types of participants: administrations, recognized private operating agencies (RPOAs), scientific or industrial organizations (SIOs), and international and regional organizations.

Administrations, in this case the Canadian Government as represented by the Department of Communications, of the ITU are members of the CCIs. Recognized private agencies, subject to the appropriate procedure and approval of the Administration, may become members of the CCITT or CCIR or both. As a result of the organization memberships, they have a seat on the Executive Committee of the Canadian National Organization of CCIR (CNO/CCIR), if they are members of the CCIR, or a seat on the Steering Committee of CCITT (CNO/CCITT), if members of CCITT.

SIOs which are engaged in the study of telecommunications problems, or in the design or manufacture of equipment intended for telecommunications services, may similarly be admitted in an advisory capacity to participate in the work of the CCIs study groups. International and regional organizations, which co-ordinate their work with the ITU and which have related interests, may be admitted to participate in the work of either or both of the CCIs.

The ITU Radio Regulations provide the basis for orderly development and sharing of the radio frequency spectrum throughout the world. Canada, represented by the Department of Communications, has an interest in the making of Radio Regulations because of the extensive use Canada makes of the facilities that utilize the spectrum. The Department therefore participates in the development of these regulations by its work in the CCIR. It should be noted that the CCIR itself does not directly produce standards or regulations, the prime product being recommendations which the CCIR considers to be sufficiently complete to serve as the basis for international coordination of radio services sharing the frequency spectrum. These recommendations usually form the technical basis for World Administrative Radio Conferences (WARC) where ITU Radio Regulations are prepared and approved. These regulations legally constitute part of the ITU Telecommunications Convention and are therefore of the nature of a treaty between governments.

Although the Department of Communications plays the prime Canadian Government role in CCIR work, the Department of National Defence, the Department of Transport, the National Research Council and the Canadian Radio-Television and Telecommunications Commission also engage directly in this work. In addition the Canadian Broadcasting Corporation (CBC), Teleglobe Canada, Telesat Canada, the Canadian Association of Broadcasters (CAB), CNCP Telecommunications and the TransCanada Telephone System (TCTS) all participate in CCIR as Canadian recognized private operating agencies (RPOAs). Finally SPAR Aerospace Limited and Bell Northern Research participate as Canadian scientific and industrial organizations (SIOs).

3.7 The Role of Standards in Canadian Law

All standards issued by the SCC through the National Standards system together with other standards issued by SWOs and other standards-writing bodies are purely voluntary from a legal viewpoint. Individual trade associations may require their members to follow their own standards as a condition of membership, but this is an internal matter. ITU regulations do have the force of an international treaty but these refer solely to telecommunications traffic between Canada and other countries and are not mandatory within Canada, except as noted below.

With this situation the question arises as to the usefulness of voluntary standards if they cannot be enforced. The answer to this is that firstly there are considerable trade and other pressures to comply with a standard, and secondly when necessary, the standards are referred to in laws, regulations and by-laws at various levels. For example, the electrical code series of standards issued by the CSA are referred to in many building by-laws and other legal instruments.

The advantage of this approach of keeping standards setting and standards implementation mechanisms separate is that the standards setting organizations can set and modify technical standards as the technological and other needs arise without recourse to the legislative mechanisms. At the same time, a law or regulation can be written to ensure that the "latest issue" of a particular standard is used in a specific situation, thus allowing the laws, by-laws or regulations to take advantage of the latest technological standards.

There is an exception to this situation. When a government department, such as the Department of Communications, has the right to set regulations or standards under a specific act, such as the Radio Act, the regulations or standards it sets do have the force of law on department licencees to whom such standards and broadcast procedures apply. The Department of Communications' Broadcast Standards and Broadcast Procedures are examples of these, and licencees not meeting these standards may lose their licences.

4. INTERNATIONAL IMPLICATIONS

Canada is a member of the General Agreement on Tariffs and Trade (GATT). One of the multilateral agreements within GATT is the "Agreement on Technical Barriers to Trade" (also known as the "Standards Code"), which came into force on the 1st of January 1980.

In broad terms the objective of this agreement is to ensure that technical standards and regulations are not set up with a view to creating obstacles to international trade. This Agreement pledges signatories to:

- ensure that technical regulations and standards are not prepared, adopted or applied with a view to creating obstacles to international trade. Furthermore products imported from the territory of any party shall be accorded treatment no less favourable than that accorded to the products of national origin and to like products originating in any country in relation to such technical regulations and standards. They shall likewise ensure that neither technical regulations or standards themselves nor their application shall have the effect of creating unnecessary obstacles to international trade.

5. ROLE OF THE DEPARTMENT OF COMMUNICATIONS

Section 5 of the Radio Act empowers the Minister of Communications ... "to regulate and control all technical matters relating to the planning for and the construction and operation of broadcasting facilities "... and in particular to ..." prescribe the technical requirements in respect of radio apparatus used in broadcasting undertakings and the technical requirements in relation to its installation and operation". In addition, under Section 7, the Minister may make regulations classifying radio stations and prescribing with respect to each class of station

i) the type of radio apparatus to be installed including the technical characteristics and the manner of installation,

ii) the frequencies and power to be used, and

iii) the nature of the service to be rendered except in the case of a broadcasting service.

In practice the implementation of these powers involves a consultative process with all interested parties, and a proper concern for existing international and bilateral agreements. For example the Technical Advisory Committee on Broadcasting composed of broadcasters, regulators and manufacturers, advises the Department on matters concerned with broadcasting, particularly those aspects affecting the use of the radio spectrum. Technical standards for transmitting equipment are developed by the Canadian Radio Technical Planning Board which also consists of representatives of manufacturers and users.

The Department maintains a strong interest in the development of new technologies and the establishment of a framework which will guide the introduction of new services for Canadians. It sees a major need for standards, both nationally and internationally, to facilitate the maintenance and growth of Canada's highly effective communications industries.

As such, it has placed itself in the role of catalyst for such things as videotex, through the establishment of the Canadian Videotex Consultative Committee. This Committee, headed by the Department, consists of interested industry and user representatives and has as its mandate the advising of the Deputy Minister of Communications on all matters concerned with teletext/videotex in Canada. As a result of its work a draft Broadcast Specification (BS-14), outlining the use of the vertical blanking interval for broadcast videotex, has been issued for review and comment by the broadcasting industry.

The consultative process used recently to initiate videotex standards may serve as a model for the future development of HDTV standards, but the actual mechanism employed will no doubt depend on the applications foreseen, whether industrial/commerical or broadcasting. If the latter service is envisaged then a mechanism must be established to tackle the fundamental question as to whether HDTV must fit into existing channeling plans (in Canada and between Canada and U.S.A.). Since we are now operating essentially in a saturated medium, the question of which, if any, services must be dropped becomes a social and regulatory problem. This may run counter to the present thrust of technical regulation which is to get more out of the existing spectrum.

6. FUTURE STANDARDS FOR HDTV IN CANADA

The establishment of voluntary standards is traditionally a long drawn out process. The main reason for this is that, if such standards are to be long lived and successful, they must be the result of hard won consensus and agreement from all potential users. However, the current mechansim for the establishment of such standards in Canada is somewhat unco-ordinated. As noted previously, the current system has produced some good results in the recent work of the TAPAC and CIPOM in the area of information technology. It is difficult to estimate the probability of success there may be in the agreement of standards for HDTV in the present organization.

It should be noted that the Department of Communications is undertaking a review of the standard-setting process in Canada. As a part of this review, the Department let a contract for an independent study of current activities, which should give rise to recommendations on the future development, approval, and implementation of National Standards in the field of telecommunications and information technology. One would hope that HDTV would benefit from a revised Canadian structure if such is implemented. A single non-partisan body could undertake the expeditious development of national telecommunications standards for HDTV.

The prompt establishment of HDTV standards is particularly important if Canadian manufacturers and consumers are to benefit from the introduction of new technology in a whole new information medium.

7. CONCLUSION

This paper has attempted to review the complex subject of the Canadian standard-setting process, particularly as related to high definition television. The purpose and need for such standards are reviewed, as are the national and international organizations which have an effect on the National Standards System of the Standards Council of Canada.

The current review by the Department of Communications may well assist in the early establishment of Canadian standards for HDTV. The urgent need for such standards is recognized by those associated with the development of such a new technology. Also, the planned introduction of the service using certain transitional standards may assist in lessening the cost to the consumer and the manufacturers.

If Canada is going to take an early lead in the production and use of HDTV systems, a composite set of preliminary standards is required. In turn this may assist Canadian manufacturers in obtaining a significant share of a new market. Our probability of success in achieving this goal would seem to be significantly affected by our success in developing such preliminary standards.

Reference

1. "A Study of the Role of the Department of Communications in Telecommunications Standardization", Philip A. Lapp Limited, for the National Telecommunications Branch of the Department of Communications, Ottawa, under DSS Contract No. OST81-00-228, dated June, 1982.

WORKSHOP NUMBER: 1 WORKSHOP DATE: Wednesday, Oct. 20/82

TOPIC: "HDTV: ELECTRONIC NIRVANA?"

CHAIRMAN: Robert O'Reilly, CBC

This opening workshop sought to examine questions regarding the needs and the markets for HDTV. The first panelist noted that the aspect ratio of the human eye is approximately 2:1 and suggested that a similar ratio for HDTV would allow greater involvement by the viewer. He suggested that the best approach would be to adopt new standards for HDTV without striving for compatibility with existing TV. The distribution medium should not be cable, due to bandwidth limitations, but rather DBS and video disc, and possible VCR. A larger screen would be required, in order to induce consumers to purchase the receiving and display equipment.

A number of questions were posed that must be answered before HDTV is implemented. At what pace should HDTV be introduced? What weight should be placed on the large investment in existing TV receivers? What national policy is required to ensure a fair share of world-wide manufacture and marketing? The needs of non-broadcasters must be considered; for example, bars, theatres, video juke boxes, and the print media such as magazines. It was suggested that North America should concentrate on the technology, development, and manufacture of data-related services.

Discussion turned to opposing views on the ability of cable to deliver HDTV in the future. Many views were expressed which doubted cable's present technology as being compatible with HDTV. This view was reinforced from a non-technical point of view when one considers that one of the major selling points of cable is its myriad of channels. If HDTV requires 2 or 3 slots for one service, this will not likely be well received by the cable industry.

This view was countered by the argument that cable, having attained a large penetration, would for one or two HDTV channels be the best distribution medium along with DBS and video disks. The present spectrum assignment in Europe, for example, precludes broadcasting of HDTV.

There also exists the possibility of a technical rebuild in the cable industry. A switched, optically fibred city with reverse channel capability would be the most flexible and desirable. The technology to do this is just becoming available now. There was some doubt as to whether this rebuild would come from the telephone or cable industries.

The present practice of assignment of a cable monopoly on a geographic basis was discussed. This single company control was thought too powerful and should be brought under some form of public sector control. However, if the cable company has sufficient capacity (and to date this has been the case) to carry all services demanded by the public, is this control necessary?

Many parallels were made between the proposed introduction of HDTV and, for instance, the 33 1/3 RPM LP, the telephone, FM radio, and the Compact Digital Audio Disk. All were non-compatible and initially 'rich man's toys'. These examples, it was argued, point to the philosophy that HDTV should not be compromised by compatibility.

The motion picture industry has agreed on the wisdom of providing a wide picture. But, the TV industry is proceeding to develop enhanced definition within the existing standards, and the resulting improvements will be scarcely noticeable to the viewer. However, if so much money is spent to convert to EDTV, there could be a reluctance to convert to HDTV.

The aesthetic problem of the visual pollution that a proliferation of DBS reception dishes could cause in our urban areas was also addressed. This, it was felt by most, would not be a problem with the small (2-3 foot) dish sizes required in comparison with that experienced in the past with VHF yagis.

The view was expressed that, while we must be cautious in establishing standards for HDTV, we must begin in the near future in order to plan for the satellites that will carry the service.

Finally, the group's attention focussed on the philosophic, but perhaps more important question of <u>why</u> should HDTV be considered. What improvement will result from <u>its</u> introduction? Are we once more looking for a problem for our HDTV solution?

WORKSHOP NUMBER: 2 WORKSHOP DATE: Wednesday, Oct. 20/82

TOPIC: "HDTV: COSTS, BENEFITS, AND OPPORTUNITIES"

CHAIRMAN: Robert O'Reilly, CBC

The workshop started with a discussion of HDTV business opportunities. USA is disadvantaged in having only 50% of the manufacturing share of television receivers and other video equipment. Canada is in an even worse situation with 1% or less share of the market; furthermore, the Japanese development of HDTV hardware is much advanced. On the other hand, Canada has the opportunity of implementing a bandwidth rich DBS system and a corresponding cable and fibre optic implementation strategy.

Potential applications are expected to first develop in industrial areas where the need for HDTV is already known to exist, and where there is not presently any large investment in standard definition equipment; for example in the medical, welding, and robotic fields; in the medical field for non invasive diagnosis using fiber optic catherization; in the welding field for more accurate inspections of the finished work and in the robotic manufacturing field for improved spatial perception.

The general observation was made that satellite program distribution is a surrogate magazine stand in the sky. There are presently 55 national networks in the USA serving 40,000 earth stations. These networks offer software ranging from language training to coverage of community affairs and in-depth news programs. HDTV could be like another powerful magazine. Thus, HDTV would be competing against other media for leisure time and disposable income. Numerous questions were posed relative to the need for HDTV, the quality of the software, and the effect of HDTV on people's lives. It was reiterated that the objective was to improve the viewer's sense of "being there", although it was observed that presently viewers see the world on the surface only because they hear about it in "30 seconds news clips", which don't reach the analytical part of the brain but instead put it to sleep.

It was noted that the content is shaped by the medium and that it is too early to speculate on how content providers will exploit HDTV. For example, the first programs were radio with pictures because producers were comfortable with the older medium and applied theirexperience directly to the new medium before learning the new possibilities of television.

Discussion turned to the observation that pressure is growing for HDTV because the available production quality is not reaching the home TV set. However, it was also noted that great improvements in technical quality could be made with present-day TV standards, thus putting in question the reality of the expressed need for HDTV. It was observed that in 50 years time people will expect a higher definition TV system in the same way that people now expect carpets whereas 20 years ago linoleum was sufficient. Fashions change, standards of living rise and money becomes available to support new innovations. HDTV is inevitable. Therefore it is necessary to sort out problems of how and where it is going over a longer term than 10 to 20 years.

The workshop concluded with the observation that engineers are lousy sociologists. There did not appear to be a consensus on the question of HDTV versus EDTV. However, there were strong feelings that once the public sees HDTV, they will buy it.

WORKSHOP NUMBER: 3 WORKSHOP DATE: Wednesday, Oct. 20/82

TOPIC: "PRODUCTION HARDWARE FOR HDTV"

CHAIRMAN: M. Auclair, CBC

In opening the workshop, the chairman welcomed the participants and introduced the panel members. The following topics were offered as possible starting points for discussion: the All Digital System, the Enhanced TV System and the Receiver Only Enhancement were suggested as possible starting points.

The first panelist mentioned Educational television as another user of HDTV production hardware. Sciences and arts would greatly benefit from an increase in resolution and color rendition.

A number of questions were raised regarding tape recording technology required for HDTV. How long will it be before this hardware is needed? How much are customers willing to pay for its development? Will these machines be analog or digital? The observation was made that bit reduction techniques will render impossible post-production manipulation because of the impairments they create.

One of the panelists expressed the opinion that an ideal HDTV system should be able to display all that the eye can see and that 900 M bits/sec rate or 450 MHz bandwidth would be necessary to achieve that goal. He mentioned that it is possible to reduce this requirement in several ways by restricting the picture content. However, only digital adaptative techniques can promise an acceptable bit rate and still "fool most human eyes most of the time".

It was mentioned that HDTV production hardware can be divided into four main classes: shooting equipment, storage devices, post-production gear and the final release product. Shooting equipment and the post-production gear completely specify the characteristics of a system; the two other classes being media related. Video equipment cannot really compete with film for shooting equipment due to its cost, reliability and portability problems. However, electronics offer a slight advantage in post-production because of its ease of manipulation. It was mentioned that development of the HDTV production hardware depends on three factors: 1) the presence of a standard, 2) a good knowledge of the system characteristics, and 3) a sustained growth of the market. Aspect ratio was felt to be more important than resolution itself. It was concluded that compromises in specifying HDTV should be avoided.

The question of the need for HDTV was posed since there is tremendous potential in existing systems. Given the fact HDTV technology is presently a bit fragile, it is more likely that satellites launched in the next 5 to 8 year time frame will carry

Enhanced Television instead of HDTV. It was noted that we are approaching the point where we can specify a system that will be free from present constraints.

In the discussion that followed, it was mentioned that aspect ratio was more important than resolution itself. The film industry experience was used as an example to indicate that reduction in resolution to obtain a higher aspect ratio, pays at the box office.

An aspect ratio of 1.85 was said to be ideal for HDTV.

There was some discussion concerning the constraints imposed by high aspect ratio on image pick-up devices and lenses. The observation was made that solid state sensors will not have this problem. It was concluded that current constraints in technology should not limit the identification of goals for HDTV.

On the question of HDTV vs ETV (Enhanced Television), the comment was made that in order to obtain Enhanced Television, a camera working at double the actual line number and at higher field rate would be necessary. It was also mentioned that the reduction of aliasing thus obtained would increase the perceived blur associated with movement.

It was mentioned that more information and discussions are needed on the ETV concept.

The observation was made that in a digital television studio context, non real-time processing may be required. This would not be acceptable for sport events.

In discussing the issue of HDTV Standards, it was pointed out that HDTV progress and equipment manufacture is inhibited by the non-existence of a standard, and a lack of knowledge of the desired HDTV characteristics.

It was stated that the demand for a better product does not usually come from the public. However, those who have seen the NHK-CBS HDTV demonstration in the United States are ready to pay as much as twice the current receiver cost to obtain an HDTV system for their home.

Dealing with the question of HDTV equipment versus film equipment, it was noted that 85% of present market requirements for prime time viewing are shot on film.

It was observed that standard quality video cameras are being used for film production and that, in fact, the demand for such cameras exceeds availability. Even though this type of camera is very complex, it seems reliable.

Moving to the issue of R&D, it was concluded that no research is being done on HDTV in North America and that research is needed on compatibility and the psycho-physics of HDTV. The tests carried out in Japan should be repeated here.

The workshop identified the following points:

1) HDTV characteristics need to be defined. There is an urgent need to run the same tests that the Japanese have run for production equipment requirements. There is no answer to the question of who will bear the cost of such work.

2) These tests should lead to a standard. If not, a de facto standard will result.

3) Aspect ratio, to some extent, is considered more important than resolution.

4) Current constraints of technology should not impose limits on HDTV specifications, i.e. no compromise.

5) Enhanced ETV should be more closely investigated as an alternative to, and as a first step towards, HDTV.

6) There is no consensus whether HDTV will be digital or analog.

7) There is no consensus regarding the benefit and advantages of HDTV over film cameras.

WORKSHOP NUMBER: 4 WORKSHOP DATE: Wednesday, Oct. 20/82

TOPIC: "HDTV - THE PRODUCERS DREAM"

CHAIRMAN: H. Greenberg

The workshop was opened with the statement that producers are looking for any new method of production or exhibition that will show off his/her product at its best.

It was considered that HDTV could give an opportunity to the producer with regard to expanding his creativity, offering more screen area in which to put more action. It was also suggested HDTV along with microprocessor technology would stimulate new developments in programming such as allowing television viewers to participate in the direction that a particular program takes.

In discussion of film and program production, it was noted that there is a need for more research to be done on the original production of images in an effort to give the film look to video pictures. It was mentioned that a company in Texas already offers a service whereby, on receiving a videotape, they will return it with the film look. The television camera/lens system should be capable with computer aid if necessary, to produce the effects found with film cameras such as soft filter, vaseline smeared glass, diffusion lens, etc. Also, the TV camera should provide the mobility and flexibility found today in the film camera.

The market for HDTV needed serious consideration. HDTV can provide the possibility for high production creativity (high resolution and aspect ratio) and perhaps should not be aimed to reach just the consumer market; especially if it will end up being converted to present TV formats to be received by existing TV receivers. It was felt that the average consumer will continue to watch his badly adjusted, out of focus, green, magenta or blue programs often seen through snow without complaints. It was questioned as to whether the high cost of HDTV is worth it for consumers who may not appreciate its quality. If HDTV is to end up only on the consumers' TV screen, it would be wise to spend the money on the script rather than on the technology. Therefore, it was felt that the advantages of HDTV might better be directed towards a more restricted market such as the 100/150 seat theatres, mini and dinner theatre, exhibition halls and for specifed science programs such as medicine. Others saw a market for HDTV applications at the consumer level, i.e. Telidon, computer games, DBS from Place des Arts or National Arts Theatre with the possibility of having more active audience via DBS or fibre optics, which would change the consumer from a passive viewer into an active one. The workshop was not clear as to which market HDTV should pursue and for whom such good quality images would be produced. It was pointed out that in the United States, many households now own ½" Betamax or VHS systems. The same amount of dollars has been spent on large screen projection equipment. However, in 90% of these homes the color, focus and brightness of the monitors will be badly adjusted.

The workshop also discussed formats. A producer was asked which format he would choose i.e. 1:1.33 or 1:1.85 if money was not a factor and the reply was 1:1.85. A producer is looking for any technology that will improve his product. At the present time his product is not seen for its real worth when shown via conventional television systems. It was felt that the priorities for aspect ratio changes for HDTV will not come from the consumer level. Psychological research, however, has shown that a wider aspect ratio is better. The viewer likes the freedom to see what he/she wants. HDTV could offer more information on the screen for viewer selection. It was asked whether our present method and procedures for television editing show too much use of squeeze zooms and electronic manipulation which restricts the viewers choice of seeing that which he/she chooses to see. HDTV would eliminate the need for some of these presently used production techniques.

The use of conventional software high definition television was discussed and this led to questioning how narrowcasting and DBS could open up other potential fields of software. For example, the medical profession might benefit from HDTV for operations or techniques that require a picture of high definition. Science teaching such as holography or laser technology would take advantage of HDTV.

The workshop asked whether HDTV is being exploited for the right reasons? It must not be considered as a means to an end i.e. the end meaning a universal use of large screens. Are we trying to find a use for the technology rather than develop a technology to respond to a need? After all, we have high definition already available on film, and we must avoid confusing HDTV image origination with film transferred and displayed via HDTV.

High definition television definitely offers a new tool for post-production and editing. Matting and fancy optical techniques are more readily done electronically than on film. Not only does this speed up production, but where time is saved, so is money. With existing methods and equipment some problems arise where film is intercut with video scenes. The video often looks flat and unrealistic. HDTV should improve this. A production using all the technology available needs to become a box office hit before producers will take advantage of the many facilities. A recent Hollywood production "Tron" which used many computer graphics and electronic gadgetry pulled very small audiences compared to a live action thriller such as "Raiders of the Lost Ark".

It was unanimously felt that Canada lacks an R&D department within a government agency which would take on research on topics such as HDTV. Canada has an important contribution to make and, in our real evaluation of the motion picture industry, an integral part should be a funded technical branch to develop ideas alongside the technological advances. More financial backing is required from the government to support this rapidly expanding industry for television. More motion picture or video productions should be made for box office profits, thereby allowing money to be put back into R&D for improved images.

WORKSHOP NUMBER: 5 WORKSHOP DATE: Thurdsay, Oct. 21/82

TOPIC: "HDTV - A TECHNOLOGY IN SEARCH OF APPLICATIONS"

CHAIRMAN: K.P. Davies, CBC
O. Roscoe, DOC

The workshop began with a presentation of a proposed relationship between the motion picture industry and HDTV. Such a relationship would be based on (1) electronic cinematography and (2) a satellite delivery system serving a world-wide audience with video cinemas at the point of viewer contact. Pay or subscription TV could also form a part of the delivery system.

Releasing a major production to a world market simultaneously would have a number of important advantages. First, it would reduce the opportunity for piracy. It has been estimated that the number of bootleg copies of "Star Wars" equalled the number of authorized prints in circulation prior to the release date. Presently the large number of legitimate prints dispersed through the delivery system provides ample opportunity for piracy, which would be reduced by a single release from one source. The publicity that precedes a prolonged release schedule also creates a market for copies.

Electronic simultaneous release could have substantial financial implications as well. Under the present system of sequential release, some films of merit fail to reach their potential audience because adverse critical comments modify the release pattern. A film in simultaneous release could reach a financial break-even point in one day, before the word reaches a significant portion of the audience. A global DBS release could also decrease advertising costs by shortening the advertising campaign to the two preceding days. Satellite distribution could open world markets to geographically isolated producers, such as Australia.

There is too much emphasis on the broadcast use of HDTV. The motion picture industry will be the proving ground, therefore it behooves broadcasters to cooperate fully in return for guinea pig trials. The experience of the motion picture industry will change broadcast practices and the shape of the broadcast industry.

Results of the CBS system, using a number of isolated camera/VTRs and editing the presulting tapes as film, are not yet in as they have not revealed cost figures. However, original production cost savings through the use of the present electronic medium has not been proved. Attempts by drama producers to use tape have suffered cost over-runs. Videodisc may be more suitable for motion picture editing.

If no standard is set by the broadcasting community, the motion picture industry would probably set their own, and as things now stand that would likely be the NHK system and therefore this could become a de facto standard. In any case, motion picture management wants one world-wide standard. Using present TV standards, tape distribution is less attractive than film. EDTV is not a good solution for film production. If an EDTV system were adopted, it would probably rule out the development of an HDTV system for a long time to come, if ever.

It was suggested that 1125 lines will not provide sufficient resolution for motion picture applications: 1500-2000 are needed, but such a system is a long way off. Much development is needed and many theoretical designs are not yet on the drawing boards. However, there has been no proof of a correlation between low resolution films and audience acceptance. The "Concert for Bangladesh" was shot on 16mm and blown up to 70mm for a successful, commercial presentation.

Educators now have an array of audio-visual training aids, some of which provide satisfactory results at nominal cost and except for very special applications such as some medical subjects (histology and anatomy), HDTV will find that it is competing and will lose out due to cost. Educational institutions will not be able to afford HDTV until its cost compares favorably with standard television.

A possible application of HDTV is for continuing education or professional upgrading. A great many organizations already successfully use videocassettes. In the NTSC standard however, the home--type display is a constraint for some subjects.

In speculating on possible HDTV applications, it was suggested that an impressive display which provides a greater perception of reality (or unreality), or and "increased experience", would appeal to the consumer and money would be spent even when particularly high quality is not present, e.g. the Sony Walkman (R) or $800.00 plus car stereos. The demand for better graphics in video games was also considered to support this view.

In discussing research and development on HDTV applications, it was suggested that military requirements, traditionally on the forefront of technology, may speed development of HDTV. It was also suggested that people working on the technology should involve artistic people in R&D. It was noted that when film or tape was used for training, better simulations produced a better experience and hence a greater quality of training.

WORKSHOP NUMBER: 6 WORKSHOP DATE: Thurdsay, Oct. 21/82

TOPIC: "GETTING HDTV TO THE CONSUMER"

CHAIRMAN: A. Toth, BNR

The workshop opened with a discussion on the non-broadcast aspects of HDTV and quickly focussed on the question of compatibility.

Discussion in favour of compatible systems reasoned that these could provide the consumer with an interim improvement before he benefits from a large screen and would not force the viewer to change his receiver immediately. Compatibility was seen as helping distributed television to compete in the short-term with cable, disc and tape program sources and in the long-term by holding out the promise of higher quality services. Compatible systems would be most favoured in Europe where there is a shortage of bandwidth. Thus there was a possibility that the MAC system would emerge as a common format. Furthermore, compatible formats could take into account the situation that in many cable systems, much of the capacity is already used, leaving little room for HDTV which requires more bandwidth than presently used.

Arguments in favour of non-compatible systems were largely based on advancements in technology expected to become available in the near future. VLSI technology, including frame memory availability, will permit a high level of processing at the receiver, thus leading to the possibility of transmission. Direct broadcasting by satellite will be commonplace by the end of the decade, and will be a practical and economical method of reaching the home consumer. For satellite reception, new receiving equipment attached to the consumers' TV set is required anyway, and compatibility conversion capability could be included in it. For satellite transmission, separate component signals are less susceptible to interference than composite signals and could become preferred for signal modulation. Optical fibre systems will be an alternate means for distributing HDTV. Even now such systems have reached a stage of development that repeaters are required only at 20 km intervals. It was noted in the workshop that there is a push for a universal production standard, and that this standard could be used for a non-broadcasting applications.

WORKSHOP NUMBER: 7 WORKSHOP DATE: Thurdsay, Oct. 21/82

TOPIC: "HDTV - KEEPING THE LINES STRAIGHT"

CHAIRMAN: R. Zeitoun, DOC

During this workshop considerable time was spent examining the role of policy and regulations in the broadcast industry. Several views were offered which cautioned against "over-regulation". If a highly technical area is very tightly regulated, new technological developments frequently outdate these regulations rendering them meaningless. In addition, very tight regulations hinder development work on improvements to the technology. Manufacturers are hesitant to produce for "non-standard" requirements, limiting available hardware for this research.

The view was expressed that regulations should not protect one industry over another, as this would destroy healthy competition (which is viewed as the "ideal"). The need for any regulation at all was questioned if HDTV is not broadcast, but distributed on disk or subscription closed circuit for such applications as business information and electronic mail services. It was finally argued that government regulation of the production aspects of HDTV such as aspect ratio, should be approached with caution.

North American input to HDTV development to date has been rather limited and our opportunity to specify required policy andregulation is quickly passing by. Unless government and industry quickly plan and support an HDTV R&D effort, de facto standards will come into existance from market control by off-shore industry.

The question of HDTV compatibility was broached. Obviously there is a very large existing public investment in the present broadcast technology and this cannot be ignored. In any system technological improvements eventually outstrip the basic specifications and entire new systems are demanded. There are examples where this has occurred in the past; e.g. the 33½ RPM LP disc and FM radio. None, however, have had the dollar impact that a future non-compatible HDTV system would have.

It was recognized that there were dangers, however, with compromise to achieve compatibility. What compromise in achievable quality would be acceptable for the sake of a compatible HDTV format - was it 20%, 30% or 50%? It is possible to adopt a purist attitude and to accept no compromise, but this would make demands that push present technology to the limit. NHK in Japan has realized this and is waiting for necessary bandwidth compression (a compromise) before making their system available to the public. Use of DBS will also force compromise because HDTV will make heavy demands on a limited frequency spectrum resource.

EDTV and HDTV were discussed as two major thrusts for future development. The industry is presently searching for something new to sell to consumers. EDTV will probably evolve due to this considerable pressure, whether the improvements warrant it or not. Better CRT'S, comb filters and cheap LSI'S are available now to fuel this push. These receivers will utilize existing screen sizes of 20 to 26 inches and eliminate present NTSC, PAL and SECAM problems of flicker, twitter, crosscolor etc.

The second thrust, HDTV, could be the non-compromising, non-compatible system of the future. That is when the large size, high resolution displays are planned to be available at costs attractive to the public (say in 10 to 15 years). It was hoped that this could be a world HDTV standard with possible PAL, NTSC and SECAM derivable sub-output. This, it was felt, would require a global effort to achieve, but was a goal well worth pursuing.

Finally the session turned towards a discussion of available spectrum for possible HDTV use. Experimentation and resulting decisions on the bandwidth required for HDTV were called for. The view was expressed that in the future the lines of demarcation between broadcast and fixed (communication) satellite services will be less and less clear, removing the need for their distinction.

During the workshop, the attached paper by D. Fink was tabled for discussion.

An engineer's perspective on policy

Donald Fink
Head, Study Group on HDTV, Society of Motion Picture and Television Engineers (SMPTE), USA

High definition television technology is now available for use in the production of motion pictures distributed on film to cinemas. Its future delivery to the home most likely by cable or direct from satellites will offer the viewer much more vivid television images than do today's 525 or 625 line standards. An 1125 line HDTV system has been demonstrated by NHK, the Japan Broadcasting Corporation, and well-known producers are now beginning to use it in Hollywood. However, the delivery of HDTV to the home is less immediate because of its massive spectrum requirements and because a low-cost, large, wide-screen display for HDTV images in the home is not yet available.

The current development of integrated circuit technology offering sophisticated signal processing (and the evolution of a mass market for such chips) will some day make possible a partnership between a 'smart' transmitter and a correspondingly 'smart' receiver. These systems will greatly reduce spectrum occupancy, and thus increase the likelihood that operational services to the home will be widely implemented.

The progress in integrated circuitry will also benefit efforts under way to develop inexpensive, flat wall screens. However, twenty years of research have yet to yield major results. For the foreseeable future, cathode ray projection systems (which are unlikely to decline significantly in cost and therefore unlikely to be available on a mass scale) represent the only means for the large display of HDTV.

Among the public policy issues raised by the prospect of a home HDTV service are (a) the need to serve existing receivers by HDTV transmissions without degrading their performance; (b) the objective of a single worldwide set of HDTV transmission standards; (c) the probable shortage of frequency assignments for direct broadcast from satellite (DBS) HDTV transmissions and (d) the advantages of a deliberate rather than a rushed approach to HDTV standardisation. The imminent introduction of HDTV techniques into the motion picture industry will create a laboratory for gaining experience while the possibilities offered by technical (integrated-circuit) devices come into sharper focus.

Two forces underlie the current interest in high-definition television. The first is the realisation by the motion picture industry that substantial production cost savings (estimated at 20% of total operating costs) can be found by using HDTV cameras, view-finders, monitors, video tape recorders, and editing consoles. This equipment greatly reduces the time required for shooting, processing and editing, relative to the use of film.

The second force is the realisation by many in the television broadcast industry that a substantial enhancement of the impact of home television service can be achieved by the use of a large, wide screen and stereo sound. When a wide screen is viewed from a close distance, peripheral vision comes into play. If the detail of the image remains satisfactory, an impressive involvement of the viewer in the programme subject matter is found to occur. The effect is greatly enhanced by stereophonic presentation of the accompanying sound.

Research and development in HDTV is under way in many countries, but the foremost effort is that of the Japanese. After more than ten years of research, and expenditures said to total $200 million, NHK in Tokyo has developed an 1125 line HDTV system, using equipment developed in the NHK laboratories, as well as by Sony, Matshusita and Ikegami.

The NHK system employs images scanned at 1125 lines per frame, 30 pictures per second, interlaced, an aspect ratio (width to height) of 5 by 3, a black-and-white (luminance) bandwidth of 20 MHz and a colour (chrominance) bandwidth of 6 MHz. The system has been demonstrated in Tokyo by satellite transmission and reception, using FM modulation occupying a bandwidth of 100 MHz. Analogue signals have been used throughout. All the necessary equipment (cameras, videotape recorders, amplifiers, transmitters, receivers and 'direct view' as well as projection displays) has been developed and is capable of operation under standard studio and field conditions. The images shown in February 1982 on a projection display that measured eight feet diagonally (as well as on a 'direct view' picture tube screen that measured two feet diagonally) were of excellent quality. Their resolution was equal to that of 35mm film projection, and had a signal-to-noise ratio better than 43 decibels.

In the United States, another HDTV system intended for use in motion picture production was demonstrated in October 1981 by Compact Video Systems Inc. The studio camera operated at 655 lines, 30 frames per second, interlaced, the chrominance signal being interlaced in frequency with the luminance signal on a subcarrier of 7.16 MHz. The total bandwidth occupied by the transmissions was 10 MHz. The system uses four digital frame stores which facilitate the comparison of colour and luminance values within and between frames, and thus provide a much more efficient videotape storage of programme material. As costs decline, this technology will also have a great role in signal compression during transmission.

Compact Video Systems record the signal on 2 inch tape. The video signal is then transferred by an undisclosed process to 35mm film and projected by a standard projector. The images thus produced have been considered by expert observers to be nearly the equivalent of a 35mm film projected in a viewing room, and equal to or better than film seen in a typical neighbourhood cinema. This achievement, using a total bandwidth of only 10 MHz, has important implications in respect to the ultimate choice of the bandwidth for a standardised HDTV service.

AT HOME

The prospect for HDTV service in the home is less immediate. Two barriers exist. The first and most fundamental is the very large amount of spectrum space (of the order of 15 to 25 MHz) required for the transmission of HDTV images as opposed to the 6 MHz required for conventional standards. The lack of spectrum available for terrestrial broadcasting makes the conventional broadcasting of HDTV signals problematical and, possibly, not feasible. However, alternate means of distribution, such as coaxial or fibre optic cable and direct broadcast from satellites, are more promising. In the USA, CBS has petitioned the Federal Communications Commission for authority to construct and operate an experimental/developmental 3 channel HDTV satellite system in the 12 GHz band, to begin sometime after the middle of the decade. Another DBS applicant, Comsat's Satellite Television Corporation, has proposed HDTV experimentation over a system whose first satellite generation will be primarily dedicated to the existing NTSC service.

The second barrier to the early use of HDTV in the home is that a suitably large, wide-screen, display device (ie, a flat screen having dimensions of the order of one by two metres, of adequate brightness, small weight and low power consumption, at an acceptable cost) does not yet exist. Indeed, its attempted development over the past 20 years has been disappointingly slow. Improvements in the projection of images from cathode ray tubes, as were demonstrated by NHK and CBS in their 1982 demonstrations, seem to be the only open avenue for the immediate future. These projection systems, in all probability, will be too costly to attract a wide market for the home.

SPECTRUM ECONOMY

The spectrum requirements for an HDTV service are so large as to call for highly advanced means of achieving economy in the transmission of information. The route to this objective is now well established in the development of VLSI (very large scale integrated) circuits that can store the full content of a colour television image and permit sophisticated signal processing to reduce redundancy and other types of spectrum inefficiency. For example, equipment now exists which can store 200,000 picture elements (the details in a standard television image under the present standards), each represented by eight bits, and totalling a randomly accessible storage of nearly two million bits. These 'frame stores' now cost $10,000 or more, and are used only in research laboratories and for the conversion of programmes between the 525 line and 625 line standards. However, experts expect the cost of these frame stores to be reduced within the next decade to a level permitting their use in domestic television receivers of conventional design. They could also be used in the HDTV receivers of that future time.

Such an achievement (the inclusion in domestic receivers of frame stores and ancillary integrated circuits) would permit for the first time a new form of partnership between a 'smart' transmitter, providing an economic use of the spectrum by efficient signal processing, and a 'smart' receiver which would offer the inverse signal processing to recover the full picture information prior to display. This processing would also permit receivers to use any of several standards of transmission. In particular, transmissions on a given regional standard could be transformed to another, local, standard. HDTV transmissions could, by the same methods, be transformed for conventional receivers of current design (eg, NTSC, PAL or SECAM) so that the HDTV programme could be displayed on such receivers with the quality for which they were originally designed. The latter type of conversion would be carried out in a 'black box' decoder attached to the outside of the receiver.

In the opinion of informed engineers working on HDTV systems the delivery of a high-quality, high-definition television service to the home will not be possible unless and until such a partnership between 'smart' transmitters and receivers is established. While the eventual realisation of this aim seems certain, much care must be exercised in present planning to avoid unnecessary complexities and costs in the future. There arise, therefore, a number of questions of public policy that must be addressed now to take account of the political and economic factors that may impede the orderly realisation of an HDTV service to the public.

PUBLIC POLICY ISSUES

Among the many policy issues raised by the prospect of HDTV is the need to insure the continued operation, without any degradation of performance, of the 500 million television receivers now in use throughout the world. Whatever HDTV service or services may be established, it is essential that some form of 'standards conversion' be provided which will permit NTSC, PAL or SECAM receivers of present and future design to make use of the HDTV transmissions.

Of particular importance is the fact that such standards conversion would be greatly simplified, at least in the initial phases of HDTV service, if the number of lines used in the HDTV images were twice that of the standard to which they are to be converted (ie, 1050 lines for conversion to the 525 line NTSC standard and 1250 lines for conversion to the 625 line PAL and SECAM standards. However, since a 1125 line system has already been demonstrated the prospect of multiple, incompatible standards seems quite real.

Although economic and political considerations may favour multiple standards, the question must be faced: should not the administrations of the world take advantage of the possibility of establishing just one worldwide standard for an HDTV service? The feasibility of an international agreement on a single set of HDTV standards is suggested by the October 1981 unanimous agreement within the Comité Consultatif International des Radiocommunications, the CCIR (in which the NTSC, PAL and SECAM consortia are fully represented), on a single set of international standards for digitised video signals. These standards will be used in the broadcast plant of all stations, whether their transmissions are by the NTSC, PAL or SECAM standards. Moreover, there is growing support for an additional set of international standards embracing all facets of studio and field production operations, which would greatly facilitate the exchange and interconnection of programme sources. While this trend toward the international standardisation of in-plant and production methods is not, in itself, a trend toward the international acceptance of overall HDTV system standards, it is nevertheless a clear indication that the international technical community is now ready to count the cost of a proliferation of regional standards and that the technology underlying worldwide HDTV standardisation is seen to be realisable.

An important consideration is the distribution of the engineering design costs involved in equipment manufacture. In-plant and production equipment (for studio and film operations) is produced in lots of hundreds or at most thousands of units, and the engineering costs of providing for multiple standards constitute a high proportion of the unit price. In contrast, receivers designed for the home are produced by the millions, and the engineering costs of providing for two sets of HDTV standards are spread so widely that their impact in price would be modest. Still, the prospect of a free trade in all HDTV equipment markets suggest that a single standard for HDTV might better serve the public interest if it can be attained. Perhaps more likely (and certainly better than the current situation involving three incompatible standards) would be two HDTV standards. One standard might be agreed by the United States and Japan (both of which now use 525-line NTSC) while the other would join the Europeans (now divided between PAL and SECAM).

There is also a problem with the massive bandwidth requirements for an HDTV satellite service. The number of frequency assignments in bands suitable for a DBS service will be severely limited unless great success in bandwidth compression techniques is achieved. Until this occurs, any operational HDTV channel would impose an 'opportunity' cost of two to three standard television channels. In countries that are anxious to maximise the diversity of their information sources this issue will be a serious one.

Another policy issue has to do with the timing of international efforts towards standardisation. An all-out immediate effort would be unwise, because technical progress and cost reductions in integrated circuit technology are now extremely rapid. Too early a decision on standards would in all likelihood be overtaken by events and subverted by technical change.

This issue raises a related consideration; namely, the need for all national administrations to concentrate, in the short term, on improvements in the services possible under the existing NTSC, PAL and SECAM standards. None of these services currently approaches its ultimate potential. In recent years, for example, the horizontal resolution of NTSC images in receivers equipped with line-comb filters has been increased by some 50%, thus permitting the full recovery of the luminance resolution required to be transmitted by the FCC rules governing the NTSC system.

The inclusion in receivers of full frame stores and ancillary integrated circuits will provide similar increases in vertical resolution, as well as permitting many other improvements in signal processing with respect to small area flicker, the constancy of optimum receiver adjustment, and the complete absence of cross-colour and cross-luminance effects.

In fact, only when the full potentials of the NTSC, PAL and SECAM systems are realised in these ways will it be possible by market testing (comparing the then-existing conventional receiver performance with the improvements then offered by the proposed HDTV service) to ascertain how much value the average viewer then places on the superior performance of the HDTV receivers.

A deliberate pace in the development of HDTV standards for home service is also called for by the fact that current HDTV technology seems likely to be used by the motion picture industry in the immediate future. The use of HDTV methods in film-making and exhibition will provide a test-bed within which the success or failure of specific technical methods can be assessed in real time by those engaged in planning the eventual world standard, or standards, for the distribution of HDTV.

PRIORITIES IN HDTV PLANNING

The probable sequence of events leading to a HDTV service for the home is now clear. The first milestone has already been past. Convincing demonstrations by NHK, the Japanese public broadcasting organisation, have shown that a viable HDTV system, with all the essential items of equipment, exists. The broadcasting authorities and manufacturing organisations of other countries have an 'existence proof' on which to rely and to organise their activities in the HDTV field.

The first, and perhaps most immediate, priority for action is a decision on a direct broadcast satellite HDTV service in the 12 GHz band. In Europe, Africa and Asia the 1977 WARC set up a plan to transmit PAL and SECAM services, using the standard PAL and SECAM signals, with the chrominance content interlaced in frequency with the luminance component. This plan has the advantage that a simple demodulation of the FM transponder signal at the receiver would provide the standard PAL or SECAM signal for which the receiver had been designed. But the plan has a serious disadvantage. It does not allow for the extension of the luminance bandwidth that would be required for the conversion of the DBS service to HDTV. An alternative means of using these 12 GHz channels has been suggested by the UK's Independent Broadcasting Authority. The IBA's system would permit such an extension. These options deserve immediate attention in Regions 1 and 3. In Region 2 (the Americas) the decisions on the use of the 12 GHz band for direct satellite HDTV broadcasting can be made in the context of the RARC meeting in 1983. Planning for the regional conference should allow for the experimentation and gradual introduction of a 12 GHz direct satellite HDTV service as the technology evolves over the life of the RARC plan.

A second priority deserving early attention is the use of two or three adjacent cable television channels fed by a domestic satellite to provide simultaneously conventional and HDTV services. This prospect is more immediate in Canada or the USA, where about one-half and one-third respectively of the television homes presently have cable connections, than in countries where the penetration of cable service is substantially less widespread. In this option, one cable channel would carry the NTSC, PAL or SECAM signal in essentially the same form as is now broadcast, except that the luminance signal would be limited to frequencies below those of the chrominance signal. One or two adjacent channels would then be used to carry supplementary high-frequency luminance and chrominance information which would not be received by conventional receivers but would be accepted by HDTV receivers for creating the HDTV images. Although many Canadian and US systems plan to have as many as 100 channels of 6 MHz for television and interactive information service to the home, an early decision is needed to reserve a number of channels of double or triple width for HDTV possibilities.

A third priority would involve using satellites in the 'fixed' service category to distribute HDTV programme material to terrestrial television broadcasting stations, which would subsequently broadcast it to the audience surrounding the station. One possibility is to use portions of the spectrum in the gigahertz range. In this proposal, the terrestrial station would transmit the HDTV gigahertz signals in a form receivable by conventional NTSC, PAL and SECAM receivers (using a channel format perhaps similar to that described above). The gigahertz terrestrial broadcast signal would also contain the additional luminance and chrominance information required by HDTV receivers.

The objection to such a method of terrestrial broadcast distribution is that propagation in the gigahertz spectrum can incur serious blockages from obstructions between the transmitter and the receiver. This propagation problem contrasts with conventional VHF and UHF broadcasting in which complete blocking occurs only when the obstruction is very large compared with the wavelength in use. Even then, diffraction around such objects often permits reception behind them. It is important for national administrations to know, at an early date, the extent to which such gigahertz broadcasting can be considered. In the USA, CBS has just announced an experiment in this area.

While these questions are being studied and results demonstrated, the continued advance of VLSI circuit technology will continue apace. But a still further HDTV priority exists in the need to motivate the semiconductor industry to devote the large investment required for the frame stores and other integrated circuits that will be used primarily in the HDTV service. At the moment, the motivation behind VLSI development and production resides almost exclusively in the market provided by the computer industry. There is a need for an early effort on the part of those involved in HDTV system development to establish the technical requirements and the potential market for HDTV receivers. They must convince the semiconductor industry that current design studies, leading to the eventual high-volume production of HDTV integrated circuits, are justified.

Finally, underlying the attention of all national administrations, is the prospect of a national HDTV service being instituted at an early date in the country which has devoted so much effort and money to this technology over the past ten years — Japan. The real possibility that NHK will begin a DBS HDTV service intended for the Japanese public within the next few years, and the then clear pressure on other nations to do likewise, lends an urgency to definitive planning, study and action that would not otherwise exist.

Donald Fink is Chairman of the Study Group on High-Definition Television of the US Society of Motion Picture and Television Engineers (SMPTE). He served as Vice Chairman of the US National Television System Committee which developed the NTSC colour standards in the early 1950s. He was Executive Director of the Institute of Electrical and Electronics Engineers (IEEE) from its formation in 1963 until 1974, and today holds the title of Director Emeritus.

This article represents the author's personal views, but not necessarily those of the organisations with which he is associated. It is based upon a paper commissioned by the Tobin Foundation for use in a recent meeting at Leeds Castle, England, of twenty-five top officials and executives in international telecommunications. A report on the meeting, including its discussion of HDTV, will be made available to *InterMedia* readers.

WORKSHOP NUMBER: 8 WORKSHOP DATE: Thurdsay, Oct. 21/82

TOPIC: "CONSUMER HDTV EQUIPMENT"

CHAIRMAN: A.G. Day, P. Eng., CAB.

The workshop explored the new technology for displays, the opportunities for industry, and the probable evolution of TV hardware in the home.

The principle was exposed that the ERE, the "Enhanced Revenue Experience" occurred only due to JVD, the "Just Valuable Difference" being great enough because of sufficient JND's, "Just Noticeable Differences" for the public to want the product. Quality has improved substantially from that of the past, so future systems must show very noticeable improvements to gain acceptance, e.g. from the present 300 lines resolution to perhaps 500.

Screen size is important, and participants did not feel that projection displays would be successful in home environments though they were the only practical techniques available today. Screens from 30-40 inches across would be a practical limit, with equipment depth minimized so as to pass through doorways, and present screen brightness would have to be retained.

Controls would probably be remote from the display, and stereo sound, with the larger display, would be desirable. Stereo sound assists even on present, small speaker receivers. It is particularly effective for distributed sounds such as crowd noise, and for off-screen commentary.

The hardware will feature much improved colour response and avoid the present cross-colour problems. In the home, three receiver types should be anticipated; the present type, the new receiver, similar to the present except for the enhancement by processing in a "black box", and the special HDTV receiver having the processing included plus a larger, wide screen display. The price of the latter should not be substantially greater than that of the new receiver.

Evolution of the receiver stems, not from public demand, but from competition in the receiver industry. The major improvements will include the comb filter, already available on some models and a substantial help in improving cross-colour and resolution, and steps to reduce line visibility and peripheral flicker. A key element is a frame store on a chip which would permit, besides processing opportunities, display in sequential rather than interlaced modes.

There appear to be no insurmountable problems in HDTV distribution by DBS at either 12 or 22 GHz, though it is acknowledged that Regions˜1 and 3 will have greater carrier-to-noise headroom than Region 2 at 12 GHz. The DBS mode can avoid some of the major quality constraints experienced in terrestrial NTSC broadcasting.

NTSC limitations in resolution, once the 6 MHz VSB channel is not the major constraint, are due to the colour decoding process and to the display screen dot matrix which presently limits bandwidths to about 4 MHz. However, high resolution screens are now available with dot pitch improved by better than 2:1.

It was generally conceded in the workshop that there were a great many trade-offs, involving resolution, aspect ratio, noise, and of course, relative cost, a prime consideration. However, the major improvements which should bve aimed for would be first, aspect ratio, then improved (doubled?) line structure, and with avoidance of cross-colour problems.

WORKSHOP NUMBER: 9 WORKSHOP DATE: Thurdsay, Oct. 21/82

TOPIC: "CONCLUSIONS"

K. DAVIES OPENING STATEMENT

Mr. Davies explained that the purpose of the plenary session is to review aspects of the workshop sessions, to try to obtain some conclusions, to answer some of the questions raised about HDTV and to try to formulate some directives. He expressed his satisfaction on the quantity and the quality of the exchanges between the participants and the colloquium. He noted that, he as well as many other participants, had certain views on HDTV that has changed a lot due to the colloquium. He added that the colloquium may have created more questions than answers, but that at least the questions are in logical order now. Mr. Davies then invited the chairmen of the sessionsto present theirsummaries.

K. DAVIES CONCLUSION

Mr. Davies made the observation that HDTV is much more than resolution; content, aspect ratio, contrast signal to noise ratio are equally important. He mentioned that we can now see the beginning of a new format where the different components such as pick up device, display, processing or transmission may have different standards and that it will be a challenging job to design the various interfaces that will minimize the impairments.

We have seen that HDTV has a good future in electronic cinematography, that ETV is very well suited for DBS, cable or current broadcast. He made the remark that there is a lot of work to be done in display technology in order to obtain the ideal HDTV display. He mentioned that the receiver will have to include a frame store in order to achieve the separation of functions that are envisaged and keep an acceptable transmission rate.

Mr. Davies concluded that HDTV people are aiming at a moving target, actual standards are providing better and better pictures thus represent a real challenge.

DON FINK

Mr. Fink stated that a real milestone had occurred during the colloquium. To explain his statement, he mentioned that the advent of standards for black and white and color television from the U.S. resulted from the threat that the FCC would stop the development of the industry in the absence of a standard. He suggested that a successful non-compatible HDTV system in Japan ready to invade the world market could be the threat necessary to put HDTV on its way. He added that for the first time in his experience, there were four days of good papers and good interchange on a topic of major importance to the electronic industry. To conclude, Mr. Fink suggested that this kind of colloquium should be held at least every two years.

CLOSING ADDRESS TO THE HDTV COLLOQUIUM

OTTAWA, OCTOBER 18-21, 1982

Donald G. Fink

Chairman, SMPTE Study Group on
High-Definition Television

I have requested that Ken Davies allow me a few minutes at this stage in the proceedings because it is important not only that we, the guests of the Canadian organizers of this Colloquium, but also our Canadian hosts, understand what a milestone has been passed here this week. Let me go back just a bit to justify making so bold a statement. It happens that there were two major catastrophes that preceded the introduction of monochrome and color television in the United States. In 1939, the Federal Communications Commission withdrew the authority for commercial telecasting, and announced that this authority would not be renewed - no further growth of the television industry whatever - until industry-wide agreement had been reached on the standards for black-and-white television. That was the reason for forming the first National Television System Committee (NTSC). Besides changing the number of lines from 441 to 525, NTSC did little but confirm the validity of previous work, but it did offer the industry-wide agreement. In 1941, the NTSC put its standards before the FCC and the impasse had been cleared. Thus black-and-white television was freed to develop in the U.S.A.

In 1948, the FCC announced that the then assigned channels for television had become so crowded that it would issue no new licenses for television broadcast stations until further notice. That disaster got the blood hot in a number of important bodies, including General David Sarnoff of RCA and Mr. William Paley of CBS. Under their pressure, as well as that of many industry leaders, no time was lost in attempting to break this new impasse, but also to introduce a new service, color television on channels no wider than the existing 6 MHz standard. This was the signal for forming the second NTSC, with the charge to produce and to offer to the FCC an industry-wide agreement on standards for compatible color television broadcast. Final approval came in 1953, just a year after the freeze on licensing stations had been lifted. In 1954 the FCC authorized these standards, but there was almost a ten-year delay before the sale of color television receivers made a major impression on the industry.

I point out that these accomplishments, of great benefit throughout the World today, did not happen merely because correct answers could be found to the problems of a new service in an engineering sense. They happened, also (and perhaps in major part), because powerful individuals and organizations were aroused by the interruption of their businesses. They were fighting a threat to the continued growth of their markets.

I don't know for certain where such a threat will emerge that will send high-definition television on its way. But I am quite sure that such a threat will come. One reasonable scenario is that a non-compatible public HDTV service will be instituted by direct broadcast satellite (DBS) for the Japanese Islands, using the NHK 1125-line system, and that over a period of years it will become an acknowledged success as a public service and as the basis for a new market in the television industry. By then everyone else in the television world will be reacting to the fact that, in this new market, they are at the mercy of the Japanese entrepreneurs. That is the kind of threat that will get a lot of work done on HDTV outside Japan, but perhaps too late.

Why do I put this history and scenario before you? Only to emphasize that this week, for the first time in my experience, we have participated in four days of a Colloquium offering excellent up-to-date papers, and informed interchange among experts in the workshops. The active and enthusiastic participation by all present has been truly outstanding.

I say to you, Ken, and to all your associates who planned and executed this Colloquium, on behalf of all of us who have come from outside Canada, that we are very much in your debt. It took much thoughtful, careful planning just to get the Colloquium under way, and much more effort to implement it in such splendid fashion. The facilities, the hotel, the way in which the staff has participated at every level - all have been provided in the highest tradition of professional activity.

This meeting has given the HDTV art new momentum that must be maintained. I don't know just how high in the Canadian Government one must go to get the authorization to expand the requisites of manpower and money, but this Colloquium <u>must</u> be repeated. Perhaps not every year, but at least every other year.

Why is a meeting on HDTV in Canada so appropriate? My view is that your country is an ideal test-bed for such presentation and exchanges. Canada is not, at least not yet, a threat to the rest of the World in this business. Here in Canada you can invite everyone of consequence in HDTV engineering, and they will come, as they have this week. Japan is represented by their highest talent. So are the broadcasting institutions of the British Isles, who incidentally at the moment are at each other's throats on technical and political issues about the standards for DBS transmission in Europe. Experts from France and Germany are here. Fully half of the principal contributors to the work of the SMPTE HDTV Study Group are in attendance. One reason we're all here is that we don't feel threatened. We are fully prepared to give and to take. So a milestone has been passed.

In closing, let me again congratulate Ken and everyone else who started planning this meeting a year ago and who have pulled it off so well. I intend to write to the Minister of the Department of Communications and to the Chief of the Canadian Broadcasting Corporation to ask that we all be permitted to maintain and extend the momentum of this meeting in future years.

Thank you very much.

AUTHOR	AFFILIATION	COUNTRY	SESSION
Ahmed, S.N.	DOC	Canada	2.8
Amero, R.	DOC	Canada	5.2
Barrette, R.E.	CAE	Canada	4.2
Bastikar, A.R.	DOC	Canada	5.2
Bowen, Carrol	Kalba Bowen Assoc.	U.S.A.	3.1
Bowen, Robert R.	DOC	Canada	2.9
Chang, K.Y.	DOC	Canada	4.3
Childs, Ian	BBC	England	1.2
Chouinard, G.	DOC	Canada	3.2
Crozier, B.	DOC	Canada	4.3
Dubois, E.	INRS-Telecommunications	Canada	2.6
Fink, Donald G.	SMPTE	U.S.A.	5.3
Fujio, Takashi	NHK	Japan	1.3, 2.10 & 3.3
Guite, Michel	Kalba Bowen Assoc.	U.S.A.	3.1
Hara, Elmer H.	DOC	Canada	2.4
Hogan, William H.	Ruxton Limited	U.S.A.	4.1
Hunt, M.J.	DOC	Canada	2.8
Jackson, R.N.	Philips Research Laboratories	U.K. & The Netherlands	2.7
Koenig, Joseph	Interactive Image Technologies	Canada	3.5
Lowry, John D.	Digital Video Systems	Canada	2.4
O'Reilly, Robert R.	CBC	Canada	1.1
Ohba, Yoshinobu	NHK	Japan	3.3
Powers, Kerns H.	RCA	U.S.A.	1.6
Prasada, B.	BNR	Canada	2.5
Reed, V.C.	Skyline Cablevision	Canada	3.4
Rhodes, C.	Scientific Atlanta	U.S.A.	1.5
Richardson, K.	DOC	Canada	5.2
Robson, T.S.	IBA	England	1.4
Rossi, John P.	CBS Technology Center	U.S.A.	2.2
Tan, S.L.	Philips Research Laboratories	U.K. & The Netherlands	2.7
Toth, Arpad G.	BNR	Canada	2.1
Vivian, Western	University of Michigan & Kalba Bowen Assoc.	U.S.A.	5.1
Welch, B.L.	CAE	Canada	4.2
Wendland, B.	University of Dortmund	F.R.G.	2.3